

Health and the Environment

A Crosscutting Issue in Global Change Research

compiled by

Thomas Krafft, Rick Bissel, Mark Rosenberg

with contributions from

P. K. Das, L. Garcia-Castrillo Riesgo, M. Löytonen, T. Kistemann,
G. Klein, and B. Menne



German National Committee on Global Change Research, Bonn 2002

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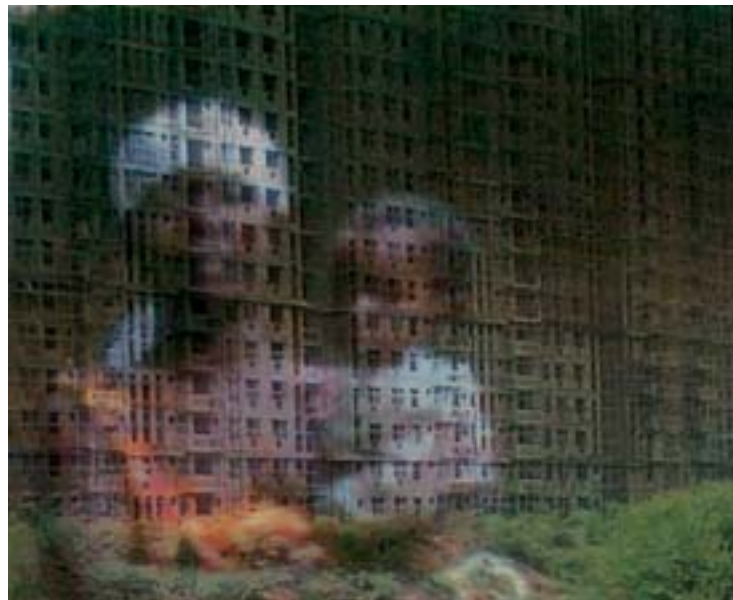


Table of Contents

<i>Figures and Tables</i>	3
<i>Abbreviations</i>	3
<i>List of Participants of the Workshop</i>	4
1. <i>Introduction</i>	6
1.1 <i>Global Change and Environmental Health</i>	6
1.2 <i>Health as a Cross-Cutting Issue</i>	8
2. <i>Criteria for Choosing Future Research Topics</i>	9
3. <i>Research Themes</i>	12
3.1 <i>Climate Change</i>	12
3.1.1 <i>Impacts of Climate Change on Health</i>	13
3.1.2 <i>Recommendation of Specific Topics for Immediate Research</i>	16
3.1.3 <i>Topics for Longer-Term Research</i>	17
3.2 <i>Urbanisation</i>	17
3.2.1 <i>Impacts of Urbanisation on Health</i>	18
3.2.2 <i>Recommendation of Specific Topics for Immediate Research</i>	19
3.2.3 <i>Topics for Longer-Term Research</i>	20
3.3 <i>Globalisation</i>	21
3.3.1 <i>Impacts of Globalisation on Health</i>	22
3.3.2 <i>Specific Topics for Immediate Research</i>	24
3.3.3 <i>Topics for Longer-Term Research</i>	24
3.4 <i>Disasters</i>	25
3.4.1 <i>Impact of Disasters on Health</i>	26
3.4.2 <i>Recommendation of Specific Topics for Immediate Research</i>	27
3.4.3 <i>Topics for Longer-Term Research</i>	27
3.5 <i>Armed Conflicts</i>	28
3.5.1 <i>Impact of Armed Conflicts and Violence on Health</i>	29
3.5.2 <i>Specific Topics for Immediate and Longer-Term Research ...</i>	31
4. <i>Data and Methodological Development</i>	32
5. <i>Literature</i>	34

Figures and Tables

Fig. 1 (page 7):

Pathways of Human effects on the Earth's Systems

Figure 1b (page 11): Heart-formed leaves of a specimen of Cissampelos mucronata.

Parts of the plant are known as a traditional malaria remedy in East Africa.

Photograph by F. Matthies.

Fig. 2 (page 13):

Sources of Uncertainty in Climate Health Impact and Adaption Assessment

Fig. 3 (page 14):

Climate Change and its effects on human health

Fig. 4 (page 25):

Adaption to Global Change

Fig. 5 (page 27):

Diagrammatic Illustration of Vulnerability to Disasters

Table 1 (page 17):

Distribution of the World Population by Urban Place of Residence, 1950 to 2030

Table 2 (page 18):

Distribution of the World Population by Size of Urban Settlement, 1975, 2000, and 2015

Abbreviations

<i>GIS</i>	<i>Geographic Information System</i>
<i>ICSU</i>	<i>International Council for Science</i>
<i>IDNDR</i>	<i>International Decade for Natural Disaster Reduction</i>
<i>IGBP</i>	<i>International Geosphere-Biosphere Program</i>
<i>IHDP</i>	<i>International Human Dimensions Program</i>
<i>IPCC</i>	<i>International Panel on Climate Change</i>
<i>IPRA</i>	<i>International Peace Research Association</i>
<i>NKGCF</i>	<i>Nationales Komitee für Global Change Forschung / German National Committee on Global Change Research</i>
<i>TAR</i>	<i>Third Assessment Report (IPCC)</i>
<i>WHO</i>	<i>World Health Organization</i>
<i>WCRP</i>	<i>World Climate Research Program</i>

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1. Introduction

Following a request from ICSU (International Council for Science) and IHDP (International Human Dimension Programme), the Scientific Secretariat of the German National Committee on Global Change Research organised an international workshop on the subject "Health and the Environment". The main objective of the workshop was to identify research priorities in the field of health and environment in the context of global environmental change. The workshop provided an international and interdisciplinary forum:

- to discuss the lessons learned from earlier efforts,
- to identify the major linkages between global environmental change and health,
- to identify key issues and methodological changes,
- to prioritise immediate research needs.

This report summarises the recommendations of the workshop on "Health and the Environment – A crosscutting Issue In Global Change Research" held in Bad Honnef/Bonn, Germany in February 2001. The report is structured into the following sections:

Chapter 1 provides short working definitions of "Global Change", "Health and Environment", and "Health as a Crosscutting Issue".

Chapter 2 outlines the criteria which have been developed to prioritise future research topics.

Chapter 3 summarises priority research themes identified by the workshop participants.

Chapter 4 covers methodological questions and imperatives for data development.

1.1 Global Change and Environmental Health

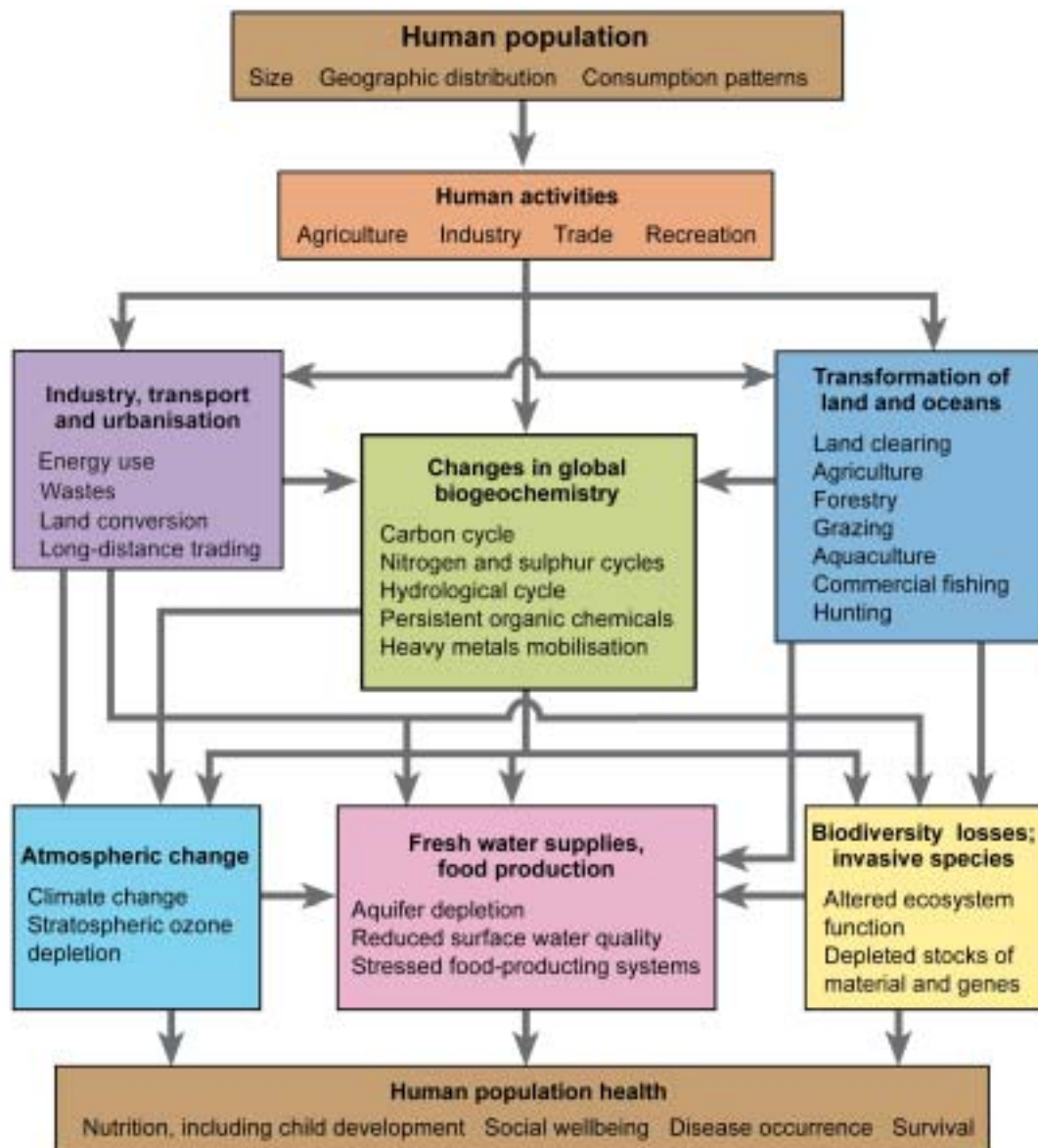
Global Change Research is the attempt to analyse the complex processes and interactions of the integrated Earth System. Global Change is thereby understood as a phenomenon which the international Global Environmental Change Programmes have described as follows:

"Over the last few decades, evidence has mounted that planetary-scale changes are occurring rapidly. These are, in turn, changing the patterns of forcings and feedbacks that characterise the internal dynamics of the Earth System. Key indicators, such as the concentrations of CO₂ in the atmosphere, are changing dramatically, and in many cases the linkages of these changes to human activities are strong. It is increasingly clear that the Earth System is being subjected to an ever-increasing diversity of new planetary-scale forces that originate in human activities, ranging from the artificial fixation of nitrogen and the emission of

greenhouse gases to the conversion and fragmentation of natural vegetation and the loss of biological species. It is these activities and others like them that give rise to the phenomenon of global change.” (IGBP SCIENCE No.4, p.6)

These large scale environmental changes are also likely to significantly alter human health risks.

Fig. 1: Pathways by which human directly and indirectly affects Earth’s physical and ecological systems, thereby posing risks to human health



Pathways by which human directly and indirectly affects Earth’s physical and ecological systems, thereby posing risks to human health. The diagram has five sequential layers: (i) characteristics of human societies; (ii) types of economic activities; (iii) areas of direct impact on the environment; (iv) resultant global environmental changes (including global biogeochemistry box); and (v) health impacts. Global climate change – which currently attracts much attention – is one of a number of large-scale human-induced environmental changes. These various changes in Earth’s biophysical systems: (i) influence one another (e. g., warming of the lower atmosphere exacerbates ozone depletion in the stratosphere), and (ii) affect human health cumulatively and often interactively.

Source: McMichael 2001:285.

The phrase “Environmental Health” conventionally comprises those aspects of human health, including quality of life, that are determined by physical, chemical, biological, social and psychological factors in the environment. Research on environmental health has so far been mainly focused on contaminants in water, soil, air and food and the quantification of the adverse effects on human health. The unprecedented dynamic and the large scale effect of global change will require increased research efforts and new approaches to environment and health. To reduce the scientific uncertainties regarding health impacts of global change we need a better understanding of the interacting dynamics which change the Earth System (fig 1). Since health effects are very likely to be synergistic and cumulative in vulnerable populations a better understanding of the concept of vulnerability and the economic circumstances and infrastructural capacity of nations and regions will be essential.

1.2 Health as a Cross-Cutting Issue

On the face of it, it seems unnecessary to have to defend health as a cross-cutting issue. From an evolutionary perspective, health is the issue: without good health the species will not flourish, or may even disappear. From a scientific viewpoint, health is multidisciplinary and cross-cutting; it takes virtually all of the physical and social sciences to begin to understand the causes and effects of human health. And since our health status affects how we perform, health affects all in which we are engaged; truly as cross-cutting as any issue we face.

Health is important to everyone; good health is universally recognised as an important value, as confirmed at Alma Ata and other international meetings. As such, the value of health cuts across all cultural value sets, economic and political systems, religions, genders, educational levels, and throughout the ages. “Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.” (WHO, 1946)

In terms of global change, in addition to having its own value as a core human attribute, health is important because it is sensitive to environmental changes. Global changes that impact the physical environment also affect human health, often in ways we are just now learning. Some of these changes can lead to human crises and deprivation, and health is a key resource in overcoming crises and deprivation. “If we all lived in an environment that was supportive of health and if we enjoyed good nutrition and housing, safe water and sanitation, received vaccination against key communicable diseases, kept peace with our neighbours and avoided unhealthy activities such as tobacco smoking, most of us would survive for at least 70 years.” (WHO, 1997)

The world’s decision makers pay attention to economic productivity, both for its policy implications and as another measure of well-being. Health is a key component of economic productivity and spending. While good health is an essential component of the human energy needed to be economically productive, investing in health care became an important component of national economies.

In summary, health is the ultimate cross-cutting issue. It is only understood and improved through the application of multiple disciplines, and is sensitive to virtually all of the issues identified as being components of “global change”. It is also crucial helping humans to overcome the deficits caused by the changes we have wrought.

2. Criteria for Choosing Future Research Topics

To develop a research agenda on health and the environment in the context of global change research, criteria are required for choosing future research questions. First and foremost as a guiding principle to any research, there needs to be a clear expectation that the research will reduce the uncertainty in our understanding of the links among global change, health and the environment. Beyond this guiding principle, four criteria (magnitude, geographical spread, exposure/vulnerability, health impact of the problem) are suggested below to aid in the choices which need to be made about where research should be focussed.

A key issue, which also needs to be taken into account in assessing future research questions on health and the environment is that many if not most research questions do not start out as global questions. For example, the outbreak of foot and mouth disease in the United Kingdom in 2000 started out as a highly localised outbreak of disease. Had there been better surveillance of animal diseases and more rapid and effective interventions, the outbreak of foot and mouth disease might have remained little more than a local tragedy with the destruction of livestock in one area of the United Kingdom. What makes a disease like foot and mouth a candidate for global change research is that it illustrates how the forces of globalisation can change a local event into a global issue.

As discussed below (see 3.3.), two of the key elements of globalisation are the magnitude and rapidity at which people, animals and goods and services now move around the world. In a globalised world, the magnitude and rapidity at which livestock are moved from country to country and continent to continent means that what appears to be perfectly healthy livestock might in fact be carrying a highly communicable disease. Similarly, the magnitude and rapidity at which people move from country to country and continent to continent means that they can carry a virus unwittingly from place to place exposing either an unsuspecting human or animal population. While the fear of foot and mouth disease spreading to other parts of Europe was mainly because of the movement of animals, the fear in places as far-flung as Australia, New Zealand, Canada, the United States and the countries of South America was based mainly on the movement of people.

Magnitude

What the above example suggests is that one criterion for choosing future research questions is whether the impacts are significant in many places across many countries around the world. This criterion needs to be assessed not only in terms of health impacts based on communicable diseases, but health impacts, which take place in discrete locations resulting from global changes in the environment. For example, the depletion of the stratospheric ozone is leading to increasing rates of skin cancer, but those rates are highly differentiated by where the countries are located relative to their proximity to the South Pole in particular.

Geographical Dimension

The above example also suggests that a second criterion for choosing future research questions is whether the environmental and health issues are sufficiently transnational to be considered global change issues. Environmental impacts may occur at any geographic scale. They may even spread beyond the local. To be considered a global change issue, the potential health impacts, however, must be transnational. For example, the nuclear disaster at Chernobyl was initially a highly localised event but the environmental impacts and hence the health impacts became a global issue as the nuclear contaminants were carried around the world on global air currents. An example at the national scale is the variation in the toxic waste policies of sovereign states, which has led to the international movement of toxic wastes from the countries where they are generated to other countries, which are willing to receive them. Health impacts have mainly to be expected in the receptor countries. As an example at the regional scale, the link between environmental impacts and health impacts can be seen with the increasing grouping of countries into supranational political units (e.g. the European Union). The setting of environmental standards have health impacts, which go well beyond regional borders. Finally as an example at the global level, the contributions of all countries to air pollution will have health impacts which are also global in nature.

Exposure / Vulnerability

A third criterion, which needs to be taken into account in identifying future research questions, is exposure/vulnerability. This is not a "how much" criterion, but a "who" criterion. That is to say, future research questions need to be selected on the basis of who is most likely to be exposed or vulnerable to environmental factors affecting their health. For example, it is the rural poor of sub-Saharan Africa who are most vulnerable to long-term droughts and the resulting implications for their health.

Health Impact

The fourth criterion, health impacts, can be analysed along a number of scales. For example, one scale is to measure the proportion of the population affected. A second possible scale is to measure how much of the population is affected in terms of mild to severe impacts. A third possible scale is to measure the health impacts on a scale of rare, endemic, epidemic, to pandemic. A fourth scale is whether the health impact is short or long-term and a fifth possible scale is whether the health impact is non-life threatening, debilitating or life threatening.

What these scales imply is that the size of the exposed or vulnerable population can be quantified. Those research questions, which focus on bigger populations and on those who are at greater risk, should be addressed before these, which focus on small populations and/or on those who are at least risk. The scales are not, however, independent of each other and this needs to be recognised.

As criteria for choosing future research questions what is also implied is that in priority setting exercises, all four criteria ought to be taken into account.

Research questions, which focus on many places in many countries around the world (i.e., they meet the magnitude and geographical spread criteria), where the most exposed/vulnerable parts of the population can be identified (i.e., they meet the exposure/vulnerability criterion) and where the numbers at risk are greatest (i.e., they meet the health impact criterion) ought to receive the highest priority for attention by the global research community on health and the environment.

Figure 1 b: Heart-formed leaves of a specimen of *Cissampelos mucronata*. Parts of the plant are known as a traditional malaria remedy in East Africa. Photograph by F. Matthies.



3. Research Themes

According to the aim of the workshop identifying priority issues for increased research efforts, the following five research themes were selected by the workshop participants through intensive discussion:

- Climate Change,
- Urbanisation,
- Globalisation,
- Disasters,
- Armed Conflicts.

3.1 Climate Change

Since the first indications of possible climatic changes there has been a heated debate in the scientific literature on the possible impacts of the anticipated climate changes on human health. The most recent assessment report of the Intergovernmental Panel on Climate Change (IPCC) states vigorously that “global climate change will have a wide range of health impacts” and, furthermore: “overall, negative health impacts are anticipated to outweigh positive health impacts” (McMichael, Githeko 2001, p. 453). The possible impacts range from the altered occurrence of infectious diseases to increased mortality and morbidity resulting from additional heat stress especially in urban areas. While there seems to be a general consensus on the potential for influence of climate change on human health, very little seems still to be known about the actual causal pathways and linkages between climate change, environmental change and health impacts. Our understanding of the vulnerability of affected people is insufficient as is our knowledge of possible adaptation and mitigation strategies. Missing is also a scientifically sound and tested framework of sensitive indicators to monitor and assess climate related health impacts on different scales.

Climate Change, caused both by anthropogenic influence and natural variability, has been emerging as one of the most challenging problems facing the world in the 21st century. Assessments of the global and regional impacts of climate change have gained increasing importance for global environmental change research in the last two decades and stimulated ongoing debate on climate policies. Findings from the World Climate Research Program (WCRP), its sister programmes, the International Geosphere-Biosphere Program (IGBP) and the International Human Dimensions Program (IHDP), and the IPCC process have clearly indicated, that some regions are more vulnerable to climate change than others due to physical and socio-economic factors. Global circulation models project spatial differences in the magnitude and direction of climate change. Furthermore the positive and negative consequences of climate change are determined by the vulnerability of the biophysical environments and the socio-economic situation of the affected population. Vulnerability is understood as a function of sensitivity to present climatic variability, the risk of adverse future climate change and the capacity to adapt. Therefore, climate change is clearly a global phenomenon, but differential impacts in combination with

dissimilar vulnerabilities will result in a complex geography of climate change health impacts. To add further complexity, climate change, global environmental change, and economic globalisation occur simultaneously with the causal linkages and the combined impacts still little understood (fig. 2).

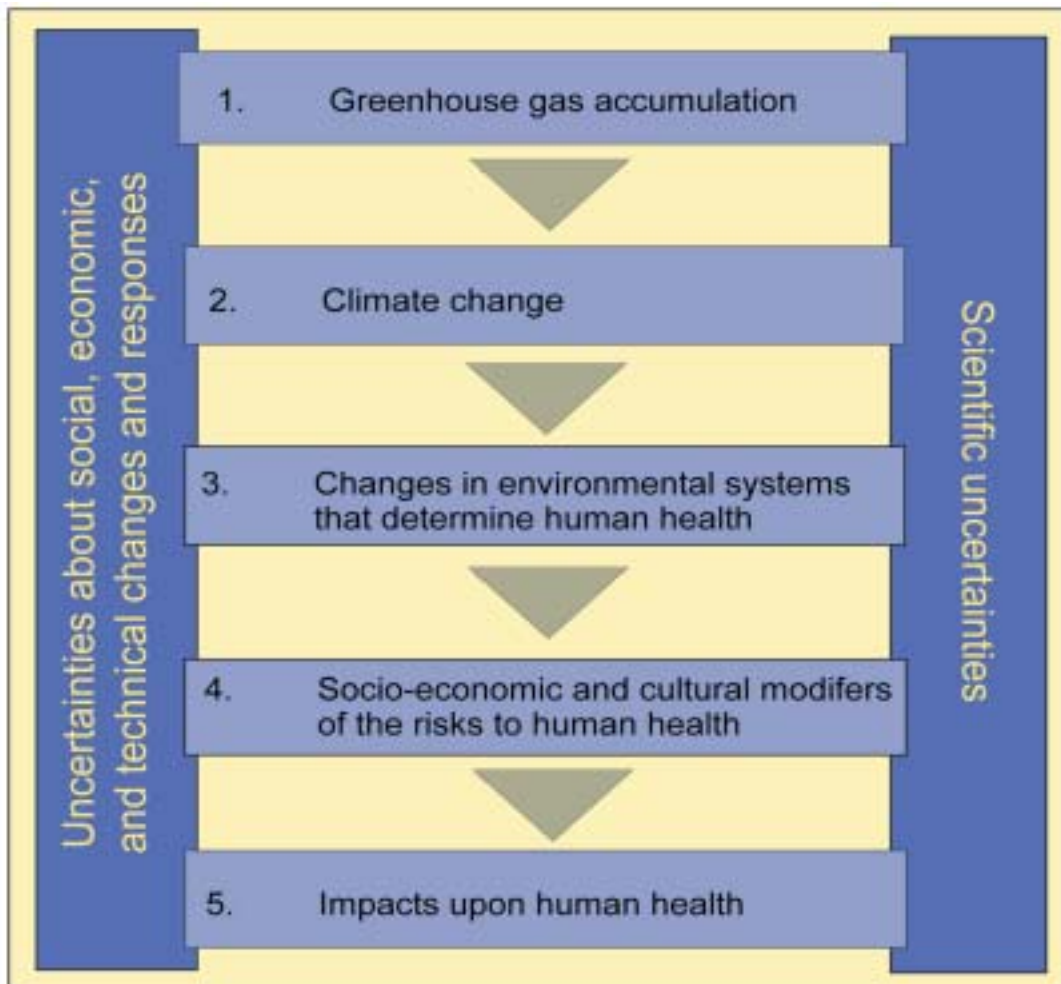


Fig. 2: Sources of Uncertainty in Climate Health Impact and Adaptation Assessment (McMichael 2000)

3.1.1 Impacts of Climate Change on Health

The recent assessment of the potential health impacts of climate change published as part of the IPCC – Third Assessment Report (TAR) has again established that global climate change will have a wide range of mainly negative impacts on human health. Similar evidence comes from a recent report prepared by the National Health Assessment Group as part of the congressionally mandated U.S. National Assessment of the Potential Consequences of Climate Variability and Change. This report indicates that the potential health impacts of climate change are quite diverse demanding improved health infrastructure and enhanced targeted research (fig. 3). Both reports identify inter alia the following critical health issues of climate change:

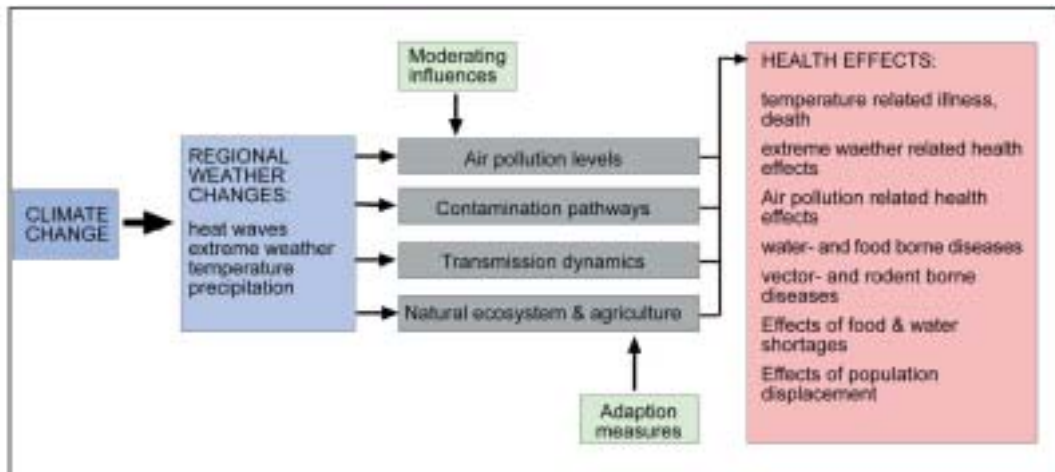


Fig. 3: Climate Change and its effects on human health (Patz et al. 2000)

- Thermal stress,
- Extreme events and weather disasters,
- Water supply,
- Health effects related to air pollution,
- Communicable diseases.

Thermal Stress

Climate Change is likely to be accompanied by an increase in the frequency and intensity of heat waves, while milder winters could reduce some of the excess morbidity and mortality resulting from cold weather. The net impact on mortality rates is still very difficult to determine and depends also on socio-economic factors. Any increase in the frequency and intensity of heat waves is very likely to increase the numbers of additional deaths from hot weather mainly in urban areas. In addition, heat waves are also associated with non-fatal impacts such as heat stroke and heat exhaustion. Populations in developing countries are expected to be especially vulnerable due to the lack of the resources for appropriate adaptation measures.

Extreme Events and Weather Disasters

Direct and indirect impacts of climate change on human health are likely to occur via changes in the magnitude and frequency of extreme events. Populations in developing countries are considered to be more vulnerable to the effects of extreme events. Disasters occur when severe climate hazards and high vulnerability converge (see 3.4). The health impacts of natural disasters include physical injury, decrease in nutritional status, increases in respiratory and diarrhoeal diseases. Extreme weather events can cause considerable numbers of deaths and injuries. However, substantial indirect health impacts also occur because of damages to the local infrastructure and the health system and the resulting population displacement. Bereavement, property loss, and social disruption may increase the risk of depression and mental health problems. Furthermore, climatic changes can affect food security depending on the sensitivity of food systems to climatic disturbances

(i.e. droughts) and the coping capacity of institutions and peoples in sensitive regions resulting in malnutrition and related health problems.

Water Supply

Water, even in the solid stage, seldom stays still for longer. Meteoric water circulates through the hydrosphere, atmosphere, biosphere, pedosphere, and upper parts of the crust. This, the water cycle, involves evaporation, condensation, precipitation, and runoff. It is not a close system. The potential of water cycle to influence environmental change is made evident by considering the turnover of atmospheric moisture. Hence, water is one of the most important common chemical compounds on earth. Moreover, water forms the most important part of the physical construction of all that lives on earth, as it constitutes almost 80 percent of all living tissue. However, the water availability for human consumption is very poor. While about 97 percent of all water on our planet is located in the oceans and seas, only about 0.29 percent of the freshwater resource is directly available as surface water in lakes and rivers or as shallow ground water; the remaining freshwater, about 2.24 percent of all water is confined in polar ice or glaciers and deep aquifers. Water mismanagement, deforestation, industrialisation can seriously affect the hydrological cycle and thus the availability amount of accessible water. The world-wide decrease of water quality is a result of unbalanced activities that have disturbed the global natural and ecological system. Thermal heating of fresh surface water bodies is seen to deteriorate the microbial water quality (e.g., algae blooming, correlation of surface water temperature and cholera incidence in the Ganges delta (Colwell et al. 2000).

Health Effects related to Air Pollution

The dispersal and ambient concentrations of air pollutants is strongly influenced by weather conditions. Large high pressure systems often create an inversion of the normal temperature profile, trapping pollution in the shallow boundary layer at the Earth's surface. Though the direct impact of climate change on air pollution can only be assessed on a local or regional scale it can be assumed that any increase in anticyclonic conditions would tend to increase air pollution concentration in cities. Formation and destruction of ozone is accelerated by increases in temperature and ultraviolet radiation. Existing air quality models indicate that decreases in stratospheric ozone and elevated temperature increase ground-level ozone concentration.

Communicable Diseases

Many important communicable infectious diseases are transmitted by vector organisms, which are sensitive to temperature, humidity, precipitation and wind field. Climatic changes of these factors could therefore affect the potential transmission of infectious diseases. However, the transmission of vector borne diseases to humans is dependent on many complex and interacting factors that determine their incidence and geographical distribution. Factors influencing the transmission dynamic of a disease include inter alia land use and irrigation systems, human population density and human behaviour. The transmission dynamic is also influenced by the availability and efficiency of public health strategies including vector control programs, the availability of safe drinking water, and sewage and waste management systems. Climatic changes and weather variability also influence the occurrence and endemic or epidemic transmission of water-borne and food-borne diseases.

Since the publication of the IPCC Second Assessment Report, which for the first time designated a whole chapter on health impacts, additional research has

analysed natural climate variability in relation to interannual variations in infectious diseases and the relationship between daily weather and mortality in various urban populations. Predictive modelling of the impact of climate scenarios on vector-borne disease transmissibility has undergone further improvement, though the scientific debate on the validity of the results produced by these models is still ongoing. Still, there is an urgent need to focus research efforts more sharply and to develop a framework that helps to integrate global and local perspectives to shape an area related understanding of environmental health risks and the threats to public health.

3.1.2 Recommendation of Specific Topics for Immediate Research

Many of the impacts of climate change are still uncertain, therefore the following characteristics and challenges should be applied for any scientific assessment of the actual and potential health impacts of climate change:

- Climate change is a gradual and long-term process. Identification of health impacts caused or influenced by climate change therefore requires carefully planned epidemiological studies within an ecological framework, and with a long-time horizon.
- Epidemiological studies focussing on the climate change impacts on health have to carefully recognize the possible confounding effects to clearly differentiate between climatic and other co-existing factors.
- While analysing climate change impacts, the ability of social, technological, and/or behavioural adaptations as well as prevention strategies to reduce vulnerability has also to be included.
- The complexity of effects resulting from climate and environmental change and the modulating influences of population vulnerability and societal response underline the need for multidisciplinary research approaches.

Some specific research topics for immediate research are:

- Improving our abilities to quantify current and future regional burdens of disease resulting from climate change, including vector borne diseases, gastro-intestinal diseases and respiratory diseases.
- Identifying the implications of climate change for adaptation and mitigation strategies.
- Analysing the links between climate change and environmental degradation and their subsequent potential impacts on health.
- Improved surveillance for short and long-term health effects from extreme events and weather disasters on different scales.

3.1.3 Topics for Longer-Term Research

- Relationship of global governance to climate change impacts on health.
- Cost-benefit analysis of prevention/preparedness programmes vs. mitigation strategies.
- Improve precision and reliability of integrated risk assessments on a regional scale.

3.2 Urbanisation

Almost half of the world's population now lives in cities. The second half of the 20th century witnessed conversion of the population from rural to urban on all continents, in highly industrialised as well as in the poorest countries. The Population Division (2001) of the United Nations projects that in 2007 the global population will be equally divided between urban and rural dwellers. By 2030, about 60 percent of the global population will be urban, even in the less developed regions of the world (see Table 1).

The urban poor have always been at risk from water borne diseases, respiratory infections and the adaptation of vector borne infections to urbanisation because of poor housing and sanitary conditions. Cities at the beginning of the 21st century pose a new set of risks linked to the environment, which goes beyond the urban poor affecting the young and the old and even the rich. Those risks include exposure to air pollution, traffic accidents and the urban heat island amplification of heat waves (see 3.1, 3.4).

- The world's population has gone from being a mainly rural population to one where the majority of the people by 2010 will live in cities. Even though each individual case of urban agglomeration has its own local and cultural background on one hand, and side effects on the other hand, its continuous spreading across all continents makes urbanisation a global change issue. The reasons for the mass movement have been the same in past centuries and continue to be the same: poverty and social pressure, in many cases oppression and armed conflicts move the people towards the cities where they hope to see a better future and expect to have their own and their families needs fulfilled.

Distribution of the World Population by Urban Place of Residence, 1950 to 2030

Year	Percentage Urban			
	1950	1975	2000	2030
World	29.7	37.9	47.0	60.3
More developed regions	54.9	70.0	76.0	83.5
Less developed regions	17.8	26.8	39.9	56.2

Source: United Nations, Population Division (2001)

Table 1: Distribution of the World Population by Urban Place of Residence, 1950 to 2030

- Almost a quarter of the world's population will live in cities with populations of one million or more by 2015 (see Table 2). The social, economical and ecological consequences of the growth of these "mega cities" by number and size go beyond the capacities and responsibilities of local or national governments, and the rapid exchange of people, goods and information between these huge centres calls for a proper analysis of determining factors and global effects – especially on the health and well being of an increasing number of individuals living in "mass isolation". Rapidly, belts of poverty and ill health are growing in the peri-urban areas.
- The increasing focus of research on multidisciplinary concepts is converging worldwide, since all the "mega cities", "world cities", or megalopolis across the world are facing similar challenges and needs. Some of them have learned essential lessons during the last decades, have developed and implemented strategies to create big but healthy cities – centres of welfare, social stability and communication, as well as experimental areas for sustainable development at the urban scale. Sharing this experience with other growing or exploding centres of aggregation will need a global approach and global responsibility: None of the 10-million-super-cities will exist on its own, and they all need productive interaction and partnership.

3.2.1 Impacts of Urbanisation on Health

- In General, urbanisation has facilitated the development of systems that ensure supply of goods and services to all citizens in the most effective way. Easy access to health care, essential drugs and, of utmost importance, health education helped to reduce infant mortality and to improve life expectancy between 1950 and 1980 in developed and developing countries. Therefore urbanisation is

Distribution of the World Population by Size of Urban Settlement, 1975, 2000 and 2015

Major Area	Range of Population Size	Year (Percentage)		
		1975	2000	2015
World	5 million or more	4.8	6.9	8.7
	1 to 5 million	8.0	11.6	14.1
	Less than 1 million	25.1	28.5	30.6
	Rural areas	2.1	53.0	46.6
More Developed Regions	5 million or more	9.3	9.5	9.9
	1 to 5 million	13.9	18.5	20.6
	Less than 1 million	46.8	48.1	49.3
	Rural areas	30.0	24.0	20.3
Less Developed Regions	5 million or more	3.2	6.3	8.5
	1 to 5 million	6.0	10.0	12.7
	Less than 1 million	17.6	23.7	26.8
	Rural areas	73.2	60.1	52.0

Source: United Nations; Population Division (2001)

Table 2: Distribution of the World Population by Size of Urban Settlement, 1975, 2000 and 2015

generally associated with good health services, while some of the typical urban health problems have to do with a lifestyle not supportive to individual health (like sedentary life and work style, excessive eating or drinking combined with social or economic tension and perceived insecurity).

- Densely populated and (geographically or ecologically) disadvantaged urban and peri-urban areas are associated with negative health, mainly due to the concentration of people with lower education and income in these areas. Here, infectious diseases which always have been associated with urbanisation, the concentration and composition of air pollution and the decline in water quality in mega cities (e.g. Mexico City) have led to growing concern, and call for improving equal access to basic services, not only in health care, but especially in providing healthy environmental conditions. Diseases associated with modern industrial life combine with suffering from environmental contamination, thus creating an increasing demand for implementing remedial and prevention strategies at the same time.
- Globally available knowledge on many health impact-exposure connections calls for global exchange of experience on some of the “well known” issues on environmental health, like e.g.: Airborne lead exposure mainly from petrol products is resulting in lead-induced deficits in children’s intelligence; the expanding use of automobiles is increasing mortality and morbidity due to car accidents; heat waves in large cities particularly place elderly people at risk; indoor air pollution mainly from the use of solid fuels is a major risk factor in cities in the developing countries (Smith 2000).

3.2.2 Recommendation of Specific Topics for Immediate Research

All research, which seeks to link urbanisation, health and the environment needs to take into account the critical importance of focussing on vulnerable groups

Box 1: Definition of Megacities

There is no agreed upon terminology yet. However, the United Nations Population division uses the term mega cities and defines them as urban agglomerations with a population of 10 million or more. In 1950, only New York qualified as a mega city. In 1975, 5 cities met this definition. In 2000, 19 cities were included by the Population Division in their list and they project that there will be 23 cities who meet their definition by 2015. Of the 19 mega cities in 2000, only 4 are unambiguously located in developed countries (Tokyo, Osaka, New York and Los Angeles). Of the remaining 15, 4 are in South and Central America (Mexico City, São Paulo, Buenos Aires and Rio de Janeiro), 2 are located in Africa (Lagos and Cairo) and the remainder are located in Asia (Bombay, Calcutta, Shanghai, Dhaka, Karachi, Delhi, Jakarta, Metro Manila and Beijing).

Taking into account cities of 5 million or more, there were 41 in 2000 and these will increase to 59 in 2015. Only 10 of these cities were in developed countries in 2000 and only 11 will be in developed countries in 2015.

(i.e., the urban poor and the homeless, especially the very young and the elderly part of the population). There needs to be recognition that the dimensions of the research will vary depending on whether the focus is on urbanisation in a developed country context or a developing country context. However, when it comes to research on strategies for creating sustainable and healthy living conditions in the process of urbanisation, the pathways of thinking will converge very quickly.

Growing mega cities in the past and today have been facing similar basic problems on all continents. While discussion and global communication about the magnitude of these problems is very effective, the low implementation rate of existing solutions raises serious questions about mechanisms for commitment and enforcement at local, national and global level. The global availability of experience gained in urbanisation processes world-wide over the last two centuries calls for research into the mechanisms of political and economic interventions, which have created success or failure in the one or the other case.

In order to improve living conditions in urbanising centres, it is essential to explore the mechanisms for improving the exchange of good experience and to study the forces that hinder the implementation of strategies that have proven to be successful elsewhere. All efforts in this direction need to take into account, that locally engaged people will be involved and guarantee ownership, regardless whether in an official or a volunteer function. Imposing excellent (academic) solutions from elsewhere has not been a success in the long run, while building capacities and creating motivation will help to build sustainable infrastructure. However, through transparent education on "best practice" the mobilisation of local initiatives, NGOs and volunteers can focus on achieving best results in health gain.

One essential element will be a global database, which will show in real case studies (in developed as well as in developing countries):

- Which means of reducing exposure to solid waste, water and land contamination have changed the vulnerability to disease in the short and long term.
- Which strategies for reducing exposure to air pollution have been effective in changing patterns of vulnerability to disease in the short and long term (e.g., elimination of lead exposure from petrol use affects childhood development in the short and long term).
- Are transport policies available encouraging health promoting mobility and reducing effectively changing morbidity and mortality due to road accidents?
- How to develop culturally and locally acceptable housing policies in order to reduce the role that indoor air pollution plays in the morbidity and mortality of the urban poor in the short and long term.

3.2.3 Topics for Longer-Term Research

- Developing a framework for the assessment of the positive and negative consequences of urbanisation in the health and the environment of vulnerable populations. Forecasting models which take into account urban population

growth, land use changes and the implications for air and water quality will be applied for defining the demands on infrastructure and for coping strategies in order to prevent harmful effects on population health.

- Research into the changing mechanisms of perception and adaptation to health and environmental risks among vulnerable populations living in fast-growing and mega cities will focus on the development of appropriate models of health behaviour and promotion which reflect the conditions under which vulnerable populations live in fast-growing and mega cities within developed and developing countries. Education and training systems (modules) should be made available (in local language) in order to develop the "health competence of the mega-citizen". Special emphasis has to be put on the development of early childhood education and health competence of parents.
- A comparative assessment of "sustainable cities" is needed to understand the ecological and economic balance of urbanisation. The ecological effects of urbanising areas on their wider surroundings have to be understood in their global economic consequences (e.g., long range transboundary air pollution, acid rain from industrial urban areas, or eutrophication of remote aquatic or terrestrial systems). The "polluter pays principle" has no clear logic and consequently has never been applied effectively, but it needs to be converted into a knowledge based "prevention rewarding principle". The "rewards" have to be allocated systematically in the urban area itself as well as in the areas, which are supplying it with resources (food, water, energy and goods) and are taking care of its various outputs (products, waste, pollutants).

3.3 Globalisation

According to Voisey and O'Riordan (2001) three different perspectives on the meaning of globalisation can be identified: globalisation as world-systems theory, globalisation as an expression of modernity; and globalisation as a cultural phenomenon and dual process. Yet another way of thinking about globalisation is to distinguish among globalisation as an economic process, globalisation as a political process and globalisation as a cultural process. The first emphasises "the global market where borders are crossed and distances travelled with minimal effort by firms, currencies and commodities" (Voisey and O'Riordan: 33). The second emphasises "the continuing erosion of the nation state's powers and abilities to control or regulate an increasingly volatile and uncertain world in the face of many changes – for instance, environmental risks or the rise of transnational organisations on the world stage" (Voisey and O'Riordan: 33). The third emphasises "the homogenisation and hybridisation of worldwide culture." (Allen, 1995: 113 as cited in Voisey and O'Riordan: 33).

Packed within these definitions are common beliefs around the importance of the ease, rapidity and volume with which people, goods, services and ideas are now able to move around the world with only minimal ability of nation states to control those movements or the impacts of those moves. Also packed within these definitions is the view of some writers on globalisation that individual nation states have less power and/or ability to control or regulate environmental risks because of the transnational nature of the environment. With greater volatility and uncertainty surrounding our ability to understand how the environment is changing and the rapidity and volume of movement of people, animals and goods around the world,

the need to understand the implications of globalisation for the health of the global population has never been greater.

- Martens et al. (2000) have argued globalisation, environmental change and health need to be seen in broader perspective than just global climate change. In addition to climate change, they identify six additional themes connecting globalisation, environmental change and health: stratospheric ozone depletion; loss of biodiversity; nitrogen loading; terrestrial and marine food producing systems; freshwater supplies and persistent organic pollutants.
- Yach and Bettcher (1998: 735) argue that “global health futures are directly or indirectly associated with the transnational economic, social and technological changes taking place in the world.”
- McMichael et al. (1999: 207) suggest that globalisation challenges the more traditional and reductionist view of an “individual centred view of health” and health research. In response to this challenge, they call for a systems-based view of health and the environment taking into account “altered life-supporting functions of whole biophysical systems at global and regional levels and within a longer time frame.”
- Kirkbusch (2000) argues that globalisation in the form of increased transfer of international health risks and growing health inequalities worldwide poses a challenge to the ability of nation states to ensure the health of their populations.

3.3.1 Impacts of Globalisation on Health

- Loss of biodiversity and of naturally produced chemicals and genes which might have medical and health improvement benefits can be linked to the practices of international pharmaceutical (e.g., through their use of international patents), forestry (e.g., through clear-cutting practices), and mining (e.g., through strip-mining) companies especially in developing countries desperate for economic development.
- “Invasive species” spreading into non-natural environments via intensified human food production, commerce and mobility and the effects of nitrogen loading on the acidity and nutrient balances of the world’s soils and waterways leading to changes in plant biochemistry, the pattern of plant pests and pathogens can be linked to the globalisation of agriculture production.
- In an effort to satisfy the global market for food, terrestrial and marine food producing systems controlled by multinational food producers are “adding further stresses to the world’s arable lands and pastures” (Martens et al. 2000) and ocean fisheries.
- Long-live and biologically active chemicals have become widely distributed across the globe.
- The need for improved international health governance which takes into account the forces of globalisation.
- International spread of communicable diseases resulting from international travel.

Health and Global Change

Global Transnational Factor

Macroeconomic prescriptions

Structural adjustment policies and downsizing

Structural and chronic unemployment

Trade

Tobacco, alcohol, and psychoactive drugs

Dumping of unsafe or ineffective pharmaceuticals

Trade of contaminated foodstuffs/feed

Travel

More than 1 million persons crossing borders/day

Migration and demographic

Increased refugee populations and rapid population growth

Food security

Increased demand for food in rapidly growing economies. For example countries in Asia

Increase in global food trade continuing to outstrip increases in food production, and food aid continuing to decline

Environmental degradation and unsustainable consumption patterns

Resource depletion, especially access to fresh water

Water and air pollution

Ozone depletion and increases in ultraviolet radiation

Accumulation of greenhouse gases and global warming

Technology

Patent protection of new technologies under the trade related aspects of intellectual property rights agreement

Communications and media

Global marketing of harmful commodities such as Tobacco

Foreign policies based on national self-interest, xenophobia and protectionism

Consequences And Probable Impact On Health Status

Marginalization, poverty, inadequate decreased social safety nets^a

Higher morbidity and mortality rates^b

Increased marketing, availability and use^b

Ineffective or harmful therapy^b

Spread of infectious diseases across borders^b

Infectious disease transmission and export of harmful lifestyles (e.g. high-risk sexual behaviour)

Ethnic and civil conflict and environmental degradation^c

Structural food shortages as less as food aid is available and the poorest countries of the world are unable to pay hard currency^b

Food shortages in marginalized areas of the world; increased migration and civil unrest^a

Global and local environmental health impact^b

Epidemics and potential violence within and between countries (water wars)

Introduction of toxins into human food chain and respiratory disorders

Immunosuppression, skin cancers and cataracts

Major shifts in infectious disease patterns and vector distribution (e.g. malaria), death from heat waves, increased trauma due to floods and storms and worsening food shortages and malnutrition in many regions of the world

Benefits of new technologies developed in the global market are unaffordable to the poor^c

Active promotion of health-damaging practices

Threat to multilateralism and global cooperation required to address shared transnational health concerns^c

^a Possible short-term problem that could reverse in time

^b Long-term negative impact

^c Great uncertainty

Source: Yach and Bettcher (2001)

- Exacerbation of old and emergent new communicable diseases.
- Energy production, environmental effects and health (Haines and Kammen, 2000).

3.3.2 Specific Topics for Immediate Research

Taking into account the negative and positive differential impacts of globalisation on developed countries in comparison to developing countries, the rich compared to the poor, dominant groups compared to marginalised groups some specific topics for immediate research are:

- The development of models of international health governance which effectively take into account the forces of globalisation.
- The type of effects that the international trade in food is having on arable lands and freshwater supplies, food security and health with the introduction of new plant and animal species particularly in developing countries.
- Whether old infectious diseases and emerging new infectious diseases are spreading more rapidly, and into places where they were unknown as a result of the international movement of people and animals and how this represents a threat to human and animal health and the environment.
- The examination of the implications of the international trade in fossil fuels for the health and environment of people in the developing countries.
- The implications of the international trade in toxic wastes for the health and environment of people living in receptor countries.
- The implications of increasingly globalised food, pharmaceutical, forestry and mining production for satisfying health and environmental needs at the local level.
- Identifying patterns of appropriate technologies (or the like) versus the simplifying global application of locally disastrous approaches (e.g., dams for water supply in difficult locations and with disastrous ecological consequences)

3.3.3 Topics for Longer-Term Research

How the culture of change and the changing of culture embodied in globalisation positively and negatively affect the understanding of the links between health and the environment.

The effects that the culture of change and the change in culture are having on health promotion and health behaviour where health is linked to the environment.

3.4 Disasters

Human exposure to natural disasters is increasing as a result of multiple global change phenomena, including population dispersion and density, changes in weather patterns and environmental degradation. Exposure to human-caused disasters is also increasing as a result of increased industrial use, and global transport of hazardous substances. Both kinds of disasters carry the potential for significant injury and disease sequelae, and may damage health care systems and lifeline infrastructure (water supply, sanitation, power, shelter).

Disasters, loosely defined as an event that causes great harm to a human population in such a manner that the population cannot effectively respond without the aid of organised outside groups, have been with us as long as human communities have existed. However, worldwide changes in some crucial aspects of the human-environment relationship have conspired to make the world's population of human beings increasingly more susceptible to harm from disasters. These factors are:

- **Demography:** Increasing human population dispersion puts humans in harm's way. As the population expands, humans find themselves occupying terrain previously unoccupied because of its inherent dangers, i.e. floodplains, cliff-sides, avalanche run-outs, coastal lowlands, and deserts. Whereas natural events could previously affect these areas without direct impact on human populations, the same events now precipitate disasters.
- A second demographic issue has to do with population density: Increasing population density may predispose to epidemic disasters. High density significantly favours the transmission of communicable diseases via airborne droplet, waterborne, and vector borne pathways. Another changing variable

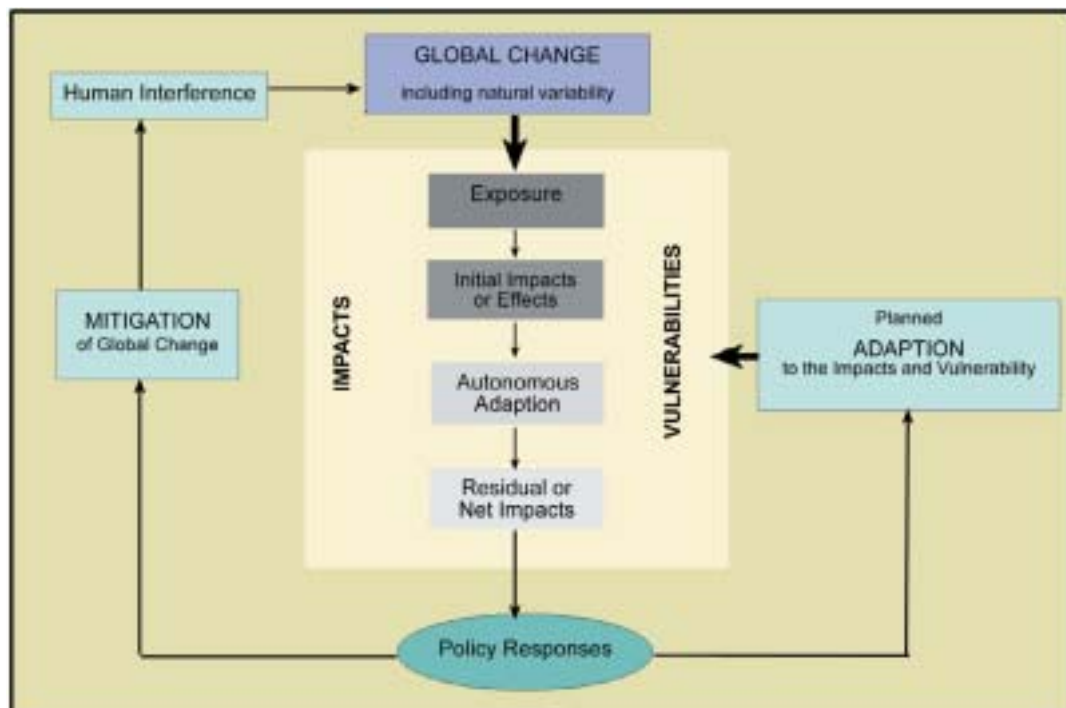


Fig. 4: The role of adaptation and adaptive capacity in impact and vulnerability assessment (adapted from Smit et al., 1999)

comes into play here to increase the effect of population density on potential catastrophic disease outbreaks: Increased rapid world travel enhances the probability that microbes will be carried from an endemic population to one that has no experience.

Disaster events may increase in frequency and intensity due to climate change, for the following reasons:

- Climate change may lead to increased storm intensity. In addition to increased storm intensity in areas that are familiar with storms, new climate patterns may result in storms in areas without frequent previous experience and preparedness.
- Climate change may lead to drought and long-term crop failures, particularly in tropical and subtropical regions. Massive crop failures have clear health impacts on affected populations and can require massive international resource expenditure to attempt relief to the stricken population.
- Land cover degradation leads to increased flooding and landslides.
- Rising sea levels may lead to more lethal storm surges.
- Increased industrialisation leading to greater risk of toxic substance disasters.

3.4.1 Impact of Disasters on Health

The increase in populations vulnerability to extreme weather is primarily caused by the combination of population growth, poverty, and environmental degradation. Disasters are directly and indirectly responsible for major deviations in the public health status. This occurs via several phenomena:

- Injuries and deaths caused directly by the event.
- Increases in respiratory and diarrhoeal diseases resulting from crowding of survivors, often with limited shelter and access to potable water.
- Damage to primary and secondary health care systems.
- Damage to life-sustaining infrastructure (water, sanitation, shelter).
- Damage to economies in already stressed regions. Damage to economic and agricultural infrastructure can lead to years of decreased economic status, putting the health of already stressed populations even more at risk.
- Spread of infectious disease. Such disease increases can result either directly from damage related to the disaster event, or be caused indirectly through the human response to the event (i.e. crowding in emergency shelters).
- Increased risk of water-related diseases as a result of disruption of water supply or sewage system.
- Imperilled nutrition through crop loss and destroyed transport systems.

- Disasters may lead to population migration into areas with different microbial ecologies.
- Disasters may lead to short- and long-term mental health consequences.

3.4.2 Recommendation of Specific Topics for Immediate Research

- Epidemiology of climate change, as it relates to altered disease patterns and increased vulnerability to severe events.
- Research into measures of effectiveness and efficiency in the health response to disasters.
- Research into low-resource methods of local response to the health consequences of disasters.
- Assessment of low-resource early warning mechanisms and barriers to their utilization.
- Public awareness/perception of disaster risks and preparedness/response options.
- Research into the understanding of population's capacity to adapt to extreme weather events.
- Research into the relationship of vulnerability of population and their individual, community and geographical basic infrastructure - basic needs assessment.
- Research to examine the applicability of disaster mitigation and disaster preparedness methods/tools of different regions under certain social and cultural conditions.
- Research to develop a model of disaster mitigation which can be used as an applicable instrument for different regions.

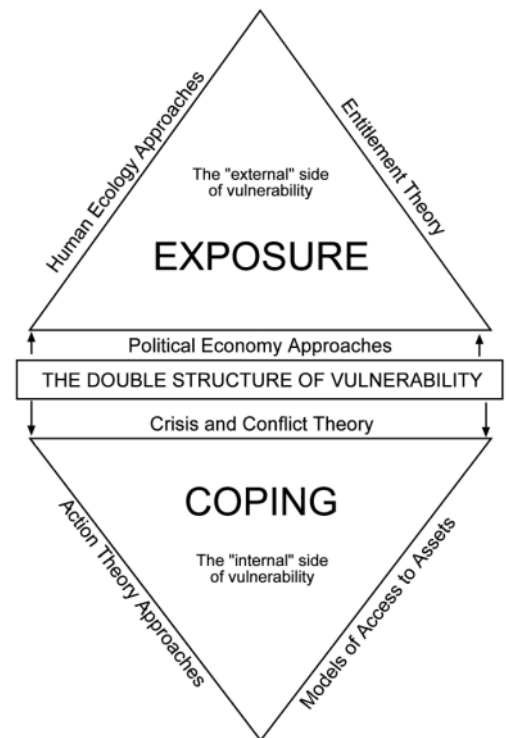


Fig. 5: Diagrammatic Illustration of Vulnerability to Disasters (Bohle 2001)

3.4.3 Topics for Longer-Term Research

- Research into relationships between climate change and specific hazards, such as storm surges, avalanches/landslides, and sand storms.
- Changing perception of risk and vulnerability in the context of disasters.

- Research into the development of low cost methods of minimising lifeline vulnerability in economically depressed regions (an IDNDR priority).
- Research leading to the development and diffusion of world-wide risk zoning maps from a health perspective.
- Research into improved information sharing mechanisms with local health departments (an IDNDR priority).
- Modelling which populated regions will be affected under specific event scenarios, and how the corresponding infrastructure systems will respond.
- Research into the development of a comprehensive health-risk atlas (GIS) which can function as a tool for an effective decision-support system.

3.5 Armed Conflicts

Peace is the prerequisite for health. War and other forms of armed conflict and “organised violence”, are “by definition” directed towards death and violation of human bodies, and indirectly, by destroying resources, homes and products create conditions adversely affecting health.

The traditional and clearly defined pattern of “bilateral” war between nations, states or countries of earlier centuries has been changed into a global patchwork of numerous acts and forms of violence, to a large extent linked to ethnically motivated conflicts, maintained by globally organised networks for increased sales and distribution of lethal weapons. A change in tactics makes the civilian population a primary target, either by “anonymous” bombing of cities or by displacing large populations and thus creating huge movements of refugees. More than at any time since the Second World War, armed conflict is now a major global change issue affecting the environment and health.

- Change in war tactics: Civilians are now primary targets. In World War 1 approximately 19% of casualties were civilians. The number rose to 48% in World War 2, and is now over 90% in recent conflicts in Africa and the Balkans. This change has massive implications for public health at global scale, not only limited to areas of declared war.
- Expansion of ethnic and sovereignty conflicts since the demise of the Soviet Union: The power bloc competition during the Cold War kept regional and ethnic conflicts at a minimum. The demise of the Cold War has left open power vacuums that have led to widely increased local and regional conflicts.
- Rapid expansion of arms sales, guaranteeing future lethal conflict: During the Cold War arms sales were largely to the militaries of client states. Two things have since happened: 1) The lethal weapons held by failed states are now often in the hands of splinter groups, and; 2) Arms manufacturers are now selling increasingly lethal weapons to small groups world-wide.
- The environmental change (loss of arable land, etc.) and degradation as a result of war. For example, the use of defoliants in Vietnam and the torching of oil wells in Kuwait.

- Potential for use of Mass NBC Weaponry: Nuclear, biological, and chemical weapons of mass destruction were previously held only by states with organised military checks and balances. Now, such weapons are becoming increasingly available to small groups.

3.5.1 Impact of Armed Conflicts and Violence on Health

There is no need to take account in detail of the effects of armed conflicts on peoples health:

War and terrorist attacks bring death, violence and diminish well-being by:

- Injuries, through specifically targeting projectiles or landmines and other explosives,
- Destroying access to appropriate nutrition, to water and sanitation, Primary Health Care and Disease Control Programs, resulting in the resurgence of diseases which have been under control, and
- Access to Advanced Medical Care by targeting secondary and advanced medical care facilities.
- Lack of safety is growing due to the spreading of globally organised systems of violence, including terrorist attacks into big cities, homes, even to places far away from the cause or source of conflict. This creates social tension, fear and public concern, which harms the well being of many people and may initiate migration.

In recent cases of armed conflicts, health and environment agencies and specialists have been called in for assessment of the health and environment impact of military action. While the honourable humanitarian assistance delivered by thousands of volunteers, national and supranational aid organisations deserves respect and admiration, we have to question seriously the increasing demand for the bookkeeping type of analysing the damage after bombing civil targets, power stations of industrial areas. Also, the forecast of health effects of unpredictable attacks with biological or chemical weapons, contamination of water supplies and food with pathogens has no reliable evidence base on which appropriate precautionary or remedial action could be based. Therefore, the need for preventive concerted action has been expressed repeatedly – usually after another failure of traditional diplomacy in the efforts to deal with a new creeping type of armed conflict, calling for a broader participation of disciplines who traditionally were not systematically involved in conflict preventing activities. With reference to a note in the 1999 London Declaration adopted by the Ministers of Health and Environment of the WHO EURO Region, substantial follow up is needed, on the initiative of a delegation who felt “it is necessary to carry forward more concrete action aimed at eliminating as soon as possible the environment and health consequences of military conflicts and at precluding such conflicts in the future”.

More concrete action with a focus on the environment and health aspects of armed conflicts and violence will find a solid basis on research and work carried out under

the leadership of the International Peace Research Association, bringing together many disciplines like politics, sociology, theology, economy and medicine. Studies have been carried out related to medicine and violence (not health and violence) clearly following the medical approach of dealing with the suffering, treating the victims of violence. A new initiative seems to be necessary in order to mobilise the public health professionals for global action directed towards preventing conflicts and violence.

All efforts to establish capacities and infrastructure, like water and food production and distribution, training and education of local staff, either at the national level or with support from international bodies, will be interrupted or totally destroyed by armed conflicts. Even short periods of war can have a long lasting impact, just like one serious and untreated infection can do long lasting harm to an individual. It is therefore essential to engage all professionals on environment and health in the prevention of conflict and in collaborative problem solving, using the experience gained in resolving other society based conflicts of interest, which have wide health implications (e.g. local fighting over water resources exploitation between different cities or different users located at one source of water, which have been solved in many places all over the world by collaboration, not by fighting).

The 18th General IPRA Conference has been arranged under the title "Challenges for Peace research in the 21. Century. A Dialogue of Civilizations" in autumn 2000. One of the plenary sessions was bridging peace research and "Sustainable development, the Challenge for the coming millennium". It is important to note, that the "international civil society" has not yet been very successful in both areas: neither has the global availability of knowledge and resources changed the patterns of unsustainable abuse of natural resources, nor has the post-cold-war-period been used to establish a better global balance of human interest. Both areas seem to suffer from the same systematic deficits, as far as the global implementation of globally available knowledge is concerned. The lessons learned, and the needs for identifying the gaps in presently applied mechanisms of sharing experience and distributing the benefits of this experience in a more equal way, point out into which direction research activities should be oriented.

Worldwide, "the most powerful predictor of the rate of national or collective violence – war, civil insurrection, and terrorism – is the size of the gap in income and wealth between the rich and poor nations...Primary prevention" (of violence) "can also be described in more positive terms: ensuring that people have access to the means by which they can achieve a feeling of self worth, such as education and employment, and a level of income, wealth and power that is equal to that which other people enjoy, by universalising social and political democracy." (J. Gilligan, *Lancet* 2000, 355:1802-1804) And further down Gilligan draws the parallel line between violence and environmental health: "A century and a half ago, public health and preventive medicine discovered that cleaning water supply and the sewer system was more effective in preventing epidemics of illness and death than all doctors, medicines and hospitals in the world. When those same medical specialities are applied to the study of violence, we discover that cleaning up the social and economic system, by reducing huge inequities in income and wealth between the rich and the poor, are more effective in preventing epidemics of violence and death than all police, prisons," (armies) "and punishments in the world.... We can prevent violence if, and only if, we replace the moral and legal approach with the approaches of public health and preventive medicine."

3.5.2 Specific Topics for Immediate and Longer-Term Research

Sharing Experience linking Peace and Health in Sustainable Development

Analyse functioning networks of co-operation in early warning, preparedness and preventive action in outbreak, escalation or recurrence of crisis and relate their experience to similar networks and structures in environmental health. In both areas, success and failure has been analysed case by case, and similarities are visible. e.g.:

- Lack of ownership, or participation of people involved or suffering,
- Bias of action by economic, political or religious dogmas,
- Lack of resources for sustaining processes that have been identified as being useful long term measures.

Link Environment and Health Research to Peace Research

The Dialogue of civilisations is on the way identifying better ways of communication between different cultures, in order to avoid imposing solutions developed by "economically strong cultures" on "softer cultures". Processes studies in environmental health make it clear, that global spreading of the habits, which made European and other states in the northern hemisphere "successful" will not lead to sustainable global success in human and not even in economic terms. Approaches like equity, equal access to resources, and other attempts to reduce the tension between and within groups of people in different states, continents or cultures need to reflect more carefully the differences between cultures and established civilisations. The balance between scientific and cultural values needs to be analysed case by case, wherever conflict potential arises in local, national or global scale:

While political approaches in sustainable development were suffering from the dominance of "technological-scientific" dogmas, peace research was conducted as a separate field under the leadership of "political-legal-sociological sciences". A more holistic approach is necessary, which needs development of common "indicators", common language and a more visible harmonisation of "separate actions towards the same goal".

4. Data and Methodological Development

Data bases

Global change research on health and the environment continues to be impeded by the lack of integrated data bases that contain meaningful information on health, the environment and demographic and socio-economic factors of populations at risk. Limiting the development of such data bases is a lack of agreement at the international level on what variables need to be measured, how they should be measured, at what geographical scale they should be measured and over what time period.

To overcome such limitations would require a multi-disciplinary and multinational group of researchers who have the endorsement of the international research community. It is not clear from where the international institutional support for such an exercise would come. It is also not clear that even if these hurdles could be jumped from where the financial support would originate for such data collection, especially in developing countries.

Some of the data limitations can be overcome by the development of new methodological techniques (see below) and the failure to address the above issues will not, in and of itself, lead to a shortage of data for global change research on health and the environment. What is problematic, however, is that the methodological techniques available cannot resolve the problems of an absolute absence of data from some countries and the inability to carry out analyses at the appropriate geographical scale over the appropriate temporal scale with respect to the groups most at risk.

Methodologies

Modelling, Simulation, Risk and Vulnerability Assessment

The use of geographic information systems (GIS) is becoming increasingly widespread in research linking global change, health and the environment (see Gatrell and Löytönen, 1998).

While GIS has the potential to overcome some of the data problems discussed above, it should not be viewed as a universal panacea for all data problems especially those regarding the lack of international agreement on what needs to be measured. While not as widespread in their use, simulation models are also being increasingly used to forecast what the likely outcomes of global changes in the environment will mean for specific diseases (e.g., see Martens' work on the likely spread of malaria). There needs to be support for increasingly sophisticated simulation models which take into account the implications of the spread of diseases for the varying degrees of vulnerable populations and at more geographically disaggregated scales. This also raises the potential for research into more appropriate models for risk and vulnerability assessment.

Methods for Long-Term Monitoring and Evaluation of Prevention/Mitigation Strategies

Since the links among global change, health and the environment are dynamic by definition and local, national and international bodies do intervene to either prevent or to mitigate the impacts which result, there is a need for research which takes advantage of long-term monitoring. In creating long-term monitoring systems, however, many of the same issues are likely to arise as those discussed above in the section on data bases. Assuming these issues are resolved, there also needs to be research carried out which will improve the abilities of the research community and governments at all levels to evaluate the prevention and mitigation strategies being employed over the coming decades. A critical issue in the evaluation of prevention and mitigation strategies which will need to be taken into account is how to go beyond the relatively simple cost-benefit methodologies currently available.

Translational Methodologies

It has become a truism of international science, that even much of the most valuable research which gets published never leads to action among those who are most likely to have the power, ability and means to effect change (i.e., national and international governing bodies and the public). Gaining a better understanding of the links among global change, health and the environment needs to be furthered by research into translation methodologies which take the languages of science and turn them into the languages of policy and action without diminishing the importance of the science.

Finally, a consideration which underlies all aspects of the development of data and methodologies is the differences in resources among developed and developing countries. There needs to be particular emphasis on ensuring that data and methodological development does not become another form of hegemony which divides the research community.

5. Literature

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