International Dimensions of Climate Change

The Implications for the UK's Health Sector of the International Dimensions of Climate Change, 2010 to 2100

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1. Introduction

1.1 Brief and aim of the Report

During the summer 2010, Foresight commissioned the Health Protection Agency (HPA) to contribute a report on the health sector for inclusion in its International Dimensions of Climate Change (IDCC) project.

Foresight is within the UK Government Office for Science (GO-Science) and aims to help Government think systematically about the future. Foresight uses the latest scientific and other evidence to provide signposts for policymakers in tackling future challenges.

The HPA is an independent agency that was set up by the government in 2003 to protect the public from threats to their health from infectious diseases and environmental hazards. It gives advice to the public, provides data and information to government to help inform its decision making, and advises people working in healthcare. It also makes sure the nation is ready for future threats to health.

Foresight's International Dimensions of Climate Change (IDCC) project aims to improve our understanding of how climate change in other parts of the world could impact the UK to 2100. Specifically, it will look at how climate change impacts overseas will affect the UK, taking into account the interaction of climate change with international non-climatic drivers of change. It is expected that the IDCC project will inform the Climate Change Risk Assessment to ensure that UK Government adaptation policy takes appropriate account of international impacts.

It is envisioned, for the purpose of the IDCC project, that the effects of Climate Change outside of the UK will have two major components:

- direct effects, resulting, for example, from systemic changes in precipitation, temperature, sea level, extreme events (increasing in magnitude and/or frequency)
- indirect effects due to global shift to low carbon (for the purposes of this project, such a drive to low carbon is deemed to be a concomitant of climate change itself). Such indirect effects might be due to international legislation and regulation, changing attitudes and behaviours, and changes in risks.

The above climate change effects will then interact with key socio-economic drivers (such as demographic shifts) and translate into implications/impacts in key areas overseas.

The aim of this Report is therefore to explore the implications, opportunities and threats for the UK's health sector that may arise from the impacts of climate change overseas, in the period up to 2100. For the purpose of this Report the health sector includes considerations about the health of the UK's population, the UK's healthcare system, and the UK's role and participation in international health agreements.

The Report will begin by exploring the main possible impacts of climate change overseas and how these may relate to health (Chapter 2). This analysis will then be used to explore the possible secondary impacts on the UK and its population. Chapter 3 will explore the potential effects on population health, while Chapter 4 will focus on the potential effects on health services and health policy, including the UK's role in international health.

1.2 Method statement

The Report was researched and drafted during the summer 2010. A list of the key issues and topics to be considered was first agreed upon between the lead authors and Foresight. The lead author then sought views and contributions from colleagues across the HPA,

representing a range of expertise in climate change, infectious diseases, environmental health and epidemiology, and international health.

Due to the time constraint on producing this Report, a full literature review was not deemed feasible. The conclusions presented here are based on expert experience and accumulated evidence, including peer-reviewed and 'grey' literature. The peer-reviewed literature was extracted mainly from health journals, as well as relevant climate change and disaster publications, including from the Intergovernmental Panel on Climate Change (IPCC). The grey literature included references to publications from the World Health Organisation (WHO), the United Nation's International Strategy for Disaster Reduction (UNISDR), as well as UK institutions.

Another limiting factor in writing this report has been the relative paucity of evidence and analysis of the possible effects of climate change on health. Overall, there is comparatively little epidemiological knowledge of how climate variations can affect climate-sensitive health outcomes, although some aspects (such heatwaves) have been studied more than others. For some health outcomes, such as infectious diseases, the effect of weather variations has been studied, but making inferences as to the impact of climate change is not straightforward. The relationship between the different aspects of climate change and their potential health outcomes is complex and multifactorial. Its analysis needs to take into account not only the factors that may affect the source of exposure, but also how susceptible people are to the exposure, the different possible routes of exposure and the capacity for the population to adapt. In other words, the impact climate change might have on health is mediated by changes to the environment, the adaptability of the various vectors of disease, human intervention to prevent and adapt to emerging conditions, and people's individual behaviour patterns. In this report, we will therefore not attempt a proper risk assessment for the health sector, but rather simply attempt to identify possible opportunities and threats as part of a horizon-scanning exercise.

2. The health-related effects of climate change outside the UK

Climate change is likely to have a range of effects overseas, which could in turn be expected to impact on the UK's health sector. The aim of this Report is not to attempt a comprehensive review of the potential impacts of climate change globally. However, it was deemed useful to provide a short overview of the global impacts that are, directly or indirectly, likely to 1) affect health and 2) have repercussions on the UK.

This overview aims to set the scene by answering the following questions:

- Which parts of the world are most likely to be affected and how?
- What are the relevant global impacts of climate change likely to be?
- Are climate change mitigation and adaptation strategies abroad likely to have relevant impacts?

The drivers to impacts on the UK that will be considered in this chapter are both direct health effects of global warming and changing weather patterns, including:

- extreme events
- sea level rise
- gradual environmental change

as well as indirect effects, which are possible consequences of the effects listed above:

- migration
- change in lifestyle and energy sources.

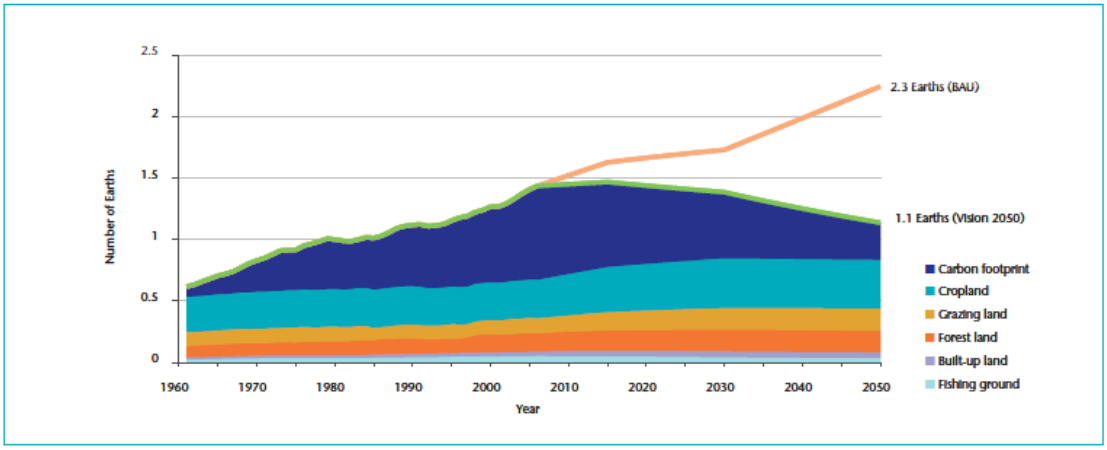
2.1 The context

The UK's Climate Change Risk Assessment will consider several emission scenarios in particular (High emissions A1F1; Medium emissions A1B; and Mitigation scenario E1), and Foresight initially requested that IDCC reports utilise these same scenarios if possible and appropriate. Robust and comprehensive climate change scenarios have not yet been built for health and it would have been difficult to model potential health impacts, which are indirect and multi-factorial consequences of climate change, consistently back to these scenarios within the limited scope of this Report. Nevertheless, a general understanding of the projected levels of global warming and environmental change is necessary background to exploring the likely health consequences of climate change.

Although other work has also been undertaken on the consequences of climate change, a recent report from the World Business Council for Sustainable Development (WBCSD) helps to focus the issues and highlight the global ecological footprint we may have unless radical action is taken to curb the use of resources at current and forecast rates. The report provides an analysis of possible ecological footprints for 2050 (WBCSD 2010), which models the potential impact our lifestyle might have on environmental resources comparing changes in human behaviour with a "business as usual" approach. The analysis is based on median population projections for 2050 of 9.2 billion; a 50% reduction from 2005 levels of carbon emissions by 2050; improvements in forest yields through managed forests and an increase in forest areas after 2030; an increase in average global crop yields of 2% a year or more above recent historical levels as a result of the dissemination of best practice; and high levels of innovation. Global average food consumption is similar to current Costa Rican food consumption levels. The assumptions for the "business-as-usual" path are the same for population and food consumption, while those for carbon emissions, forests and crop yields differ. Carbon emissions increase with increased population and economic growth, forest areas continue to follow the 1950-2005 linear trends while forest plantation and crop yields remain constant. Carbon emissions are shown in the ecological footprint through the carbon footprint component. This translates the amount of carbon dioxide emissions into the amount

of productive land and sea area required to sequester said carbon dioxide. The project then models the date by which we would hit one planet (Figure 1).

Figure 1: Ecological footprint against business-as-usual – how many 'Earths' do we use? (Source: Vision 2050, World Business Council for Sustainable Development 2010)



The IPCC's Fourth Assessment Report (AR4) provides an in-depth assessment of possible climate change scenarios and impacts. Table 1 summarises projections for average global temperatures and sea level rise by 2100 for high and medium emissions. Higher global temperatures have been linked to a higher risk of extreme events, including typhoons/hurricanes and floods. Warming over many land areas is expected to be greater than the global annual mean warming because land mass has less water available for cooling, which in turn can be linked to a greater risk of weather events such as heatwaves and drought (IPCC 2007).

Table 1: Projected global average surface warming and sea level rise at the end of the 21st century (summarised from AR4, p70, table TS.6 (IPCC 2007))

Scenario	Temp change (°C increase at 2090-2099 relative to 1980-1999)		Sea level rise (m increase at 2090-2099 relative to 1980-1999) *
	Best estimate	Likely range	
High emissions A1F1	4.0	2.4 – 6.4	0.26 -0.59
Medium emissions A1B	2.8	1.7 – 4.4	0.21 – 0.48

*model excluding future rapid changes in ice flow

The Stern review (Stern 2006) concluded that that the impacts of climate change are not evenly distributed and the poorest countries will suffer earliest and most. The AR4 also concludes (IPCC 2007) that some regions of the world are likely to be especially affected by climate change:

- **Africa**, especially the sub-Saharan region, through a combination of current low adaptive capacity and what is expected to be higher than average warming. Rainfall is likely to decrease in much of Mediterranean Africa, the northern Sahara, and in the winter rainfall region and western part of southern Africa. There may be an increase in rainfall in East Africa, and it is unclear how rainfall in the Sahel, the Guinean Coast and the southern Sahara will evolve.
- **Small islands**, due to their population and infrastructure's high vulnerability to sea-level rise and storm surge
  Sea levels are likely to rise on average during the century and affect the small islands of the Caribbean Sea, Indian Ocean and northern and southern Pacific Oceans. The patterns of rainfall that affect these small islands are also likely to change.

- **Asian megadeltas**, such as the Ganges-Brahmaputra and the Zhujiang, because there are very densely populated and highly exposed to sea-level rise, storm surge and river flooding.
  In most parts of Asia warming is likely to be above the global mean and precipitation is likely to increase. The frequency of intense precipitation events is likely to increase in parts of South Asia, and in East Asia. Extreme rainfall and winds associated with tropical cyclones are likely to increase in East Asia, Southeast Asia and South Asia.
- **The Arctic**, because warming is projected to be higher than the average and the environment is especially vulnerable

The effect of climate change in the Arctic is unlikely to have a direct impact on the UK's health sector, although it may have significant consequences otherwise (including mineral resources and oil extraction, and potentially on northern hemisphere weather systems). However, environmental change in the other regions mentioned above could be expected to impact on the UK's health sector through migration and British strategic and historical links with the region.

Mainland Europe is the closest continental mass to the British Isles and an area with which there is significant flux of population. AR4 projects that annual mean temperatures in Europe are likely to increase more than the global mean. Winters are likely to become warmer in northern Europe, while summers become warmer in southern and central Europe. Annual precipitation is very likely to increase in most of northern Europe and decrease in most of the Mediterranean area. Risk of summer drought is likely to increase in central Europe and in the Mediterranean area. The duration of the snow season is very likely to shorten, and snow depth is likely to decrease in most of Europe (IPCC 2007).

2.2 Extreme weather events

Some of the more spectacular impacts of climate change are likely to be an increase in the frequency and strength of extreme weather events across the world (IPCC 2007). The occurrence of more frequent and more severe extreme weather events globally may affect the UK through a variety of mechanisms, which will be explored in the next chapters. These mechanisms include population migration, British citizens and assets abroad, requests for aid and assistance, political and strategic ties with disaster-prone regions of the world, and the UK's involvement in international agreements and scientific collaborations.

Effective extreme weather event management requires extensive planning targeted at four elements: preparedness (policies and procedures designed to facilitate effective response); response (actions taken immediately before, during and after a disaster to protect people and property and to enhance recovery); recovery (actions taken after a disaster to restore critical systems and return a community to pre-disaster conditions); and mitigation (actions taken before or after a disaster to reduce the impacts on people and property of future hazards). Vulnerability to extreme weather events is generally higher in the poorer areas of the world, which lack the resources to prepare for and prevent disasters, and where the baseline health and economic status of the population is often low (UNISDR 2009a).

The type of weather events that are most likely to be affected by global warming are heatwaves, floods, wind storms and drought. Such natural disasters can impede development and often have long-term health consequences.

Heatwaves
In Europe, there is likely to be an increased risk of more intense, more frequent and longer-lasting heat waves (IPCC 2007). The European heatwave of 2003 is an example of the type of extreme heat event lasting from several days to over a week that is likely to become more common in a warmer future climate. The European summer of 2003 was characterised by highly anomalous meteorological conditions, and was extremely hot and dry (Schär and Jendritzky 2004). UNEP (2004) reported that the extreme drought and heat wave that hit

Europe in the summer of 2003 had enormous adverse social, economic and environmental effects, such as the death of thousands of vulnerable people (Table 2), the destruction of large areas of forests by fire, and effects on water ecosystems and glaciers, power cuts and transport restrictions and a decreased agricultural production.

Table 2: Mortality from the European heatwave 2003
(Summarised from INSERM: "Surmortalité liée à la canicule de l'été 2003", AP September 25, 2003 quoted in UNEP 2004)

Country	Casualties
France	14 082
Germany	7 000
Spain	4 200
Italy	4 000
UK	2 045
Netherlands	1 400
Portugal	1 300
Belgium	150

The main causes of illness and death during a heatwave are respiratory and cardiovascular diseases (Semenza 1996). Some of this rise in mortality may be attributable to air pollution, which makes respiratory symptoms worse, but the main contributor is the strain extreme heat places on the heart, which for elderly people and those with chronic health problems can be enough to precipitate a cardiac event (Havenith 2001). Older people and those with chronic and severe illness are particularly vulnerable, although during an extreme heatwave everyone can be affected (Ebi 2007). Living in urban areas (where temperatures are higher because of the 'urban heat island' effect) and undertaking activities that include high levels of physical exertion also puts people at increased risk (Shimoda 2003). In 2003, northern France was especially severely affected by the heatwave through a combination of extreme weather, urban heat island effect and insufficient preparedness. The impact of the 2003 heatwave on health and health services in France was so severe that it prompted a major review of prevention and emergency planning strategies (Grynszpan 2003). Better planning and preparedness appears to have successfully mitigated the potential impact of heatwaves: when a second heatwave hit France in 2006, casualties were less than predicted using a model developed using evidence from the 2003 event (Fouillet 2008).

Flooding

IPCC projects an increased risk of flooding events due to climate change (IPCC 2007). Some of this trend has already been observed in many parts of the world. Wet extremes are projected to become more severe in many areas where mean precipitation is expected to increase. In a warmer world, rainfall might also tend to be concentrated into more intense events, with longer periods of little rain in between. An increase in the likelihood of very wet winters is projected over much of central and northern Europe, suggesting an increased chance of flooding over Europe and other mid-latitude regions due to more intense or more frequent rainfall and snowfall events producing more runoff. Projections also point to an increase in summer precipitation in the tropics, with implications for more flooding in the Asian monsoon region and other tropical areas. In addition to the increased flood risk from more intense rainfall, there may be an increased risk of fluvial flooding. River discharge is likely to increase, creating an increased risk of intense storm-related precipitation events and flooding in a number of major river basins.

Flooding affects health in many ways (Jonkman and Kelman 2005, Ahern et al 2005, Ohl and Tapsell 2000), including deaths and trauma from drowning, injuries, electrocution; a risk of infectious disease and chemical contamination; longer term mental health issues; and by exacerbating pre-exiting conditions and delaying treatment and healthcare delivery. It is likely that the health burden is higher than is routinely identified because reporting is often not optimal. Health impacts occur during and after the event in the 'clean-up' phase and better preparedness can mitigate the impacts (WHO Euro 2003).

Wind storms

Modelling studies suggest that future tropical cyclones could become more severe. This could mean fewer weak storms and greater numbers of intense storms. Such changes may already

be underway: for example there are indications that the net number of Category 4 and 5 hurricanes per year has increased over the past 30 years. A number of modelling studies have also projected a tendency for more intense but fewer storms outside the tropics. Models also suggest that storm tracks in both hemispheres may change by several degrees of latitude, which would mean that intense storm could in the future affect areas that are as yet not, or rarely, affected (IPCC 2007). Wind storms can create large scale devastation, and, as with flooding, have direct and indirect impacts on health through injuries, damage to infrastructure leading to increased exposure to the weather and unhygienic living-conditions, and loss of access to healthcare. Hurricanes and typhoons can have disastrous consequences in highly-developed countries, although it is the less-developed parts of the world that are most vulnerable and less likely to recover rapidly or effectively. For example although Hurricane Katrina was hugely costly it corresponded to only a small fraction of the US GDP, while the hurricane in 1998 in Honduras amounted to over 75% of its GDP (Handmer 2003).

Droughts
The IPCC projects that in a future warmer climate, summer dryness and winter wetness is likely to increase in most parts of the northern middle and high latitudes. Summer dryness point toward a greater risk of drought, especially as dry extremes are projected to become more severe in areas where mean precipitation is projected to decrease. This increase in the risk of drought is particularly expected to affect large parts of Africa, where adaptive capacity and baseline population health is already low (IPCC 2007). Droughts can have severe health impacts, in particular as a consequence of water and food scarcity and poor sanitation (increased by water scarcity). These impacts can create long-term endemic health problems such as associated with chronic malnutrition. A review of the Ethiopian famines (Taye 2010), for example, point to malnutrition complicated by infectious disease as the main cause of increased mortality. Young children were especially vulnerable. Other adverse health impacts were complex and long-lasting, including restricted growth, negative implications on mental development and shortened life expectancy. The consequences of a severe drought may also affect subsequent generations, and can have significant impacts on development.

2.3 Gradual environmental change

Climate change may also produce gradual changes to the environment which will be complex and multifactorial and take place over an extended period of time. It is possible that overall, these slow cumulative effects will have a more substantial impact than spectacular short-term ones such as those resulting from extreme weather events. Gradual climate-change related environmental degradation may result from a number of factors including sea level rise, increased water scarcity and warmer, drier weather.

The Foresight IDCC project has commissioned separate reports about the impacts of sea level rise. We will therefore simply mention it, possibly compounded by severe storms and floods, as a possible driver of change to land availability, local patterns of livelihood, and social and economic change generally in those regions most affected.

Foresight has also commissioned another report on the relationship between food security and climate change. Here again, we simply mention it, although it may be a significant driver of change and associated health impacts. Water scarcity, prolonged droughts, and generally warmer climatic conditions may lower the yield of arable land. Local food production may be affected, which might impact on global food security, equity and food distribution mechanisms and markets. Already vulnerable populations may become poorer and even more vulnerable to environmental change and external pressures. Such a process would be likely to increase existing health inequalities across the world (Costello 2009). Achieving global development objectives, exemplified by the current Millennium Development Goals (MDGs), could become an increasing challenge (see Appendix for more detail about the MDGs).

It has sometimes been suggested that another potential indirect consequence of environmental change might be an escalation in conflict. Research has identified a number of

major risk factors for war, with particular emphasis is given to low per capita income, economic decline and dependency on natural resources (Collier-Hoeffler 2000). The importance of natural resources and low income points to a potential escalation of conflict in war-prone zones linked to the additional pressures from climate change and water scarcity. However, the probability of such conflicts occurring is, as yet, unclear (Sondorp 2010).

2.4 Migration & displacement

Foresight's Global Environmental Migration project (due to report in Autumn 2011) will examine how future environmental change could affect human migration in the long-term around the world. Climate change-related migration, if it becomes significant, could have repercussions on population health and demand for health services in the UK. These potential repercussions on the UK will be explored in Chapters 3 and 4. Here we briefly explore the possible drivers of population movements, but we refer the reader to the forthcoming Foresight report for a more in-depth analysis.

Climate change could potentially increase the movement of populations. Such population movement could include:

- Migration as a response to the impacts of gradual environmental change (eg sea-level rise, drought, desertification and land degradation)
- Displacement following extreme weather events (eg floods, landslides, hurricanes)
- Resettlement as a consequence of mitigation and/or adaptation measures (eg dams, residential clearances)

Overall, there are limited data on migration and it may be misleading to assume that all people in affected areas want or are able to move. Experience shows, for example, that following an extreme weather event people return as soon as possible provided there is sufficient local support and recovery (Tacoli 2010). Conversely the need for income diversification, due to incremental environmental degradation, may lead to further population movements.

Population movements may have a negative impact on health when migration involves a sustained period of impoverishment and the destruction of support networks. Health may also be more immediately affected when populations have to live in unsanitary conditions which can increase exposure to infectious disease and chemical pollution, such as make-shift ‘displacement’ camps and under-developed urban areas. Population movements may affect the UK, for example as a consequence of requests for development aid or through pressures on the UK population to support relatives abroad.

2.5 Overseas Territories and Small Island States

One particular set of circumstances where UK involvement might be especially important is when considering the small islands that are UK Overseas Territories or part of the Commonwealth. A large number of Overseas Territories and Commonwealth nations are small, low-lying islands, including St Helena, Pitcairn Island, Tristan da Cunha and, in the Caribbean, Montserrat, Anguilla and the Turks and Caicos Islands. Small Island and Developing States (SIDS), as they are commonly called, are among the areas of the world that are most vulnerable to climate change because of their limited size, geographical isolation, high exposure of population and infrastructure and limited adaptive capacity. They are frequently located in regions prone to natural disasters, often of a hydrometeorological and/or geological nature (Sear et al., 2001). Their economies are often reliant on a limited resource base and subject to external forces, such as changing terms of trade, economic liberalisation, and migration flows. Overall, their adaptive capacity to climate change is comparatively low, even where traditionally there has been some resilience in the face of environmental change (IPCC 2007). For example, the Caribbean Community Climate Change

Centre estimates that, if the current rate of climate change and emissions are not mitigated, Caribbean islands could see an increase in hurricane damages, loss of tourism revenue, and infrastructure damages that could total $22 billion annually by 2050 and $46 billion by 2100 (Bueno et al. 2008).

These characteristics of SIDS and their relentless negotiations have already begun to affect international relations, with for example a resolution of the United Nations' General Assembly that focuses on the possible security implications of climate change (Resolution A/63/L.8/Rev.1 on 3rd June 2009) in which the UK was involved. It is likely that pressures and negotiations about structural and financial aid and about migration will continue. Although some of these negotiations are expected to be among neighbouring countries (such as with Australia and New Zealand for the Pacific SIDS), the UK may be involved further, due to its status in the Commonwealth and as a highly developed country. The UK will also need to envisage potential outcomes and solutions for those vulnerable islands that are Overseas Territories and to consider what the impacts might be on the UK's health sector.

2.6 Indirect effects of mitigation and adaptation strategies

Strategies to mitigate and adapt to climate change are increasingly likely to involve different and new sources of energy, approaches and materials to build infrastructures and lifestyle changes. Examples include the use of non-fossil fuel energy sources, low-energy Compact Fluorescent Bulbs for lighting, and low-carbon means to heat and ventilate houses. Although poorer countries may find it more difficult to switch to new technologies, demand for low-carbon technology already exists (Chatham House 2010). One example of such projects is the introduction of low-greenhouse gas biomass cooking technologies (Bhattacharya 2002).

There is uncertainty about the environmental and societal impacts of mitigation and adaptation strategies, and related potential health impacts. Even if these health effects occur in developing countries, the UK, as a highly developed nation, may be indirectly affected. For example, building dams and coastal defences can create local environmental degradation and forced migration, which in turn could potentially affect immigration to the UK. Waste management of new technologies could also, if not appropriately managed, create new toxic environmental exposures and degradation. Richer nations have a role to play in avoiding environmental contamination in poorer areas of the world through unsafe waste management and recycling practices. Past examples of such unsafe practices have led to mass health effects in Cote d'Ivoire where toxic waste of European origin was deposited without safeguard (IPCS 2006) and to several outbreaks of lead poisoning through unsafe recycling of batteries by deprived populations (Haefliger 2009, Vogt 2009).

3. Health and public health impacts in the UK

3.1 Change in population characteristics and health needs

Climate change-related migration, if it becomes significant, could have an impact on UK demographics and influence the health needs of the population as people may move from the most affected areas. Developed countries are seen as the main destination of migrant flows in many studies after floods (Perch-Nielson 2008). However, as discussed in Section 2.4 climate change-related migration trends are difficult to assess. If immigration to the UK is affected, especially in the event of 'catastrophic' climate change, with large areas being severely affected and uninhabitable, then the influx of new immigrants might change the proportion and composition of ethnic groups in Britain.

Immigration could affect the disease burden of the UK, since many of the particularly vulnerable areas of the world also have a higher rate of endemic disease and immigrants from those areas may enter the UK with pre-existing disease or higher risk factors for developing the condition after they have settled in the UK. For example, tuberculosis is especially prevalent in sub-Saharian Africa and South-East Asia (WHO 2010), HIV infections are most prevalent in sub-Saharian Africa (UNAIDS/WHO 2008) and almost 80% of people with diabetes live in low or middle-income countries (WHO 2009b). However, some of these differences in risk factors are associated with lifestyle choices and public health conditions in the originating country, and may disappear after the first generation.

A number of climate change migrants may arrive with limited financial resources. Socio-economic deprivation in general tends to be associated with a lower health status, for a number of reasons including standard of living, lifestyle and occupational risk factors and barriers in access to health services (which can be language, educational or financial barriers). These new immigrants may therefore present a range of challenges for health services, although many of these challenges are likely to be similar to those of existing immigrant communities.

On the other hand, an influx of immigrants could also have some benefits for the UK. For example, as population growth trends are higher in the developing world, immigration could contribute young people to what is expected to be an ageing UK population. Immigrants may also add to the workforce, including staff in the health services.

3.2 Infectious diseases

Evidence about the relationship between natural variation in meteorological variables (especially temperature and rainfall) and the outcome of many infectious, mainly vector-borne diseases, is extensive. However, longer term trends are more difficult to evaluate since it is difficult to disentangle to the role of climate change from numerous other factors such as ecological changes, economic development, changes in land use, population growth, migration and urban expansion and development of public health infrastructures. In addition, although models have been developed to stimulate the effects of climate change on diseases such as malaria, dengue and cholera, these models cannot necessarily be used as prediction tools because it is difficult to integrate the physical and biological feedback and human adaptation factors, such as vaccines, drugs and public health programmes, which could mitigate many adverse impacts.

The WHO Comparative Quantification of Health Risks (McMichael 2004) uses standardised comparative risk assessment methods for estimating aggregate disease burdens attributable to different risk factors to assess health risks. This approach has been used to assess the

health consequences of climate change worldwide and concludes that climate change will bring some health benefits such as lower cold-related mortality and greater crop yields in temperate zones, but these will be greatly outweighed by increased rates of other diseases particularly infectious diseases and malnutrition in developing regions. It emphasise the fact that the effects of climate change are predicted to be heavily concentrated in poorer populations in developing countries and that the greatest impact is likely to be on under 5 year olds. These populations are especially vulnerable, having a higher baseline rate of endemic diseases and fewer resources to adapt and respond.

Infectious disease distributions can change through (a) *direct* effects of climate change (e.g. warming of the ambient temperature, sea level rise), or through (b) *indirect* effects of causing more severe weather patterns (e.g. droughts, floods or storms). In a large susceptible population, a small increase in risk can have a large impact.

Predicted Changes in infectious diseases patterns outside UK

Change in conditions for food and water-borne diseases
It is anticipated that there may be an increased risk of diarrhoeal diseases in developing countries, while richer countries will experience no or little additional risk of diarrhoeal diseases (McMicheal 2004, IPPC 2007). The predicted increase will be due to a combination of a number of factors but water, in particular clean water, shortages are expected to play a major role. Droughts may lead to low river flows and an increase in relative pathogen load (Senhorst and Zwolsman 2005). Heavy rain may also contribute by producing run off of surface contaminants into water supplies. Extreme weather events such as flooding also carry a risk of subsequent contamination of water supplies (IPCC 2007).

Any reduction in water supplies will be crucial, as there are already 1.1 billion people globally who do not have access to adequate supplies of safe water and a total of 2.4 billion people who do not have access to sanitation. Improved water supply and sanitation has been shown to reduce morbidity from diarrhoea, ascaris infections, guinea worm, trachoma, as well as diarrhoea-specific mortality, and general child mortality. Any increased shortage of clean water is likely to increase the incidence of these infections.

The impact in the areas of the world which are most vulnerable to water shortages is likely to be severe, all the more so as many are in low-income countries which often lack the resources to respond. Thus, unless the global economy changes, these countries will need financial support to tackle the consequences of diarrhoeal diseases which will particularly affect the under-5years. Potentially there might also be a small direct risk to the UK through contamination of food and other products from these regions, but surveillance systems and point of entry testing in the UK should detect contaminated products and hence reduce the risk.

Change in conditions for rodent-borne diseases
Diseases transmitted by rodents, such as rats, mice and voles, may increase in areas outside UK depending on the lifecycle of these hosts. Their lifecycle itself depends on weather conditions and other environmental factors, such as land use, vegetation and food availability. Severe weather conditions, such as floods and heavy rainfalls could create the environmental conditions for a potential increase in the risk of some rodent-borne diseases, such as leptospirosis (Ahern et al 2005, Ko et al 1999). Thus travellers from the UK may be exposed when visiting these areas.

Change in conditions for vector-borne diseases
Vector-borne diseases, such as malaria and dengue which are both transmitted by mosquitoes, make a major contribution to the global burden of disease. Half of the world's population is at risk of malaria, and an estimated 243 million cases led to an estimated 863000 deaths in 2008 (WHO 2009a).

For the reasons described above, the effect of climate change on vector-borne diseases is likely to be complex. Weather patterns, such as the El Niño-Southern Oscillation have been

shown to affect the intensity and distribution of vectors, such as mosquitoes (Kovats et al 2003, Haines et al 2006a, Depradine and Lovell 2004) and an increase in ambient temperature (Bouma and Dye 1997) and rainfall is generally thought to increase both the availability of breeding grounds for mosquitoes and their development. On the other hand, droughts have been observed to decrease malaria incidence in Senegal and Niger over the last decade (Mouchet et al 1996). Drought has also been reported to increase the number of water storage vessels around houses and thereby increase the number of suitable breeding sites close to human habitation and facilitate the spread and outbreaks of dengue fever (Pontes et al. 2000).

In its 4th Assessment Report the International Panel on Climate Change concludes with very high confidence that climate change is likely to have mixed effects on malaria: in some places the geographical range is expected to contract, while elsewhere the geographical range is likely to expand and the transmission season may be changed (IPCC 2007).Climate change is also likely to change the range of other infectious disease vectors. Dengue which is the world's most important vector-borne viral infection has seen unprecedented global spread over the past decades but studies reporting associations with climatic conditions have been inconsistent (IPPC 2007).

Summary of possible impacts on the UK

Infectious diseases overseas could impact on health in the UK:

Directly

- Migration and travel, through the arrival of affected persons in the UK whether these are UK Nationals who acquired their infections overseas or visitors to UK ('imported cases')
- The potential risk of outbreaks in the UK, either from individuals above leading to person-to-person spread or due to imported vectors or contaminated food products ('autochthonous cases')

Indirectly

- The potential for an increase in the need to provide technical and financial assistance to areas vulnerable to and affected be climate-change to support the control and management of infectious diseases and climate-related disasters
- Importation of potentially contaminated products such as foodstuffs

3.3 Air pollution

Air Quality

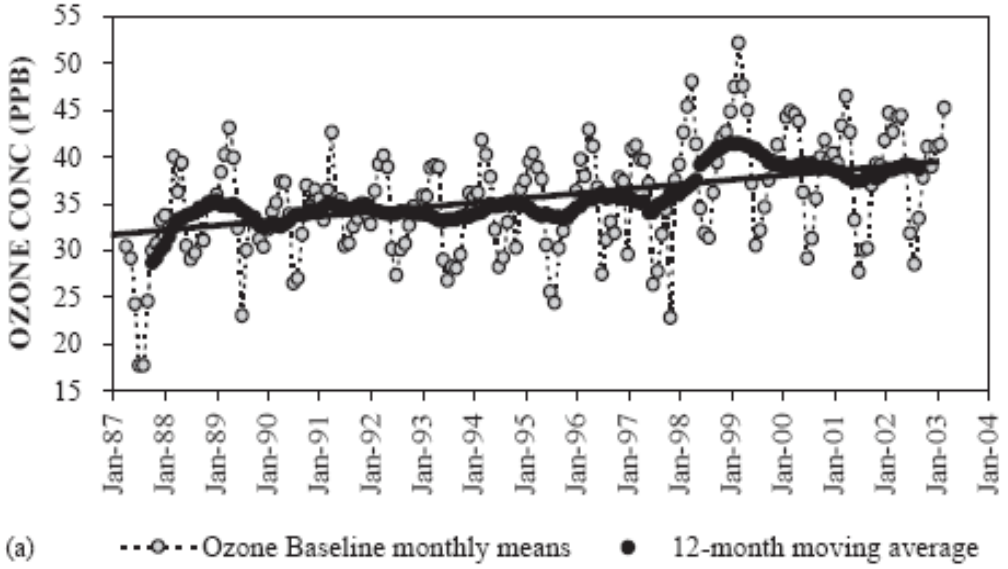
There is strong evidence that long-term exposure to air pollutants has an effect on mortality and morbidity, particularly by exacerbating cardiovascular and respiratory disease (COMEAP 2009). Air quality is affected by various processes and events, ranging from industrial processes and motor vehicle emissions to events such as ozone peaks, forest fires and sand storms.

Climate change is likely to have an impact on local, regional and continental air quality due to changes in atmospheric emissions of pollutants, pollutant transport and chemical transformation patterns (Kinney 2008, Jacob and Winner 2009). Changes in emissions of industrial, transport-related and biogenic pollutants (mainly nitrogen oxides and volatile organic compounds) in continental Europe will affect ground-level ozone and fine particle ($PM_{2.5}$) concentrations in the UK (Derwent et al. 2006, Jenkin 2008, Athanassiadou 2010). Furthermore, changes in temperature, precipitation and atmospheric circulation patterns attributed to climate change may affect ground-level concentrations of allergenic pollutants such as pollen (D'Amato et al. 2010).

Ozone

Tropospheric (i.e. ground-level) ozone has well established health impacts, particularly respiratory illness and cardiovascular disease. Ozone represents an example of how concentrations in the UK are influenced by local and global processes. Although magnitudes of extreme peaks of ozone in the UK have fallen in recent years as a result of emission control policies in Europe, the frequency of short-term episodes where ozone concentrations are elevated to potentially harmful levels has increased. Future concentrations of ozone are difficult to predict since ozone precursor emissions (and future regulations) play a large role. Of note, historical trends in ozone show a doubling in the northern hemisphere since pre-industrial times. During the last few decades of the 20th century, background ozone increased steadily in the northern hemisphere, as can be seen from monitoring data from Mace Head in Ireland (Figure 2), a site which is not directly affected by anthropogenic sources of pollutants (Simmonds et al 2004). This steady increase in background hemispheric ozone levels has the effect of reducing the positive impact of controlling local emissions of precursors (Derwent et al. 2006). Future ozone trends are uncertain and modelling studies show a range of predictions and much spatial variation (Dentener et al. 2006, Stevenson et al. 2006, Athanassiadou et al 2010). This highlights the uncertainty of climate change effects on ozone over large spatial scales and the sensitivity to the choice of emissions scenario used.

Figure 2 Significant growth in surface ozone at Mace Head, Ireland, 1987-2003.
(From Simmonds, P.G.; Derwent, R.G.; Manning, A.L.; Spain, G. Atmospheric Environment. 38:4769-4778; 2004)



Global baseline monitoring networks for ozone, a key atmospheric constituent, have been put in place and provide the basic observations for directly monitoring the global climate system, but major geographical gaps remain (UNFCCC 2010).Those already in place include the Global Baseline networks such as the Global Climate Observing System (GCOS) Surface Network (GSN), the GCOS Upper-Air Network (GUAN) (subsets of the full WMO WWW/Global Observing System (GOS) surface and upper-air networks) and the WMO Global Atmosphere Watch (GAW) networks for ozone, plus related satellite observations. Analysing these data on ozone and the consequent potential health impacts would be of value in understanding the possible public health impacts in the UK.

Forest fires and sand storms

Increased desertification and sandstorms in Africa could also have an impact on air quality in the UK due to the long-range atmospheric transport of fine particles. There is evidence that Saharan dust already affects air quality in south and west Europe and the Caribbean (Prospero and Lamb 2003, Borge et al 2007, Vardoulakis and Kassomenos 2008) potentially increasing daily mortality in these regions (Perez et al 2008).

Forest fires in continental Europe (e.g. fires of summer 2010 in western Russia), which may be partly attributed to global warming, can also cause higher concentrations of fine particles in the UK due to the long-range transport of smoke (Witham and Manning 2007). Many other similar incidents have occurred around the world and may impact on the UK or Commonwealth countries. These events include the 1997/98 haze following drought conditions and burning in Indonesia (Field et al 2009) and in 2009 drought, heat wave and bushfires in Melbourne, Victoria, Australia (Victorian Government Department of Sustainability and Environment 2008).

3.4 Sun exposure-related diseases

Stratospheric ozone acts as a protective filter against certain harmful components of ultraviolet radiation (UVR) from the sun. The ozone depletion which has been observed since the 1970's (likely as a result of man-made emissions) has been correlated with increases in harmful UV-radiation in some parts of the world, including parts of Europe, Latin America and Australia (IPCC 2007, EEA 1994, Martens 1998, Kefkens, 2002, Krzyścin 2008). Although the situation has been improving in past years, it is expected to be a slow recovery process over 50 to 60 years. However, some evidence suggests that climate change might delay the recovery of the atmospheric ozone layer by one or several decades (Gao, 2010, Kefkens 2002).

Exposure to UVR from the sun is associated with a range of conditions affecting the skin and eyes (AGNIR, 2002), which presently cause significant mortality and morbidity in the UK. Melanoma, the least common but most severe form of skin cancer, was a rare disease in the 1960s, but a long-term increase in incidence and mortality has occurred in most white populations across the world over several decades (CancerUK 2010, ONS 2005). Exposure to UVR is associated with an increased risk of skin cancer. Chronic exposure to the sun also causes photoageing of the skin. Effects of UVR exposure on the eye include a range of non-malignant clinical lesions affecting the cornea and conjunctiva. Chronic exposure of the eye to intense levels of UVR contributes to the development of cortical cataract, although the extent to which UVR exposure is an important risk factor for cataracts in the general population is unclear. The chief beneficial effect of UVR exposure is its role in the production of vitamin D in the skin, which is essential for healthy bone growth and maintenance.

People who have fair complexions, ie: light skin, red or blond hair and blue eyes are at increased risk of harm from UVR exposure (Armstrong 2001). Given this, population movements from the UK can be an important factor in the incidence of sun-related disease. It is notable for example that Australia, where the sun is very strong and much of the population came from northern Europe, has very high incidence of skin cancer. The younger people were when they emigrated, the higher their risk has proved to be later in life. Childhood exposures are regarded as particularly important in affecting the risk of skin cancer (Rigel 2008, Whiteman 2001).

There is also evidence that short, intense exposures of the type arising from sunbathing are important in the causation of melanoma, but chronic cumulative exposures may also be relevant. Traditionally people were mainly exposed to UV light as a result of outdoor occupational activities, and their exposure level changed progressively with the seasons. People also had skin generally adapted to the climate of the part of the world in which they were living. Nowadays, high-income populations make a significant contribution to their sun-exposure through leisure activities, including short periods of intense exposure, e.g. when sun-bathing and during holidays abroad. Incidence of skin cancer is higher in more affluent groups.

Increased availability of sunlight or higher temperatures does not necessarily translate to higher UVR exposures. People may avoid the sun when it is strongest and spend time outdoors in the evenings when it is weaker, as in Mediterranean countries. People may also

become more aware of messages to protect themselves from the sun by limiting their exposure, wearing hats/clothes and glasses.

In summary, the effect of climate change on sun exposure related diseases is uncertain and will depend to a large extent on how people's behaviour changes in response to climate change. Disease results from individual sensitivity, the pattern and duration of exposure to sun, the level of UVR in the sun light one is exposed to, and the extent to which sun protection is used.

3.5 Mental health

The impacts of climate change overseas might have an indirect effect on mental health in the UK. This effect would likely occur mainly through immigration of populations with mental health conditions that were either pre-existing or due to the migration process itself. For example, adverse psychological and psychosocial outcomes are well documented in the aftermaths of natural disasters for example major depression and post-traumatic stress disorder (Galea 2007). Should either temporary or permanent migration occur into the UK as a result of extreme weather events it is possible that migrants will suffer from mental ill health and will be in need of psychological support. Migration due to coastal change and sea-level rise could also lead to more mental illness in the affected populations (Page & Howard 2010). Another potential cause of mental stress in migrant populations can be culture shock. Most of the migration will occur from the developing world to the developed and there are different cultural norms of family size. Family planning programmes, for example, will need to respect and protect human rights.

4. Health service challenges and opportunities

The international effects of climate change may present British health services with a range of opportunities as well as challenges. Further research on this topic and evidence of the potential impacts would be beneficial, as this is a comparatively new area for health services to explore. In this chapter, based on limited evidence, we will attempt to point to the potential effects of climate change overseas on health service development and policy.

4.1 UK assistance to foreign countries in disaster response and preparedness

A warmer climate with more frequent and severe extreme weather events is likely to increase the need for disaster management, including responding to health emergencies and improving disaster preparedness. As can already be observed, when local response is overwhelmed there is often a demand and opportunities for other countries, especially but not only rich nations, to intervene. In the future, this trend may be compounded by several factors. First, climate change and extreme events carry the risk of increasing local vulnerabilities and increasing health inequalities (IPCC 2007, UNISDR 2009a, Costello 2009). Secondly, health resources, including qualified staff and equipment, is disproportionately distributed in the richer nations. For example, Africa has 25% of the world's burden of disease but has only 3% of its healthcare resources and 1% of health workers. North America, in contrast, has 3% of the disease burden but 25% of healthcare resources and 30% of health workers (Crisp 2010). A warmer future is therefore likely to mean more demand for international health crisis aid, with contributions from governments as well as NGOs and charities. The UK's foreign and health policy-makers of the future are therefore likely, if not increasingly likely, to need to juggle the pressures of limited resources and national priorities with those of international aid and emergency intervention.

A number of opportunities for British health specialists and policy-makers may also arise as a consequence of the increasing need for disaster management worldwide. There may be continuing or new opportunities for international scientific collaboration. Useful lessons and skills can be brought back to the UK by those staff that benefit from the international experience. International collaboration can also be a means to transfer expertise to less developed nations, thereby increasing their ability to manage health crises and possibly contributing indirectly to their development. The WHO and Global Health Workforce Alliance report (2008) makes the point that the shortage of health workers in the world is largely due to not enough health workers being educated and trained. Although it does not discuss the potential impacts of climate change, the report includes recommendations that national governments draw up and implement 10-year scale-up plans for education and training curricula are focused on the health needs of the country, are community- and team-based, and institutions make greater use of innovative means to increase education and training capacity. The report also recommends that strengthening information systems, drawing from both education and health sectors, and government as well as institutions, are a priority.

There may also be further opportunities for the UK to influence international health and climate change agreements and policies. Examples of current such initiatives and policies to which the UK is contributing scientifically, in the context of the United Nation's International Strategy for Disaster Reduction (UNISDR) and the World Health Organisation (WHO), include:

- The Hyogo Framework for Action 2005-2015, set up to build up the resilience of nations and communities to disasters

- The UNISDR Global Assessment Report (UNISDR 2009b): the central message of the Report is that reducing disaster risk can provide a vehicle to reduce poverty, safeguard development and adapt to climate change, with beneficial effects on broader global stability and sustainability.
- SREX AR5: a Special Report on "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation." Undertaken by IPCC and UNISDR, and which will be included in the IPCC's Fifth Assessment Report.
- 'Safer Hospitals', a joint WHO – UNISDR initiative to build the resilience of health facilities worldwide.

(Further information about these initiatives is included in the Appendix.)

4.2 Potential impacts on UK health services

The international dimensions of climate change will affect UK health services on top of increasing impacts of climate change mitigation and adaptation policies at home. Currently the UK health service is beginning to review how it will adjust to climate change and extreme events. Vulnerability of hospitals and health care facilities is not just an international issue it is also a problem within the UK. For example, 7% of hospitals and 9% of primary health care facilities in England are located on high or moderate risk flood areas (Environment Agency 2009). Unfortunately no standard recording of extreme events or hazards affecting health facilities has been developed as a global standard so shared learning is currently limited. The NHS's Sustainable Development Unit recently reflected on scenarios for low-carbon healthcare in 2030 in England, concluding that it faces an uncertain future which reflects the global view (NHS SDU 2009). The changes to healthcare policies in the decades ahead are likely to be multifactorial, with climate change being only one of many possible drivers.

As discussed in Chapter 3, UK health services might need to adapt to new population needs following possible changes in demographics due to migration and possible direct impacts on the British population of climate change effects abroad, such as infectious diseases, air pollution and UV exposure. The extent to which these changes will affect health service priorities in the UK will depend on the extent to which they take place, which is highly uncertain. Such new population health needs would also have to compete with other pressures on resources, including competing health needs and likely increasing budget constraints.

Awareness of the international dimensions of climate change and involvement in international disaster reduction efforts may also provide opportunities for developing British expertise on climate change and disaster management-related health specialities. Such specialties would include tropical medicine, emergency medicine, environmental public health and health protection. It may also create new opportunities and challenges for the NGOs and charities working in and out of the UK. Non-governmental charitable organisations have traditionally been involved in disaster management and working with 'hard-to-reach' immigrant populations and asylum seekers in the UK (for example: Oxfam, Medecin Sans Frontieres).

4.3 Public health policy challenges and opportunities

As with health services, if health policy in the UK is affected by the international dimensions of climate change it would be on top of the likely increasing impacts of climate change at home. Areas that are the most likely to be challenged by the international dimensions of climate change are international health development and aid (DFID, DH). There will be at least two major challenges for the public health agenda: a research challenge, to improve our still limited understanding of the health impacts of climate change; and an ethical challenge, to ensure that climate change policy does not widen health inequalities.

As seen throughout this report, the evidence base and analysis of the potential impacts of climate change and extreme weather events on health is still in its infancy. More research to better qualify and quantify these effects is clearly needed (UNISDR 2009a) including:

- Further epidemiological and multi-disciplinary assessments of impacts,
- More comprehensive and reliable data gathering mechanisms and databases,
- Modelling, policy analyses and life-cycle analyses to improve our understanding of the potential impacts of adaptation and mitigation strategies and technologies.

It is likely that public health policy will increasingly have to integrate climate change into its thinking. If reducing health inequalities is to remain a public health priority in the UK, one challenge will be to ensure that measures to respond to climate change do not further widen the gap (Porritt 2009). Public health and health protection achievements could be used as some of the criteria by which climate change measures are judged (Chan 2009). Climate change can act as an amplifier of existing health risks, but action against climate change can have substantial health co-benefits (Global Humanitarian Forum 2009). The health sector has a crucial role in minimising the threats and maximising the opportunities of climate change (Bone and Nurse 2009). Health is a large well respected global community with over 59 million health workers globally and it is uniquely placed for the challenge of climate change by being well respected, being present in almost every community in the world and having a common set of values and goals (Neira 2009).

4.4 Potential changes in international health agreements and institutions

The global health agenda

The global health agenda is entering a new and possibly more complex phase. The focus has gone beyond prevention and control of infectious diseases such as AIDS, malaria, influenza and tuberculosis to more strongly address basic issues of how health affects development and security (Chatham House 2009). And indeed, there is strong empirical evidence from both developing and developed countries that not only does economic growth improve health, but improved health also significantly enhances economic productivity and growth (Atun 2006). In addition, direction, and in some cases funding appears to be shifting towards multilateral organizations, whereas influence still remains primarily in the hands of individual states (Chatham House 2009). Global health funding has increased in recent years, alongside a proliferation in the number of global health actors and initiatives. Private funding organisations now play a large and influential role (McCoy 2009).

In a warmer climate, those regions of the world which suffer the most may be increasingly likely to want to have their voices heard and needs recognised. Low income countries, which are likely to carry some of the heaviest burden of climate change, may become increasingly vocal about the shape the international health, development and climate change agenda should take. The recent submissions to the UN by Pacific SIDS (Resolution A/63/L.8/Rev.1 on 3rd June 2009) provide one example of how vulnerable countries may try to influence international politics. Less-developed countries may also become increasingly protective of their natural resources and less willing to allow their exploitation by foreign businesses. In 2007 for example, Ecuador announced it would seek compensation to leave its oil reserves under the Amazonian rainforest untouched (Gordon 2007).

The international climate change and health agenda will be set against this evolving and complex backdrop. A warmer climate with more frequent natural disasters is likely to have an influence on the global health agenda, as well as possibly affecting international health agreements. Such effects can already be observed in the context of the World Trade Organisation, as when substantial drought in western Russia, a major wheat producing region, affected world trade on the wheat markets (Farchi 2010). The need to integrate climate change and health policy has already been recognised: At the Sixty-first World Health Assembly, the 193 Member States of WHO adopted a resolution on climate change and health calling for intensified action to strengthen adaptation policies and plans and asking

WHO to support these efforts through a work plan for scaling up the Organization's activities in this area, with special reference to advocacy, partnership within the health system and with other sectors, scientific evidence and health system development (WHO, 2008 a and b).

The UK will likely face both challenges and opportunities in this changing context, as will other developed countries. There could be increasing demand for foreign aid and contributions to international health and development initiatives. There could also be increasing opportunities for cooperation and influence internationally. The UK, with its innovative experience of home-grown climate change policy (Climate Change Act 2008, UK Climate Change Risk Assessment), might be well placed to provide leadership on a range of international health and public health issues.

The European health agenda

Closer to home, climate change is also increasingly likely to influence European policies and negotiations, including the health agenda. The warming climate and extreme weather events do not respect borders, and there is likely to be an increasing need for pan-European cooperation and integration of the impacts of climate change into European Union (EU) policy. Avoiding and reducing the health effects of climate change and developing and implementing the associated policies and measures requires inter-sectoral cooperation and forward thinking. The need for health system action to address the health impacts of climate change has been recognized at both global and European political levels (Memme 2008). Existing European health networks and institutions, such as the European Centre for Disease Control (ECDC) and the WHO Regional Office for Europe, may have a role to play in informing and influencing this agenda. New pan-European health resources may need to be created. The UK could see these as opportunities for scientific cooperation, with potential multilateral benefits.

5. Conclusion

This Report has focused on the potential repercussions that the international dimensions of climate change may have on the health of the UK's population, the UK's healthcare system, and the UK's role and participation in international health agreements – the combination of which we have called the UK's 'health sector' for the purpose of this report.

Climate change overseas may impact on the UK's health sector through a range of mechanisms:

- A likely increase in the frequency and severity of extreme weather events, with immediate and long-lasting health consequences
- Likely gradual environmental change, particularly from the impacts of changes in rainfall patterns and sea-level rise
- A potential increase in population movements: migration and displacement
- The potential indirect health opportunities and threats new mitigation and adaptation technology may pose.

Although there is still limited evidence on many of these aspects of health impacts, it is likely that the following issues will be those most relevant to the UK due to climate change overseas:

Possible impacts on population health and health service priorities in the UK:

- Potential changes to the proportion and composition of minority ethnic groups in the UK due to climate-change migration. The likelihood and extent to which this is likely to happen and have a significant impact of UK population health is very difficult to determine as there is conflicting evidence about potential climate-change related migration patterns.
- Potential changes to the pattern of infectious diseases overseas due to environmental change that might encourage vector dissemination. This might affect the UK population mainly through migration and travel, either through the arrival of affected persons in the UK whether these are UK Nationals who acquired their infections overseas or visitors to UK ('imported cases'). There might also be a potential risk of outbreaks in the UK, either from infected individuals causing person-to-person spread or due to imported vectors or contaminated food products ('autochthonous cases').
- Potential increase in the risk of air pollutants travelling across borders from neighbouring countries. Of particular importance is the possible risk of increased air pollution and ground-level ozone due to the climatic conditions and extreme events in mainland Europe.
- Potential increase in sun-related disease, in particular skin cancers and cataracts, due to a possible increase in UV radiation exposure of British citizens. However, the actual effect of climate change on sun exposure related diseases is uncertain and will depend to a large extent on how people's behaviour changes in response to climate change.
- Potential indirect effects on the prevalence of mental health problems in immigrant populations in the UK. These could be associated with the migration process itself, the impact of disasters on people's lives and the challenges of acculturation.

Possible impacts on the development of the UK's public health and international health policies:

- Potential changes to the dynamics of UK assistance to disaster-struck countries and international aid, including the potential for an increase in demand for aid but also an increase in opportunities for scientific collaboration and for influencing the international agenda and disaster risk reduction.
- Potential increase in the need and opportunities for developing climate change and disaster-medicine related specialties, including tropical diseases, health protection, environmental public health and emergency medicine.

- Potential new opportunities and challenges for the UK's 'third' health sector: NGOs and charitable organisations.
- Potential challenges for the public health agenda, in particular a research challenge to improve our limited understanding of the health impacts of climate change; and an ethical challenge to ensure that climate change policy does not widen health inequalities.
- Potential change to the context and direction of the global health agenda, to which the UK would need to adapt. The UK, with its innovative experience of home-grown climate change policy, might be well placed to provide leadership on a range of international health and public health issues.
- Potential evolution of European policies and negotiations, including the health agenda, to integrate climate change-related issues. Here again, the UK would have to adapt to a possibly changing political agenda, but may also find new scientific and policy opportunities.

One of the main observations of this report is the paucity of evidence on the effects of climate change on health. The evidence base and analysis of the potential impacts of climate change and extreme weather events on health is still in its infancy. More research to better qualify and quantify these effects is clearly needed. Additionally, given the complex and multi-factorial nature of the mechanisms and impacts of health and climate change, these issues are likely to be best understood through close multidisciplinary and cross-sectorial collaboration of health, environmental and development specialists.

A recent conference of specialists (Chatham House 2009) suggested the following areas of priority for research: more robust, multi-disciplinary research on the complex interactions between climate, public health and disease, including developing more robust data collection and reporting of observed climate and weather-related health effects; and assessing plans for dealing with and mitigating the impact of climate change in economic development programmes and foreign assistance to developing countries.

Observations throughout this Report support these remarks. Other gaps in evidence that were identified through the Report include:

- Further epidemiological and multi-disciplinary assessments of impacts,
- More comprehensive and reliable data gathering mechanisms and databases,
- Modelling, policy analyses and life-cycle analyses to improve our understanding of the potential impacts of adaptation and mitigation strategies and technologies.

Appendix

Millennium Development Goals (MDGs)
The United Nations Millennium Declaration of 2000 incorporated eight Millennium Development Goals (MDGs) designed to address basic human needs and rights for every individual around the world (UN 2000). All 192 United Nations member states agreed to the contents of the declaration, which called for the achievement of these goals by the year 2015. The eight Millennium Development Goals are:

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality rate
5. Improve maternal health
6. Combat HIV/AIDS, malaria, and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

In the United Nations 'the Global Partnership for Development at a Critical Juncture Millennium Development Goal 8' review of the Millennium Development Goals the links between climate change and health are not explicit (2010). However the Global Facility for Disaster Reduction and Recovery (GFDRR) a partnership between the World Bank and the United Nations International Strategy for Disaster Reduction (UNISDR) supports the implementation of the Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. In 2009, the GFDRR focused on advocating for disaster-resilient health and education systems, with a view to providing tools for safer hospitals and schools.

UNISDR
Disaster loss is on the rise with grave consequences for the survival, dignity and livelihood of individuals, particularly the poor, and hard-won development gains (UNISDR 2005). Indeed the United Nations International Strategy for Disaster Risk Reduction stated that disaster risk is increasingly of global concern and its impact and actions in one region can have an impact on risks in another, and vice versa. This, compounded by increasing vulnerabilities related to changing demographic, technological and socio-economic conditions, unplanned urbanization, development within high-risk zones, under-development, environmental degradation, climate variability, climate change, geological hazards, competition for scarce resources, and the impact of epidemics such as HIV/AIDS, points to a future where disasters could increasingly threaten the world's economy, and its population and the sustainable development of developing countries. In the past two decades, on average more than 200 million people have been affected every year by disasters.

HYOGO
As a result UNISDR launched the Hyogo Framework for Action 2005-2015: International Strategy for Disaster Reduction, Building the Resilience of Nations and Communities to Disasters (UNISDR 2005) Specific gaps and challenges were identified in the following five main areas:

(a) Governance: organizational, legal and policy frameworks;
(b) Risk identification, assessment, monitoring and early warning;
(c) Knowledge management and education;
(d) Reducing underlying risk factors;
(e) Preparedness for effective response and recovery.

Of note the Hyogo Framework for Action, in the section on Reducing underlying risk factors, recommends the promotion of the integration of risk reduction associated with existing climate variability and future climate change into strategies for the reduction of disaster risk and adaptation to climate change, which would include the clear identification of climate-related disaster risks, the design of specific risk reduction measures and an improved and routine use of climate risk information by planners, engineers and other decision-makers.(UNISDR 2005)

GAR

UNISDR has continued it work on disaster risk and climate change. Since 1975, disasters have claimed the lives of more than 2.2 million people. Storms, floods, droughts, heat waves and other weather-related phenomena are responsible for two thirds of the fatalities and economic losses from disasters (UNISDR 2009b). The central message of the UNISDR Global Assessment Report is that reducing disaster risk can provide a vehicle to reduce poverty, safeguard development and adapt to climate change, with beneficial effects on broader global stability and sustainability.

UNISDR considers that firstly, climate change will likely increase the frequency and/or severity of weather and climate hazards (IPCC 2007) and secondly, climate change will simultaneously increase communities' vulnerability to natural hazards due to the combined effects of ecosystem degradation, reduced availability of water for ecosystems and agriculture, and changes in peoples' livelihoods. This new configuration of weather-related hazards, coupled with processes like sea-level rise and rapidly expanding coastal cities, will lead to more disasters in future—unless prompt action is taken to reduce disaster risk. UNISDR encourage governments to reduce this risk by:

- assessing and reducing vulnerability to existing weather and climate hazards,
- incorporating disaster risk reduction into national adaptation and development plans, and strengthening the resilience and adaptive capacity of the most at-risk communities

SREX AR5

In recognition of the links between disaster risk reduction and climate change adaptation, the Intergovernmental Panel on Climate Change (IPCC) with UNISDR has undertaken a Special Report on "Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation." This report, due out in 2011, will help policy-makers evaluate options for reducing disaster risks related to climate change. The Special Report will also be included in the IPCC's Fifth Assessment Report.

Safer hospitals

Hospitals are powerful symbols of social progress with the *World Disaster Reduction Campaign on Hospitals Safe from Disasters Campaign*' (UNISDR 2008-9) referring to them as 'a prerequisite for stability and economic development' having 'symbolic social and political values which contribute to a community's sense of security and wellbeing (WHO, PAHO, ISDR, and World Bank.2008) However, hospital vulnerability varies throughout the world both in terms of location and events. For example, in Latin America and the Caribbean reports state that 50% of healthcare facilities (includes all health resources in a community such as hospitals, primary healthcare clinics) are located in high risk areas (WHO, PAHO, ISDR, and World Bank 2009). A recent study showed that hospitals are vulnerable to both natural and man made disasters and that hospital evacuations do occur globally. It highlighted the paucity of published data and policy on hospital evacuation and emphasised the vital need to collect data on triggers, reasons for evacuation, sheltering facilities and the process of evacuation (Bagaria et al 2009).

The Second Session of the Global Platform for Disaster Risk Reduction (DRR) was held from 16-19 June 2009 Geneva, Switzerland. Recognizing that the world is increasingly facing threats from natural disasters – with the impacts of climate change compounding the situation – UN Secretary-General Ban Ki-moon stressed that DRR is the frontline defence and a crucial investment for the future. In the Chair's Summary in the closing plenary said that specific targets were also identified – reflecting the conference's deliberations – as catalysts for cutting deaths and economic losses brought on by disasters. These targets included that by 2011, a global structural evaluation of all schools and hospitals, and by 2015 firm action plans

for safer schools and hospitals developed and implemented in all disaster prone countries (UNISDR 2009c)

As a result of the Global Platform the World Health Organization (WHO) and the United Nations Secretariat for International Strategy for Disaster Reduction (UNISDR) launched the Thematic Platform: Disaster Risk Reduction for Health at the International Day for Disaster Reduction on 14 October 2009. They have committed to establish the platform, through which local, national and international partners will collaborate on actions to reduce deaths, injuries and illness from emergencies, disasters and other crises (WHO and UNISDR 2009). Of note WHO and UNISDR state that all face enormous challenges from natural hazards, conflicts, food crises, climate change, disease outbreaks and now pandemic influenza. The historical record should be sufficient reason to increase investment in disaster risk reduction however, risks are expected to increase due to factors such as climate change affecting the frequency and severity of hazards and settlement of risk-prone areas due to urbanization pressures. The areas of activity WHO and UNISDR will include in the platform's role will be to advocate, share information and catalyse action on risk reduction for health, focusing on actions to raise awareness of the imperative for risk reduction due to the widespread immediate and long-term impacts of emergencies, disasters and other crises on health. The dynamic nature of risk due to changing hazards, vulnerabilities and capacities will be taken account, including reducing the risks associated with climate change.

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