



# PROTECTING HEALTH FROM CLIMATE CHANGE

Global research priorities



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## CONSULTATION MEETING

*Chair:* Tony McMichael

*Rapporteurs:* Kristie Ebi, Wilfred Kriesel

*Working Group Chairs:* Chris Portier, Buruhani Nyenzi, Howard Frumkin, Kiran Dev Pandey, Dominique Charron

*Working Group Rapporteurs:* Jostacio Lapitan, Bettina Menne, Diarmid Campbell-Lendrum, Hamed Bakir, Alexander von Hildebrand

## BACKGROUND REPORT AUTHORS

*Assessing the scale and nature of health vulnerability to climate change:* Tony McMichael, Helen Berry, Colin Butler, Tony Capon, Keith Dear, Ivan Hanigan, David Harley, Tord Kjellstrom, Robyn Lucas, Lyndall Strazdins

*Assessment of effectiveness and cost-effectiveness of health protection strategies and measures relating to climate change:* Zaid Chalabi

*Assessment of the health impacts of potential adaptation and mitigation measures in other sectors:* Kristie Ebi and Jonathan Balbus

*Development of decision-support and other tools, such as surveillance and monitoring, for assessing vulnerability and health impacts and targeting measures appropriately:* Sari Kovats and Zaid Chalabi

*Assessment of the likely financial costs necessary for health protection from climate change:* Anil Markandya and Aline Chiabai

*Partnerships for Climate Change and Public Health Research:* David Rogers

## SUMMARY REPORT AUTHORS

Diarmid Campbell-Lendrum and Roberto Bertollini

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# EXECUTIVE SUMMARY

**Climate change is now recognized as one of the defining challenges of the 21st century, and protecting health from its impacts is an emerging priority for the public health community. Further, the potential range and magnitude of associated health risks should be central to the rationale for actions to mitigate the occurrence of climate change.** Research in this field is increasing, but it is still comparatively weak in relation to the complexity of the issue and the magnitude of the health risks that may arise from inadequate or inappropriate responses. In addition, to date, research has mainly concentrated on the identification, characterization and quantification of the linkages between climate and health, with less focus on applied research to lessen associated health risks.

**National governments are now committing to undertake evidence-based actions to protect health from climate change.** In May 2008, the 193 Member States that constitute the World Health Assembly (WHA) passed a resolution calling for a stronger commitment from Member States and the World Health Organization (WHO) to protect health from climate change. In particular, the resolution called on WHO to work with other agencies to identify research requirements and pilot projects that should be supported by the international community on a series of practical themes, with the aim of designing effective actions.

**In response to the WHA resolution, WHO convened a global consultation of public health researchers, practitioners, representatives of the United Nations (UN) and other agencies, and donors.** This culminated in a meeting attended by over 70 leading professionals in this field. Their insights have contributed to the development of a series of recommendations for priority areas of research and risk management, and guidance on how to support further progress on this issue.

**Research on climate change and health must be placed more firmly within the overall context of improving global health, and health equity, rather than being considered as a stand-alone issue.** Most of the health impacts of climate change arise as a result of the extension or amplification of existing health hazards. Related research should have a greater focus on operational decisions, linking decreasing the burden of climate-sensitive diseases and managing weather-related health risks to the long-term aim of ensuring that populations are resilient to climate change. This should include making use of the huge research capacity that is already addressing relevant issues, such as vector control or air pollution.

**Improved risk assessment is necessary to inform decision-makers about the broad range of health impacts due to climate change at the international, national and local levels.** Research in this field should build stronger bridges between assessment of the immediate health risks of climate variability and the effects of long-term climate change, in the context of other relevant trends, such as socioeconomic development and urbanization. This should include improved estimation of the contribution of both meteorological hazards, and climate change, to the burden of mortality and morbidity, with greater attention to previously



neglected mechanisms, such as the diverse effects of population displacement, or the degradation of water supplies and other ecosystem services. It should further use disaggregated data to identify and describe the health risks to particularly vulnerable population groups, especially those exposed to multiple hazards.

**There is a need for a comprehensive evaluation of the effectiveness, and cost-effectiveness, of interventions aiming to protect health from climate-related hazards.** As climate change will exacerbate many existing health problems, expanding the coverage of proven interventions for those problems should both improve health now and reduce the impact of future climate change. However, there have been few systematic evaluations of environmental health interventions, and fewer still that consider whether they will be compromised by climate change. It is recommended that a programme of systematic reviews of the cost-effectiveness of interventions to address key climate-sensitive health risks, over a range of contexts, be carried out. Meanwhile, tools for cost-effectiveness analyses that take into account the uncertainty and very long timeframes that characterize climate change should be developed, and best practices at local and national levels identified.

**Research on the health effects of mitigation and adaptation decisions in other sectors can help to avoid harm, and identify important opportunities for health promotion.** Around the world, climate change is forcing societies to consider fundamental changes in how they supply energy, transport, housing, food and water. Applied research can help maximize the health co-benefits of greenhouse gas mitigation, and avoid health-damaging “maladaptations” to climate change. This should include definition of best practice for assessing health in mitigation policies, from “macro” level policies (e.g. carbon pricing), to local and sector-specific decisions, such as home insulation schemes. It is recommended that sectors such as household energy use, electricity production and transport should be a particular priority for mitigation studies, and that such studies should expand to include a wider range of pathways to health impacts. There is a particular requirement for studies of the health effects of adaptation policies in the agriculture and water sectors, such as increasing use of wastewater. These sectoral studies can be complemented by settings-based approaches that provide a more holistic assessment of the effect of, for example, urban development plans on all aspects of health and well-being.

**Applied research on surveillance and other decision-support tools is necessary to enhance operational effectiveness and early warning.** WHO has published general guidance for vulnerability assessment and adaptation planning, and there is a wide range of decision-support tools for identifying and prioritizing risks. Existing disease surveillance systems and operational procedures already cover most climate-sensitive diseases, and there is great interest in using environmental information to enhance early warning for health threats. The main recommendations are for applied research to improve the application of these tools. This should include pilot testing of existing guidance during climate change adaptation planning, such as preparation of National Adaptation Programmes of Action. Similarly, there is currently a lack of field-testing of the usefulness of weather and climate predictions, as measured by improvements in health or more efficient use of resources. Other research is needed to improve understanding of the kinds of information, dissemination methods, and participatory approaches that are most effective in engaging decision-makers, including the general population.



**Improved economic assessments of the costs associated with the health impacts of climate change can help support investment in health adaptation programmes, and support mitigation policies that enhance health.**

The few relevant studies suggest that unmitigated climate change, in the coming several decades, will significantly increase financial costs to health services, for example through increased demands for prevention and treatment of diarrhoea, malaria and malnutrition. Similarly, economic evaluations of mitigation policies suggest that these could bring major health co-benefits, covering much of the cost of the initial investment. While critically important, this field is in its infancy. There is a need for much greater standardization of methods, particularly on how best to represent uncertainty, the relative value of future benefits (e.g. discounting), and the achievement of equity. These methods should be applied to assess the health costs of inaction on climate change, the costs and benefits of investing in health adaptation, at the global, regional or local level, as well as of mitigation actions impacting on health. A wider range of health impact pathways than those considered so far should be taken into account.

**The necessary research effort will not occur spontaneously: It requires a sustained process to update and adapt priorities and mobilize resources, as well as recognition that the strengthening of applied interdisciplinary research to protect health is an essential investment in responding to the challenge of climate change.**

An iterative process of consultation between researchers and decision-makers (particularly those from the most vulnerable populations), is needed to update and adapt research priorities. This may be best accomplished not by a single formal process, but by a continuous collaboration and exchange of information among actors through a variety of means (i.e. consultations on specific issues or in different geographical areas). The establishment of a virtual forum, which would also highlight opportunities for research funding and training, and for collaboration on research projects, should be considered. High priority should be given to building capacity in this field, with a focus on developing countries that are most vulnerable to the health effects of climate change and have the weakest research capacity. This will require additional funding, although the necessary investment is likely to be very small compared to current investment in climate research, marginal compared to the economic implications of adaptation and mitigation decisions, and trivial compared to the potential health consequences of either unmanaged climate change, or poorly designed climate policies.



# INTRODUCTION

Weather and climate affect the key determinants of human health: air, food and water. They also influence the frequency of heatwaves, floods and storms as well as the transmission of infectious diseases. In addition, policies to mitigate climate change (for example in the energy, transport or urban planning sectors) have a direct and important influence on health, for example through effects on local air pollution, physical activity, or road traffic injuries.

At the 2008 World Health Assembly (WHA), 193 Member States of the World Health Organization (WHO) committed through Resolution 61.19 to a series of actions to confront the health risks associated with climate change, and called on WHO to provide support.<sup>1</sup>

The resolution makes a clear request for more applied research on the linkages between climate, policies addressing climate change and health outcomes, requesting WHO:

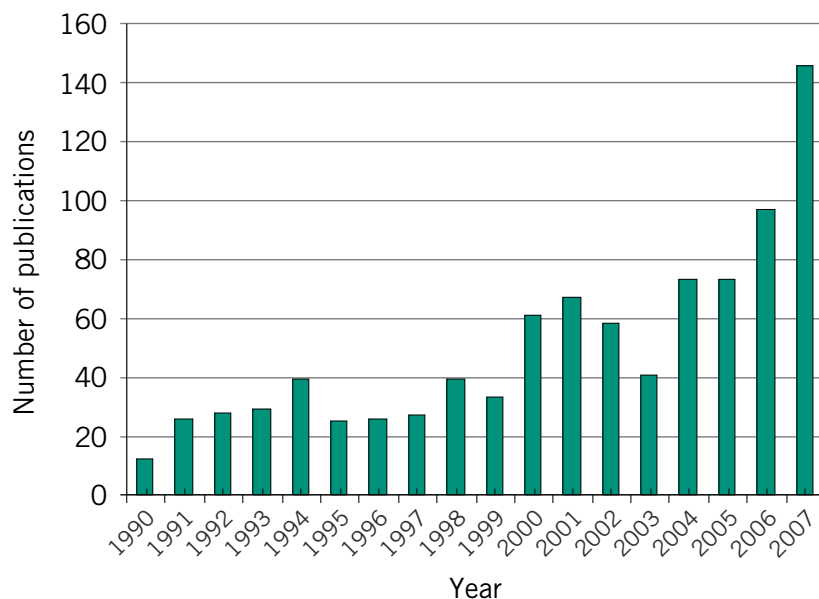
*to continue close cooperation with appropriate United Nations organizations, other agencies and funding bodies, and Member States, to develop capacity to assess the risks from climate change for human health and to implement effective response measures, by promoting further research and pilot projects in this area, including work on:*

- *health vulnerability to climate change and the scale and nature thereof;*
- *health protection strategies and measures relating to climate change and their effectiveness, including cost-effectiveness;*
- *the health impacts of potential adaptation and mitigation measures in other sectors such as water resources, land use and transport, in particular where these could have positive benefits for health protection;*
- *decision-support and other tools, such as surveillance and monitoring, for assessing vulnerability and health impacts, and targeting measures appropriately;*
- *assessment of the likely financial costs and other resources necessary for health protection from climate change.*

This is a formidable challenge. The linkages between climate change and health are complex, and interact with many other influences. For example, the main concern regarding climate change is that it has the potential to worsen existing health challenges, such as control of water- and vector-borne diseases, particularly for the poorest populations. However, factors such as socioeconomic status, access to health services, and local capacity to cope with weather-related hazards, all determine the level of health vulnerability to climate change, and must be taken into account when assessing risks or planning adaptation measures.



**Figure 1:** Articles indexed in Pubmed referring to “health” and either “climate change” or “global warming”



*Note:* Research on the links between climate change and health is increasing rapidly, but lags far behind other health research fields. The graph shows the number of articles indexed in Pubmed referring to “health” and either “climate change” or “global warming”, from 1990 to 2007. During the same period, more than eight times as many articles referred to “health” and “air pollution”, and over 40 times more referred to “health” and “smoking”.

*Source:* The authors.

Applied research in this field should therefore not separate climate change and health as a single, stand-alone issue, but instead contribute to the wider goal of improving overall health and health equity, through:

- (1) Addressing current health burdens that may be made worse as a result of climate change, especially in low-income countries and high-risk communities;
- (2) Making use of the vast body of existing research knowledge and capacity that is available in related fields, such as management of environmental health risks, or control of infectious diseases;
- (3) Responding directly to the requirements of decision-makers, particularly those responsible for the health of the most vulnerable populations;
- (4) Providing information on the health consequences of decisions at all levels, from mitigation of climate change, to management of climate risks and vulnerability factors, to treatment of diseases that are affected by climate;
- (5) Helping decision-makers to prioritize how they use their resources, and ensure that research and control efforts in climate change and health build on, rather than distract from, ongoing efforts to address immediate health challenges.

Research to help achieve these aims spans a broad spectrum, from the more academic to the more applied.<sup>2,3</sup> Basic, epidemiological and academic public health research includes research on exposure-response relationships, on estimating the current and potential future health impacts of climate change (including through currently poorly understood mechanisms such as ecosystem degradation), and understanding risk perception and risk communication. At the other end of the spectrum lies operational or action research, which aims to evaluate, for example, the overall impacts and cost-effectiveness of specific policies to protect and promote health, or to promote community engagement in defined settings.

In order to guide research in this field, WHO carried out a global consultation. Experts on climate change, health and related disciplines produced background reports covering each of the themes identified by the WHA Resolution, as well as an additional report on how to support research in this field.<sup>4-9</sup> This was followed by an online consultation, and a three-day workshop attended by over 70 leading researchers, health practitioners, and representatives of funding bodies and other United Nations (UN) agencies. This report presents the conclusions and recommendations from this process, with the aim of improving the evidence base for policies to protect health from climate change.



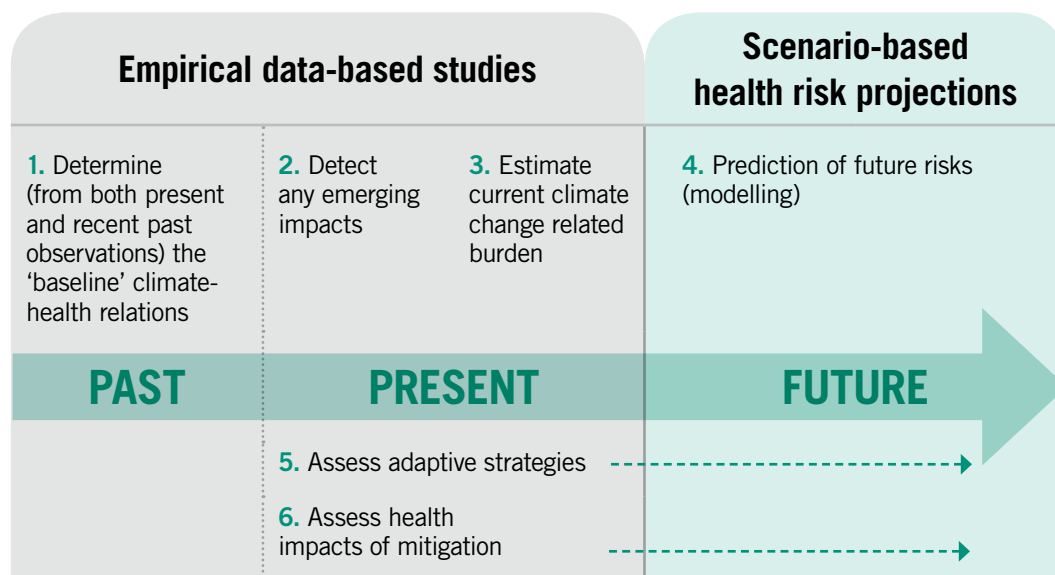
# RECOMMENDATIONS FOR THE GLOBAL RESEARCH COMMUNITY

## I) ASSESSING THE RISKS

Climate change will act, mostly, as a multiplier of existing health risks. The absolute magnitude of impacts will therefore reflect the extent of climatic-environmental exposure, the susceptibility of the exposed population, the background frequency of each particular disease or cause of injury or premature deaths, and the capacity of public health practices and services to further reduce those frequencies and respond to changing patterns of weather and climate-related health risks.<sup>4</sup>

Improved understanding of the health risks resulting from climate change is relevant to two important policy objectives: (i) for more fully informed decision-making about the need for, and schedule of, mitigation of climate change; and (ii) as an information base for choosing and developing adaptive strategies to lessen already unavoidable health-related consequences of climate change.

**Figure 2:** Research tasks relevant to informing policies to protect health from climate change



*Note:* A wide range of research tasks are relevant to informing policies to protect health from climate change. These span: (1) learning from the recent past; (2) detecting current (observable) impacts; (3) statistically estimating current impacts (without direct observation); and (4) using information from category 1, applied to scenarios of climate change, to estimate future risks to health. Tasks (5) and (6) relate to assessing current interventions, and are dealt with elsewhere in this report.

Source: McMichael et al.<sup>4</sup>

## Improved evaluation of current climate-related health risks, rather than a primary focus on risks over very long timeframes

Improved understanding of current climate-health relationships is essential to all other research objectives, from the identification of effective interventions, to evaluation of cost-effectiveness and overall impacts. A greater focus on immediate health risks also provides a better match to the relatively short time horizons of most decision-makers. It lays the basis for iterative, evolving strategies to manage weather-related risks (such as from natural disasters), seasonal or interannual variability (e.g. in the transmission of infectious disease), and gradual climate trends. Relevant approaches include the application of well-established methods, such as time-series studies to describe the current relationships between meteorological variables and health risks, and rapidly developing fields such as empirical and biological modeling of the climatic and other determinants of infectious disease distribution. Robust evidence of current climate-health relationships is also essential for any assessment of longer-term risks, through screening of health outcomes likely to be affected by climate change in the population of interest, and estimation of likely future risks to health in response to specified scenarios of climate change and changes in baseline levels of vulnerability, morbidity and mortality.

## Identification of vulnerable populations and life stages

More systematic research is needed to identify subsections of populations that are most vulnerable to particular climate-related hazards (e.g. case-control studies to identify age- or sex-related differences in risk of death or injury in extreme weather events), or multiple hazards (e.g. identification of geographical populations or ethnic groups living in “hotspots” of food insecurity, infectious disease and flood or drought risks). Conversely, it is necessary to identify the characteristics of health “resilience” that improve ability to adapt to climatic and related changes.

## Quantification of the fraction of morbidity and mortality attributable to climate hazards, and to climate change

Further research is required to improve estimates of the fraction of current morbidity and mortality that is reasonably attributable to climate-related hazards (such as natural disasters, food shortages, and climate-related infectious diseases), and the potential future effects of climate change on these burdens, at global, regional and local levels. This should include systematic reviews to collate currently dispersed information on some health impacts (e.g. on the immediate health implications of floods or other natural disasters), as well as the development of new methods for assessing risks that are currently difficult to evaluate in a systematic or quantitative manner (e.g. the range of immediate- and long-term health implications of regional drought and food shortages).

## Better assessment of neglected climate-health linkages

To date, the research agenda on health risks from climate change has mainly focused on those risks that are easier to address with standard epidemiological methods, such as the impacts of heat and cold extremes. It is necessary to be more proactive,



and to prioritize research on those health risks that may cause the greatest health impacts (burdens), and where such information is most likely to help improve policy. Currently neglected areas include those that are potentially quantifiable using current methods (e.g. the effects of climatic conditions on a range of sensitive vector-borne diseases, both globally and locally), those that are difficult to quantify (e.g. effects on food and nutrition or mental health), those that have a long causal chain between climate and health impacts (e.g. the diverse health effects of population displacement), and those that are emerging or uncertain (e.g. altered risks of asthma or kidney stones). Assessing the particular characteristics of health risks arising from climate change should firstly include development of new risk assessment methods that are comprehensive enough to assess diffuse and uncertain risks, and yet remain systematic, transparent and replicable, as well as improved ways of handling, expressing and communicating the inherent uncertainties throughout much of this field of research.

## II) IDENTIFYING THE MOST EFFECTIVE INTERVENTIONS

The increasing concern over health risks arising from climate change is stimulating greater focus on identifying and implementing preventive interventions.<sup>5</sup> Given that climate change is likely to exacerbate existing health challenges, a significant part of the associated risks should be avoidable through wider implementation of existing, proven and cost-effective interventions, coupled with more strategic forward planning, as well as through the development of new interventions.<sup>10, 11</sup> As climate-related health burdens are borne predominantly by the poor and other vulnerable groups, strengthening deployment of existing, effective interventions can bring immediate improvements in health and health equity-related challenges, as well as decreasing vulnerability to future health-related risks of climate change.<sup>12</sup> For example, studies suggest that preventive measures, such as improved water supply and sanitation, are highly cost-effective in health terms and also bring other benefits<sup>13</sup> – making a strong case for investment in preventive rather than reactive or curative measures. Newer approaches to mitigating climate-related risks, such as heat health warning systems, also appear to be cost effective.<sup>14</sup>

Ideally, there should be a single, standardized evidence base of comparative effectiveness and cost-effectiveness of relevant health interventions, allowing decision-makers to select the optimal intervention strategy for a given population or setting. However, due to the difficulties in evaluating interventions to manage environmental risk factors in different contexts, this evidence base is far from complete. Also, changes in climate and natural environment – as well as in socioeconomic conditions – may affect the cost-effectiveness of current interventions. Assessment is further complicated by the complex interactions between economic growth, climate change and health, and the changing dynamics of health determinants among vulnerable populations. Classical cost-effectiveness analyses are likely to be inappropriate to inform decisions that are either long-term or far in the future, with analytical results depending as much on the approach and assumptions used, as on real differences in cost-effectiveness.<sup>15</sup>



### Systematic reviews of the evidence base for interventions

There is a lack of targeted, systematic reviews to identify and assess the effectiveness of interventions to control key climate-sensitive health risks, for example, for the control of vector-borne diseases, or heat health action plans. Further work in this field should build on the large body of existing evidence found in individual studies, and in reviews of environmental health interventions in general.<sup>16</sup> They should also give guidance on adapting general assessments of effectiveness where local data are incomplete, and interpreting whether these interventions are likely to be affected by changes in climate, or other health determinants. For example, this should include reviews of the effectiveness of approaches such as Integrated Vector Management (IVM) to simultaneously control disease, respond to ecological change and reduce pesticide use and insecticide resistance, in different settings.<sup>17</sup> There is also a role for detailed “bottom-up” case studies of settings in which health interventions were or were not effective in addressing climate-related health risks; for example through retrospective analysis of actions taken to protect health during heatwaves, including comparisons between different years, or between different locations affected by similar events.<sup>18</sup>

### Methodological research to improve analytical tools for cost-effectiveness analysis

There is a need for research aiming to develop appropriate tools for assessing effectiveness, cost-effectiveness and cost-benefit analysis that are appropriate for the particular characteristics of health risks resulting from, and influenced by, climate change. This should include specific approaches to quantitative evaluation of the effectiveness, and cost-effectiveness, of the major policy- and intervention-related decisions identified in this report, both inside and outside the health sector.

## III) GUIDING HEALTH-PROMOTING MITIGATION AND ADAPTION DECISIONS IN OTHER SECTORS

Around the world, decision-makers are considering how they can reduce greenhouse gas emissions and their impacts on the global climate, and adapt to rapidly changing meteorological conditions. Some sectors, such as energy production, will have to be fundamentally transformed if they are to achieve the goals that are now being set at global, national and sub-national levels, while also meeting the requirements of expanding economies and global populations. Many of these decisions have substantive implications for health – both positive and negative.<sup>6</sup>

For example, energy production and use, including for transport, are among the largest contributors to greenhouse gas emissions. At the same time, the disease burdens that are affected by decisions in these sectors are also substantial. They include the approximately 800 000 annual deaths from outdoor air pollution, the 1.2 million from road traffic injuries, the 1.5 million from indoor air pollution, and the estimated 1.9 million from physical inactivity.<sup>19, 20</sup> The global effort to reduce greenhouse gas emissions from energy production and use is therefore a critical opportunity for health promotion – in turn giving further support for more rapid mitigation of climate change.



Similarly, decisions taken by water and agriculture agencies, including adaptations to climate change, also have the capacity to increase or decrease risks from a range of infectious diseases, undernutrition and other health risks. Adaptation steps implemented for the water sector, including infrastructure development, irrigation and use of wastewater, are likely to change the pattern of water-related health risks, from ability to ensure necessary household water requirements, to risks of chemical and microbiological contamination, to the abundance of disease vectors. Agricultural policy and practice are also changing rapidly, both in order to mitigate climate change (e.g. through promotion of biofuel production, and lessening of methane emissions), and adapt to changing weather conditions (e.g. changing irrigation and crop selection). Each of these changes has the potential to influence food security, and hence undernutrition, currently the largest single contributor to the global burden of disease.<sup>21</sup>

While the range and potential significance of these interlinkages is becoming clearer, there remain only a very limited number of studies that explicitly measure the health implications of either general progress in reducing greenhouse gas emissions (i.e. assuming cuts across all sectors), or of specific policies or technology shifts (e.g. replacing coal-fired power with renewable alternatives). Multidisciplinary research will be required to guide decisions in other key sectors so that they also serve to protect and promote health.

### **Improved methods for assessment of the health implications of decisions in other sectors**

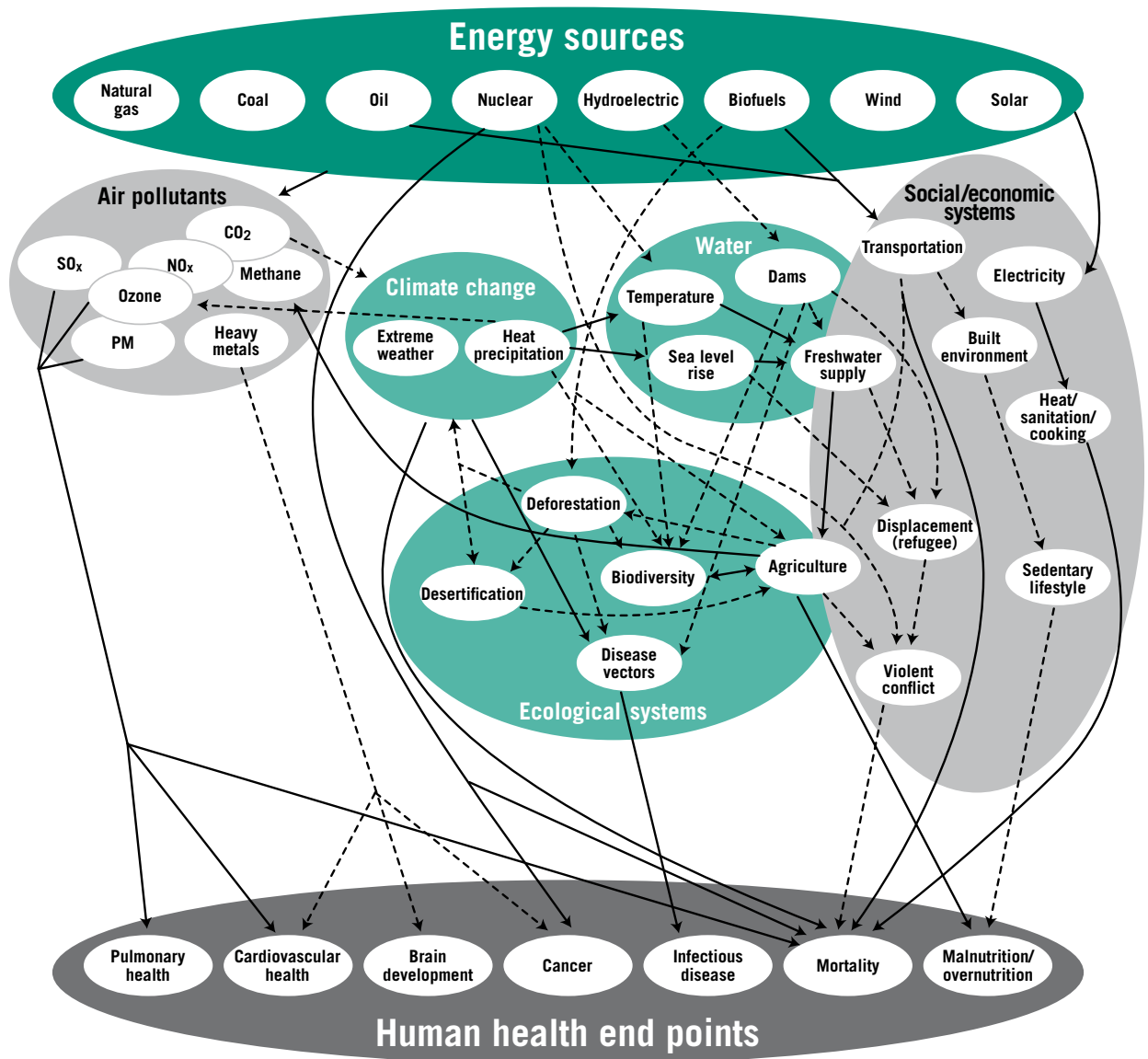
The few studies that are now beginning to assess the health consequences of decisions aiming to mitigate or adapt to climate change use very different analytical methods and assumptions, even for very similar challenges. There is a need to develop more generic guidance on conceptual frameworks and methods in order to improve comparability, and assist decision-makers to achieve the greatest health “co-benefits”, and avoid harm. This should cover the full range of potential decisions, from the “macro” level (e.g. global contraction and convergence in carbon dioxide (CO<sub>2</sub>) emissions; carbon pricing policy and incentives), to more local and sector-specific decisions (e.g. city-level policies to promote public transport, or to protect a natural watershed). The methods developed should be flexible enough to take account of very different local contexts, such as the fundamental issue that poorer populations will generally have to increase rather than reduce energy consumption in order to guarantee basic living conditions and promote health. Finally, new methods should also help describe how costs are distributed across different sectors and how benefits are spread across various population groups, as costs and benefits that apply outside of the responsibility of a given sectoral decision-maker are often ignored.

### **Health implications of climate change mitigation: energy and transport sectors**

Past research has mainly focussed on how policies that reduce greenhouse gas emissions may also improve health by reducing outdoor air pollution. While further research on this pathway is important, there is a fundamental requirement for more comprehensive assessments that also address other pathways for health, such as the potential substantial effects of active and sustainable transport on health via enhanced physical activity, decreased obesity, and fewer injuries. Research in this

field should take account of contextual factors other than climate policy (for example, higher and more variable prices of fossil fuels due to increasing global demand and possible flattening off of supply), and should address clearly defined, realistic policy choices under specific background conditions (e.g. the implications of replacing a polluting energy source with an alternative, rather than simply removing it).

Figure 3: Direct and indirect routes by which energy sources may affect human health



Note: Decisions in other sectors, such as energy, have multiple important effects on health, which have not yet been fully investigated.

CO<sub>2</sub> = carbon dioxide; NO<sub>x</sub> = nitrogen oxide; PM = particulate matter; SO<sub>x</sub> = sulphur oxide

Solid lines indicate health impacts that have been quantified, and dashed lines indicate qualitative evidence.

Source: Gohlke et al.<sup>24</sup>



## Health implications of climate change adaptation: water, food and agriculture sectors

Water and agriculture sectors are responding to climatic, demographic and economic changes, with actions having potentially profound health implications. Research should be promoted for a better assessment of the health implications of: a) strategic decisions, such as investment in water demand management (improving efficiency of water use and reducing waste, thereby increasing water availability); b) specific policies (e.g. promotion of small dams, which increase water access but can increase infectious disease transmission) and; c) technologies to deal with water stress (e.g. the use of reclaimed water and desalinization). In the food and agriculture sector, there is a need for the rapid assessment of the health impacts of policies that are fast-acting such as the increased production of biofuels, which may impact on food security, as well as modelling of the effects of more gradual changes, such as crop selection.

## Improved integration of climate change mitigation, adaptation and health through “settings-based” research

Many important decisions affecting climate change mitigation, adaptation and health are by their nature multisectoral. For example, urban development plans cut across all major sectors, with the final decision-making power often lying with a single authority, such as the mayor or local authority. There is therefore great potential for multidisciplinary research to describe the range of societal benefits of, for example, the promotion of green spaces (e.g. reduced heat island effects, improved opportunities for social interactions and physical activity, resilience to flooding), or improved building standards (e.g. reduced energy consumption, greater resilience to extreme weather, reduced opportunities for infectious disease transmission).<sup>22,23</sup>

## IV) IMPROVING DECISION-SUPPORT

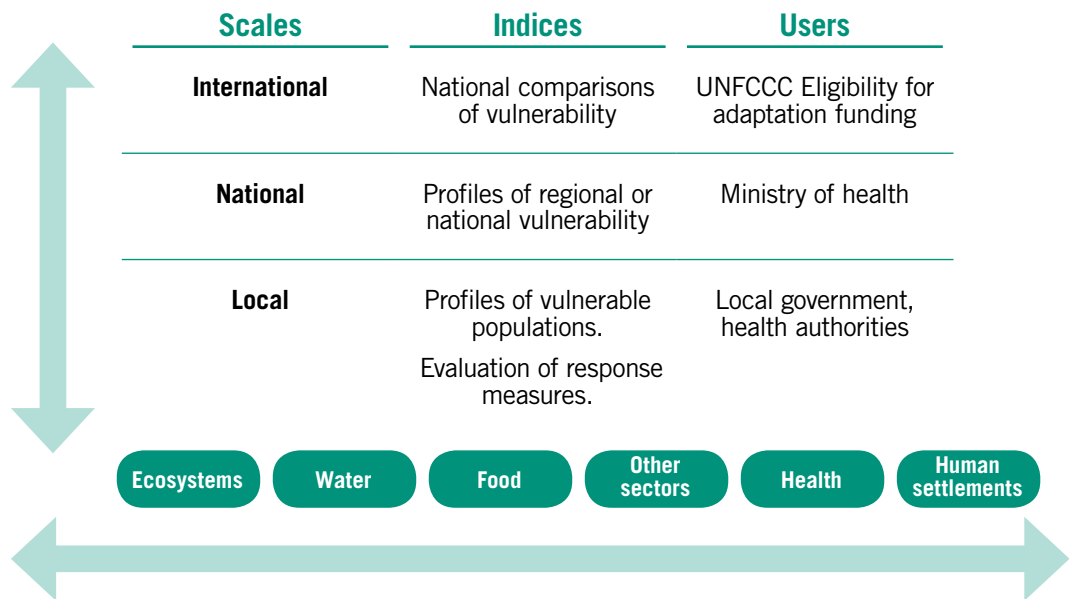
Assessments of climate change vulnerability and health risks, particularly at the national level, are essential for adaptation planning. They identify key health strategies, policies and measures, and help to set priorities and allocate resources.<sup>7</sup>

National assessments also help ensure that health is appropriately represented within international policy processes, such as the national communications to the UN Framework Convention on Climate Change (UNFCCC), and the National Adaptation Programmes of Action (NAPAs). These support sharing of best practices across countries, and help to mobilize resources for adaptation in developing countries.

Guidance for climate change and health impact assessment has been published by WHO.<sup>25</sup> In addition, a wide range of decision-support tools already exist for identifying and prioritizing risks, such as health impact assessment, cost-effectiveness analysis, multicriteria decision-analysis, and environment and health indicators. However, these may not necessarily be appropriate for the particular characteristics of health risks from climate change, including long-term, wide-ranging, uncertain, and non-linear, impacts.

Similarly, once risks have been identified as a priority for action, existing disease surveillance systems and operational procedures help to define when and how to intervene. However, these procedures may have to be revised so they are adequate to address evolving patterns of health risk due to climatic and other changes.

**Figure 4:** Decision-making at different scales: international, national and local



Source: Kovats and Chalabi<sup>7</sup>

### Research to improve vulnerability and adaptation assessments

A stock-taking of the coverage of health issues in national communications and assessments is required, including evaluation of both the process (experts, participation) and the outcome (design, funding and implementation of health adaptation programmes). This area of research should include cataloguing, critical review, pilot testing and revision of the current guidelines for climate change impact, adaptation and vulnerability. This should ensure that decisions are evidence-based, make best use of available resources, and show “due diligence” in considering whether long-term decisions such as building health facilities or water and sanitation infrastructure are still likely to be appropriate in the different climate, socioeconomic and demographic conditions that may evolve in coming decades. In addition, development of a quantitative “health software” model, which shows both existing and projected future burdens of climate-sensitive diseases, would assist integrated assessment of the effects of climate change, and promote allocation of climate change adaptation funds to protect health.



## Improvement of operational predictions

There is a need for improved and more rigorous assessment of the accuracy of weather and climate predictions for operational early warning systems, from immediate weather-related hazards such as heatwaves and floods, through interannual timescales (e.g. projection of seasonal variation in infectious disease transmission) to longer-term risks (e.g. gradually-rising sea-levels). This should include improved descriptions of prediction uncertainty at local, and regional versus global scales, and the implications that this brings for health protection decisions. It should include value of information analysis of where improvements in collection and integration of climate and health data would bring the greatest improvements in operational performance.

Health protection decisions could be improved through better disease/health surveillance systems, particularly in developing countries. This should include building on existing long-term health surveillance initiatives and networks, such as the Demographic Health Surveillance and INDEPTH systems, through developing and testing indicators of health vulnerability to climate and other hazards in critical regions.

Action research is necessary to carry out “end-to-end” evaluation of the decision-making process from the identification of an emerging health risk (e.g. the early warning or detection of a malaria epidemic), through operational procedures (e.g. division of responsibilities between meteorological and health services) and thresholds of climate or health indicators that trigger defined responses, to assessment of effectiveness and cost-effectiveness of interventions to protect health.<sup>26–28</sup>

## Improved understanding of decision-making processes

The most important barrier to improved policy is often not a lack of research data, but poor knowledge management: A failure to ensure that research is relevant to the requirements of stakeholders, is carried out in a way that engages them in the process, and is presented in a manner that can be easily incorporated into their decision-making processes.<sup>29</sup> A better understanding is required of how key groups of decision-makers – from national policy-makers, to public health professionals, to individual citizens – perceive the health risks posed by climate change, and the kinds of information that would help them to take effective action.<sup>30</sup> This should include the full spectrum of health risks and potential responses, from evaluating how well policy-makers outside of the health sector understand the health implications of their decisions, to how individuals perceive and respond to early warnings of health risks from heat waves and other extreme events. It should also include research on the effectiveness of health promotion and social marketing messages in promoting “win-win” policies and individual decisions, which can simultaneously help to mitigate climate change and improve health.<sup>31</sup>



## V) ESTIMATING THE COSTS OF PROTECTING HEALTH FROM CLIMATE CHANGE

The international community has committed to invest substantial resources in both climate change mitigation and adaptation, and is currently debating the necessary level of investment and the most appropriate mechanisms. In order to access these resources to protect health, it will be necessary to estimate the size of the overall financial bill and the potential benefits of investment in health protection.<sup>8</sup> Improved economic assessments, as well as better understanding of their limitations, should also ensure that health is more realistically represented in the economic assessment models that are currently used to guide climate change policy.<sup>32</sup>

The early evidence from global, national and local studies suggests that the costs of treating additional cases of illness resulting from climate change may be substantial, and considerably higher than the current budgets allocated for these diseases in most developing countries.<sup>33</sup> However, studies of the health economics of climate change are in their infancy. There are very few estimates of adaptation costs, and these are difficult to compare with other health cost studies because of the use of different metrics and analytical assumptions. The nature of climate change, and the diverse and often indirect ways in which it poses health risks, presents particular challenges. These include the challenge of joint cost (interventions paid for by one sector may have implications across a range of other sectors), as well as the difficulty in distinguishing between ‘costs of inaction’ (i.e. the costs and physical impacts associated with climate change in the absence of planned adaptation or mitigation) and ‘costs of adaptation’ (the costs of taking measures to reduce or to cope with additional health impacts arising as a result of climate change).

In addition, there has been relatively little work on estimating the economic value of the potential health co-benefits that may be gained through climate change mitigation. Considering only the implications of greenhouse gas mitigation on air quality, the most recent assessment report of the Intergovernmental Panel on Climate Change (IPCC) concluded that there is “much evidence”, and “high agreement”, that “the monetized health benefits may offset a substantial fraction of the mitigation costs”.<sup>34</sup> However, these assessments have not yet taken into account many potential health benefits, and costs, for example valuing lives saved through improvements in insulation and energy efficiency in houses, or from facilitating safe public and active transport.<sup>35</sup>

### Definition of harmonized methods to estimate costs and benefits

In order to promote comparability between economic assessments, there is a need for definition of best practice in assessing the effectiveness and cost-effectiveness of interventions to protect health from climate change, as well as the distribution of costs and benefits in the population. This should also define appropriate assumptions on critical parameters such as the discounting of costs and benefits over time, the importance of equitable distribution of costs and benefits within the populations affected, and methods for describing uncertainty (i.e. not just “best estimates”, but also best- and worst-case scenarios).



## Assessment of the health costs of inaction and the costs of adaptation

The very small number of existing studies at the global, regional or local level should be increased. Such assessments should include interventions that are not primarily undertaken by the formal health sector, and describe the size and distribution of both health and non-health benefits across different population groups. They should also include simulation and sensitivity analysis to describe how the multiple sources of uncertainty affect estimates of the costs and benefits of investments, including identifying those that are likely to remain “good deals” under any reasonable scenario of climate change.

## Improved economic assessment of the health co-benefits of climate change mitigation

Economic valuation of the direct health implications of climate change mitigation is particularly relevant to policy-makers: Policies that can reduce direct or indirect health costs while also cutting greenhouse gas emissions are more likely to be implemented. This should include extending the harmonized methods described above, and applying them to provide an economic valuation of health costs avoided by alternative policies for climate change mitigation at the global, regional and local levels.

# IMPLEMENTING THE AGENDA: PARTNERSHIPS FOR CLIMATE CHANGE AND HEALTH RESEARCH

WHO Member States have made a clear request for applied multidisciplinary research that can support both climate-informed public health policies, as well as health-informed climate policies. While some research donors, such as the European Community, support both international and interdisciplinary collaboration around this issue, the global research effort linking climate and health disciplines is relatively small. Barriers include comparatively few financial resources; weak incentives for individuals to engage in interdisciplinary applied research; allocation of the majority of health research funding to technological and curative solutions rather than population health; and weak institutional partnerships between the research and the operational community that hamper both the communication of user requirements to researchers and the delivery and implementation of applied research to users.<sup>9</sup>

This calls for a change in research emphasis, a more demand-driven approach to defining the research agenda, and more integrated funding support to address defined problems. There are several overlapping partnerships that cover parts of this agenda. They include, for example, the work of WHO and the Global Forum for Health Research in defining overall health research properties; support from the Special Programme for Research and Training in Tropical Diseases (TDR) for research on environmental influences on tropical infectious disease;<sup>36</sup> and multidisciplinary initiatives covering climate change and health in specific regions and countries.<sup>37</sup> In addition, many government, charitable and private sector donors are currently developing research portfolios on climate change and health. However, these do not yet cover the full range of functions necessary to produce applied research that responds directly to the requests of Member States, and other stakeholders, particularly in developing countries.

## Support an iterative process for reviewing and adapting the research agenda

There is a need for an iterative process of consultation between the research community and decision-makers, involving civil society and particularly representatives of vulnerable groups. This should serve to provide a two-way reality check and education, ensuring that researchers provide information that is as relevant as possible to operational decisions, and that decision-makers are clear about what research is currently possible, or may be in the future. This consultation process is equally relevant at global, regional and local levels, and for all levels of applied research, from providing information on international investments in health adaptation to climate change, to the operational design of early warning and response systems for infectious disease epidemics.



## Box 1: Facilitating research on climate change and health: the role of WHO

Research to support health protection from climate change requires contributions from a wide range of disciplines, and the needs will vary from location to location, and through time. No single organization should assume responsibility for defining a research programme that will be appropriate to all actors, in all places. At the same time, however, climate change is a shared global challenge, putting at risk the health and well-being of all populations. WHO therefore contributes to supporting research in this field, in the following areas:

**Linking the research and operational communities:** WHO will continue to reflect the requests of Member States on this issue, made through the World Health Assembly and WHO Regional Committee Meetings. WHO will establish a high-level panel on climate change and health, which will periodically review the state of current knowledge and report to the WHO Director-General, other relevant UN agencies and Member States on the implications for health protection globally. WHO also ensures that relevant research findings are integrated into relevant technical programmes, and encourage their uptake by our national counterparts in ministries of health and other operational agencies.

**Iterative development of research priorities:** WHO commits to work with other partners that bring together health policy-makers and public health researchers to periodically review and update research priorities at the global level. WHO also encourages the refinement and adaptation of these priorities by actors with a specific population, sectoral or disciplinary focus.

**Direct support for targeted research projects:** Where appropriate, WHO engages directly in research projects to meet the expressed needs of Member States, and makes use of its particular strengths of stable and strong relationships with the operational health sector, access to health data, and networks within the public health research community. Relevant research activities would include, for example, assessments of the health co-benefits of mitigation policies at the global and regional levels, and evaluation of the effectiveness of interventions at the national or local levels. They would also include the production and update of key resources, such as guidance on assessing health vulnerability to climate change and planning adaptation strategies.

In all of these activities, WHO works to reduce its own contribution to greenhouse gas emissions, and encourages its partners to do the same.

## Establish a virtual forum on climate change and health research

Although a great deal of relevant research information and capacity exists, it is highly dispersed across disciplines, individuals and institutions. A virtual forum on climate and health could help to provide a clearing house to bring together the existing body of relevant research methods, tools, data sets and research results, to periodically review the state of the art and major gaps in responding to the requests of decision-makers, and highlight opportunities for research funding and training opportunities. It would also facilitate collaboration between researchers working in this field, including between developing and developed country researchers.

### Establish expert panels to provide oversight, develop guidance and tools

Many of the research tasks outlined above will require a multidisciplinary group either to provide guidance and oversight (e.g. in reviewing and periodically revising the global research agenda, or producing “best-practice” guidance for economic assessments on climate change and health), or to carry out technical projects (such as global assessments of the current and future burden of disease attributable to climate change). In order to ensure coherence, these technical processes should be aligned with relevant international initiatives, such as the IPCC, the Global Energy Assessment, and the Comparative Risk Assessment for health burdens.

### Build capacity for climate change and health research, with a focus on developing countries

None of the above will be possible without strengthening research capacity. This will require a particular focus on low- and middle-income countries, where both the health impacts and opportunities for health improvements are likely to be greatest, and yet where research capacity and output are weakest. Capacity-building activities should include opportunities at all stages of career development, from university training curricula, to postgraduate and fellowship support, to opportunities to act as reviewers on grants. As far as possible, it should capitalize on existing programmes, for example promoting appropriate coverage of health within climate change research initiatives such as the International Development Research Centre (IDRC) programme on Climate Change Adaptation in Africa,<sup>38</sup> and the inclusion of climate change as a priority within existing health research programmes.



# REFERENCES

1. *Climate change and health: Resolution of the 61st World Health Assembly*. Geneva, World Health Organization, 2008.
2. Confalonieri U, Menne B, Akhtar R, et al. *Human health*. In: Parry ML, Canziani OF, Palutikof JP, Linden PJvd, Hanson CE, eds. *Climate Change 2007: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press, 2007: 391–431.
3. Woodward A, Scheraga J. Looking to the future: challenges for scientists studying climate change and health. In: McMichael AJ et al., eds. *Climate change and health: risks and responses*. Geneva, World Health Organization, 2003.
4. McMichael A et al. *Assessing the scale and nature of health vulnerability to climate change*. Technical report for WHO global consultation on “Guiding research to improve health protection from climate change”. World Health Organization, 2008.
5. Chalabi Z. *Assessment of effectiveness and cost-effectiveness of health protection strategies and measures relating to climate change*. Technical report for WHO global consultation on “Guiding research to improve health protection from climate change”. World Health Organization, 2008.
6. Ebi K, Balbus J. *Assessment of the health impacts of potential adaptation and mitigation measures in other sectors*. Technical report for WHO global consultation on “Guiding research to improve health protection from climate change”. World Health Organization, 2008.
7. Kovats RS, Chalabi Z. *Development of decision-support and other tools, such as surveillance and monitoring, for assessing vulnerability and health impacts and targeting measures appropriately*. Technical report for WHO global consultation on “Guiding research to improve health protection from climate change”. World Health Organization, 2008.
8. Markandya A, Chiabai A. *Assessment of the likely financial costs necessary for health protection from climate change*. Technical report for WHO global consultation on “Guiding research to improve health protection from climate change”. World Health Organization, 2008.
9. Rogers D. *Partnerships for climate change and public health research*. Technical report for WHO global consultation on “Guiding research to improve health protection from climate change”. World Health Organization, 2008.
10. Scheraga J et al. From science to policy: developing responses to climate change. In: McMichael AJ, Campbell-Lendrum DH et al., eds. *Climate change and health: risks and responses*. Geneva, World Health Organization, 2003.
11. Campbell-Lendrum D et al. Global climate change: implications for international public health policy. *Bulletin of the World Health Organization*. 2007, 85:235–237.
12. Friel S et al. Global health equity and climate stabilisation: a common agenda. *Lancet*. 2008, 372(9650):1677–83.
13. Hutton G, Haller L. *Evaluation of the costs and benefits of water and sanitation improvements at the global level*. Geneva, World Health Organization, 2004.
14. Ebi KL et al. Heat watch/warning systems save lives – Estimated costs and benefits for Philadelphia 1995–98. *Bulletin of the American Meteorological Society*. 2004, 85(8):1067–.
15. Tol RSJ. Is the uncertainty about climate change too large for expected cost-benefit analysis? *Climatic Change*. 2003, 56(3):265–289.
16. Hutton G. Economic evaluation of environmental health interventions to support decision making. *Environmental Health Insights*. 2008, 2:137–155.
17. *Global strategic framework for integrated vector management*. Geneva, World Health Organization, 2004.



18. Fouillet A et al. Has the impact of heat waves on mortality changed in France since the European heat wave of summer 2003? A study of the 2006 heat wave. *International Journal of Epidemiology*, 2008.
19. *The world health report 2002*. Geneva, World Health Organization, 2002.
20. Ezzati, M et al. *Comparative quantification of health risks: global and regional burden of disease due to selected major risk factors*. Geneva, World Health Organization, 2004.
21. Black RE et al. Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet*. 2008, 371(9608):243–60.
22. Campbell-Lendrum D, Corvalan C. Climate change and developing-country cities: implications for environmental health and equity. *Journal of Urban Health*. 2007.
23. Bloomberg MR, Aggarwala RT. Think locally, act globally: how curbing global warming emissions can improve local public health. *American Journal of Preventive Medicine*. 2008, 35(5):414–23.
24. Gohlke JM et al. Health, economy, and environment: sustainable energy choices for a nation. *Environmental Health Perspectives*. 2008, 116(6):A236–7.
25. Kovats R et al. *Methods of assessing human health vulnerability and public health adaptation to climate change*. Rome, World Health Organization – European Centre for Environment and Health, 2003.
26. *Using climate to predict infectious disease epidemics*. Geneva, World Health Organization, 2005.
27. Jones C et al. District-based malaria epidemic early warning systems in East Africa: perceptions of acceptability and usefulness among key staff at health facility, district and central levels. *Social Science & Medicine*. 2008, 67(2):292–300.
28. Cox J, Abeku TA. Early warning systems for malaria in Africa: from blueprint to practice. *Trends in Parasitology*. 2007, 23(6):243–6.
29. *The Health and Environment Linkages Initiative: managing the linkages for sustainable development: a toolkit for decision-makers*. Geneva, World Health Organization/United Nations Environment Programme, 2008.
30. *A gap analysis for the implementation of the Global Climate Observing System programme in Africa*. International Research Institute for Seasonal to Interannual Prediction, Technical Report Series. New York, 2006.
31. Semenza JC et al. Public perception of climate change voluntary mitigation and barriers to behavior change. *American Journal of Preventive Medicine*. 2008, 35(5):479–87.
32. Stern, N. *Stern review on the economics of climate change*. London, UK Treasury, 2006.
33. Ebi KL. Adaptation costs for climate change-related cases of diarrhoeal disease, malnutrition, and malaria in 2030. *Globalization and Health*. 2008, 4: 9.
34. Barker T et al. Technical summary. *Climate change 2007: mitigation*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, Cambridge University Press, 2007.
35. Younger M. et al. The built environment, climate change, and health: opportunities for co-benefits. *American Journal of Preventive Medicine*. 35(5):517–26.
36. Special Programme for Research and Training in Tropical Diseases (TDR): For research on diseases of poverty, <http://www.who.int/tdr/>, 2008.
37. International Livestock Research Institute (ILRI)/Google. Global Challenge Dialogue on Climate and Health in Africa, 2008.
38. International Development Research Center. Climate Change Adaptation in Africa, <http://www.idrc.ca/ccaa/>, 2008.



# APPENDIX: PARTICIPANTS IN ELECTRONIC CONSULTATION AND MEETING

## TECHNICAL EXPERTS AND REPRESENTATIVES OF PARTNER AGENCIES

**Maarten van Aalst**, Associate Director and Lead Climate Specialist, Red Cross/Red Crescent Climate Centre, The Netherlands

**Josep M Antó**, Director, Center for Research in Environmental Epidemiology (CREAL), Spain

**John M Balbus**, Chief Health Scientist, Environmental Defense Fund, USA

**Cristovam Barcellos**, Oswaldo Cruz Foundation, Brazil

**Aderrez Bouchama**, Department of Comparative Medicine (MBC03), King Faisal Specialist Hospital & Research Centre, Saudi Arabia

**Colin Butler**, National Centre for Epidemiology and Population Health, The Australian National University, Australia

**Daniel Carucci**, Vice President for Global Health, United Nations Foundation, USA

**Dominique Charron**, Program Leader, Ecosystem Approaches to Human Health International Development Research Centre, Canada

**Luis A Cifuentes**, Head, Center for the Environment, Catholic University of Chile, Chile

**Ulisses Confalonieri**, Oswaldo Cruz Foundation, Brazil

**Christine M Coussens**, Senior Program Officer, Institute of Medicine, USA

**Valerie Detemmerman**, Senior Scientific Officer, World Climate Research Programme, World Meteorological Organization, Switzerland

**Alhassane Adama Diallo**, Director, African Center of Meteorological Applications for Development (ACMAD), Niger

**Ferrán Ballester Díez**, Valencia School of Health Studies (EVES), Spain

**Kristie L Ebi**, Intergovernmental Panel on Climate Change Technical Support Unit, Stanford, USA

**Paul R Epstein**, Centre for Health and the Global Environment, Harvard Medical School, USA

**Howard Frumkin**, Director, National Center for Environmental Health, US Centers for Disease Control and Prevention, USA

**Kathryn Gallagher**, Science Policy Council Staff Team Leader, US Environmental Protection Agency, USA

**Kee-Tai Goh**, Director, WHO Collaborating Centre for Environmental Epidemiology, Ministry of Health, Singapore

**Debarati Guha-Sapir**, Director, WHO Collaborating Centre for Research on the Epidemiology of Disasters (CRED), Catholic University of Louvain, Belgium

**Yasushi Honda**, Associate Professor, Environmental Health Sciences Unit, University of Tsukuba, Japan

**Yun Chul Hong**, Department of Preventive Medicine, Seoul National University College of Medicine, Republic of Korea

**R Sari Kovats**, Public and Environmental Health Research Unit, London School of Hygiene and Tropical Medicine, UK

**Wilfried Kreisel**, Former Executive Director, Health and Environment, WHO/HQ, Switzerland

**Rocio Licht**, Programme Officer, Adaptation, Technology and Science Programme, UN Framework Convention on Climate Change, Germany

**Elisabet Lindgren**, Karolinska Institute, Stockholm, Sweden

**David Lynn**, Head of Strategic Planning & Policy Unit, The Wellcome Trust, UK

**Anil Markandya**, Professor of International Development, University of Bath, UK

**Glenn McGregor**, Director School of Geography, Geology and Environmental Science, University of Auckland, New Zealand

**Tony McMichael**, Professor, National Centre for Epidemiology & Population Health, The Australian National University, Australia

**Paola Michelozzi**, Department of Epidemiology, ASL, RM/E, Italy

**Zac Morse**, Associate Director of Research, Fiji School of Medicine, Fiji

**Jo Nurse**, Consultant in Public Health, Department of Health, UK

**Buruhani Nyenzi**, Director, Climate Prediction and Adaptation Branch, World Meteorological Organization, Switzerland

**Sylvie Olifson**, Health Economist, Global Forum for Health Research, Switzerland

**Kiran Dev Pandey**, World Bank, USA

**Mathilde Pascal**, Specialist on Climate Change and Health, National Institute of Health Surveillance, Department of Environmental Health, France

**Michel Pletschette**, European Commission Directorate General for Health and Consumers, Belgium

**Katherine Pond**, Robens Centre for Public and Environmental Health, University of Surrey, UK

**Christopher Portier**, Associate Director, National Institute of Environmental Health Sciences, USA

**Annette Richardson**, Consultant, USA

**Elisabeth Robert-Gnansia**, Head of Methods, Research and External Relations Department, Agency for Health and Safety, France

**Ian Roberts**, Professor of Epidemiology and Public Health, London School of Hygiene & Tropical Medicine, UK

**David Rogers**, President, Health and Climate Foundation, Switzerland

**David J Rogers**, Professor of Ecology, Oxford University Department of Zoology, UK

**Giovanni Rum**, Senior Programme Officer, Group of Earth Observation, Switzerland

**Carmen Perez Samaniego**, Health Section, German Agency for Technical Assistance (GTZ), Germany

**Fernando Simón Soria**, Carlos III Health Institute. National Epidemiology Centre, Ministry of Science and Innovation, Spain

**Kirk Smith**, Professor of Global Environmental Health, University of California, Berkeley, USA

**David Stone**, Principal Specialist in Environment and Health, Natural England, and Health and Environment Alliance, UK

**Hiwot Teka**, Program Coordinator, Climate and Health Working Group, Ethiopia

**Madeleine Thomson**, Senior Research Scientist, International Research Institute for Climate and Society, USA

**Tomas Turecki**, European Commission Directorate General for Research, Belgium

**Paul Wilkinson**, Reader, Public and Environmental Health Research Unit, London School of Hygiene & Tropical Medicine, UK

**Alistair Woodward**, Head, School of Population Health, The University of Auckland, New Zealand

**Jin Yinlong**, Director, Institute for Environmental Health and Related Product Safety, China Centers for Disease Control, China



## REPRESENTATIVES OF THE MINISTRY OF HEALTH, SPAIN

**Margarita Alonso Capitán**, Department of Environmental and Occupational Health, Ministry of Health and Consumer Affairs, Spain

**Remedios Avilés Mañoso**, Secretariat General for Health, Ministry of Health and Consumer Affairs, Spain

**Marina Ayuga Martínez**, Department of Environmental and Occupational Health, Ministry of Health and Consumer Affairs, Spain

**Mario Cárdbaba Arranz**, Department of Environmental and Occupational Health, Ministry of Health and Consumer Affairs, Spain

**Fernando Carreras Vaquer**, Department of Environmental and Occupational Health, Ministry of Health and Consumer Affairs, Spain

**Carmen Castañón Jiménez**, Department of External Relations, Ministry of Health and Consumer Affairs, Spain

**María Teresa De Martín y Martínez**, Secretariat General for Health, Ministry of Health and Consumer Affairs, Spain

**Ildelfonso Hernández Aguado**, Director General of Public and International Health, Ministry of Health and Consumer Affairs, Spain

**Natividad Nalda Izquierdo**, Department of External Relations, Ministry of Health and Consumer Affairs, Spain

## WORLD HEALTH ORGANIZATION – HEADQUARTERS

**Roberto Bertollini**, Coordinator, Evidence and Policy on Environment and Health, Public Health and Environment Department, World Health Organization, Switzerland

**Diarmid Campbell-Lendrum**, Scientist, Evidence and Policy on Environment and Health, Public Health and Environment Department, World Health Organization, Switzerland

**Carlos Dora**, Coordinator, Interventions for Healthy Environments, Public Health and Environment Department, World Health Organization, Switzerland

**Jostacio Lapitan**, Technical Officer, Urbanization and Emergency Preparedness, WHO Kobe Centre, Japan

**Maria Neira**, Director, Public Health and Environment Department, World Health Organization, Switzerland

**Annie Roberts**, Intern, Evidence and Policy on Environment and Health, Public Health and Environment Department, World Health Organization, Switzerland

**Johannes Sommerfeld**, Scientist, Special Programme for Research and Training in Tropical Diseases (TDR), Switzerland

## WORLD HEALTH ORGANIZATION – REGIONAL OFFICES

**Hamed Bakir**, Regional Advisor on Health and Environment, WHO Regional Office for the Eastern Mediterranean, Centre for Environmental Health Activities, Jordan

**Sally J Edwards**, Regional Advisor in Environmental Epidemiology, Pan American Health Organization / WHO Regional Office for the Americas, Office for Caribbean Program Coordination, Barbados

**Alexander von Hildebrand**, Regional Advisor on Health and Environment, WHO Regional Office for South-East Asia, India

**Bettina Menne**, Medical Officer, Global Change and Health Focal Point, WHO Regional Office for Europe, European Centre for Environment and Health, Italy

**Tanja Wolf**, Technical Officer, Global Change and Health, WHO Regional Office for Europe, European Centre for Environment and Health, Italy

## WORLD HEALTH ORGANIZATION – SUPPORT STAFF

**Anne-Laure Lameyre**, Evidence and Policy on Environment and Health, Public Health and Environment Department, World Health Organization, Switzerland

**Judy Sanchez Santana**, Evidence and Policy on Environment and Health, Public Health and Environment Department, World Health Organization, Switzerland

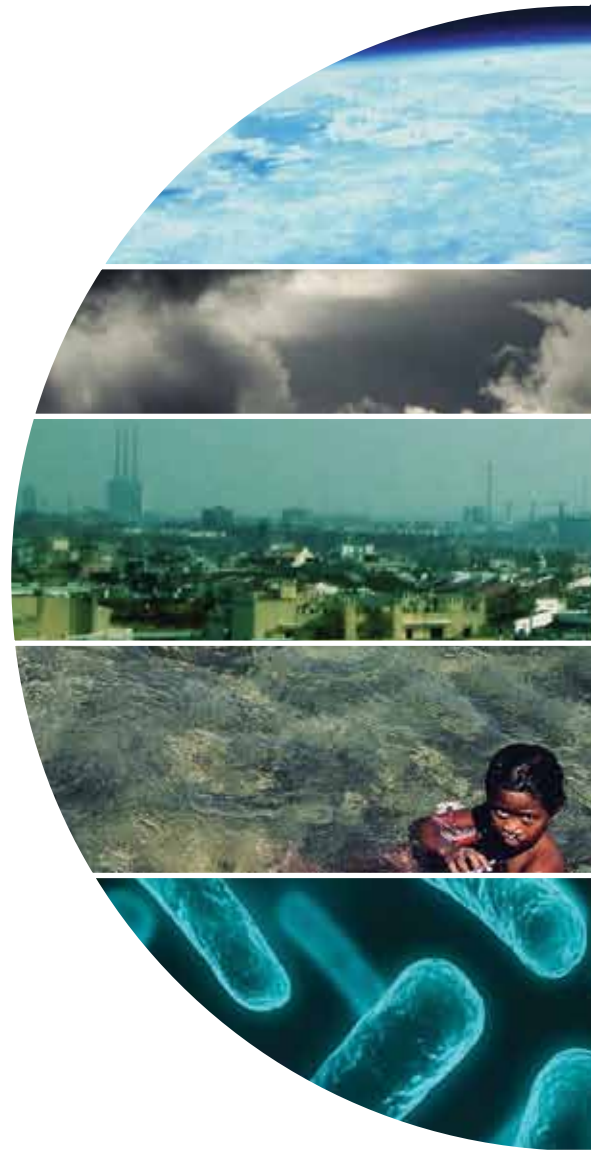




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This report describes the results of an international consultation with researchers, research donors, public health practitioners and representatives of partner agencies within and outside the United Nations system. It aims to provide guidance on the most important contributions that the global research community can make to help protect human health from the impacts of climate change.

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