

Pim Martens and Anthony J. McMichael

# Environmental Change, Climate and Health

Issues and research methods



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# ENVIRONMENTAL CHANGE, CLIMATE AND HEALTH

Issues and research methods

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# ENVIRONMENTAL CHANGE, CLIMATE AND HEALTH

## Issues and research methods

The advent of global environmental change, with all its uncertainties and requirement for long-term prediction, brings new challenges and tasks for scientists, the public and policy makers.

A major environmental upheaval such as climate change is likely to have significant health effects. Current mainstream epidemiological research methods, in general, do not adequately address the health impacts that arise within a context in which ecological and other biophysical processes display nonlinear and feedback-dependent relationships. The agenda of research and policy advice must be extended to include the larger-framed and longer-term environmental change issues. This book identifies the nature and scope of the problem, and explores the conceptual and methodological approaches to studying these relationships, modelling their future realization, providing estimates of health impacts and communicating the attendant uncertainties.

This timely volume will be of great interest to health scientists and graduate students concerned with the health effects of global environmental change.



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## Foreword

Over the past two decades there has been a rapid evolution of research concepts and methods in relation to global environmental changes – their processes, impacts and the response options. The scale and complexity of these environmental problems are, in general, greater than those that individual scientists or their disciplines usually address. This is particularly so for those components of the topic that are furthest “downstream” from the pressures, or their drivers, that initiate the processes of global environmental change.

Indeed, in seeking to detect or forecast the population health impacts of global environmental changes there is an additional difficulty. Not only is the impact of research contingent on various assumptions, simplifications and projections made by scientists working “upstream” on the environmental change process per se, but the category of outcome – a change in the rate of disease or death – is one that usually has multiple contending explanations. If a glacier melts, then temperature increase is a very plausible explanation. Likewise, if birds, bees and buds exhibit their springtime behaviours a little earlier as background temperatures rise, that too is reasonably attributable to climatic change. However, if malaria ascends in the highlands of eastern Africa, regional climate change is just one contending explanation – along with changes in patterns of land use, population movement, increased urban poverty, a decline in the use of pesticides for mosquito control, or the rise of resistance to antimalarial drugs by the parasite.

There is also the problem of the time-frame. Much of the postulated health impact of global environmental change is likely to unfold over coming decades, as environmental stresses increase and life-support systems weaken. Yet, scientists generally prefer to work with empirical observations. Given that preference, and a well-honed body of scientific methods appropriate to empirical research, why try to use mathematical models to estimate how a change in global climatic conditions

would affect patterns of infectious diseases, when the simple alternative is to sit back and wait for empirical evidence?

Well, that question is very much the nub of the issue. The world cannot afford to sit back and await the empirical evidence. The luxury of unhurried scientific curiosity must, here, be replaced by a more urgent attempt to estimate the dimensions of this problem – the health consequences of global environmental change – and then feed this information, with all its imperfections and assumptions, into the policy arena. Consideration of human health impacts is a crucial, even central, issue in the emerging international discourse on “sustainable development”.

This, then, is a timely volume. There is an indisputable need to clarify the concepts and research procedures, and to illustrate recent and current research activities in this domain. The ongoing spectrum of health impact research entails learning from the recent past, detecting emergent health impacts and modelling future impacts. It also requires the assessment of how changes in world futures (social, economic, technological, political) will modulate these impacts, and how populations can or are likely to adapt to the change in environmental conditions.

If anything, this volume is overdue. The recognition of global environmental changes has already been a major spur to scientific development and methodological advances in many other disciplines, especially those elucidating and modelling the processes of change themselves. Accordingly, for example, our ability to model the world’s climate system has increased many-fold over the past decade. In contrast, because of the abovementioned complexities that beset research into human health impacts, compounded by an apparent diffidence on the part of most epidemiologists and other population health scientists to engage in this unfamiliar domain, advances have been relatively slow to emerge in this disciplinary area. This volume will help to change that.

It is a well-rounded volume. The range of chapters includes attention to historical and social context, to differing conceptual domains of research, to questions about the assessment of population vulnerability, and to exploring and evaluating societal adaptation options. The challenge of scientific uncertainties is addressed – a challenge that looms large in research that deals with complex biophysical, ecological and social processes and which seeks to estimate future trajectories of population health risks.

Finally, this is an important volume because population health is so central to the formulation of humankind’s “sustainable development” trajectory. If the life-support systems are weakened, and health is jeopardized, then we are all on the wrong track. Health scientists therefore have a major role and responsibility

in informing this international discourse. The team of authors assembled in this book has had impressive and wide-ranging experience in the pioneering stages of this great scientific undertaking. Their shoulders should now be stood upon by others.

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# 1

## Global environmental changes: anticipating and assessing risks to health

ANTHONY J. McMICHAEL & PIM MARTENS

### 1.1 Introduction

The meaning of the word “environment” is elastic. Conventionally it refers to the various external factors that impinge on human health through exposures common to members of groups, communities or whole populations, and that are typically not under the control of individuals (i.e. the exposures are predominantly involuntary). Thus, “environmental exposures” are usually thought of as physical, chemical and microbiological agents that impinge on us from the immediately surrounding (ambient) environment.

The “environmental” roles of socioeconomic status in the determination of disease patterns, including aspects such as housing quality and material circumstances, have also claimed increasing attention from health researchers. This, however, requires a more inclusive definition of “environment” – one that embraces social and economic relations, the built environment and the associated patterns of living.

Note also that we typically view the environment as being “out there”. It surrounds us, it impinges on us – but it is *not* us. This implied separateness reflects the great philosophical tradition that arose in seventeenth-century Europe as the foundations of modern empirical western science were being laid by Bacon, Descartes, Newton and their contemporaries. For several centuries this view helped us to manage, exploit and reshape the natural world in order to advance the material interests of industrializing and modernizing western society. In recent times, however, the magnitude of that environmental impact by human societies has increased exponentially. Consequently, in the light of the now-evident accruing environmental damage and the ongoing deterioration of many ecological systems, we must re-think our relationship to that “external world”. We must recognize the essential dependency of human society and its economy upon the natural world. That dependency is manifest in the risks to human health that have arisen, or will arise, from the advent of these large-scale environmental changes – changes that

are the current hallmark of the impact of the modern human species upon the ecosphere.

## 1.2 “Environment”: the wider dimension

During the last quarter of the twentieth century we began to see evidence of a general disturbance and weakening of the world’s life-supporting systems and processes (Loh *et al.*, 1998; Watson *et al.*, 1998). This unprecedented disruption of many of Earth’s natural systems by humankind, at the global level (Vitousek *et al.*, 1997), reflects the combined pressure of rapidly increasing population size and a high-consumption, energy-intensive and waste-generating economy.

Global economic activity increased 20-fold during the twentieth century. Meanwhile, in absolute terms, the human population has been growing faster than ever in this past quarter-century, capping a remarkable fourfold increase from 1.6 to six billion during the twentieth century (Raleigh, 1999). The last three billion have been added in 14, 13 and, most recently, 12 years, respectively. While we remain uncertain of Earth’s human “carrying capacity” (Cohen, 1995), we expect that the world population will approximate to nine billion by around 2050, and will probably stabilize at around 10–11 billion by the end of the twenty-first century.

In September 1999, the United Nations Environment Program issued an important report: *Global Environment Outlook 2000* (United Nations Environment Program, 1999). Its final chapter begins thus:

The beginning of a new millennium finds the planet Earth poised between two conflicting trends. A wasteful and invasive consumer society, coupled with continued population growth, is threatening to destroy the resources on which human life is based. At the same time, society is locked in a struggle against time to reverse these trends and introduce sustainable practices that will ensure the welfare of future generations . . .

There used to be a long time horizon for undertaking major environmental policy initiatives. Now time for a rational, well-planned transition to a sustainable system is running out fast. In some areas, it has already run out: there is no doubt that it is too late to make an easy transition to sustainability for many of these issues . . .

These are strong words. The report urges national governments everywhere to recognize the need for urgent, concerted and radical action. The report’s assessment concurs with others, such as the detailed analysis of changes in major global ecosystems carried out by the World Wide Fund for Nature, leading to an estimation that approximately one-third of the planet’s vitality, its natural resource stocks, have been depleted over the past three decades (Loh *et al.*, 1998). In Box 1.1 the main types of global environmental changes are addressed. It is of interest to review, as historical narrative, the changing profile and scale of human intervention in the



environment. From that review, in Section 1.3, we can thus better understand how we have arrived at today’s situation.

### BOX 1.1

#### **The main types of global environmental change**

The main global environmental changes, of a kind that were not on the agenda a short quarter-century ago, are summarized below.

##### *Climate change*

During the 1990s, the prospect of human-induced global climate change became a potent symbol of these unprecedented large-scale environmental changes. Since 1975 average world temperature has increased by approximately 0.5 °C, and climate scientists now think this may be the beginning of the anticipated climate change due to human-induced greenhouse-gas accumulation in the lower atmosphere (Intergovernmental Panel on Climate Change, 2001). Weather patterns in many regions have displayed increasing instability, and this may be a foretaste of the increasing climatic variability predicted by many climate change modellers.

##### *Stratospheric ozone depletion*

Meanwhile, higher in the atmosphere, a separate problem exists. Depletion of stratospheric ozone by human-made industrial gases such as chlorofluorocarbons (CFCs) has been documented over several decades. Terrestrial levels of ultraviolet irradiation are estimated to have increased by around 5–10 % at mid-to-high latitudes since 1980. This problem is now projected to peak by around 2010–2020. Simulation models estimate that European and North American populations will experience an approximate 10 % excess incidence of skin cancer in the mid-twenty-first century (Martens *et al.*, 1996; Slaper *et al.*, 1996). These changes in the lower and middle atmospheres provide the most unambiguous signal yet that the enormous aggregate impact of humankind has begun to overload the biosphere. The capacity of the atmosphere to act as a “sink” for our gaseous wastes has been manifestly exceeded.

##### *Loss of biodiversity*

The loss of biodiversity is another major global environmental change. As the human demand for space, materials and food increases, so populations and species of plants and animals around the world are being extinguished at an accelerating rate – apparently much faster than the five great natural extinctions that have occurred in the past half-billion years since vertebrate life evolved. The problem is not simply the loss of valued items from nature’s catalogue. It is, more seriously, the destabilization and weakening of whole ecosystems and the consequent loss of their products and their recycling, cleansing and restorative services. That is, we are losing, prior to

their discovery, many of nature's chemicals and genes – of the kind that have already conferred enormous medical and health-improvement benefits. Myers (1997) estimates that five-sixths of tropical vegetative nature's medicinal goods have yet to be recruited for human benefit. Meanwhile, "invasive" species are spreading into new non-natural environments via intensified human food production, commerce and mobility. These changes in regional species composition have myriad consequences for human health. Just one example: the choking spread of the water hyacinth in eastern Africa's Lake Victoria, introduced from Brazil as a decorative plant, has provided a microenvironment for the proliferation of diarrhoeal disease bacteria and the water snails that transmit schistosomiasis (Epstein, 1999).

### *Nitrogen loading*

Since the commercialization of nitrogenous fertilizers in the 1940s, there has been a remarkable, sixfold, increase in the human "fixation" of biologically activated nitrogen (Vitousek *et al.*, 1997). Humankind now produces more activated nitrogen than does the biosphere at large. The recent United Nations Environment Program Report (1999) suggests that disruption of the biosphere's nitrogen cycle may soon turn out to be as serious a problem as the better-known disruption of the world's carbon cycle. This increased nitrogen loading is affecting the acidity and nutrient balances of the world's soils and waterways. This, in turn, is affecting plant biochemistry, the pattern of plant pests and pathogens, and the species composition of ecosystems. Via the sequence of eutrophication of waterways, leading to algal blooms and oxygen depletion, nitrogen loading is beginning to sterilize coastal waters, such as Chesapeake Bay in Maryland, the Baltic Sea, and the Gulf of Mexico.

### *Terrestrial and marine food-producing systems*

Meanwhile, the ever-increasing demands of agricultural and livestock production are adding further stresses to the world's arable lands and pastures. We enter the twenty-first century with an estimated one-third of the world's previously productive land significantly damaged by erosion, compaction, salination, waterlogging or chemical destruction of organic content, and with about half of that damaged land showing reduced productivity (United Nations Environment Program, 1999). Similar pressures on the world's ocean fisheries have left most of them seriously depleted. These changes compromise the capacity of the world to continue to provide, sustainably, sufficient food for humankind.

### *Freshwater supplies*

In all continents, freshwater aquifers are being depleted of their "fossil water". Agricultural and industrial demand now often greatly exceed the rate of natural recharge. Water shortages are likely to cause tensions and conflict over coming decades (Homer-Dixon, 1994; Gleick, 2000). For example, Ethiopia and the Sudan, upstream of Nile-dependent Egypt, increasingly need the Nile's water for their own