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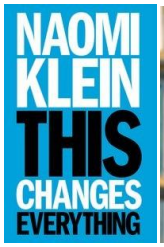
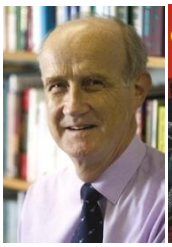
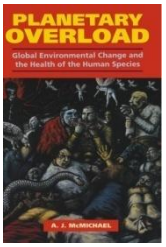
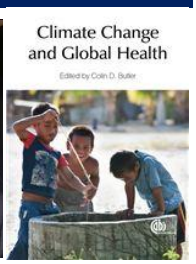
Food systems. World health
Into the fire

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Access November 2009 IPCC sixth report summary here
Access December 2009 Tony Michael, Colin Butler on climate here
Access January 2014 Tony McMichael on climate here
Access March 2014 IPCC report on food systems impacts here
Access March 2014 IPCC report on world health impacts here
Access April 2014 Editorial on climate and food systems here
Access May 2014 Editorial on climate and food systems here
Access May 2014 Tony McMichael, Helen Berry, Colin Butler on climate here
Access June 2014 Colin Butler on climate here

Introduction

As stated at the United Nations in New York on 23 October, all people concerned with health or nutrition, which in effect means all people, are right now faced with the biggest challenge and the biggest opportunity in their lifetimes. Everybody knows that global temperatures are rising, and that so far nothing much has been done to turn down the heat that is caused by overuse and abuse of the planet's resources. Everybody also knows that the scale of the rise in temperature will, at present trends, make life on Earth more difficult for some and intolerable for many, will destroy plans and hopes to make life on Earth more equitable, and will get worse.

A question asked by public health and nutrition professionals in the past was: What has this got to do with us? This question is now answered, including in this issue in *WN* by Tony McMichael and Colin Butler. The most serious impact of increased temperatures will be – and in some parts of the world now is – on food supplies, food and nutrition security, and vulnerability to starvation, deficiencies, infections. No relevant professional can in conscience ignore these dreadful prospects.

A question asked by citizens in the past was: What can we do? This question is now answered here, by Naomi Klein, and by the pictures in the following pages. The answer is also implied by the mission statement of the *World Nutrition Rio2012* conference which, modified, is 'knowledge-decision-action'. As with the response to women's rights, gay rights, the rights of people with AIDS, the rights of the landless, and earlier in history the struggles for independence and democracy and for the emancipation of blacks, women, workers and slaves, citizens can and will rise up in solidarity to insist on really effective action to slow, stop and reverse global heating. This is no longer a dream. Half a million people and more, endorsed by over a thousand civil society organisations, have now taken to the streets all over the world.

All significant advances in public health involve the use of law. They all also involve direct action. The implications of global heating include and go beyond public health. They concern the nature, quality and for many populations the continuation of life on Earth. Rising temperatures do not now much affect privileged people in protected countries, such as most who discuss and enact public policies. But violent storms and floods that are not mere acts of nature are now devastating vulnerable populations, and causing food shortages which now are sparking riots and uprisings.

The writing is on the walls, and on the banners of demonstrators all over the world. The hard tasks now include incessant and indomitable actions that will stop the fundamental causes of sick and fevered societies. Naomi Klein believes this implies a new world order in which systems of governance change, leaders with new world views are elected, corporations are restrained, and consumers are citizens. This implies a whole new way of being in the world. The September manifestations may begin this process of peaceful revolution.

Knowledge + decision = direct action

This time the people have not waited to be told the problems and the solutions and what to think, by UN officials, national politicians, or interested parties. At last, the people have taken to the streets, to accuse and indict the political and economic system of reckless ruthless unrestrained corporate greed licensed by governments, that is the engine of the humanity and the living and physical world.

The manifestations took place in 160 countries at over 2,000 locations. In New York City over 300,000 people marched on the weekend before the 23 September United Nations summit on climate change. UN secretary-general Ban Ki-moon personally fulfilled his pledge to 'link arms with those fighting for climate action'. It has been a long time coming. At last, corporate-created climate change, whose worst effects are agreed to be on food and nutrition systems and world health, with all this implies, has become and will remain a political issue that will shape world governance.

New York City, 21 September. Over 300,000 citizens marched, some seen here in mid-town Manhattan. 'In the face of an 'absolutely unprecedented emergency', say the 18 winners of the Blue Planet Prize (the 'Nobel for the environment'), 'society has 'no choice but to take dramatic action to avert a collapse of civilisation. Either we will change our ways and build an entirely new kind of global society, or these ways will be changed for us'.

An authoritative and penetrating report on climate change, its meaning, causes and impact, and necessary action, perhaps the best so far, was published in early 2012. This is an edited version of the summary by John Vidal of the Guardian.

'The current system is broken' says Robert Watson, the UK government's chief advisor on the environment, one of the group of 18 Blue Planet 'environment Nobel' prizewinners responsible for the report. 'It is driving humanity to a future that is 3-5C warmer than our species has ever known, and is eliminating the ecology that we depend on for our health, wealth and senses of self.'

The group also includes US climate scientist James Hansen, José Goldemberg, Brazil's secretary of environment during the Rio Earth summit in 1992, and Paul Ehrlich of Stanford University. It was commissioned by the UN Environmental Programme, for the 2012 Rio+20 environmental summit.

Apart from bleak warnings about climate and biodiversity, the report challenges governments to think differently about economic 'progress'. Thus: 'The rapidly deteriorating biophysical situation is more than bad enough, but it is barely recognised by a global society infected by the irrational belief that physical economies can grow forever, disregarding the facts that the rich in developed and developing countries get richer and the poor are left behind. The perpetual growth myth ... promotes the impossible idea that indiscriminate economic growth is the cure for all the world's problems, while it is actually the disease that is at the root cause of our unsustainable global practices'.

The report warns against over-reliance on markets and urges politicians to listen and learn from how poor communities all over the world see the problems of energy, water, food and livelihoods as interdependent and integrated as part of a living ecosystem.

'The long-term answer is not a centralised system but a demystified and decentralised system where the management, control and ownership of the technology lie in the hands of the communities themselves and not dependent on paper-qualified professionals from outside the villages' it states.

'Community-based groups in the poorer most inaccessible rural areas around the world have demonstrated the power of grassroot action to change policy at regional and national levels... There is an urgency now to bring them into mainstream thinking, convey the belief all is not lost, and the planet can still be saved.'

The answer to addressing the critical issues of poverty and climate change is not primarily technical but social, say the group. 'The problems of corruption, wastage of funds, poor technology choices and absent transparency or accountability are social problems for which they are innovative solutions are emerging from the grassroots.'

To transition to a more sustainable future will require simultaneously redesigning the economic system, a technological revolution, and, above all, behavioural change. 'Delay is dangerous and would be a profound mistake. The ratchet effect and technological lock-in increase the risks of dangerous climate change: delay could make stabilisation of concentrations at acceptable levels very difficult. If we act strongly and science is wrong, then we will still have new technologies, greater efficiency and more forests. If we fail to act and the science is right, then humanity is in deep trouble and it will be very difficult to extricate ourselves'.

Climate. Food systems. World health
This changes everything

Naomi Klein
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This Changes Everything. Capitalism vs the Climate, by Naomi Klein, is now published. It is already a best-seller, as are her previous books *No Logo. Taking Aim at the Brand Bullies* (1999) and *The Shock Doctrine. The Rise of Disaster Capitalism* (2007). Like them, *This Changes Everything* indicts not capitalism as such, but the current ruthless reckless unregulated form of corporate capitalism that, she states, is the essential cause of the current fuel, finance and food crises, and also of 'climate change'.

New York City, 21 September. UN secretary-general Ban Ki-moon receives notice of 2 million signatures with Al (An Inconvenient Truth) Gore, and New York City mayor Bill de Blasio

This is a story about bad timing. One of the most disturbing ways that climate change is already playing out, is through what ecologists call 'mismatch' or 'mistiming'. This is the process whereby warming causes animals to fall out of step with a critical food source, particularly at breeding times, when a failure to find enough food can lead to rapid population losses.

The migration patterns of many songbird species, for instance, have evolved over m millennia, so that eggs hatch precisely when food sources such as caterpillars are at their most abundant, providing parents with ample nourishment for their hungry

young. But because spring now often arrives early, the caterpillars are hatching earlier too, which means that in some areas they are less plentiful when the chicks hatch, with a number of possible long-term impacts on survival.

Similarly, in West Greenland, caribou are arriving at their calving grounds only to find themselves out of sync with the forage plants they have relied on for thousands of years, now growing earlier thanks to rising temperatures. That is leaving female caribou with less energy for lactation, reproduction and feeding their young, a mismatch that has been linked to sharp decreases in calf births and survival rates.

The deregulation disaster

Scientists are studying cases of climate-related mistiming among dozens of species, from Arctic terns to pied flycatchers. But there is one important species they are missing – us. *Homo sapiens*. We too are suffering from a terrible case of climate-related mistiming, albeit in a cultural-historical, rather than a biological, sense. Our problem is that the climate crisis hatched in our laps at a moment in history when political and social conditions were uniquely hostile to a problem of this nature and magnitude – that moment being the tail end of the go-go 80s, the blast-off point for the crusade to spread deregulated capitalism around the world. Climate change is a collective problem demanding collective action the likes of which humanity has never actually accomplished. Yet it entered mainstream consciousness in the midst of an ideological war being waged on the very idea of the collective sphere.

Regulation as a dirty word

This deeply unfortunate mistiming has created all sorts of barriers to our ability to respond effectively to this crisis. It has meant that corporate power was ascendant at the very moment when we needed to exert unprecedented controls over corporate behaviour in order to protect life on Earth. It has meant that regulation was a dirty word just when we needed those powers most. It has meant that we are ruled by a class of politicians who know only how to dismantle and starve public institutions just when they most need to be fortified and re-imagined. And it has meant that we are saddled with an apparatus of 'free trade' deals that tie the hands of policymakers just when they need maximum flexibility to achieve a massive energy transition.

Confronting these various structural barriers to the next economy is the critical work of any serious climate movement. But it's not the only task at hand. We also have to confront how the mismatch between climate change and market domination has created barriers within our very selves, making it harder to look at this most pressing of humanitarian crises with anything more than furtive, terrified glances. Because of

the way our daily lives have been altered by both market and technological triumphalism, we lack many of the observational tools necessary to convince ourselves that climate change is real – let alone the confidence to believe that a different way of living is possible.

And no wonder: just when we needed to gather, our public sphere was disintegrating. Just when we needed to consume less, consumerism took over virtually every aspect of our lives. Just when we needed to slow down and notice, we sped up. Just when we needed longer time horizons, we were able to see only the immediate present. This is our climate change mismatch, and it affects not just our species but potentially every other species on the planet as well.

The good news is that, unlike reindeer and songbirds, we humans are blessed with the capacity for advanced reasoning, and therefore the ability to adapt more deliberately – to change old patterns of behaviour with remarkable speed. If the ideas that rule our culture are stopping us from saving ourselves, then it is within our power to change those ideas. But before that can happen, we first need to understand the nature of our personal climate mismatch.

Incessant consumption

Climate change demands that we consume less, but being consumers is all we know. Climate change is not a problem that can be solved simply by changing what we buy – a hybrid instead of an SUV, some carbon offsets when we get on a plane. At its core, it is a crisis born of overconsumption by the comparatively wealthy, which means the world's most manic consumers are going to have to consume less. The problem is not 'human nature,' as we are so often told. We weren't born having to shop this much, and we have, in our recent past, been just as happy (in many cases happier) consuming far less. The problem is the inflated role that consumption has come to play in our particular era.

Late capitalism teaches us to create ourselves through our consumer choices. Shopping has become how we form our identities, find community and express ourselves. Thus, telling people that they can't shop as much as they want to because the planet's support systems are overburdened can be understood as a kind of attack, akin to telling them that they cannot truly be themselves. This is likely why, of the original 'three Rs' – reduce, re-use, recycle – only the third has ever gained any traction, since it allows us to keep on shopping as long as we put the refuse in the right box. The other two, which require that we consume less, were pretty much dead on arrival.

Climate change is slow, and we are fast. When you are racing through a rural landscape on a bullet train, it looks as if everything you are passing is standing still: people, tractors, cars on country roads. They aren't, of course. They are moving, but at a speed so slow compared with the train that they appear static.

So it is with climate change. Our culture, powered by fossil fuels, is that bullet train, hurtling forward toward the next quarterly report, the next election cycle, the next bit of diversion or piece of personal validation by way of our smart-phones and tablets. Our changing climate is like the landscape out the window: from our racy vantage point it can appear static, but it is moving, its slow progress measured in receding ice sheets, swelling waters and incremental temperature rises. If left unchecked, climate change will most certainly speed up enough to capture our fractured attention – island nations wiped off the map, and city-drowning super-storms, tend to do that. But by then, it may be too late for our actions to make a difference, because the era of tipping points will likely have begun.

We need to become local

Climate change is place-based, and we are everywhere at once. The problem is not just that we are moving too quickly. It is also that the terrain on which the changes are taking place is intensely local: an early blooming of a particular flower, an unusually thin layer of ice on a lake, the late arrival of a migratory bird. Noticing those kinds of subtle changes requires an intimate connection with a specific ecosystem. That kind of communion happens only when we know a place deeply, not just as scenery but also as sustenance, and when local knowledge is passed on with a sense of sacred trust from one generation to the next.

But that is increasingly rare in the urbanised, industrialised world. We tend to abandon our homes lightly – for a new job, a new school, a new love. And as we do so, we are severed from whatever knowledge of place we managed to accumulate at the previous stop, as well as from the knowledge amassed by our ancestors (who, at least in my case, migrated repeatedly themselves).

Even for those of us who manage to stay put, our daily existence can be disconnected from the physical places where we live. Shielded from the elements as we are in our climate-controlled homes, workplaces and cars, the changes unfolding in the natural world easily pass us by. We might have no idea that a historic drought is destroying the crops on the farms that surround our urban homes, since the supermarkets still display miniature mountains of imported produce, with more coming in by truck all day.

It takes something huge – like a hurricane that passes all previous high-water marks, or a flood destroying thousands of homes – for us to notice that something is truly

amiss. Even then we have trouble holding on to that knowledge for long, since are quickly ushered on to the next crisis before these truths have a chance to sink in.

Climate change, meanwhile, is busily adding to the ranks of the rootless every day, as natural disasters, failed crops, starving livestock and climate-fuelled ethnic conflicts force yet more people to leave their ancestral homes. And with every human migration, more crucial connections to specific places are lost, leaving yet fewer people to listen closely to the land.

The air has become a sewer

Climate pollutants are invisible, and we have stopped believing in what we cannot see. When BP's Macondo well ruptured in 2010, releasing torrents of oil into the Gulf of Mexico, one of the things we heard from company chief executive Tony Hayward was that 'the Gulf of Mexico is a very big ocean. The amount of volume of oil and dispersant we are putting into it is tiny in relation to the total water volume.' The statement was widely ridiculed at the time, and rightly so, but Hayward was merely voicing one of our culture's most cherished beliefs: that what we can't see won't hurt us and, indeed, barely exists.

So much of our economy relies on the assumption that there is always an 'away' into which we can throw our waste. There's the away where our garbage goes when it is taken from the curb, and the away where our waste goes when it is flushed down the drain. There's the away where the minerals and metals that make up our goods are extracted, and the away where those raw materials are turned into finished products. But the lesson of the BP spill, in the words of ecological theorist Timothy Morton, is that ours is 'a world in which there is no "away".'

When I published *No Logo* a decade and a half ago, readers were shocked to learn of the abusive conditions under which their clothing and gadgets were manufactured. But we have since learned to live with it – not to condone it, exactly, but to be in a state of constant forgetfulness. Ours is an economy of ghosts, of deliberate blindness.

Air is the ultimate unseen, and the greenhouse gases that warm it are our most elusive ghosts. Philosopher David Abram points out that for most of human history, it was precisely this unseen quality that gave the air its power and commanded our respect. 'Called Sila, the wind-mind of the world, by the Inuit; Nilch'i, or Holy Wind, by the Navajo; Ruach, or rushing-spirit, by the ancient Hebrews, the atmosphere was the most mysterious and sacred dimension of life.'

But in our time 'we rarely acknowledge the atmosphere as it swirls between two persons', David Abram writes. 'Having forgotten the air, we have made it our sewer,

'the perfect dump site for the unwanted by-products of our industries … Even the most opaque, acrid smoke billowing out of the pipes will dissipate and disperse… into the invisible. It's gone. Out of sight, out of mind'.

The perpetual present

Another part of what makes climate change so very difficult for us to grasp is that ours is a culture of the perpetual present, one that deliberately severs itself from the past that created us as well as the future we are shaping with our actions. Climate change is about how what we did generations in the past will inescapably affect not just the present, but generations in the future. These time-frames are a language that has become foreign to most of us. This is not about passing individual judgment, nor about berating ourselves for our shallowness or rootlessness. Rather, it is about recognising that we are products of an industrial project, one intimately and historically linked to fossil fuels.

And just as we have changed before, we can change again. After listening to the great farmer-poet Wendell Berry deliver a lecture on how we each have a duty to love our 'homeplace' more than any other, I asked him if he had any advice for rootless people like me and my friends, who live in our computers and always seem to be shopping for home. 'Stop somewhere,' he replied. 'And begin the thousand year long process of knowing that place.' That's good advice on lots of levels. In order to win this fight of our lives, we all need a place to stand.

New York City. The climate marchers all over the world have been organised by a grand alliance of citizen groups, civil society organisations, social movements, including the militant Occupy! movement

Climate. Food systems. World health
The beginning of a new age

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Planetary Overload. Global Environmental Change and the Health of the Human Species, by Tony McMichael, was published in 1993. Its historical sweep, careful analysis, and warning that humans could become an endangered species, have inspired new generations of scholars and activists. In his second book *Human Frontiers, Environments and Disease. Past Patterns, Uncertain Futures*, published in 2001, he suggests that industrialisation has created a fifth Horseman of the Apocalypse. The commentary below is a digest of his inaugural paper as a fellow of the US National Academy of Sciences. *The full paper with references is accessible here*, as is *a profile of Tony McMichael*

Adelaide, Australia, 21 September. Demonstrations in over 2,000 locations all over the world emphasised the threat to the health, well-being and existence of our children and their children

Climate change poses threats to human health, safety, and survival, by way of weather extremes and climatic impacts on food yields, fresh water, infectious diseases, conflict, and displacement. These threats are now becoming recognised. Historical experiences of diverse societies experiencing climatic changes, spanning multi-century to single-year duration, as shown below, give insights into population health vulnerability. Most of these climatic changes were considerably less than those anticipated in this century and beyond.

- Long-term climate changes have often destabilised civilisations, typically by way of food shortages, consequent hunger and disease, and social disruption.
- Medium-term climatic adversity has frequently caused similar health, social, and sometimes political consequences.
- Infectious disease epidemics have often occurred in association with briefer episodes of temperature shifts, food shortages, impoverishment, and disruption.
- Societies may cope (despite hardship for some) with recurring shorter-term (decadal to multiyear) regional climatic cycles, except when extreme phases occur.
- The drought–famine–starvation nexus has been the main, recurring, serious threat to health.

Warming this century is likely greatly to exceed the Holocene's natural multi-decadal temperature fluctuations, and is also likely to occur faster. Along with greater climatic variability, models project an increased geographic range and severity of droughts. Modern societies, although larger, better resourced, and more interconnected than past societies, are less flexible, more infrastructure-dependent, densely populated, and hence are vulnerable. Adverse historical climate-related health experiences underscore the case for abating human-induced climate change.

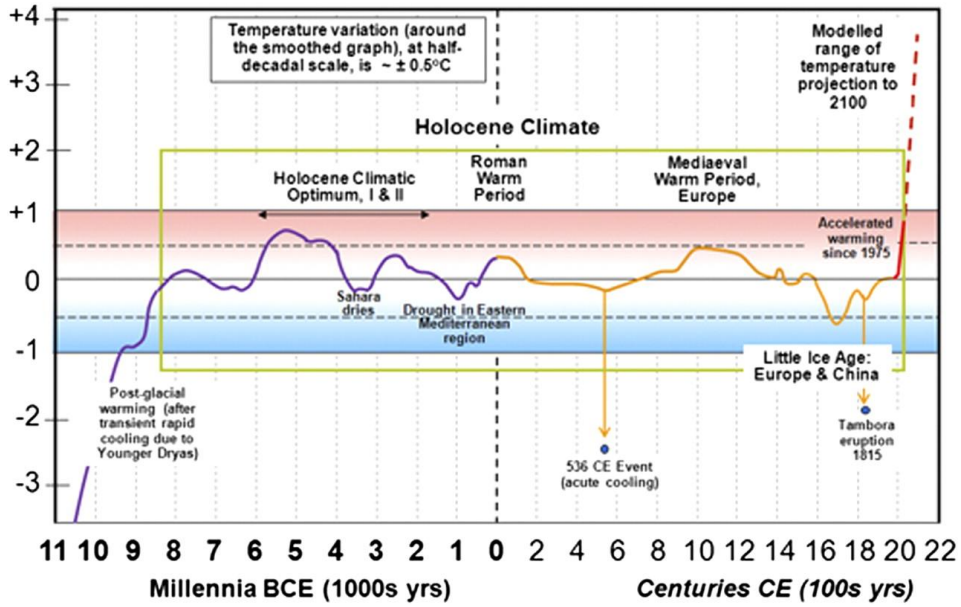
Threats to food systems and world health

Most environmental systems that sustain human population health are sensitive to climatic conditions. Public discussion of climate change impacts has until recently focused less on the risks to health than on risks to economies, physical property, and environmental amenity. But most environmental and social impacts of climate change sooner or later endanger human health. Human impacts on the Earth system are indeed creating an unsafe 'planetary operating space'.

Direct threats from heat-waves, floods, and storms are well recognised. Less well understood are the indirect risks to human health from climatic influences on food yields, water flows, bacterial and mosquito populations, viability of farm communities, and conflicts over dwindling resources.

This is apparent from history. Great undulations in the fates and fortunes of societies throughout the Holocene epoch have been associated with climatic changes, affecting crops, livestock, epidemic outbreaks, social unrest, and conflict. As shown in Figure 1, temperature changes in the Holocene have been smaller than those anticipated this century. Even so, history can inform today's responses to the prospect of substantial human-induced climate change. The assumption that humans cannot change climate and weather may, in the past, have implied futility of historical analysis. Today, as human actions increasingly influence the climate, this no longer applies.

Figure 1
Variations in Northern hemisphere temperature
11,000 BCE to 2,200 CE



Variations in northern hemisphere temperatures are here shown in degrees Centigrade relative to mean temperature during 1960-1980, averaged from multiple sources published since 2007.

Averaging of hemispheric temperature is only indicative. During early–mid Holocene (11–4,000 years before present), for example, trends in regional temperatures differed, including prolonged cooling of much tropical ocean while warming for over 2 millennia in parts of Europe, China, and Scandinavia

The history of climatic influences on food shortages is familiar, but consequent impacts on health and survival are less well understood, as are historical climatic influences on infectious disease outbreaks and interconnections between food crises, epidemics, social disorder, and conflict. The causal processes affecting health outcomes are usually complex, variously reflecting social conditions, governance, demographic stresses, militarism, and the superimposed stresses of climatic fluctuations.

Categories of risk can be differentiated by directness and type of causal pathway. Some risks are readily measured and quantified, others are not. Quantifiable risks can be projected in relation to future scenarios of climate change. In general, there is little explicit information about specific population health benefits (nutrition adequacy, child survival, longevity) during benign climatic periods. Rather, the adverse periods and outcomes customarily attract attention and documentation. However, food supplies, fertility, and population growth typically increased during longer-term stable warmer periods.

What has happened in history

Written records from up to 5 millennia ago provide evidence of climatic impacts on food shortages, famines, starvation, and deaths. Skeletal remains may corroborate under-nutrition, micronutrient deficiencies, and increased child mortality. For several other types of health risk there is little historical information before the past century. For example, information about heat-wave impacts in earlier centuries is negligible, although information about deaths and suffering from periods of extreme cold exists.

Records of major infectious disease epidemics, mostly from dynastic Egypt and Eurasia, extend back 3 to 4 millennia, but are rarely explicitly connected with climatic conditions. Such information becomes more detailed and better connected in the past half-millennium. Various plagues in the eastern Mediterranean from 1500 to 500 years before the common era (BCE) are in the biblical record. So too, more reliably, are the catastrophic plagues of Athens (5th century BCE) and of Rome such as the Antonine and Cyprian plagues (2nd and 3rd centuries CE, respectively).

Debate persists over the microbiological identity of most early plagues. Historians of the time provided diagnostic clues of variable quality. Generic words such as 'plagues' and 'poxes' are inevitably obscure; Shakespeare's 'agues and fevers' could mean many things. Modern molecular genetics is resolving some of these mysteries.

Illustrative evidence of climatic influences on major epidemics comes from the Chinese imperial archives, documenting epidemic outbreaks at province level over the past eight centuries. During the 'Little Ice Age' in Eurasia (within 1300–1850 CE), 881 epidemics were recorded in China, 32 of which afflicted three or more provinces. That record, from a translated listing assembled in 1940, matched with estimated annual temperatures in central-eastern China where the bulk of the population lived, enables analysis of epidemic years in relation to cool and warm periods. During colder periods (temperature below the 1300–1850 mean temperature) there was, approximately, a 35% greater probability of an epidemic and a 40% greater probability of a major (three-plus provinces) epidemic than during the warmer periods.

A larger body of evidence links infectious disease outbreaks with the under-nutrition, starvation, crowding, and social disruption that often resulted from, or were exacerbated by, climatic adversity. A recent analysis for Europe during the Little Ice Age has shown that the additional cooling of 0.2 °C during the coldest (17th) century was accompanied by marked harvest declines and food price rises, a doubled frequency of famine years, a 1.5 cm decline in adult stature, a tripling in epidemic outbreak rate, and a surge in armed conflicts.

There are many other examples of this nutrition–infection linkage. Some of these are:

- Smallpox outbreak in western Roman Empire in the winter of 312–313 CE in the midst of famine apparently caused by the lack of winter precipitation.
- Recurring association of hunger, starvation, and pestilence during very cold episodes in the 8th and 9th centuries in Europe.
- *Cocolitzli* epidemics afflicting post-conquest Aztec survivors during mega-droughts.
- Dysentery outbreaks in the fledgling Sydney Cove settlement, in eastern Australia, during the drought and food rationing crisis of 1790–1792.
- Epidemics of smallpox in northeast Brazil after starvation caused by the great 1878–1879 drought.

The influence of extremes of climate and weather on infectious diarrhoeal disease is also likely to have long been prominent. Cholera outbreaks in southeastern (British) India during 1901–1940 were strongly correlated with climatic extremes – both with very dry periods (with presumed high bacterial concentration in dwindling drinking-water sources) and with flooding (causing sanitation failure, displacement, and crowding). Finally, much evidence associates outbreaks of social disorder, conflict, and warfare, and their diverse health impacts, with climate-related stresses, especially food shortages.

- In China over the past millennium, multi-decadal climatic changes causing food shortages and hunger have often led to social unrest and armed conflict, contributing to most of the dynastic collapses.
- In France, the extreme and erratic climate conditions of the late 1780s exacerbated food shortages, lawlessness, and social uprising that contributed to the French Revolution in 1789.
- Three decades later in Europe, the cold 'years without summer' that followed the massive Tambora (Indonesia) volcanic eruption in 1815, led to widespread food crises, starvation, and the overthrow of several minor monarchies.
- During the past half-century, armed conflict predominately within the world's poorer countries, was approximately doubled during times of local climatic stress caused by El Niño events, associated with food shortage and unemployment.

In summary, the broad health-risk categories of under-nutrition and starvation, infectious disease outbreaks, and conflict and warfare, are the most accessible for historical study in relation to climate.

Historical analysis has benefited greatly from two recent advances. First, methods for reconstructing palaeo-climates from proxy indicators have progressed markedly. Second, the recent extension of epidemiological research into studying contemporary climate-and-health relations strengthens the knowledge base. This enhanced opportunity is reflected in recent studies of selected aspects of the historical climatic record. Nevertheless, four preliminary considerations are relevant.

Quality of historical evidence

First, the available information is time-limited. Written records extend back no more than 5 millennia, and in some cultures emerged only later if at all. Some prehistorical health information comes from archaeological and fossil evidence. Information about annual weather patterns was not kept systematically in most of Europe until 14th-century parish-based records emerged. In China, systematic observational records of climate and weather extend back a similar period. Direct temperature measurement awaited thermometers and their systematic use from the mid-19th century.

Second, today's wealthier and technology-rich societies differ in many ways from earlier societies. Although modern societies might expect to be less vulnerable to climatic stress in view of their stocks of knowledge, physical resources, technological interventions, and good governance, there are limits to that coping capacity. Further, as shown in Table 2, in several respects modern societies may be especially vulnerable.

Third, the rapid and substantial human-induced warming and associated climatic and environmental changes now anticipated has no obvious historical equivalent. A century-long temperature change of 2-4 °C (perhaps more), as currently seems likely, has no known precedent during the Holocene. Further, rapid climatic shifts during the Holocene mostly entailed cooling (especially due to major volcanic eruptions).

Table 1

Vulnerability of modern societies to climate changes

1.Food-producing systems (land and sea) are already widely under stress from soil degradation and loss, water shortages and over-fishing, plus specialisation (less resilience), widespread monocultural production, and high dependence on fossil fuel inputs.
2. Today's large populations and dense urban settlements are (*i*) conducive to infectious disease, (*ii*) exposed to urban 'heat island' amplification of heat-waves, (*iii*) often located vulnerably (flood-plains, coasts, informal hillside housing, etc.).
3. Urban living depends on much complex infrastructure, vulnerable to disruption.
4. Many large low-income populations, dependent on coastal agriculture, face significant sea-level rise this century.
5. Much of the world is now 'full,' with little vacant hinterland. Population displacement may exacerbate geopolitical instability.
6. Other human-induced 'global environmental changes' (disrupted nitrogen and phosphorus cycles, biodiversity losses, land degradation, etc.) will compound many of the health impacts of climate change (especially food shortages and under-nutrition)
7. International tensions are rising on many fronts—reflecting population pressures, economic crises, water shortages, persistent poverty, and volatile food prices.

Food yields are affected by warming and by cooling and by changes in rainfall: both excessive rain and the drought that often accompanies temperature change. Crop and animal species are attuned, by way of natural and managed selection, to their usual climate. Two dramatic examples of harvest losses on the order of 25-30%, due to very hot periods, come from Russia in mid-2010 and central-western Europe in 2003.

Infectious disease outbreaks may be triggered either by the biological (for example. under-nutrition and weakened immunity) and social consequences of a cooler climate (for example, hunger-related unrest and mobility, crowding, and shared indoors-living with animals) or else by the stimulus of a warmer climate (proliferation of bacteria, mosquitoes, and host animal species) and its sometime social consequences (for example, population growth and movement).

The fourth consideration is to avoid undue attribution of social outcomes to environmental factors such as climate. During much of the 20th century there was energetic debate over the inclusion of climatic factors in social-historical analysis – a practice viewed unfavourably by historians and social scientists as 'environmental determinism'. A more inclusive approach is now preferred.

Time-frames of climatic influence

Climatic changes influence human well-being, biology, health, and survival, within six distinguishable time-frames:

1 Influences on biological evolution (over millennia).
2 Transitions in human culture and ecology (at times of state-changes in climate).
3 Long-term climatic changes (multi-century).
4 Medium-term climatic changes (multi-decade).
5 Short-term climatic changes (multi-year).
6 Acute climatic/weather events.

Evolutionary

An extensive literature addresses likely influences of global cooling on hominine biological evolution during the late Pliocene and early Pleistocene epochs. Presumably, both 'directed' and 'plasticity' selection occurred, with the latter selecting for the behavioural and physiological adaptability needed during the climatically variable period of 2.7–2.0 million years. Meanwhile, climate-related changes in diet selected for an anatomy and metabolism suited to that diet, including evolution of the jaw and (reciprocally) a shortened colon and enlarged brain.

Ecological

Major climatic shifts propelled two great transitions in human ecology. From around 80,000 years ago, with glaciations, small bands of *Homo sapiens* drifted north-eastward out of Africa and radiated around and across greater Asia. Human culture and biology evolved regionally in response to new climates, foods, and infectious agents. Later, from approximately 11,000 years ago, after post-glaciation warming, selective cultivation of cereal-grasses emerged in South West Asia's 'fertile crescent' and perhaps soon after in several other separate centres in East Asia, South East Asia, Mesoamerica, and South America. Agrarian village settlement gradually transformed human ecology as the Holocene climate arrived.

Long-term climatic changes (multi-century)

Between 12.8 and 11.6 thousand years ago the latter stage of the post-glaciation warming was interrupted by a major cooling phase, the 'Younger Dryas', probably caused by the sudden massive release of melt-water from Canada's thawing ice sheets into the Atlantic, disrupting that ocean's heat circulation system. Over several centuries the temperature dropped by approximately 4 to 5 °C. At that time early human settlements were forming in several regions with good year-round food sources, including the Natufians in today's northern Syria and the settlements along the Nile Valley.

Several dozen Nile settlements preceded the Younger Dryas. After that climatic shock, however, only a few survived. Regional skeletal remains show an unusually high proportion of violent deaths, many accompanied by remnants of weapons. In the Natufian region, as food supplies dwindled, most settlements disbanded.

Sumeria

Southern Mesopotamia (Sumeria), with the lower Tigris and Euphrates river flood-plains, was apparently the first to develop regional-scale agriculture and a polity of multiple connected villages and towns as trading centres. The region's climate reflects a complex, seasonally varying set of weather systems. These were the 'Atlantic' circulation (west winds, warmth, and seasonal rain) driven by the North Atlantic Oscillation; the inter-decadal latitudinal fluctuations of the arid subtropical 'ridge'; the West Asian monsoon system; and periodic cold dry air from the north.

During the first, longer phase of the warmer Holocene Climatic Optimum (6000–3800 BCE) the positive 'Atlantic' weather pattern of the North Atlantic Oscillation predominated. This, plus river irrigation, facilitated the spread of agriculture. As Sumeria's climatic configuration began to change in the 4th millennium BCE, increasing food insecurity and hunger emerged. Crisis deepened, starvation spread, the

authority of rulers dwindled, and local farming communities raided one another. Clay tablets and carvings on stone steles attest to growing misery, conflict, starvation, and several epidemic outbreaks In this underfed weakened state, Sumeria was conquered by the warrior-king Sargon, ruler of the upstream Akkadian empire in northern Mesopotamia. The drying conditions subsequently extended north and, after brief regional domination, the Akkadian empire collapsed around 2200 BCE, largely undone by drought, malnutrition, and starvation.

Maya

The Mayan civilization flourished during 200–750 CE and declined during the 9th century CE. The 'Classic Mayan' civilisation, spanning the northern Yucatan Peninsula in today's northeast Mexico through to the Guatemala–El Salvador region, has long historical roots. The Mayans forged a successful way of living, despite heavy tropical forest, mediocre soils, and little surface water.

Great civilisations decline for complex reasons. The drying of the Mesoamerican climate during the 8th to 10th centuries CE has long been a candidate factor. So too have increased population pressure, deforestation, chronic soil erosion, the precarious dependence of agriculture on rainwater, and frequent intercity warfare. Recent direct evidence of severe regional drought has emerged. Three great droughts occurred during (approximately) 760–800, 840–870, and 890–920 CE, attributable, in part, to a weakening and shift in the summer monsoon.

Archaeological studies have identified three periods of social stress, architectural decline, and violent conflict close in time to the three 'palaeo-climatic' droughts. These report an increased prevalence of nutritional deficiencies and child skeletons during the drying period, along with apparent survival cannibalism.

Medium-term climatic changes (multi-decade)

Cocolitzli epidemics

In 1521 CE the Aztecs were conquered by Spanish conquistadors, with their lethal stowaway measles and smallpox viruses. Later that century, other epidemics occurred in Aztec survivors. Protracted drought conditions, punctuated by occasional years of intense rainfall, in much of Mesoamerica during the 16th century, are thought to have caused spillover of indigenous rodent-borne infections as zoonotic epidemics, compounding the Aztec depopulation

The coincidence, in timing, between the 'mega-drought' of 1540–1580, which was the longest regional drought for six centuries, clearly identified by tree-ring analysis, and the two major epidemics of 1545 and 1576, which caused 12–15 million and 2 million deaths, respectively, suggests they were caused by *Cocoliztli.* These were indigenous

hemorrhagic viral fevers transmitted by infected rodents. The rodents' food-seeking activity during drought, and their proliferation during the ensuing transient rains, would have increased human contact. Recent analogous evidence comes from the acute epidemic of rodent-borne hantavirus pulmonary syndrome in the southwestern US after the El Niño-related drought of 1992.

Black Death

The Black Death refers to the European component of the second pandemic of bubonic plague. This seems to have begun approximately 1330 CE in the region of eastern Central Asia and southwestern China. Subsequently, it extended west and, from 1347, spread through Europe over the next five years, transmitted by infected fleas feeding on infected rodents.

The geographic distribution of sylvatic bubonic plague and the timing of outbreaks reflect climatic conditions that favour a 'trophic cascade'. Over several decades the local climate may stimulate plant foods eaten by wild rodents, whose numbers grow. Weather events can disrupt rodent feeding and underground residence, causing their dispersal. Climate also influences human activities (crowding, trading, conflict) that increase rodent–human contact, directly or by way of human-cohabiting black rats.

This great pandemic may have been potentiated by a multi-decadal sequence of climatic influences. First, mild climate for several decades around 1300 CE in the Himalayan foothills of eastern Kazakhstan adjoining south-western China, fostered plant food abundance and hence wild rodent proliferation. Second, southern-central China subsequently cooled during 1310–1330, and presumably plant growth declined.

In the early 1330s catastrophic floods in central China displaced and drowned many people, and are likely also to have stressed and displaced wild rodents and increased rodent–human contact. Meanwhile, in western China conflict flared between encroaching nomadic Mongol pastoralists, whose numbers had increased on the recently verdant steppes, and Han Chinese farmers. That strife and displacement would have further increased human–rodent contacts.

This sequence of climatic influences may thus have potentiated the great Eurasian plague epidemic. Before long, trade caravans or (more probably) horse-borne Mongol armies, with 'companion' black rats, carried the disease westward into Europe in 1346–1347 by way of the Black Sea port of Kaffa. Within a decade, approximately one-third of the European population had perished.

Climatic factors may have also played a more subtle role. A legacy of Europe's Great Famine of 1315–1322 would have been an undernourished generation of newborns with a weakened immune system, who were therefore less able to survive infections three decades later.

Ming Dynasty collapse

In China the colder conditions in early 17th century were extreme. From the 1620s to the early 1640s the summers were very cold and drought widespread. The 1638–1641 drought was probably China's most severe for half a millennium. Eventually the drought encompassed the populous rice-growing Yangtze valley region in central-southern China. As yields fell, famines and hunger followed.

The food shortages during those decades coincided with the further disruptive effects of the incursion of the increasingly populous Han Chinese, who began displacing the ethnic Bai Chinese, who had long farmed in the central Yangtze region but who now retreated to higher altitudes. Yellow River flooding caused several hundred thousand deaths. The combination of food shortages, displacements, and weather disasters caused social unrest and violence, along with smallpox epidemics. The mounting social turbulence, predominantly due to starvation, culminated in an uprising in 1644 that overthrew the Ming Dynasty.

Short-term climatic changes (multi-year)

Plague of Justinian

In 542 CE an epidemic broke out in Constantinople. This was the beginning of the first pandemic of bubonic plague. Within three months about 100,000 deaths occurred in the population estimated at 500,000. The pandemic subsequently spread widely in southeastern Europe and the eastern Mediterranean region, recurring widely until the mid-8th century and killing tens of millions. The initial epidemic was probably introduced by infected black rats and fleas on ships carrying grain from the Egyptian staging port of Pelusium, at the mouth of the Nile Delta, and subsequently exported by way of Alexandria. A local plague epidemic had broken out in Pelusium in 541 CE. Its apparent source was the plague reportedly then endemic in 'Ethiopia' (the kingdom of Aksum) whose northern slopes were the major source of grain for export downstream on Nile river boats or by way of the coastal Red Sea route.

Phylogenetic evidence points to an East African origin. Infected black rats from Aksum would have travelled with grain shipments destined for Pelusium, by way of river boats or Red Sea ports. Archaeological evidence shows that black rats had colonised northeastern and northern Africa many centuries earlier, presumably migrating from their homeland in India via the longstanding sea trade.

Upstream conditions on the River Nile during postharvest season, passing through the Nubian Desert, would usually have been too hot (33–40 °C) and dry for rat survival and for flea reproduction, survival, and regurgitation of the plague bacteria. Similarly, the Red Sea coastal temperatures are some of the hottest in the world, typically approximately 41 °C in July and 32 °C in January. The tolerable temperature range for

the several critical aspects of flea biology, especially reproduction, is ≈20–30 °C, well reflected in the fact that most outbreaks have occurred in places with mean annual temperature of 24–27 °C.

Research has largely overlooked the striking coincidence of the epidemic with an abrupt global cooling event. In 535 CE, a massive volcanic eruption (perhaps in Rabaul) and its consequent atmospheric shroud, caused a rapid global cooling of approximately 3°C that lasted for a decade. Weather patterns were disrupted, with flooding in Arabia and heavy snowfalls in Mesopotamia. Dramatic crop failures, hunger, and unrest occurred at that same time in central Sweden, Ireland, northern China, and Central Asia's grassland steppes.

In Europe this coincided with a background cooling trend. The especially cooler conditions during the late 530s, along with apparent wetter weather, would have created an unusual and brief opportunity for plague-infected rats and fleas to travel north to Pelusium, where grain storage facilities doubtless sustained a thriving rat population. Although infected rats are unlikely to have survived the full journey, infected fleas can survive for long periods in protective materials. It was an easy next step for rats, fleas and bacteria to cross the Mediterranean and infect the citizens of Constantinople.

The Great Famine

In the early 14th century, northern Europe experienced the worst prolonged famine in its recorded history, the Great Famine. During the most severe 7-year period (1315–1322), there was incessant often torrential rain, floods, mud, and cold. These left long-lasting memories of widespread starvation, epidemic disease, deaths, class conflicts, rain-drenched warfare, and widespread violence and theft. In 1316, relentless rains caused such misery and starvation that horses and dogs were eaten.

In northern Europe, up to one-tenth of the population perished. Death rates were higher in towns and cities than in the countryside. Such statistics overlook the misery and bodily debilitation of the many thousands who starved. In such conditions of social disorder and impoverishment, infectious disease epidemics are likely. Indeed, a mysterious 'grim pestilence' reportedly spread in Europe – perhaps a mix of several infectious diseases. In the most afflicted localities in the Netherlands, France, England, and Scandinavia, this pestilence killed one in three persons.

The Great Famine was almost certainly due to a mix of social, climatic, and environmental changes, including economic disruptions from recent changes in land availability and agricultural practices. In such bleak settings, a change in climate can impose a critical extra stress on a vulnerable population.

Post-Tambora cooling

The heavy atmospheric sulphate aerosol pall from the super-colossal Tambora volcanic eruption in Indonesia in April 1815 caused several years of global cooling – a drop of 2 to 3 °C – and erratic weather patterns. That eruption, the most extreme for more than 1,000 years, followed an unusual sequence of four other major volcanic eruptions during 1812–1814 that had already initiated global cooling. As global temperatures fell, serious harvest failures occurred in North America, China, and in Europe. In subtropical East Africa the cooling caused an unusually severe drought.

In Europe starvation and death rates rose as food prices spiked. The price of rye increased 2.5-fold in Germany during 1816–1817. Food riots occurred in England, France, Belgium, Germany, and elsewhere. The combined miseries of hunger, starvation, and outbreaks of typhus and relapsing fever, caused many groups to migrate, notably out of the grain-starved northeast US. Typhus outbreaks occurred in London, tens of thousands died in Ireland from starvation and typhus infection, and in Glasgow much of the population succumbed to these infections. Fertility in northeast China, where the cooling and famine were severe, declined by half. In Europe hungry and hostile crowds overthrew several minor monarchies.

Late Victorian droughts

During the 1870s and 1890s extreme droughts and hotter temperatures occurred in China, South Asia, Australia, Brazil, and elsewhere. The droughts were associated with unusually strong El Niño events, causing a westward arc of desiccation through Asia, Africa, and northeastern South America. They caused an estimated 30–50 million deaths, particularly in India, Brazil, and China.

Climate did not act alone. In British India the famines of 1876–1878 resulted from a combination of El Niño-driven droughts, and colonially enforced integration of local food markets with the emerging global market into which India continued to export wheat. As a marginal concession, starving labourers assigned to make-work public projects received meagre rations. Millions of deaths ensued from starvation and infectious diseases.

In China, after prolonged drought, the Great North China Famine of 1878–1879 caused approximately 10 million deaths, from starvation and epidemic outbreaks. In North-East Brazil, where severe droughts occurred in 1877–1878, half a million farmers and families died from starvation and epidemics. In 1878 one-third of the population of Fortaleza died from smallpox.

Acute climatic/weather events

Countless acute events have occurred over the centuries. Two examples are illustrative.

Yellow Fever in Philadelphia

The severe El Niño event of 1789–1792 culminated in unusually hot conditions in North America. In July–August 1793 an epidemic of mosquito-borne yellow fever broke out in sweltering Philadelphia, well beyond the normal northern limit of this tropical disease.

One month earlier, more than 1,000 refugees had fled north to Philadelphia from the French colony of Saint Domingue (now Haiti), where a slave rebellion and a fever epidemic had broken out. Unusually warm and humid conditions prevailed in Philadelphia at that time, enabling proliferation of the *Aedes* mosquito population. During the 3 months before the unusually vast mosquito population was culled by severe early winter frosts, yellow fever caused tens of thousand deaths in Philadelphia.

The Great Drowning

The fluctuation of climatic conditions during the Little Ice Age was accompanied by several periods of more frequent extreme weather events. Many severe storms and floods along Europe's North Sea coast have occurred over the past millennium, often causing great destruction and mortality, directly and by starvation from crop losses. In January 1362, for example, the 'Great Drowning' occurred during an extreme storm along the coasts of Denmark, the Netherlands, and Germany, causing an estimated 100,000 deaths. More than 70 coastal villages were washed away. In 1588 another great North Sea storm destroyed much of the mighty Spanish Armada, while also causing deaths and coastal devastation in the Netherlands.

We have not yet been tested

Human societies typically either do not clearly perceive emerging external stress, such as climate change, or respond too late. However, sustained long-term climate change necessarily endangers previously well-adapted culture and practice, especially agriculture. Multi-century climatic changes, as impinged on the Sumerians and the Mayans, and also the Norse Vikings in Greenland, and the Western Roman Empire, can undermine, disperse, or perhaps terminate a society.

Multi-decadal climatic changes have often imposed great suffering and increased mortality, especially in most vulnerable segments of society. However, recovery, often with social and political reorganisation, usually occurs. Examples include the several occasions when sustained falls in annual Nile flows in ancient Egypt caused hunger and hardship (prompting upgraded water-risk management by Pharaonic officials), and the Great Famine in Europe in the early 14th century. The latter disruption was

compounded by the ensuing Black Death, both shocks contributing to the ongoing weakening of Europe's feudal system.

That second pandemic of bubonic plague, beginning in the 14th century, entailed a multi-decadal sequence of influences on ecological and then demographic determinants of the initial outbreak (in China) and its subsequent Eurasian spread. A further example, from China, is the loss of the imperial rulers' Mandate of Heaven by four of the six last dynasties at times of sustained climatic adversity (particularly drought), food shortages, and social uprising.

Briefer multiyear climatic fluctuations have sometimes been disastrous for health and survival, although without necessarily causing systemic damage to major social institutions, as with the great droughts of late 19th century in India and China. Other such events have destabilised societies, as occurred in the Eastern Roman Empire when stricken by the Plague of Justinian, occurring after a half-decade of abrupt marked cooling.

Short-lived, acute, climatic shocks, including extreme weather events such as floods and storms, have repeatedly wreaked great damage, injury, death, and disease. The impacts have usually been greatest in the most vulnerable populations, reflecting location, housing patterns, resources, and governance. However, although often tragic, these are transient shocks in the historical record, usually remediable by rebuilding.

Sustained or abrupt changes in climate have frequently affected food yields, nutrition and survival, epidemic outbreaks, and conflict leading to deaths, injuries, and diseases. The greatest recurring health risk has been from impaired food yields, mostly due to drying and drought. Drought has been the dominant historical cause of hunger, starvation, and consequent death. This casts an ominous shadow over this coming century. Climate modelling consistently projects an increase in the range, frequency, and intensity of droughts. As evidenced by the very recent extreme-summer experiences in Russia and Western Europe, excessive heat is equally damaging to crops and livestock.

In a warmer future world, the range, rates, and seasonal duration of many infectious diseases is likely to increase, because bacteria at higher temperatures and vector organisms such as mosquitoes, fleas, multiply faster. Infections and infestations will also pose increased risks to agriculture. If food yields fall, often accompanied by water shortages, then nutrition and health suffer, work capacity decreases, epidemics occur more readily, social cohesion declines, and conflicts emerge.

What differentiates these ancient cultures from our own is that they experienced the onset and persistence of unprecedented drought that continued for many decades to centuries. We moderns have not yet been tested. The main inferences are in Table 2.

Table 2

Lessons of history for impact of climate change now

• Long-term climate changes have often contributed to the decline of civilisations, typically by way of aridity, food shortage, famine, and unrest.
• Medium-term climatic adversity, causing hunger, infectious disease outbreaks, poverty, and unrest, has often led to political overthrow.
• Infectious disease epidemics have often accompanied or followed short-term and acute episodes of temperature shifts, food shortages, and social disruption.
• Societies can build resilience and learn to cope with recurring shorter-term (decadal to multiyear) climatic cycles, other than when extreme phases occur.
• Weather disasters afflict both rich and (especially) poor populations. Recovery, sometimes with social reorganisation, usually occurs.
• The nexus of drought, famine, and starvation has been the major serious adverse climatic impact on health over the past 12,000 years.
• Cold periods, more frequent and often occurring more abruptly than warm periods, have caused more apparent stress to health, survival, and social stability than has warming.
• Temperature changes of 1 to 2 °C can impair food yields and influence infectious disease risks. The health risks in a world forecast to undergo human-induced warming of unprecedented rapidity and magnitude (perhaps well above 2 °C) are likely to be great.

Climate change-related indicators, with continuing political procrastination, are increasing the likelihood of a 3 to 4°C average surface warming this century, and perhaps beyond. This would be an extreme and rapidly evolving long-term change in climate, without precedent during the Holocene. Such a change will pose serious risks to human health and survival, impinging unevenly, but sparing no population.

Dhaka, Bangladesh, 21 September. Large parts of the country are already inundated by rising ocean levels. Like the children here, rural communities are forced off their land into urban shanties

Climate. Food systems. World health
The prospects of famine

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Climate Change and Global Health, edited by Colin Butler, is published this month by CABI International. It has 22 chapters by 55 authors from 17 countries. It can be ordered by *accessing the form here.* Below is an extract from the 13th chapter, by Colin Butler, on famine, society, hunger, and climate change. The full chapter, with references, *is available here*. Colin Butler states that the overall impacts of a substantial rise in global temperature remain underestimated. This is because of focus on specific effects that are relatively easy to model, and less attention to third order or *'tertiary' qualitative social, economic and political effects* which are inevitable or likely, whose nature, occasion and severity cannot be predicted precisely. Overall it is reasonable to say that climate change is this century's greatest threat to the health of our species, and that of the living world and the biosphere.

Kathmundu, Nepal, 21 September. Demonstrating in solidarity. Food systems and nutrition security in much of the Indian subcontinent depends on Himalayan glaciers, now melting away

Famines are caused by an interaction of eco-climatic causes, such as drought, flood, and plant diseases, and social causes, such as poor governance, conflict, and discrimination against minorities. This interplay between eco-climatic and political events is a characteristic of 'third order' or tertiary events, which are hard to quantity, and which analyses of climate change tend to overlook. Famines and large-scale food insecurity, without frank starvation, also have the potential to harm health on a vast

scale. As other tertiary effects of climate change such as large-scale population dislocation and conflict worsen, systems of governance are also liable to fail, which will also cause famine and disorder, as already now evident in many parts of Africa.

The cost of staple foods

For centuries, the long-term trend of food prices has been downwards. But since 2005, there have been two pronounced spikes in the prices of staple foods The first one, in 2008, was driven by high oil prices, speculation, and restrictions on rice exports. However, extreme weather events are likely causes of the second rise, which started at the end of 2010. Two factors seem important, in addition to fairly high energy prices. One is the apparently relentless rise in the proportion of global food crops used for biofuels, itself largely a response to the growing scarcity of easily recoverable crude oil, essential for transport using current technology.

The second reason may be a response to extreme climatic events. The most notable of these were the Russian-Ukrainian heat-wave of 2010, and the Pakistani flood in the same year. The Russian heat-wave was especially significant because it affected the traditional 'bread bowl' of the former USSR. It led to a 66% increase in the global price of wheat within two months and a lesser rise in other grain prices. The floods in Pakistan displaced over 20 million people, some for months.

Both events reduced crop production in 2010, sufficiently to contribute to a decline in per capita global grain production. The US then experienced a severe drought and heat-wave in 2011and 2012. Although such dryness has apparently occurred at other times in the last millennium, its conjunction with such heat may be unprecedented, and thus attributable in part to elevated greenhouse gas levels.

Did climate change contribute to the Russian heat-wave? This is still debated. But there is increasing support for the proposition that the burden of proof concerning the contribution of climate changes to such events should be reversed. That is, some climate scientists are now arguing that climate change should be accepted as a contributor to these extreme events until proved otherwise.

The recent Somali famine may also be related causally to climate change. In the past three decades, the Indian Ocean has warmed especially fast, in association with increased precipitation over the tropical Indian Ocean. This has suppressed convection over tropical eastern Africa, decreasing precipitation during the 'long rains' season of March–June. Attempts to alert Somali authorities to the likelihood of famine were unsuccessful, but may have benefitted other, better-governed parts of the Horn of Africa, including Somaliland and Ethiopia. Crop production is

vulnerable to many factors associated with climate change, apart from extreme weather events. Some high-latitude regions and crops are expected to benefit.

Overall, accepted evidence suggests that the effects of climate change on land-based agriculture are increasingly adverse, especially for wheat and maize, although not (yet) for rice and soy. Nocturnal warming in tropical areas harms yields of both wheat and rice. So far, decline in land-based agricultural production generally accepted as due to increasing temperatures and changes in rainfall is small, compared with increased harvests due to improved farming knowledge and technology. It is certainly trivial compared with the amount of food fed to livestock, used for biofuels, consumed beyond baseline needs by over-nourished populations, and wasted in other ways.

The complete picture is ominous

Modelling of past and future agro-climatic effects is a formidable challenge, even without considering their health impacts. In my view, existing agro-climate models are excessively simple and biased toward the optimistic. The decline detected in food production ascribed to climate change is likely to be understated, and that of future climate change even more so.

Concern over future climate change and crops is amplified by increasing doubt over the benefits and strength of carbon fertilisation, especially for plants such as maize and sugar. Agro-climatic models increasingly incorporate predictions of positive and neutral effects. However, pests may increase, and yield of some crops like cassava, a staple for about 750 million mostly impoverished people, may be damaged. These effects to date are not incorporated into models.

Current agro-climatic models also poorly incorporate rainfall intensity, sea level rise, saline intrusion, glacial melting, and the possibilities of monsoon weakening and intensification of the El Niño Southern Oscillation and other ocean currents and atmospheric oscillations. They also omit the effect of climate change on mycotoxins, and on crop and animal diseases.

The capacity of food to provide adequate nutrition is also influenced by other factors, such as levels of physical activity, which include not just paid work, but unpaid labour such as hauling water, sometimes over hilly terrain. It is further influenced by states of health and disease that lower appetite, nutrient absorption, and metabolic rates.

Since 2003, several extreme weather events have occurred which have reduced crop production. Some of these have been linked to climate change. At present, there is

no comprehensive data set of such events. But declining crop yield growth, falling soil fertility, competition from feed and biofuels, and continued population growth, mean that reduction in crop growth due to extreme weather events is likely to impact on global food prices, per capita global food production, and thus global health.

Climate change is also predicted to have complex effects on fisheries, including by changing the pattern of ocean currents, thus redistributing marine productivity, especially to higher latitudes. Declining trends in the global phytoplankton concentration in eight out of ten ocean regions, have been linked with warming sea surface temperatures. Increasing ocean acidity and climate change- associated deoxygenated zones will also harm future marine productivity. Furthermore, ocean acidification associated with increased carbon dioxide concentrations, interferes with the development of a wide range of aquatic species. It is already harming coral reef systems and further stressing fish stocks already in decline.

Increased famines caused in part by climate change appear likely. These have profound negative effects on food security, and hence on health and nutrition. Rising food prices cause social unrest and even chaos, and can contribute to the overthrow of governments.

What is to be done?

Climate change requires adaptation. Adapting crops to cope with drought, flood and inundation from the sea is feasible to a point. But this may be possible only to thresholds of increase in global temperature which may soon be exceeded.

Mitigation is a more important priority. Much can be done to reduce the enormous waste of food, pre-harvest (such as losses on the field), post-harvest (for example, eaten by rodents) and post-processing (for example, thrown out from supermarkets or wasted after purchase). Food fed to people suffering from chronic diarrhoea can be utilised better if their illnesses can be reduced by better health care, adequate sanitation and clean water. Overfed people, especially if consuming animal products raised on grain and soy, can and should reduce their consumption of these products.

There are calls for a new agricultural revolution, to be fostered by further capital investment. This might help. Much could be done to bring the Green Revolution to Africa. The World Bank in 2013 warned that if the average world temperature rose by 4 degrees Centigrade, then the most alarming effect was likely to be on food production. But this is still likely to be affected greatly by climate change, even if global temperature increase is held at a level far lower than 4 degrees. The combination of climate change and population growth is phenomenally ominous.

Determinants of fertility in low-income populations need to be altered in ways that increase child survival and the effective demand for education and population growth. A holistic, global approach is required, which integrates society, education, health care, equity and technology.

Kiribati, Pacific Ocean, 21 September. A full member state of the United Nations, its islands are expected to be under the ocean level later this century, and its 110,000 people displaced for ever

Status

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