



Hans-Martin Füßel

Impacts of Climate Change on Human Health: Opportunities and Challenges for Adaptation Planning

November 2003

EVA Working Paper No. 4

Potsdam Institute for Climate Impact Research, Potsdam, Germany



Environmental Vulnerability Assessment

Potsdam Institute for Climate Impact Research
P.O. Box 601203
14412 Potsdam
Germany

Telephone: +49 331 2882500
Fax: +49 331 2882600
E-mail: eva@pik-potsdam.de
Internet: <http://www.pik-potsdam.de/eva/>

© 2003 – PIK Potsdam, Germany

Acknowledgements

Part of this research has been carried out within the project cCASHh (Climate Change Adaptation Strategies for Human Health in Europe), which is funded by the EU Research Directorate-General under project number EVK2-2000-00070.

An earlier version of this paper was presented at the Third World Climate Change Conference (WCCC 2003) in Moscow (Russia), 29 September – 3 October 2003. A slightly shortened version will be published in the inaugural issue of *The Green Cross Optimist* (1/2004).

The author thanks Richard J.T. Klein, Kristie L. Ebi, R. Sari Kovats, and Bettina Menne for various discussions that helped to shape the concepts presented in this paper.

Abstract

Climate change will affect the urgency of existing health risks and introduce new health risks to currently unaffected regions. This paper discusses the opportunities and challenges for planned adaptation to minimize the impacts of climate change on human population health.

Adaptation to climate change is more difficult in public health than in many other climate-sensitive sectors due to the generally limited knowledge on what one must adapt to. The climate-disease relationship is complex, pertinent epidemiological data is scarce, scenarios of future changes in relevant climatic factors are fraught with considerable uncertainty, and the same holds for non-climatic developments. Furthermore, adaptive measures that are effective in one region are often infeasible in other regions due to different socio-economic conditions and cultural preferences.

A six-step approach to adaptation planning for climate-sensitive health impairments based on existing standards for risk management is presented. This approach includes addressing the following key questions:

- How reliable is the knowledge about future changes in health risks at the spatio-temporal scale relevant for adaptation? The answer determines the specificity of the adaptive response.
- How familiar is a community with the considered health issue, and how well is it currently controlled? The answer determines the need for additional action.
- What are the expected financial and health risks associated with acting early vs. acting late? The answer determines the urgency of additional action.

Many historical examples provide evidence for the large potential of planned adaptation to reduce the burden of climate-sensitive diseases. However, the potential for specific adaptation to future changes in health risks is often limited. When uncertainty is very large, adaptation strategies should be developed that reduce the vulnerability to future climate change as well as to current climate variability. Adaptation is most urgent for health risks that are not effectively controlled at the moment, and for measures with a long lead time, such as scientific research, epidemiological data collection, and urban planning. Mitigation of climate change remains indispensable to limit the various types of risks associated with anthropogenic climate change.

1. Introduction

The health of a population reflects, in a basic sense, their social and environmental living conditions. Many key determinants of human health, such as food availability, freshwater availability, physical safety, and the microbiological environment, are strongly influenced by climatic conditions. Through the emissions of so-called greenhouse gases, humankind is altering the climate worldwide. For about two decades, scientists have assessed how climate change will affect natural and managed ecosystems, infrastructure, and economic activities. Recently, policy-makers and the public alike show increasing concern about the threats that climate change poses to human health and well-being.

Scientists as well as stakeholders employ a variety of perspectives on the issue of climate change and human health, depending on their specific interest in the topic, on their decision portfolio, and on the time horizon relevant for them. Epidemiologists investigate the relationship between climate factors and health outcomes primarily for scientific reasons; medical practitioners are concerned about the implications of climate change for their practice; public health institutions contemplate the need for additional preventive measures that could reduce climate-related health risks; and participants in international climate negotiations demand estimates of the impacts of climate change on human health that would help them to establish long-term targets for climate stabilisation. This article provides an introduction to the topic from a public health perspective, focussing on the opportunities and challenges for planned adaptation to reduce climate-related health risks.

In its most recent comprehensive assessment report, the Intergovernmental Panel on Climate Change (IPCC) projects that global mean temperature will rise by 1.4–5.8°C during this century due to anthropogenic emissions of greenhouse gases. The uncertainty is caused in equal terms by uncertainties about future levels of anthropogenic greenhouse gas emissions and by uncertainties about the response of the climate system to these emissions. For comparison, the difference in global mean temperature between now and the coldest phase of the last ice age, about 20,000 years ago, is around 5°C. However, anthropogenic climate change will not be limited to a uniform global warming. The warming is stronger over continents and in high latitudes. Precipitation changes tend to further exacerbate current regional disparities by increasing precipitation in moist regions and decreasing it in dry regions. Warmer temperatures cause sea-level rise and they intensify the hydrological cycle, thus leading to stronger precipitation extremes. Climate change also affects the frequency and intensity of other extreme events, such as storms.

2. Climate Change and Health

Climate change will have far-reaching impacts on ecosystems and economic activities. It also constitutes a major, and largely unfamiliar, threat to human health and well-being. Recent reviews of the issue published by the IPCC and the World Health Organisation (WHO) conclude that climate change will affect the urgency of existing health risks and introduce new health risks to currently unaffected regions. Whilst health impacts can be both positive and negative, there is a large consensus that adverse impacts will dominate.

A schematic picture of the various pathways along which climate change can affect human health is presented in Figure 1. Climate-sensitive health outcomes include the direct impacts of extreme climate events, such as heat waves, storms, floods and landslides; the indirect effects of climatic factors mediated through ecological systems, such as water-borne and food-borne diseases, vector-borne and rodent-borne diseases, pollen allergies, and food and water shortages; and the health effects caused by the interaction of climatic and non-climatic factors, such as increased ground-level ozone (“summer smog”). In fact, almost any impact of climate change may be associated with health effects, in particular in developing countries and in marginalised population groups that lack the capacity to cope with these impacts.

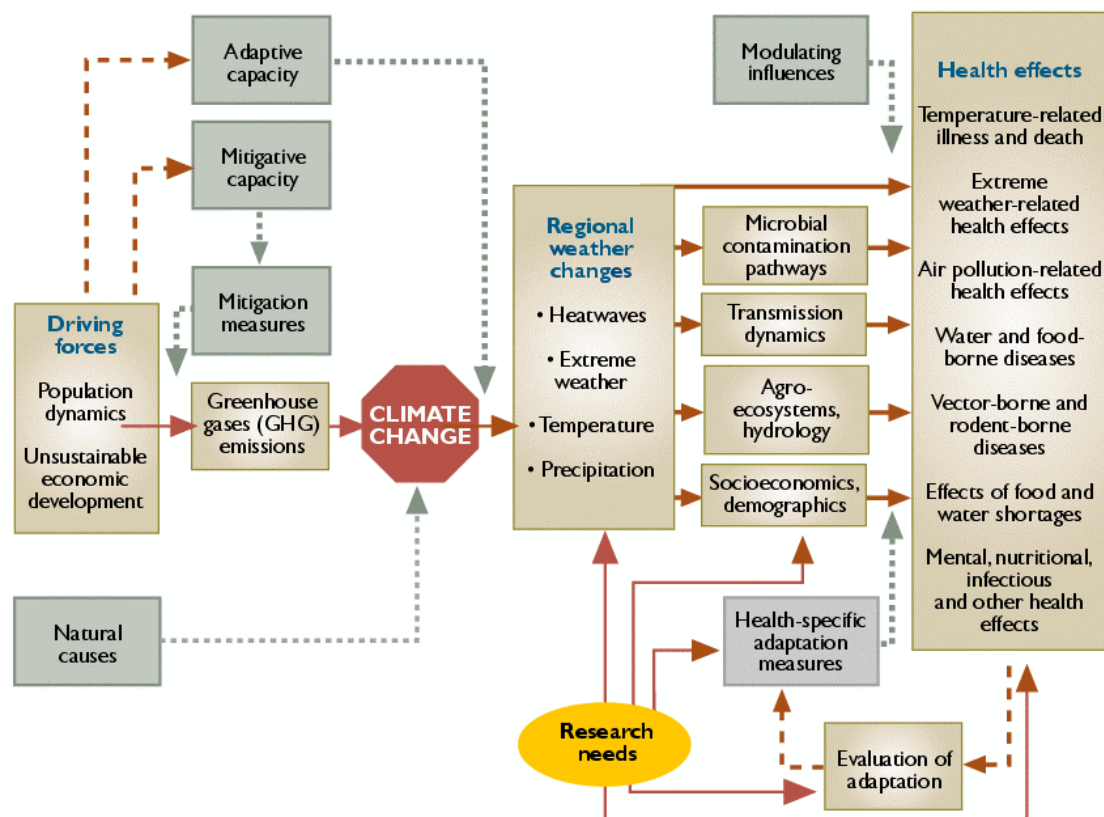


Figure 1 — Pathways for climate change effects on human health and target points for societal responses (by adaptation, mitigation, and information collection). Source: McMichael *et al.* (2003).

There is ample evidence on the links between climate variability and a number of health outcomes. It would nevertheless be naïve to assume that climate is the only relevant causal factor. Figure 1 illustrates the influence of non-climatic moderating factors, and the potential of mitigation and adaptation measures to reduce adverse health impacts. Let us take malaria as an example. Of course, malaria can only be prevalent where the climatic conditions are suitable for the parasites causing the disease and for the mosquitoes that transmit them. Whether the climatic potential for the disease is actually realised in a certain region, however, depends on non-climatic factors such as housing conditions, agricultural and land-use practices, individual protective behaviour, and the quality and accessibility of the health care system.

Assessments of the future health impacts of climate change apply temporal analogues, geographical analogues, and mathematical simulation models. However, any of these methods faces difficult challenges. Epidemiologists are empiricists by training, who have traditionally focussed on comparatively straightforward relationships between individual risk factors and health outcomes. Hence, they are not used to deal with future scenarios of dynamical changes in multiple risk factors that simultaneously contribute to the causation of a disease. In addition, regional projections of future climate change and socio-economic conditions are generally burdened with considerable uncertainty. The scantiness of reliable epidemiological data on the current relationship between climatic factors and health outcomes further hampers the assessment of future health risks, in particular in developing countries.

3. Societal Response Options to Climate Change

The basic response strategies for reducing the adverse impacts of climate change are mitigation and adaptation. The term mitigation comprises all actions that limit the amount and rate of climate change (the “exposure”) by reducing the emissions or enhancing the sinks of greenhouse gases. In contrast, adaptation refers to actions that reduce the sensitivity of populations to observed or projected climate changes. In the context of global climate change, the term vulnerability is generally used to include expectations about future sensitivity changes. The ability of a population to reduce its sensitivity to climate change depends on its adaptive capacity, which comprises factors such as the level of economic wealth, infrastructure and education, and the effectiveness of institutions. Information collection, which includes scientific research, data collection, and other activities that improve the knowledge base for adaptation planning, can be regarded as a third response strategy.

Mitigation and adaptation vary significantly in their type and scope, in their characteristic spatial and temporal scales, in the principal actors, and in their information requirements. Mitigation is the only strategy that reduces all impacts of climate change in the long term. In addition, it implements the precautionary principle and the polluter-pays principle, which are widely accepted principles in sustainable development and in international environmental policy. The primacy of mitigation is also acknowledged in the ultimate objective of the UN Framework Convention on Climate Change, which demands the “stabilisation of atmospheric greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system”. However, climate is already changing, and it will continue to do so for the next decades even if substantial mitigation efforts are being implemented. Hence, adaptation is required as a complementary strategy to minimise the impacts of unavoidable—or unavoids—climate change.

Adaptation to climate change comprises a broad range of measures that are either implemented autonomously or as a result of deliberate planning. Planned adaptation to climate change can be regarded as a risk management policy addressing a dynamically changing, partially unknown hazard. While humans have always adapted to the climate of their region, with varying degrees of success, adaptation to climate change poses new challenges as well as opportunities. Anthropogenic climate change proceeds at an unprecedented pace but we have at least some knowledge about the changes ahead. Hence there is the opportunity to initiate preventive measures before severe impacts are observed. Generally speaking, such anticipatory (or proactive) adaptation depends on reliable projections about future changes in relevant climate parameters, on the availability of effective and feasible adaptation options, and on the resources needed for implementing them.

4. Planned Adaptation to Reduce Climate-Related Health Impacts

Health-related adaptation involves a variety of public health interventions, such as monitoring and surveillance of communicable diseases, vaccination campaigns, control of food production and distribution, and public education on risk-avoiding behaviour. It also includes actions outside the classical realm of public health, such as changes in town planning and in the daily and seasonal timing of activities. While the considered measures are, in general, not new, adaptation to climate change will require action by people who have not considered climate an important factor for their decisions in the past, and who are not necessarily used to deal with newly emerging health risks.

The importance of adaptation to climate change was first emphasised in the context of agriculture and coastal zones, which provide comparatively favourable conditions for adaptation. For instance, the relationship between climate conditions and crop productivity is amenable to investigation in controlled experiments. Farmers can, in most cases, revise their decisions about the cultivated crop varieties each year, often without substantial additional costs. In the longer term, crop breeding has the potential to meet nutritional demands with crops that are better adapted to a changed climate. The conditions for anticipatory adaptation are less favourable in the case of human health. The links between climate and health are diverse, often lengthy and complex, and they involve various moderating influences. Figure 2 depicts the “cascade of uncertainties” from scenarios of greenhouse gas emissions to regional health effects of climate change, and the major sources of these uncertainties. The diagram shows, in particular, that effective adaptation needs to consider a wide range of climatic and non-climatic factors. The substantial uncertainty associated with many of them severely limits our ability to forecast what to adapt to, and, in turn, how to best adapt to the changes ahead.

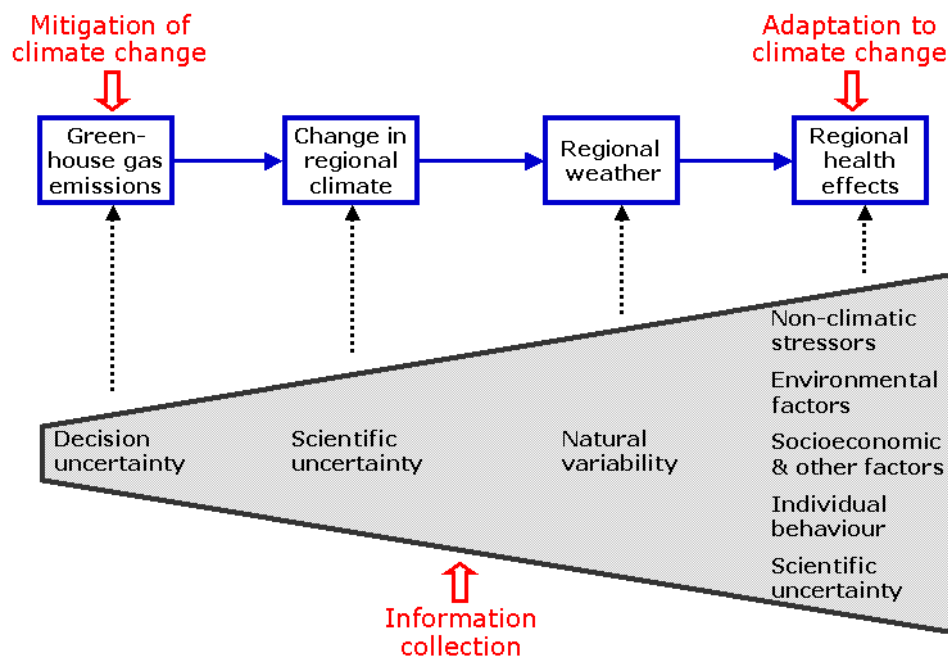


Figure 2 — Simplified causal pathway for climate impacts on human health (in blue), along with sources of uncertainty (in black) and target points for societal response options (in red).

While humans, as a species, have shown impressive flexibility and ingenuity in adapting to a very wide range of climate conditions, adaptation options for specific communities or individuals are generally limited, due to inadequate resources, infrastructure, and cultural constraints. The adaptive capacity of a community plays an important role for adaptation planning. For instance, the establishment of early warning systems, effective civil defence, and improved housing standards contributed to a ten-fold reduction in hurricane-related deaths in the USA between the 1930s and the 1990s. However, the same policy would not have been feasible in a developing country such as Bangladesh, which lacks the necessary adaptive capacity in terms of communications and transport infrastructure. It is equally important for adaptation planning to consider non-climatic co-risk factors. For instance, exceptional heat waves struck France and parts of India in 2003, causing thousands of premature deaths in each country. Despite similar climatic hazards, however, the most vulnerable population groups differed significantly between the two countries. The majority of deaths in France occurred in elderly people who did not receive timely help, partly because of social isolation, whereas those most affected in India were poor people who had no choice but to work hard in the sun. Clearly, strategies for reducing the death toll of future heat waves would need to differ substantially between the two countries.

5. Consequences for Adaptation Planning

Adaptation to climate change starts by recognising that past experience may be no longer a good guide for the future. The development of adaptation strategies to reduce adverse health effects of climate change can be divided into six major steps, as outlined below. These steps need to be embedded in a cyclical framework that includes the implementation of the proposed measures, the monitoring and evaluation of their success, and their continuous revision in the light of new information.

Step 1: Risk screening

The first step in an adaptation policy assessment for human health is the identification, based on expert judgement, of potentially relevant climate-sensitive health impairments. This includes health risks that are already prevalent as well as new risks that may emerge in the future.

Step 2: Risk analysis

In the second step, future changes in climate-sensitive health risks caused by climate change are assessed either quantitatively or qualitatively. The specificity of potential response measures is determined by the reliability of future risk projections at the spatial scale relevant for adaptation. In some cases, such as heat waves, future increases in risk levels are almost certain whereas in others, such as some vector-borne diseases with a complex aetiology, there may even be uncertainty about the sign of changes in regional risk levels.

Step 3: Risk evaluation

In the third step, the importance of future changes in risk levels is evaluated based on the available information. The evaluation considers the severity of the projected health impacts, their likelihood, and the relative importance of other health hazards.

Step 4: Examination of the adaptation baseline

In the fourth step, the adaptation baseline is determined and their efficacy is assessed. The adaptation baseline comprises all measures that are already in place to reduce a specific health risk. If climate change is expected to have only moderate effects on existing health risks, it is generally sufficient to maintain or strengthen current public health measures. However, substantial additional action may be required in the case of newly emerging health risks or if existing health risks are concerned that are not yet effectively controlled.

Step 5: Evaluation of adaptation options

In the fifth step, potential adaptation measures are evaluated according to their effectiveness and feasibility, taking into account the adaptive capacity and the specific circumstances of the respective population. Adaptation to newly emerging health risks typically requires the allocation of additional resources, which may not be available. For instance, a population that is unable to adequately control current health risks is unlikely to successfully adapt to the additional risks associated with future climate change unless exter-

nal assistance is provided. The evaluation also needs to consider whether potential adaptation measures are compatible with cultural practices and individual preferences.

Step 6: Prioritisation of adaptation options

In the sixth step, effective and feasible adaptation measures are prioritised according to their urgency. The timing of adaptation requires a careful balance of two types of risks. Early action is likely to involve the misallocation of resources due to limited knowledge what to adapt to. In contrast, postponing adaptation may give rise to substantial climate impacts that could have been avoided by earlier action. In general, early action is particularly important if the measure is already effective under current climate conditions, if irreversible or catastrophic impacts are possible, if adaptation measures have a long lead time, if decisions have long-term effects, and to reverse trends that threaten future adaptive capacity.

6. Conclusions

Anthropogenic climate change is already occurring and will continue to do so for at least the next decades. In addition to ecological and socio-economic impacts, climate change will affect the urgency of existing health risks and introduce new health risks to currently unaffected regions. Climate change differs from classical environmental health issues by the long time scales involved, by the diversity and complexity of the causal pathways that link climatic factors and health outcomes, and by the large uncertainties associated with many relevant risk factors.

Mitigation of climate change is the only long-term strategy for reducing all adverse effects of climate change. It would thus be very shortsighted to regard adaptation as a substitute to the mitigation of climate change rather than as a complementary strategy. The Kyoto Protocol to the UN Framework Convention on Climate Change presents a first—and urgently needed—step towards the establishment of a global regime for greenhouse gas emission reduction. Unfortunately, the Kyoto Protocol has not yet entered into force as a result of its outright refusal by the current US administration and of the continued indecision of the Russian government.

Many climate-related health risks can, in principle, be reduced through the timely implementation of suitable adaptation measures. Whenever there is reliable information about future changes in health risks that would benefit from early preventive action, public health should move from its current focus on monitoring, surveillance, and response to a more proactive approach that includes prediction and prevention. However, the generally large uncertainties about future risk changes are a severe impediment to anticipatory adaptation. Furthermore, potential adaptations may not be feasible because they require unacceptable behavioural changes or they are associated with prohibitive costs. In particular, developing countries that already suffer from a considerable burden of disease today will generally be unable to adapt to future climate change without significant external assistance.

The specificity of anticipatory adaptation depends on the knowledge about future risk changes on the scales relevant for adaptation; the need for additional action is determined by the expected change in risk levels and by the familiarity with the respective health risk; and the timing of action needs to balance the risks of acting either too early or too late. Comprehensive adaptation assessments require the cooperation between scientists from different disciplines and their interaction with the decision-makers who would actually implement the recommendations. The development of adaptation strategies can benefit significantly from increased information exchange on the effectiveness of intervention measures among public health managers from different regions.

Further Reading

The following references for further reading address primarily a non-technical audience.

- Climate Change and Human Health: Risks and Responses (A.J. McMichael, D.H. Campbell-Lendrum, C.F. Corvalan, K.L. Ebi, A. Githeko, J.D. Scheraga and A. Woodward, editors). World Health Organisation, Geneva, 2003. Summary available at http://www.who.dk/globalchange/Publications/20031006_1.
- Climate Change 2001 (J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White, editors). Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, 2001.
 - Chapter 9: Human Health (A.J. McMichael and A. Githeko). Full text available at http://www.grida.no/climate/ipcc_tar/wg2/347.htm.
 - Chapter 18: Adaptation to Climate Change in the Context of Sustainable Development and Equity (B. Smit and O. Pilifosova). Full text available at http://www.grida.no/climate/ipcc_tar/wg2/641.htm.
- Climate Change and Human Health: Impact and Adaptation (R.S. Kovats, B. Menne, A.J. McMichael, C. Corvalan and R. Bertollini). WHO/SED/OEH/00.4. World Health Organisation, Geneva, 2000. Full text available at http://www.who.int/environmental_information/Climate/climchange.pdf.
- IHDP Update 03/2003. Focus: Health. International Human Dimensions Programme on Global Environmental Change, Bonn, 2003. Full text available online at http://www.ihdp.uni-bonn.de/html/publications/update/pdf-files/IHDPUpdate03_03.pdf.
- Climate adaptation: Risk, uncertainty and decision-making (R. Willows and R. Connell). UKCIP Technical Report, Oxford, 2003. Full text available at http://www.ukcip.org.uk/risk_uncert/main_risk_uncert.htm.
- Relevant websites:
 - http://www.who.int/peh/climate/climate_and_health.htm
 - <http://www.euro.who.int/globalchange/>
 - <http://www.jhu.edu/~climate/>
 - <http://www.lshtm.ac.uk/cgch/>

Environmental Vulnerability Assessment

Environmental Vulnerability Assessment (EVA) is a four-year project at the Potsdam Institute for Climate Impact Research. It involves the analysis, evaluation and presentation of data and information on (i) the mechanisms and magnitude with which global change affects natural and human systems, and (ii) responses and interactions of these systems that reduce their exposure and enhance their adaptive capacity to global change. Since its beginning in 2001, EVA has addressed three research questions:

- What will be the combined effects of global change on terrestrial and coastal ecosystems and the functions and services they provide to society?
- How will these changes affect social and economic processes and how will they interact with other ongoing developments in society?
- What capacity do ecosystems and society have to adapt to global change and which are the opportunities and constraints on increasing this capacity?

These research questions have formed the basis of seven externally funded projects: ATEAM, DINAS-COAST, Security Diagrams, cCASHh, SEVERE, AVEC and WAKE.

Hans-Martin Füssel

Hans-Martin Füssel is a research associate at PIK and a member of EVA. He contributes to the EU-funded project cCASHh: Climate Change Adaptation Strategies for Human Health in Europe. As of June 2004, Hans-Martin will work as a post-doc at Stanford University in California. Hans-Martin holds master's degrees in computer science (1992) and applied systems sciences (1995) and has recently submitted his PhD thesis in physics.

EVA Working Papers

1. Adaptation to climate variability and change: what is optimal and appropriate? R.J.T. Klein, April 2002.
2. Trust, patience, respect, and sea surface temperatures: useful climate forecasting in Zimbabwe. A.G. Patt, February 2003.
3. Climate change and economic development on the coast. R.J. Nicholls and R.J.T. Klein, September 2003.
4. Impacts of climate change on human health: opportunities and challenges for adaptation planning. H.-M. Fussel, November 2003.

EVA Working Papers can be downloaded from <http://www.pik-potsdam.de/eva/wps.htm>

EVA Working Paper Series Editor: Richard J.T. Klein

