CLIMATE OF UNCERTAINTY

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GLOBAL WARMING – A HEALTH RISK

RAINER SAUERBORN

The delicate balance of the Earth's atmosphere facilitates a very special kind of order that has played a crucial role in the success of human societies for more than 10,000 years. However, industrialisation during the past two centuries has created an imbalance that significantly increases the odds of this order being replaced by chaos. One immediate priority must be to prevent the worst predictions from becoming reality through mitigation measures. But with some effects already upon us – many of which could have profound implications for the human health –, it is crucial that we learn how we can better adapt to climate change as well. Otherwise, there could be devastating consequences from the chaos that ensues.

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Think of chaos and any number of images might come to mind. For the ancient Greeks, for instance, chaos was the dark silent abyss at the beginning of the world, from which everything came into existence. Today, one might rather think of economic crashes, science experiments gone wrong, or the (seemingly) never-ending expansion of the universe. From our perspective, investigating the health implications of climate change, however, chaos is better described as 'uncertainty of change'.

Often, where chaos exists, very small changes can make a system behave completely differently. And the relatively minute change in atmospheric gas composition as a result of human emissions has indeed left our climate system in a state of uncertainty. Specifically, this uncertainty lies in the nature, extent, locations and timescale of what could be dramatic and devastating shifts in climate balance. From a human health perspective, this raises important questions: Which diseases could proliferate? Which communities will be most vulnerable? How widespread will the impact be? And, perhaps most importantly, how should we react?

Risk and uncertainty

In a high profile meeting in Stockholm this September, researchers on the International Panel for Climate Change (IPCC), of which I am a member, delivered the most exhaustive and authoritative assessment of climate change to date in the first part of their fifth assessment report. Providing an update of knowledge on the scientific, technical and socio-economic aspects of climate change, the report – which is being released in four parts – systematically presents the evolving scientific understanding of anthropogenic climate change, while also aiming to raise public and political awareness of the risks that lie ahead as the climate continues to change. Drawing on and assessing the work of more than 800 scientists and hundreds of research papers, the evidence presented is rock solid: the world is warming, we are to blame, and continued emissions of greenhouse gases will likely cause further warming and disruption to our climate system.

Particularly alarming is the reality that a 4°C rise in global average temperatures is now well within the confidence range of predictions. Indeed, if mankind continues 'business as usual' and fails to significantly reduce greenhouse gas emissions, climate researchers point to a potentially devastating risk of social, economic and environmental chaos spanning the entire planet. It raises the odds of a cascade of increasing global average temperatures, changes in rainfall patterns, more extreme weather events, and rising sea levels. Perhaps even more striking is that it could severely undermine our natural life support systems, of which climate change is tightly coupled, such as freshwater supply, agriculture, biodiversity, our oceans, the nitrogen cycle, and other key ecosystem services. While the long-term consequences for our societies are hard to predict, this is far from a reality dreamt up by science fiction writers. Indeed, the assessments by the IPCC and international organisations such as the World Bank underscore the fact that it is entirely possible that the ensuing disruption will be on a scale unlike anything we have seen before.

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The notion of a '4°C world' – an often-used figure in worst-case scenario predictions for global average temperature increases by the end of this century from the end of the last one – has drawn attention to the alarming reality that the planet could be on the edge of biological thresholds that, if crossed, could result in unacceptable social and environmental change. This is particularly concerning given that human-induced climate change is already here. In fact, mounting scientific evidence suggests that even the most comprehensive approaches to try to mitigate its effects might not be enough to prevent exposure to at least some of its risks.

On the other hand, scientific research also reveals opportunities to limit the effects of climate change to a '2°C world' – an outcome that could give us a far greater chance of avoiding the worst effects of a destabilised climate. And despite the major transformations required in all sectors of our economies, a key message I want to deliver in this article is one of cautious optimism: we can prevent the potential chaos of runaway climate change, but only by addressing it with 'order'. This will require better organised and stronger global governance that aims to significantly reduce emissions in industry, services, transport, agriculture and more, while empowering individual, social, institutional, and economic adaptation to the residual effects of climate change in a fair and sustainable way. I will examine this now step by step.

Man as perpetrator

The theme of this edition, chaos and order, is particularly suited for an article on climate change given the delicate balance of the Earth's atmosphere. Recent increases in greenhouse gases stemming from human emissions have disrupted a balance – an order, if you wish –, leading to an increase in global average temperatures of 0.7ºC during the past 200 years. During this time, because of us, carbon dioxide levels have nearly doubled. While our climate does change naturally, it usually does so over the course of thousands or tens of thousands of years. The speed and extent of current changes – measurable in merely years or decades – is unprecedented since the times when homo sapiens first emerged in Africa. With seven billion people on the planet and counting (current projections are nine billion by 2050), we are only just beginning to comprehend the full consequences.

Few areas of research have captured the attention and emotions of the public in quite the same way as climate science. The problem of acid rain in the 1970s and the massive ozone depletion discovered in the 1980s presented unprecedented social, environmental and political challenges that transcended national borders. At the beginning of the 1990s, however, growing evidence pointing the finger at mankind being the cause of major changes in global climate patterns spelled the ultimate shift to a new paradigm: Everyone is a potential perpetrator and a potential victim of climate change – albeit in very different ways, since the most immediate and devastating impacts of climate change have been on the world's poorest people, who are least responsible, yet hardest hit.

Perhaps most difficult to comprehend was how just a tiny change in the volumes and exchanges in the carbon cycle (less than one percent of natural flows) could alter the thermodynamic balance of the atmosphere, and potentially affect the conditions for all life on Earth. This is particularly striking when assessing the risks of increased instances of cyclones, sea-level rises, and precipitation changes, as well as the scary prospect of irreversible tipping points, such as the breaking-off of the Western Antarctic ice sheet or reductions in the capacity of the world's climate sinks – our forests and oceans, which absorb as much as fifty percent of current carbon dioxide emissions.

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Scientific models accounting for scenarios of how society might develop in terms of economic growth, population increases, technology development and more give various projections on how the Earth will be affected in the years to come. However, they point unanimously to the reality that a 'business as usual' approach is simply not an option if we are to avoid the planet tipping into an unfavourable state for human development – and this before we even reach the end of this century.

Man as victim

This has particularly worrying implications for the health and well-being of human societies. In 2009, when 'The Lancet' wrote in a commission report that "climate change is the biggest global health threat of the 21st century", it captured worldwide attention: one of the most respected general medical journals was underscoring the importance of an issue that few had thought so directly about in the context of human health.

Just as anthropogenic emissions disrupt the dynamic equilibrium of carbon flows (and hence the 'greenhouse effect'), climate change in all its permutations has multiple effects on the dynamic equilibrium of the determinants of human health. The direct effects of climate change on health include increasing instances of heat stroke, changes in the distribution of organisms that cause disease, and more weather disasters. Perhaps of even greater long-term concern, however, are indirect effects – changes to ecological and geophysical systems that can undermine the fundamental bases of human health: nutrition, water, air, microbes, behaviour, social determinants and the biosphere (see figure 1).

The potential implications for human health in the event of any alternative are shocking. While difficult to predict, research such as bio-mathematical modelling of vector-borne, rodent-borne and water-borne disease transmission has shown that even a small temperature rise can significantly increase instances of the eighty or so climate-sensitive diseases. Other major concerns include malnutrition as a result of drought, flooding, or salination of fertile soils, and increased instances of conditions such as mental illness as a result of social disruption. Our ongoing work on the Fifth Assessment Report strongly suggests that a powerful disturbance in the dynamic balance of the determinants of human health, of the kind we would likely see in a 4°C world, would be unmanageable and irreversible.

While negative health impacts can be best avoided through urgent mitigation efforts, there is now a realisation that some increased risks associated with climate change will be unavoidable. Consequently, adaptation is also needed to reduce human exposure to current and future risks. Renowned epidemiologist Anthony McMichael summed

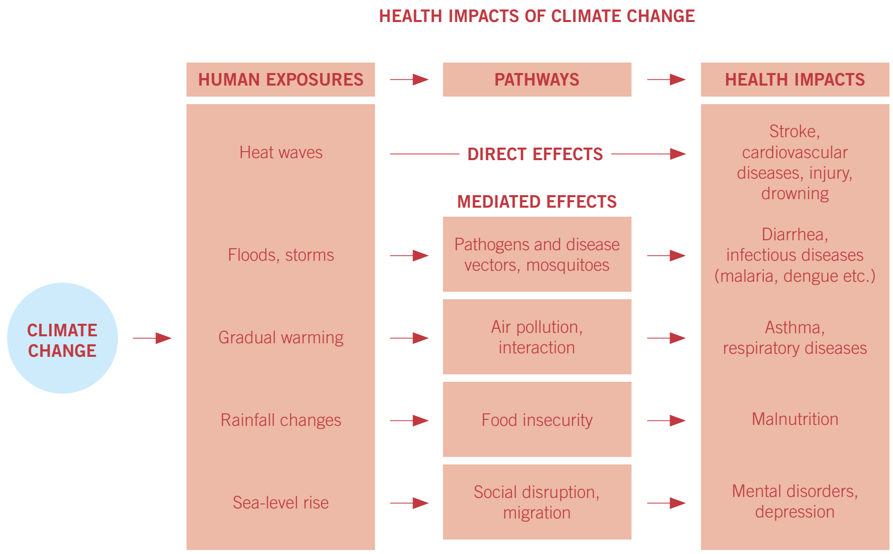

Figure 1
Direct and indirect health effects of climate change

KLIMAWANDEL UND GESUNDHEIT

AUS DEM GLEICHGEWICHT

RAINER SAUERBORN

Die Atmosphäre der Erde befindet sich in einem empfindlichen Gleichgewicht – eine Balance, die mehr als 10.000 Jahre lang die Grundlage für die Entwicklung der Menschheit bildete. In den letzten beiden Jahrhunderten jedoch ist unser Ökosystem durch die Industrialisierung tiefgreifend gestört worden. Falls es nicht gelingt, den Ausstoß von Treibhausgasen deutlich zu verringern und damit die Erderwärmung aufzuhalten, droht das Gleichgewicht auf der Erde zusammenzubrechen – mit verheerenden Auswirkungen für die Umwelt und den Menschen, insbesondere seine Gesundheit.

Zu den Folgen, die direkt spürbar sind, gehören die Zunahme von Hitzschlägen, die verstärkte Ausbreitung von Krankheitsüberträgern wie Malaria-Mücken oder auch die Unterernährung größerer Bevölkerungsgruppen infolge von Dürren, Überschwemmungen und der Versalzung von fruchtbaren Böden. Noch bedenklicher sind jedoch die indirekten Folgen des Klimawandels. Sie betreffen zum einen die natürlichen lebenserhaltenden Systeme, die für die Gesundheit so wesentlich sind – etwa die Nahrung, die wir zu uns nehmen, das Wasser, das wir trinken, und die Luft, die wir atmen. Zum anderen beeinflussen sie aber auch das soziale Gefüge, in dem wir uns bewegen, so dass mit einer steigenden Anzahl psychischer Erkrankungen zu rechnen ist.

Ein erstes Ziel muss es sein, die Erderwärmung durch präventive Maßnahmen wie die Reduktion von Treibhausgasen aufzuhalten. Einige der Auswirkungen des Klimawandels sind allerdings heute schon spürbar und nicht mehr zu stoppen. Entscheidend ist daher, individuelle, soziale und wirtschaftliche Anpassungen an diese Folgen zu fördern. Hierzu sind neue klimapolitische Institutionen erforderlich, die über die Kompetenz verfügen, auch weitreichende und unliebsame Entscheidungen global durchzusetzen. Die Wissenschaft kann dabei wesentliche Beiträge leisten, indem sie eine fundierte Informationsgrundlage für solche Entscheidungen schafft. ●

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„Wir brauchen neue, global wirksame Institutionen und Regeln für die Klimapolitik – andernfalls ist kaum absehbar, wie wir unsere Gesundheit vor den Folgen des Klimawandels schützen können."

up this challenge well when he wrote: "Mitigation is avoiding the unmanageable, adaptation is managing the unavoidable." Indeed, both mitigation and adaptation must be applied simultaneously, very much in the way that prevention and curative care are applied in medicine. In the next section, I will consider the contribution our own research plays in this context.

Man as researcher
Policy makers like to act on evidence, particularly so when large sums of money are involved. However, predicting the social and environmental outcomes of climate change is inherently difficult. Developing a higher degree of certainty in relation to this requires modelling of both climate and disease impacts. In health research, for example, statistical inference theory has been widely adopted and terms like 'confidence interval' or 'statistically significant' have become commonplace. While they cannot be applied to model projections, we can learn a lot from longitudinal data sets from the past covering decades up to now.

One such example can be found in our own research that looks at the relationship between climate variables and health impacts across long time periods. In one study we analysed of total 7,402 deaths in an area of Burkina Faso between the years 2000 and 2010 – of any cause and at any age. We looked at variables such as temperature, rainfall and humidity on the day of the respective deaths, the day before, a week before, and so on. Our research shows that the risk of dying in this African population increases significantly as the temperature the day before death rises above 30°C. For every additional degree, the relative risk of dying goes up by 2.6 percent.

"Policy makers like to act on evidence, particularly so when large sums of money are involved."

A challenge for health research lies in linking these trends to climate models. We have illustrated how this can be done in studies of malaria, a climate-sensitive disease transmitted by mosquitoes. Malaria reacts very strongly to changes in rainfall and temperature. In our study, we used a process-based malaria model in which temperature and rainfall were important variables and effectively predicted seasonal malaria transmission (see figure 2 for a comparison of this model with observed malaria transmission).

In another strand of research, we looked at changes of the spatial distribution of malaria transmission. We used a satellite-based analysis of land cover and land use data

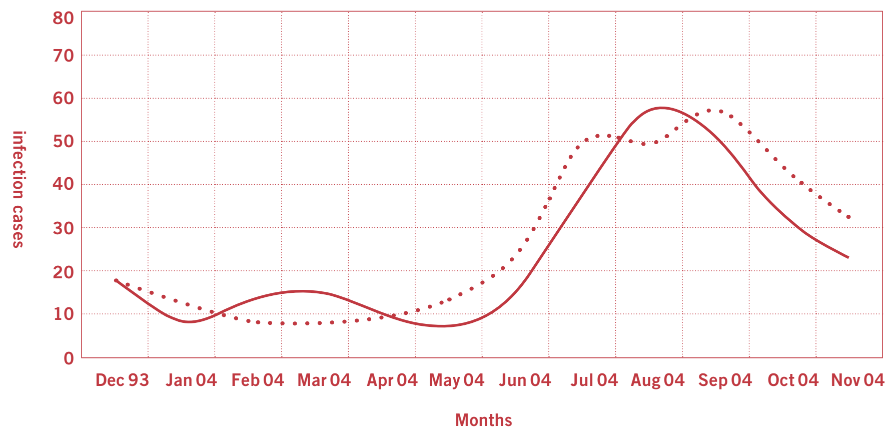

Figure 2
Number of malaria cases in children under five in the village of Goni, Burkina Faso. Model predicted (red dotted line) compared to observed (red line) malaria transmission.

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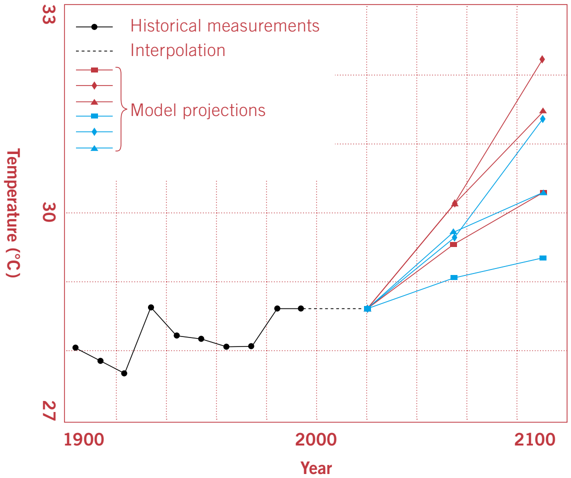

Figure 3
Figure 3 highlights the temperature changes from 1900–2010 and model projections from 2020–2100. The black line shows temperature measurements dating back to colonial times. The red and blue lines indicate projected temperature changes from 2020 to the present, based on six common climate models using information from ten meteorological research stations distributed within the study area.

and identified surface water and surrounding habitats that are favourable breeding sites for the most frequent malaria transmitting mosquito, Anopheles gambiae. The project, funded by the Manfred Lautenschläger Foundation, builds on local expertise in our Rhine Valley mosquito control program (KAPS). These mosquitoes do not breed just anywhere there is surface water like one might expect, rather they prefer sunlit, shallow, clean surface water with little vegetation beneath and moderate amounts of vegetation surrounding the site. All of these characteristics are detectable by specialised satellites.

While one cannot obviously 'see' the larvae directly, it is possible to detect Anopheles breeding sites and classify them according to whether they are likely to host malaria mosquito larvae and how many larvae per square meter they are likely to produce. This was painstakingly corroborated through field studies comparing actual larval densities in hundreds of breeding sites with the predictions based on the satellite images. The detailed maps that resulted from these studies allow local health services to target expensive larvicides to the most productive breeding sites. Knowledge of the timing of mosquito transmission and its spatial changes enable authorities to better direct malaria control efforts to the most 'dangerous' times and places – it has reduced both money and resources, as well as potentially saving lives.

This is an example of how research might help communities and health authorities to adapt to changes in the timing and spatial pattern of malaria due to climate change. It shows how research can and should provide information on the health impact of climate change both under different scenarios and for different time horizons. It also highlights the potential effectiveness and costs of adaptation policies to protect populations from climate change-related health hazards. Next, we aim to predict the future impact of climate change on major diseases using climate models – quantitative methods that simulate interactions of the atmosphere, oceans and on land. Typically existing models have a resolution that is too coarse for our purposes, however with the help of David Hondula from the University of Virginia, we effectively downscaled the model to a finer resolution (see figure 3).

Man as actor?

Countless studies highlight the importance of strategies to both mitigate and adapt to the effects of climate change in a manner that is both sustainable and fair. The question now is: Do we have the willing to push them forward? The discovery of a human influence on the ozone layer and the international agreement drawn up to address it through the Montreal Protocol did not provoke societal discussions nearly as far-reaching or emotive as the science of climate change. The treaty, which came into effect in 1989 and has been very effective in meeting its objectives, was comprehensive, legally binding, and received widespread governmental support. Unfortunately, current global governance is proving weak and toothless when it comes to legislation to address climate change.

While the World Trade Organization (WTO), for example, wields immense powers in setting and enforcing trade policies, nothing of this kind exists for emissions policy. The UN Framework Convention on Climate Change (UNFCCC) was signed by 154 heads of state in Rio de Janeiro in 1992, but its fatal flaw is that it is non-binding. The Kyoto Protocol to the UNFCCC, signed in 1997, was indeed binding but was insufficient – just a small number of countries signed up to binding commitments to reduce emissions. Many of the world's major polluters did not. Nor did low and middle-income countries in protest of the unfair share of costs between rich and poor. Attempts at new initiatives by the UN in high-profile conferences in Copenhagen, Doha, and Rio have further revealed gridlock in moving towards a global solution – economic problems or vacillating leadership often prioritised over the climate vision the world so badly needs.

Managing human activities that lead to climate change is more difficult than regulating the emissions of chlorofluorocarbons. It calls for changes that are at the heart of most societies – farming, industry, travel, energy, leisure, you name it. Meeting the challenges will require us to address issues, for instance how power is wielded, the role of key stakeholders such as non-governmental organisations and multinational corporations, and how decisions are made and enforced. In short, we need a new global order of institutions and processes for developing climate policy. Without this, it is difficult to see how our health can be protected from the chaos of climate change. ●

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