

Health Impacts of Catastrophic Climate Change: Expert Workshop

AVOID:

Avoiding dangerous climate change

AVOID is a DECC/Defra funded research programme led by the Met Office in a consortium with the Walker Institute, Tyndall Centre and Grantham Institute

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Key outcomes / non-technical summary

This report describes the results from the AVOID workshop on the impacts of catastrophic climate change on human health. Current methods of estimating future health impacts do not address the impacts of extreme events or weather disasters. Thus, for this workshop, narratives of low probability high impact extreme climate events were used to examine the possible impacts on population health. This method can be used to address events and impacts outside recent experience. The narratives used in the workshop also included discussions of complexity and interactions among the multiple causes and drivers.

Tipping points in social systems were described under climate exposures (global mean temperature changes) well below the projected thresholds for tipping points in geophysical systems (due to the high level of vulnerability in many social systems). It was also seen that the focus on tipping points can distract attention from significant but incremental increases in the burden of disease/loss of welfare.

Population health is an important metric about which the public and decision-makers care. More information on the population health effects of climate change is needed to support decision making on climate policy (adaptation and mitigation). In order for new research methods to be developed (such as the narrative approach), there is need for improvements in the research environment, including stakeholder engagement and interdisciplinarity.

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Health Impacts of Catastrophic Climate Change: Expert Workshop

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Executive summary

Climate change is likely to have serious and significant impacts on human population health. The mechanisms by which climate change may affect health are becoming better understood. Current quantitative methods of estimating future health impacts rely on disease-specific models that primarily describe relationships between mean values of weather variables and health outcomes and do not address the impacts of extreme events or weather disasters. Extreme events have the potential to disrupt community function, which is of concern for decision-makers. Estimating the magnitude and extent of impacts from low probability high impact events is challenging because there is often no analogue that can provide relevant evidence and that take into account the complexity of factors determining future vulnerability and health impacts (the social determinants of health).

Creating narratives of low probability high impact extreme climate events can be used to improve understanding and description of the possible impacts on population health. The method avoids the amplification of uncertainties in top-down approaches, and it can be used to address events and impacts outside recent experience. Narratives can provide a venue for essential interdisciplinary, intergenerational and international discussion and debate on the population health implications of low probability but high impact consequences of climate change, in both high and low income settings. In this workshop, the narrative-based approach was used to look at possible outcomes from several low probability high impact climate events, including discussions of complexity and interactions among the multiple causes/drivers.

The popular discourse about climate change tipping points is usually focussed on the irreversible changes in the climate system or related geophysical indicators. Tipping points in social systems are equally important. Tipping points are more clearly understood at the local level when, for example, temporary migration becomes permanent and a community becomes unsustainable. Tipping points in social systems are likely to occur at climate exposures (global mean temperature changes) well below the projected thresholds for tipping points in geophysical systems. This is due to the high level of vulnerability in many social systems. Further, the focus on tipping points can distract attention from significant but incremental increases in the burden of disease/loss of welfare.

Population health is an important metric about which the public and decision-makers care. More information on the population health effects of climate change is needed to support decision making on climate policy (adaptation and mitigation). In order for new research methods to be developed (such as the narrative approach), there is need for improvements in the research environment, including stakeholder engagement and interdisciplinarity.

Scope and purpose

The forthcoming IPCC Special Report on *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* focuses on three kinds of extremes with the potential to be altered by climate change:

- Extreme events for which climate change has amplified variability or may do so in the future. This category includes, among others, aspects of floods, droughts, windstorms, and extreme temperatures.
- Events in which trends outside the domain of climate increase exposure or vulnerability to climate-related extremes. Examples include coastal development increasing exposure to storm surges on top of sea-level rise or increasing urbanization amplifying exposure to heat waves in a warming climate.
- New kinds of potentially hazardous events and conditions that may occur as a result of climate change. This category includes events like glacial lake outbursts and wildfire in forests that had historically been too wet to burn.

Disasters arise from the interaction of extreme events with vulnerabilities within natural and/or human systems. Because the probability of these events in a climate changed world is unknown, it is difficult to assess the future human health risks. Risk is the product of exposure and consequence. Further, the local vulnerabilities that can be as important as exposure in determining the magnitude of possible impacts are not well characterized at the spatial and temporal scales needed for modelling. There is also the potential for significant health burdens resulting from concurrent impacts in multiple sectors. Disasters not only severely affect population health, but also the political stability of the affected regions and thus have implications for national security.

Assessment of the risks of climate change impact at different levels of emissions and climate warming is a rapidly emerging area of scientific study. There is a clear and urgent need to provide up to date and evidence-based estimates of the likely impact of climate change on human population health. In order to address this research and evidence gap, a workshop on “Health Impacts of Catastrophic Climate Change” took place in London in 2010. It brought together health and climate scientists, policy advisors and decision makers from Europe and North America to look at plausible future scenarios and consider the population health implications of global anthropogenic climate change.

Specifically, the objectives of the workshop were to:

- Characterize and quantify (when possible) impacts of selected extreme climate-related events
- Identify social “tipping points” which are important for population health
- Identify research needs for quantifying impacts of extreme climate-related events

The workshop was kindly funded by the AVOID programme – a research programme funded by the Department of Energy and Climate Change and the Department for Environment, Food and Rural Affairs. AVOID is carried out by a consortium lead by the Met Office Hadley Centre, and including the Tyndall Centre, Walker Institute and the Grantham Institute.

Health impacts of climate change

Global climate change will have important implications for human population health. It is one of the emerging set of global environmental changes that are already affecting human population health and will increasingly do so in the future.

Climate change does not exist as a separate, single exposure, but consists of a range of exposures that are relevant for human health (Confalonieri et al. 2007). Climate change will exacerbate many of the current important environmental (and social) determinants of disease. Some climate and weather factors act directly and are relatively well understood—such as the health effects of heat waves. Other health effects are mediated by climate-sensitive biological processes, such as changes in infectious disease transmission or crop yields. Health effects will be mediated by environmental effects on complex social systems. Health effects will also result from climate change impacts on income and livelihoods.

Significant climate-related decreases in access to food and clean water would cause a large future burden of disease due climate change. Such impacts were estimated to cause the largest single contribution to the burden of disease due to climate change based on the global assessment by WHO of impacts in 2000 (Campbell-Lendrum and Woodruff, 2006). Climate is only one determinant of food and water availability, however. The social, economic and environmental determinants of disease are often more important and need to be addressed within any climate change impact assessment.

The projection of population health risks from climate change typically entails extrapolation of climate-health relationships observed under the current climate and taking into account future changes in ecological, social and demographic conditions. Pathways of health impact include:

- Heatwaves, flooding and other extreme events
- Changes in water availability
- Loss of ecosystem services, including crop yields
- Communicable (including vector-borne) diseases
- Social disruption, migration, conflict

Table 1 Likelihood* of changes in extreme events associated with global climate change.

Event and Direction of Trend	Likelihood that Trend Occurred Post 1960	Likelihood of Future Trends
Warm spells / heatwaves frequency increases	Likely	Very likely
Heavy precipitation events frequency increases	Likely	Very likely
Areas affected by drought increases	Likely in many regions since 1970	Likely
Intense tropical cyclone activity increases	Likely in many regions since 1970	Likely

*Virtually certain > 99% probability of occurrence, Extremely likely > 95%, Very likely > 90%, Likely > 66%, More likely than not > 50%, Unlikely < 33%, Very unlikely < 10%, Extremely unlikely < 5%. Source: IPCC Fourth Assessment Report Technical Summary (Parry et al. 2007)

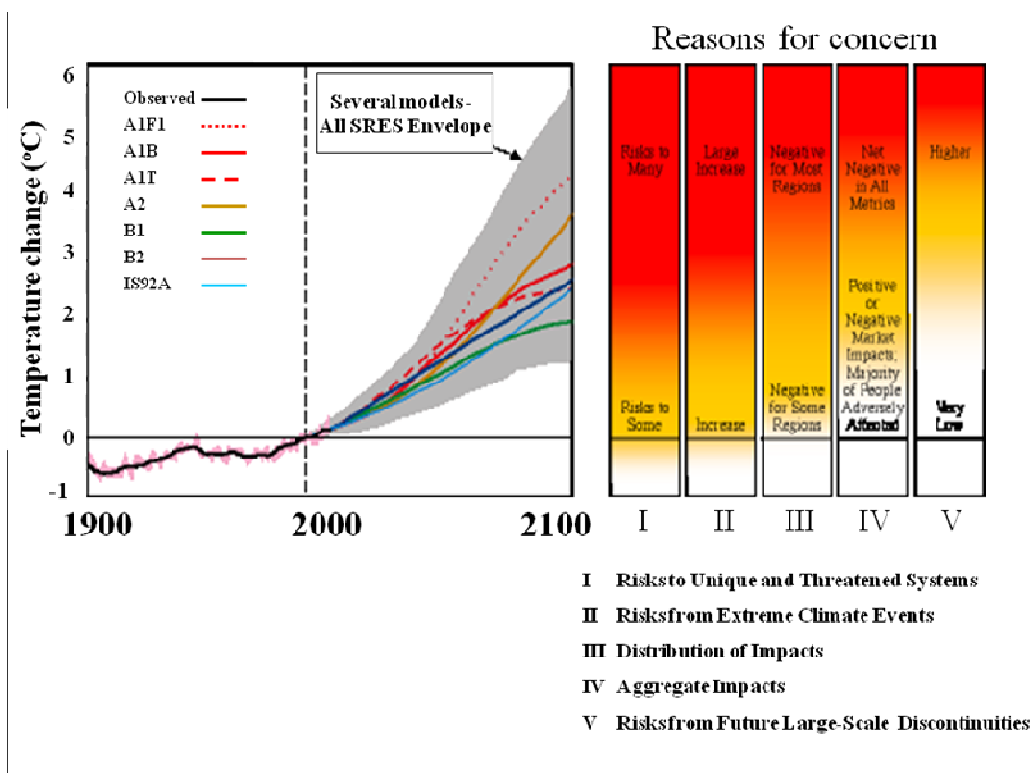


Figure 1 Reasons for concern on climate change Source: Smith et al. 2009.

Impacts on human population health are reasons for concern and support the argument for reducing carbon emissions to mitigate climate change. Impacts on health are particularly relevant for the distribution of impacts, aggregate impacts and risks from extreme climate events (Figure 1).

The potentially high burdens of climate change on health have been used as part of the justification for action on national and international climate policies. Although health is not given much direct emphasis in the UNFCCC (United Nations Framework Convention on Climate Change), it is implied. Current methods of estimating the potential burden of disease due to climate change are likely to underestimate impacts because, in general, they do not address: a) extreme events [except coastal flooding] or b) high impact low probability events.

Scientific evidence for the impacts of extremes

FLOODS AND CLIMATE EVENTS

Flooding is the most frequent weather-related disaster globally. Flood risks are expected to increase under climate change in some areas. Flood risks are currently very unevenly distributed, with countries in South Asia experiencing a particularly high burden associated with storm surges from tropical cyclones.

Only a proportion of deaths and injuries caused by flooding are a direct and immediate consequence of the event. Approximately two-thirds of floods deaths are from drowning (Jonkman and Kelman, 2005). Deaths, injuries and infectious diseases also occur through use of damaged infrastructure and during the recovery period. The overall health effects of flooding are more considerable than disasters statistics suggest (as they only report directly attributable deaths). Long term health effects of flooding include:

- Long term mortality effects
- Trauma: injuries, electrocution, fire
- Infectious diseases
- Chemical contamination
- Stress and longer term mental health issues
- Exacerbation of pre-existing conditions and delaying treatment.

Floods also have impacts on health services and critical systems, including:

- Loss of access to continuing health care and loss of essential drug access and damage to healthcare infrastructure
- Water shortages (drought during floods) due to damage to the water and sanitation infrastructure
- Disruption to food supplies and agricultural resources
- Damage/destruction of property and vital community facilities including schools
- Population displacement (short and long term)
- Disruption to livelihood and income.

Floods may cause damage to health care infrastructure (hospitals and clinics). Approximately 7% of UK hospitals and 9% of primary health care centres are sited in a flood plain (EA 2009). Floods can increase demand for emergency services. Flooded hospitals and primary care facilities may need to restrict certain services or be evacuated. Hospitals are at particular risk if patients need to be transferred elsewhere.

Flooding can also cause a shortage of drinkable water (flooded water treatment works; flooded drains/sewage treatment plants). Blocked roads can prevent delivery of bottled water to affected populations. The loss of access to water would have severe implications for human health.

ENVIRONMENTAL DETERMINANTS OF POPULATION MOVEMENT AND MIGRATION

The future impact of climate change on population distribution and population mobility is a key concern. Although several studies have projected large numbers of persons who could be displaced by climate change, such numbers are supported by very little scientific evidence.

Both extreme weather events and slow-onset climate change will contribute to increasing levels of population mobility. There are inherent uncertainties in projections of population movement (both long and short term). This is partly because of the high levels of uncertainty about the specific effects of climate change at the local level. There is also great uncertainty about the environmental causes of migration flows, especially internal movements and in particular for low-income countries that are likely to be most affected by climate change (Kniveton et al., 2008). There is little evidence that people who have already been exposed to environmental degradation do actually move in the ways and numbers predicted by the environmental refugees' studies. Migration requires financial resources and social support, both of which may decline with climate change leading to less rather than more people being able to move. Better information is important to inform appropriate policy responses at local, national and global levels.

The assumption underlying projections of high numbers of people displaced by climate change (environmental or climate refugees) is that the populations will have failed to adapt. However, migration should be seen as a key adaptive response to socio-economic, cultural and environmental change (Tacoli, 2008).

The term environmental refugee was first used in the 1970s, and was heavily influenced by neo-Malthusian assumptions that population growth would lead to migration and conflict caused by resource scarcity. Such views have not been supported by evidence, and environmental pressure as a fundamental cause of migration has been generally downplayed until recently, when increased attention to the impacts of climate change has refuelled the debate.

ENVIRONMENTAL DETERMINANTS OF CONFLICT AND COMPLEX EMERGENCIES

The health impacts of conflict and complex emergencies are considerable. As seen with weather related disasters and their statistics, the indirect impacts on mortality are often considerably larger than the observed direct effects (from violence). The excess mortality in the eastern Democratic Republic of the Congo due to conflict has been estimated to be 3.9 million (Coghlan et al. 2006). The majority of these deaths from conflict were attributable to malaria, diarrhoeal disease, respiratory infections and malnutrition (Figure 2).

Climate change is considered to increase the risk of conflicts in some regions (Jarvis et al. 2011). Such assessments, however, rely on the assumption that environmental factors and scarce resources are key causes of conflict in vulnerable areas. There is some evidence that the causes of recent conflicts such as Darfur and Chad were related to land issues (e.g. Manger 2006) but many other social, political and economic factors are also relevant. A review of the causes of conflict by the World Bank (Collier, 2006) found evidence for several risk factors, with prior conflict being the most important:

- A history of conflict

- Regime instability
- Militarisation
- Poor economic growth and low per-capita GDP
- Youth unemployment
- Geography
- Large diaspora
- Ethnic dominance
- Regional instability
- Primary commodity exports

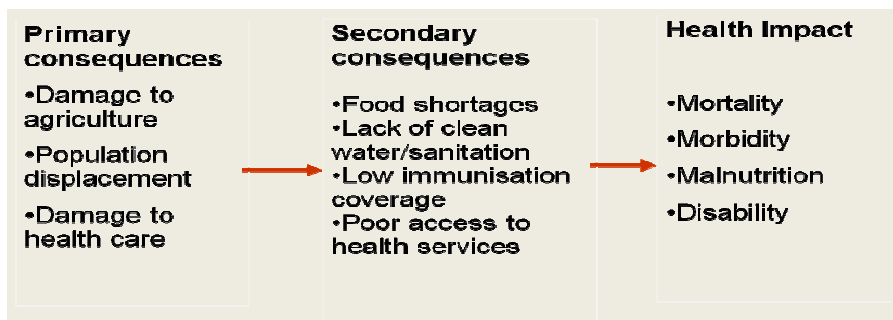


Figure 2 Health effects of complex emergencies. Adapted from CRED 2002.

Conflict is often seen as some sort of social tipping point. However, people adapt to high levels of misery and poverty. There is quite a high threshold for tolerance of adverse circumstances in human populations. Populations can experience a high health burden and the point at which conditions become “unacceptable” is often only determined in retrospect. Further, focussing only on a threshold/tipping point can ignore the significant loss of welfare that occurs up to that point.

CLIMATE, HEALTH AND MALNUTRITION

Hunger and malnutrition are major contributors to global ill health, and the number of malnourished children is increasing in absolute terms. Efforts to reduce malnutrition are expected to be limited by the impacts of climate change, with changes in average conditions and extreme events likely to reduce cereal productivity in many regions, which may in turn impact on health. The causes of malnutrition, however, are complex, and, in addition to lack of food availability, include a diverse range of socioeconomic factors such as water and sanitation provision, education and underlying health status.

Models for projecting future crop productivity and food access are available. However, projecting future malnutrition is constrained by a lack of socioeconomic data describing future worlds; scenario data is essentially limited to gross domestic product (GDP) and population. The impact of extreme events is not often considered in climate change-food impacts assessments. Drought effects, for example, could be mediated by changes (increases) in food prices.

There is a lack of observational (epidemiological) evidence regarding the impacts of drought on health. A review of the literature (Baschieri and Kovats, forthcoming), found only 16 papers that quantified drought effects on health. The majority of studies analysed health indicators (child mortality or child growth/malnutrition) during drought or just after a drought period. Only a few studies had suitable baseline data. Several studies also reported an effect of drought on cholera, malaria and meningitis transmission.

The effects of drought are complex and interact with other environmental and social factors to affect health:

- HIV/AIDS may amplify the effect of drought on nutrition (a “new variant famine”) (de Waal and Whiteside, 2003)
- Environmental factors are also an underlying factor for chronic poverty and food insecurity. A study on mortality and survival in Ethiopia reports the presence of hotspots, areas affected by multiple stresses (de Waal et al. 2006).
- Food safety. Cassava should be dried and then go through a lengthy preparation process. This was not possible because of the food shortage leading to an outbreak of spastic paraparesis in Mozambique (also reported in Tanzania)

Climate change, global health and tipping points

Climate change will have significant impacts on human population health and wellbeing. Physical scientists are able to estimate the impacts of high levels of warming (e.g. 4 or 5°C) on the cryosphere, oceans, and river flows using past analogues (past events) and understanding of key relationships in the climate system. Many potential “tipping points” have been identified that are a joint function of changes in temperature, precipitation and atmospheric composition (Lenton 2008, Held, 2008). Key thresholds (or tipping points) for human and social *systems* are likely at global mean temperatures well below those estimated for the biophysical systems.

There are several definitions of tipping points in the literature. A tipping point in the climate system can be defined as threshold that could abruptly and perhaps almost irreversibly switch a system to a different (climate) regime (Frame and Allen 2008). The current evidence from climate science is that this is unlikely to happen this century. Tipping points can also be described in relation to the irreversibility of impacts, for example, when a switch from temporary to permanent migration leads to the collapse of a particularly community. Because such terms as “tipping point” and thresholds are not well defined, it leads to confusion. Further, there are ambiguities and interdisciplinary differences in definitions for specific terms such as "catastrophe" and "dangerous".

There are few examples of global environmental thresholds in the scientific literature. Recently, the concept of planetary boundaries listed climate change as one of several changes or limits that endanger humanity. Climate change, as measured by ppm CO₂ was considered to have exceeded the threshold (at 350ppm) for “sustainable development” (Rockström et al. 2009).

Abrupt changes in the health of population are possible when “tipping points” are encountered. Examples from recent history include those associated with socio-economic collapse (e.g. post communist Russia). Abrupt changes in adaptive capacity are also possible and important. A major climate extreme event could lead to abrupt changes in the health status of a population. Another example is the severe drought and heat wave in Russia in 2010 which caused the price of wheat to increase sharply resulting in food riots in North Africa. The interaction between the severity of the event and the capacity of the population to deal with it is very important.

One useful method for addressing complex systems is agent-based modelling. Models are informed by narrative stories, by knowledge elicitation techniques, and by time-series GIS information, and allow simulation of alternative scenarios combining: population growth, major climate events, provision of economic incentives, etc. The models can be used to explore interactions between economic and environmental drivers acting at the micro-behavioural level, and the system-level outcomes such as migration rates. Such models can be used to identify possible “tipping points” in complex systems for a given community (Ziervogel et al. 2004). Such models are used for small communities and are less able to address larger populations (such as city or region).

Tipping points, as defined by climate/physical sciences, is a sudden change in state (equilibrium state), but this is not appropriate in the population health paradigm. Tipping points are challenging to identify in complex, multidimensional systems; they are only clear in hindsight. In addition, focussing on tipping point ignores important impacts where there is a general increase in poor

outcomes, and thus distract attention from incremental increases in the burden of disease/loss of welfare – an avoidable burden of climate change.

Box 1. Vulnerability and response to extreme events in Bangladesh

On 25 May 2009, cyclone Aila hit south-west Bangladesh, causing massive damage, homelessness and raising worldwide humanitarian concerns. The coastal embankment, built in the 1960s, had burst in several places, and villages went under 3m of water sweeping away everything they had. Crop and shrimp farms were also washed away. The Sundarbans was inundated under 6m of water with enormous damage to animals and plants. People were forced to take shelter on what was left of the embankment, and locals described the damage as the worst of its kind in living memory.

Aila followed cyclone Sidr which hit the coast in 2007. Although the number of deaths directly resulting from Sidr was higher than that of Aila, the recovery period has been much longer. Six months after the cyclone, the area was still under saline water and open to the tidal flow of the Bay of Bengal. This has exposed the population for longer, increasing the risk of other stresses compounding the disaster, hence further delaying rebuilding and recovery.

People in these areas have adapted to environmental changes in various ways, migration being one to secure a living in difficult times. Although people prefer to live in their forefathers homes, more and more people are now migrating in search of jobs. The process often starts with temporary migration to nearby areas that might offer employment opportunities. The period of such migration varies from one week to six months or even more. In these cases a single or a couple of members from a family leave while others stay at home. If the situation does not improve, or if a catastrophic event like a cyclone hits the area, seasonal migration may lead to permanent migration where entire families move out. Though it is difficult to establish a causal link between climate change and these migration episodes, climate change induced vulnerabilities are playing an increasingly important role in triggering permanent moves - when no other alternatives remain.

Source: Hamza et al. 2011

Decision makers – what do they need from scientists?

A panel session was undertaken in which representatives from international agencies outlined the information needed from scientists to support decision making on health and climate change, with a focus on high levels of warming and extreme events. A wide range of scientific activity could provide information useful for informed decision making, including:

Better estimates of the types of very extreme events that could arise with climate variability and change. Although such estimates are less robust than projections of changes in mean weather variables, they are important for understanding risk and for designing policies and measures to avoid, prepare for, and effectively respond to high consequence events. Further, it would be helpful to estimate how much climate change increases the probability of extreme events, to inform mitigation policies, including their costs and benefits.

The consequences of an extreme event are a function not just of the event itself, but who or what is exposed to that event, and the associated vulnerabilities. Vulnerabilities can arise because of geographic location, demographic structure and population sensitivities, socioeconomic development, infrastructure, governance, etc. Improved understanding of existing and likely future vulnerabilities that could increase the impact of an extreme event would inform policy actions.

Projections (qualitative or quantitative) are needed of the possible health impacts of very extreme events, particularly those outside the range of recent human experience. Understanding the possible magnitude and extent of very extreme events helps with designing approaches to prevent as many avoidable impacts as possible and more effectively prepare to cope with the rest.

Assessments of the costs of inaction compared to the costs of action are required to support decision making. The costs of inaction includes those if preventive policies and measures are not implemented. The costs of action include the costs of preventive policies and measures, and estimates of the extent to which they could reduce future costs of treating climate change-attributable injuries, illnesses, and deaths. Although detailed economic estimates are probably not necessary or possible, such estimates provide insights into the magnitude of possible costs and the possible reduction in costs associated with prevention. These assessments should include economic estimates of the impact of extreme events on health systems, as well as the impacts on mortality/morbidity. Such assessments have typically shown that decisions/actions taken today are less expensive than the costs of addressing future impacts.

Assessments also are needed of the health costs and benefits of policies designed to reduce greenhouse gas emissions, and of adaptation options implemented in other sectors. Such assessments need to clearly state assumptions and use robust (methodologically sound) approaches. There needs to be better evidence of the health implications of decisions in other (non-health) sectors.

Communication of a range of issues is needed particularly awareness that climate change will bring not just increases in mean weather variables and increases in heatwaves, drought, floods, and other extreme events, but also extreme events well outside the range of recent human experience. Better understanding of the possible magnitude of rare events can inform the design of preparedness activities.

The health sector needs to communicate more clearly what is relevant for domestic departments, in order for them to engage in the decision-making processes, with evidence linked to current policy priorities and time frames.

Better communication is needed of uncertainty in impact assessments. Uncertainties can be useful categorized into those that could be reduced with further research in the short term and those unlikely to be reduced by further research. This provides information on when waiting for additional information could improve decisions. This includes better representation of the unknowns – and what can plausibly happen, even if probabilities cannot be determined (e.g. high consequence, low probability events, such as those covered in the workshop). What is important to decision makers is not in the uncertainty in the estimate per se, but how the uncertainty could impact on their decision.

Narratives

Disasters arise from the interaction of extreme events with vulnerabilities within natural and/or human systems. Because the probability of these events is unknown, it is difficult to determine the human health risks, where risk is the product of exposure and consequence. Further, the local vulnerabilities that can be as important as exposure in determining the magnitude of possible impacts also are not well characterized at the temporal and spatial scales needed. There is also the potential for significant health burdens resulting from impacts in multiple sectors. Disasters not only severely affect population health, but also the political stability of the affected regions and thus have national security implications.

This workshop brought together health and climate scientists, policy advisors and decision makers from Europe and North America to look at plausible future scenarios and consider the population health implications of global anthropogenic climate change. The narratives have three interrelated objectives:

1. Improve understanding and description of the impacts of population health associated with extreme climate events.
2. Provide a venue for essential interdisciplinary, intergenerational and international discussion and debate on the population health implications of low probability but high impact consequences of climate change, in both high and low income settings.
3. Offer recommendations regarding future research and policy areas.

Workshop participants were divided into 2 groups to address the two narratives described below. The narratives were chosen to provide an example for a high and low income setting, and one where some evidence was available about potential impacts.

The groups were asked to address the following questions to aid the development of the narratives:

- What are the key mechanisms by which the climate event affects population health? What are the main uncertainties?
- Can social/health “tipping points” or thresholds be identified? What are they?
- Characterise and quantify (to the extent possible) the first and second order impacts¹ of the “climate event” on population health.
- What methods and tools should be developed to quantify these risks?
- Can these tools be used to support decision making and policy (i.e., to analyse tradeoffs: economic growth vs. security vs. equity vs. environmental sustainability)?
- What are the key research needs for climate and health scientists?

¹ First order impacts are immediate and direct impacts, and second order impacts consider longer term impacts after the event.

General Background: The World in 2020²

2008 was a watershed year for climate change: the Northwest Passage thawed for the first time in human memory; China experienced record snowstorms; a devastating cyclone hit Myanmar; rising energy prices combined with drought, other climate conditions and governance problems raised food prices around the world, sparking unrest on three continents; and the American Midwest had a 500-year flood for the second time in 15 years.

The intervening years, 2008 to 2020, saw more – in some cases much more – of the same. Changing weather patterns and increased numbers of severe weather events, along with small but perceptible increases in sea level rise, had major impacts on agricultural productivity and availability of freshwater.

Regional effects for China, Europe, India, and the United States varied, but all are facing difficult challenges. India is experiencing flooding in some places and droughts in others, with marked declines in agricultural productivity. A cyclone landed in Bangladesh in 2013 that challenged the capacity of the region to respond. Southern Europe saw severe heat, with wildfires, droughts, and brownouts due to higher temperatures. The United States experienced drought in some places and flooding in others.

The way nations deal with the challenge of global climate change shifted. A major international agreement on climate change went into effect in 2012. The treaty included a target of an 80 percent cut in global greenhouse gas emissions by 2050 relative to 2005, with interim national targets. It also included increased funding for adaptation assistance, global meteorological monitoring, and the clean development mechanism.

In 2014, the Fifth Assessment of the IPCC released, with findings that climate change is happening much faster and more dramatically than any model projected. The situation is urgent. The report prompts a global “political tipping point,” with broad acceptance of the urgency of stepping up adaptive capabilities and emissions cutting schemes.

Narrative A - Category 4 hurricane hits southern US city

Time Frame: Year 2020

Background³

The U.S. capacity for disaster relief and humanitarian assistance is under tremendous strain as a result of severe domestic weather events that continue to tax already limited resources. With economic growth, the aggregate economic and social damages due to extreme events and

² Modified from Burke and Parthemore 2008

³ Modified from NIC 2000; Cour and Snrech, 2005

disasters fell throughout the century. However, ecological damages increased with repeated damage to natural systems, resulting in escalating losses. Environmental degradation of coastal environments has increased due to weak regulation and enforcement.

Political Profile

The political situation in the United States was relatively consistent from 2008 to 2020. Environmental issues, and climate change specifically, have risen to top-tier national concerns as measured by public opinion. However, there is still limited enthusiasm for mitigation, with sharp regional differences.

The strongest action was Congress passing legislation establishing a cap and trade regime that went into effect in 2012 and is still in a start-up phase. The private sector responded to public environmental interest, however, and 2015 marks a new high in venture capital investment in renewable and low-emission energy. The U.S. continues to lag behind Europe in the implementation of adaptation policies and measures.

Economic Profile

Gross domestic product in the United States today is \$16.4 trillion (on a PPP basis, in 2007 U.S. dollars), up from \$13.8 trillion in 2007. Real growth since 2007 has been a little faster than Europe's, but slowed compared to growth from 2001 to 2007. As in Europe, per capita income recently increased; in the case of the U.S. by about \$4,300, from \$45,800 in 2007 to \$50,100 today. As in Europe, the U.S. share of the world economy has fallen by about three percentage points: from 21.4% in 2007 to 18.4% today. The distribution of incomes within the U.S. has not improved, and the gap between the richest and poorest of the population has increased.

Population Growth

Driven by immigration, the U.S. population continued to grow at about 1% annually and now stands at 327 million (up from 302 million in 2007). The trend in urbanisation has slowed. However, there has been an increase in migration to coastal areas, increasing the urban populations in the coastal cities of the southern states.

Narrative B – Drought in West Africa

Several years of drought result in a precipitous decline in crop yields in West Africa, resulting in hundreds of thousands of farmers and their families migrating.

Time Frame: Year 2020**Background⁴**

West Africa has experienced increasing urbanisation. The urban market demand has played a significant role in stimulating food production. However, there also has been a climate-related increase in the frequency of crop failures. There has been a significant increase in intensive cropping in some areas and an expansion of cropping to environmentally marginal areas. The response of many populations has been a radical change in livelihood, such as changing from croppers to livestock keepers, or the abandonment of agriculture.

Political Profile

The hallmark of the modern African State system (inviolability of borders and non-interference in internal affairs) is increasingly challenged. The OAU and regional organizations will continue to work at developing African-led intervention and peacekeeping forces to reduce conflict. The changes will not, however, lead to structuring of states into homogeneous ethnic units. While many African countries are making political and economic gains, such progress is halting and fragile.

Economic Profile

The success of key African states and inter-state organizations will continue to hinge on military and financial help from outside powers, principally the United States and France, and on a world economy hospitable to African exports of primary products. West Africa will be increasingly integrated into the world markets but will continue to base its economic growth on those natural assets that are readily exploited. Changes in the global export market now favour countries with a dynamic domestic market and a supply of qualified labour, making it difficult for many countries to compete. Countries will be vulnerable to imports, including surpluses of subsidised farm productions. The pace of technological change will be rapid and lead to tensions between and within countries as income gaps widen. Growth will carry new demands on infrastructure--water, energy, communications, waste disposal, urban transportation, public health, housing, and education. Failure to accommodate these demands will trigger disaffection with government.

Population Growth and Movement (Migration)

West Africa has experienced both rapid population growth and urbanisation and these trends will continue. The population in West Africa will be approximately 470 million, which is a doubling of the population in a generation. Fertility rates have not declined as rapidly as predicted. Population mobility will increase, the key dimensions of which are: from North to South within each country, from the interior to the coast, and from rural to urban. More than 60% of the population will be living in towns in 2020.

⁴ Modified from NIC 2000; Cour and Snrech, 2005

Workshop conclusions and recommendations

Current climate impact models, including integrated assessment models, cannot project the potential consequences of the more extreme events that are increasingly likely with climate change, the so-called fat tails of climate change. Because the consequences of these low probability events can significantly affect communities and nations, estimating the potential impacts are important for informing decision making. There is increasing awareness amongst economists that fat tails present challenges to developing and implementing policy options because of the potential magnitude, extent, and complexity of possible consequences. Among the potential consequences are serious population health impacts that could overwhelm the capacity of communities and affect development pathways and national security. Population health is a better indicator of welfare than GDP/costs. Providing better evidence of these health impacts is needed to inform climate policy and adaptation discussions.

Estimating the impacts of high consequence low probability events is challenging. There are few, if any, analogues on which to draw. Significant differences exist within and between countries in the capacity to prepare for and respond to extreme events, such that aggregate estimates over a region or continent can give a very different picture of the possible risks than estimates at smaller geographic scales. There also are challenges with estimating acute impacts and cumulated impacts (e.g. life course consequences of malnutrition and how having a significant number of malnourished children could affect community development). Difference in health systems and governance leads to lack of a standardised or systematic evidence-base on impacts or responses.

The workshop demonstrated that narratives can be used to estimate the consequences of high consequence low probability events. More time would be needed to be able to develop detailed narratives with quantitative and qualitative estimates of how specific events could affect population health, exploring the different pathways by which impacts could arise (e.g. directly from the event, indirectly through changing health determinants).

Several key themes emerged from the group discussions of the narratives.

The drivers of vulnerability (secular trends) were similar for both narratives. These included:

- Population issues
 - Migration issues
 - Population ageing
 - Increases in absolute number of vulnerable people
- Poverty
 - Increases in absolute number of vulnerable people
- Infrastructure
- Institutional Setting

All groups considered that the social and development trends in the narratives outlined before the workshop are general adverse (i.e. increasing vulnerability), although in some areas, positive trends (such as higher economic growth) should be taken into consideration. A major uncertainty was how these trends could be affected by climate change and by climate policy.

Table 2 Drivers of vulnerability in Narrative A

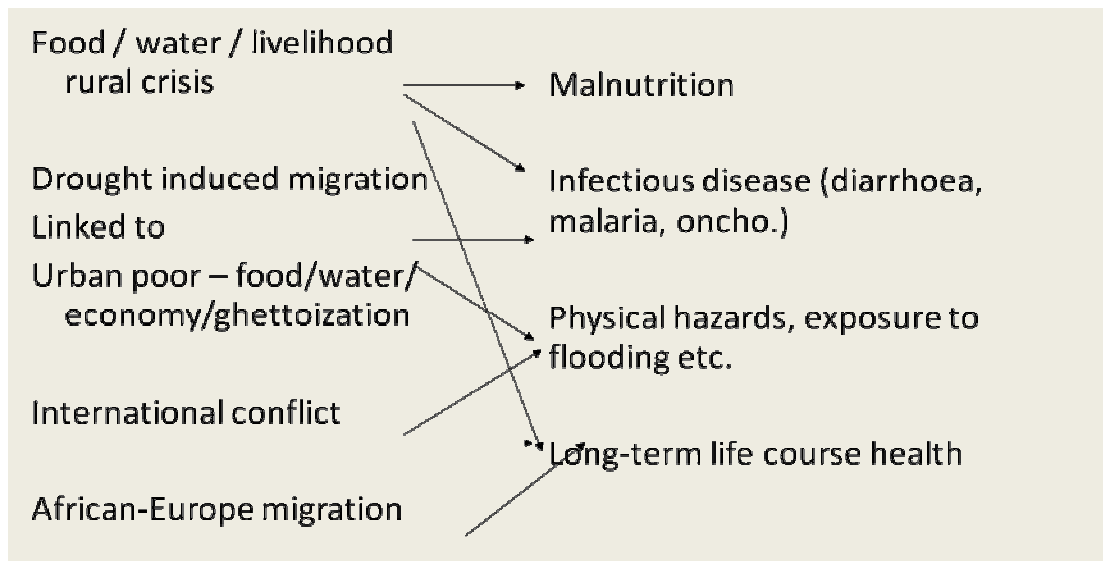
<i>Driver</i>	<i>Specific factors that determine population health impact</i>
Population:	<ul style="list-style-type: none"> • Rising population • Lots of elderly • Lots of recent migrants • Poor background health status • Already displaced population/temporary housing
Poverty	<ul style="list-style-type: none"> • Lots of urban poor • High unemployment • Increasing incomes over time, though not at the bottom
Infrastructure	<ul style="list-style-type: none"> • Health infrastructure not flood proof • High population density • Inadequate private insurance • Poor quality building codes/compliance
Institutional setting	<ul style="list-style-type: none"> • Early warning systems • Some institutional memory • Affected community participation
Increasing number of climate events	<ul style="list-style-type: none"> • Federal Emergency Management Agency (FEMA) already stressed • Damage to natural environment • Household stress • Health system stress

Disentangling the way drivers and stresses might actually interact with each other in the real world is an essential part of the narrative approach. Figure 2 shows the complex system described in Narrative B. The most important pathways would need to be identified if narrative development was carried further. Overall, there is not enough research evidence of how climate change will determine the range of social and economic determinants of food insecurity.

Quantification of the health impacts of the narrative events was difficult. The impacts were estimated for Narrative B but numbers are only approximate.

- W. Africa pop = 400 m
- 20% of that under 5 (80-160m in 2020)
- 8% mortality
- 4% attributable to malnutrition (normal year)
- 25-100% increase in malnutrition-related mortality.

Figure 3 Mechanisms of how drought event will affect health.



Research and data gaps

Several research and information needs were identified.

- Relationships between environment, household income and population movement
 - Demographic surveys, interviews
- Behaviours following extreme climate events, e.g. factors determining temporary and permanent migration
 - Interviews
- Evidence (systematic reviews) on climate-health associations from the epidemiological literature,
 - E.g. drought-malnutrition
- Improved population scenarios/projections
 - Urbanisation, migration, ageing, etc
- Tool development
 - Bayesian frameworks
 - Sensitivity analysis around the components
- Economic costs of health impacts – indirect impact
 - Methods of costing
 - Econometric approaches to quantify impacts in the wider population
- Development of analytical methods to support
 - Decision-making under catastrophic and irreversible events
 - Decision-making under low probability high impact events

Development of the narrative approach

The workshop participants found the narrative discussions interesting, informative, and enjoyable. The advantage of the narrative approach is that it is able to handle complexities associated with high consequence events, including the interactions between the multiple causes/drivers across a wide range of disciplines and explore multiple outcomes. The workshop participants were able to explore multiple, interacting pathways by which an extreme event could affect population health, only some of which could be quantified. By taking a multi-disciplinary approach, the resulting narratives provide a more comprehensive and potentially more realistic assessment of possible consequences than could be achieved with a model. Having a better understanding of cascading and interacting pathways offers opportunities for identifying intervention points that could avoid or reduce possible consequences. This approach allows the exploration of impacts outside recent experience. Further, the method avoids the amplification of uncertainties in the top-down approaches.

Significant preparation is needed to ensure that the narrative approach is as successful as possible. Of particular importance are the framing of the narratives (including developing a preliminary storyline of the impact explored, the temporal and spatial scale of the narrative, and contextual issues, such as demographics, economics, effectiveness of governance, etc.) and providing quantitative and qualitative information on key pathways. Recommendations include:

- Develop some shared, conceptual, online modelling tools. e.g. weADAPT [<http://www.weadapt.org/>],
- Develop methods to disseminate the results – from science to policy
- Develop guidance on the use of narratives
- Integrate the narrative approach into training tools, e.g. for Red Cross and for conducting vulnerability and adaptation assessments.

Because this is a fairly new approach for public health, there is a need for some evaluation of the method – to identify when the narrative is useful. There is also a need to provide a “mechanism” for generating useful narratives. The narratives was that they could be a potential tool for national, regional or even global level preparedness for a particular organization (e.g. for the International Red Cross and Red Crescent).

Narratives should be seen as another tool, complementary to other methods (such as appropriate quantitative methods for risk assessment) and not a substitute. However, it is clear that narratives can provide an effective communication tool, informed by science. The use of stories should be further developed (e.g. Bangladesh case study, Hamza et al 2011, see above) as they help the public better understand the risks of climate change.

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Appendix 1 – Workshop Programme

Day 1: Wednesday, 9 June 2010			
9.00-9.40	Part I. Introduction and context	Introduction, welcome, objectives of workshop The AVOID Programme	K Ebi - P van der Linden - Met Office
9.40-10.30		Introduction to climate change and health impacts Methods and results	S Kovats - LSHTM
10.30-11.00		Coffee/tea break	
11.00-12.00		Recent results from the AVOID Programme	S Gosling - University of Reading
		Overview of climate science - catastrophic climate change	D Frame - University of Oxford
12.00-1.00		Lunch	
1.00-2.30	Part II. Policy needs	What are the needs of policymakers? Panel discussion	D Campbell-Lendrum - WHO C Scaramella - WFP N Banatvala - DH J Clark - DFID
2.30-3.00		Coffee/tea break	
3.00-5.00	Part III. Scientific evidence	Climate, disasters and health	D Grynszpan – HPA
		Climate, health and malnutrition	A Baschieri – LSHTM
		Environmental determinants of population displacement and migration	C Tacoli - IIED
		Health effects of complex emergencies	E Sondorp – LSHTM
		Summary and discussion	K Ebi – ESS
6.30-9.00		Dinner	
Day 2: Thursday, 10 June 2010			
9.00-10.30	Part IV.	Social “tipping points”	T Downing - GCAP
		Introduction to narratives, context, tasks	K Ebi - ESS

	Narrative case studies	Work in groups Group A - Narrative A [Council Room] Group B - Narrative B [Charter Room]	
10.30-11.00		Coffee/tea break	
11.00-12.00		Work in groups	
12.00-1.00		Lunch	
1.00-2.30		Work in groups	
2.30-3.00		Coffee/tea break	
3.00-5.00		Groups report back, discussion	S Kovats - LSHTM
Day 3: Friday, 11 June 2010			
9.00-10.30	Part V. Conclusions and consensus	Plenary discussions Agree on workshop conclusions [consensus statements for workshop report and publication] <ul style="list-style-type: none">• What do we know about the health impacts of catastrophic climate change?• Can we define/describe “tipping points”?•	S Kovats & K Ebi - Co-Chairs
10.30-11.00		Coffee/tea break	
11.00-12.30		Next Steps <ul style="list-style-type: none">• What are the policy needs?• Research and information gaps• Methods and tools•	A Haines - LSHTM Chair
12.30		Close of workshop	

Appendix 2 – Workshop participants

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