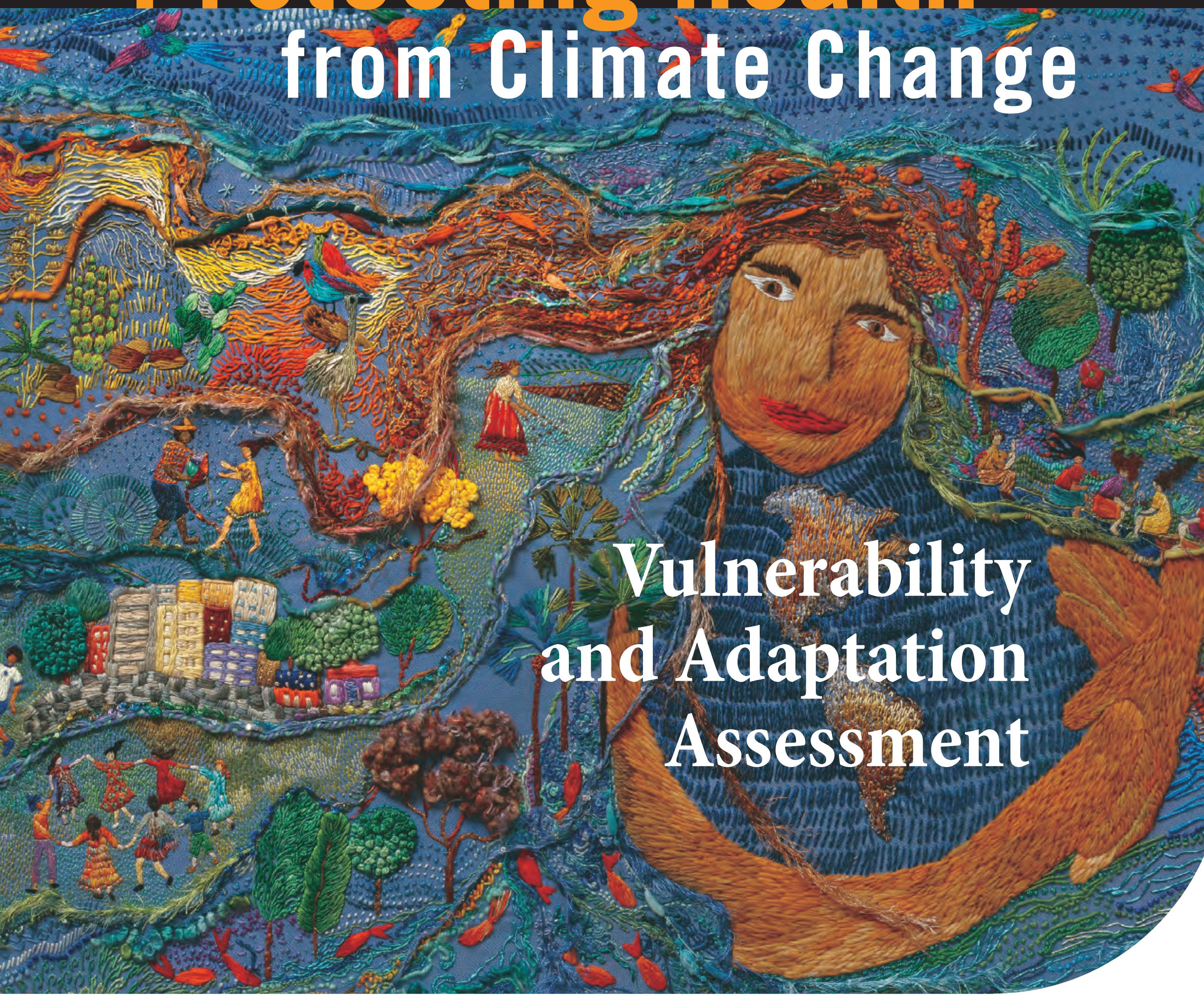
Protecting Health from Climate Change

Vulnerability and Adaptation Assessment



World Health Organization

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Extreme weather events can damage and destroy critical health infrastructure, and reduce health system efficiency.

Preface

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There is now strong evidence that the earth's climate is changing rapidly, due mainly to human activities. Increasing temperatures, sea-level rises, changes in precipitation patterns and extreme events are expected to increase a range of health risks, from the direct effects of heatwaves, floods and storms, to more suitable conditions for the transmission of important infectious diseases, to impacts on the natural systems and socioeconomic sectors that ultimately underpin human health. Much of the potential health impact of climate change can, however, be avoided through a combination of strengthening key health system functions and improved management of the risks presented by a changing climate.

Decision-makers from around the world have recognized this challenge. In 2008, the 193 countries that constitute the World Health Assembly (WHA) passed a resolution committing countries to strengthen action to protect health from climate change; and in 2009, the World Health Organization (WHO) Executive Board endorsed a workplan that defined the specific ways in which WHO should support countries in achieving this aim. These mandates have been further adapted and refined through the regional governing bodies. A consistent request throughout all of these mechanisms is for WHO to support countries in planning and implementing adaptation.

The critical first step in this process is to carry out a vulnerability and adaptation assessment. This allows countries to assess which populations are most vulnerable to different kinds of health effects, to identify weaknesses in the systems that should protect them, and to specify interventions to respond. Assessments can also improve evidence and understanding of the linkages between climate and health within the assessment area, serve as a baseline analysis against which changes in disease risk and protective measures can be monitored, provide the opportunity for building capacity, and strengthen the case for investment in health protection.

WHO has responded to this global demand by building on past guidance and technical tools to outline a flexible process for vulnerability and adaptation assessment. In 2009, the WHO Regional Office for the Americas and WHO prepared draft guidance for this process, which was pilot tested in studies across all WHO Regions. In July 2010, representatives of ministries of health from 15 countries came together in Costa Rica with WHO and subject area experts to share their experiences and provide feedback on how to improve the guidance for the conduct of vulnerability assessments.

This document is the result of this process. It is intended not as a final, definitive guide but as an important part of an evolving set of resources that will support effective and evidence-based action to protect health from climate change.

Boxes

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Abbreviations

CBD	United Nations Convention on Biological Diversity
CCD	United Nations Convention to Combat Desertification
DPSEEA FRAMEWORK	Driving Force, Pressure, State, Exposure, Effect, Action Framework
FIOCRUZ	Fundação Oswaldo Cruz
GIS	geographical information systems
GRIP	Global Risk Identification Programme
HARS	heat alert and response system
HIA	health impact assessment
IPCC	Intergovernmental Panel on Climate Change
IRI	The International Research Institute for Climate and Society
LDEO	Earth Institute's Lamont-Doherty Earth Observatory
NGO	nongovernmental organization
SRES	standardized reference emission scenarios
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VRAM	Vulnerability and Risk Analysis and Mapping
WCASP	World Climate Applications and Services Programme
WHA	World Health Assembly
WHO	World Health Organization
WHO/EURO	World Health Organization Regional Office for Europe
WHO/SEARO	World Health Organization Regional Office for South-East Asia
WMO	World Meteorological Organization

Keywords

Climate
Disease susceptibility
Environmental exposure
Environmental health
Health policy
Public health
Risk assessment
Risk management

1.0 Introduction

A small landholders women's group meeting near Changli, Nepal.

Climate change is adversely affecting the health of populations around the world, with the greatest impacts in low-income countries (Confalonieri et al., 2007; McMichael et al., 2003a; WHO, 2002, 2009). Impacts can arise from the following:

- The effects of climate change on natural and physical systems, which in turn alter the number of people at risk of malnutrition, the geographical range and incidence of vector-borne, zoonotic and food- and waterborne diseases, and the prevalence of diseases associated with air pollutants and aeroallergens. Additional climate change in coming decades is projected to significantly increase the number of people at risk of these major causes of ill health (Confalonieri et al., 2007).
- Climate change-related alterations in the frequency, intensity and duration of extreme weather events (e.g. heatwaves, floods, droughts and windstorms). Each year, these events affect millions of people, damage critical public health infrastructure, and cause billions of dollars of economic losses. The frequency and intensity of some types of extreme weather events are expected to increase over coming decades as a consequence of climate change (IPCC, 2007b), suggesting that the associated health impacts could increase without additional preventive actions.
- Climate change can affect population health through climate-induced economic dislocation and environmental decline, and through development setbacks incurred by damage to critical public health infrastructure and to livelihoods by extreme weather events.

Public health has experience in coping with climate-sensitive health outcomes. The current state of population health reflects (among many other factors) the degree of success or failure of the policies and measures designed to reduce climate-related risks. Climate change will make it more difficult to control a wide range of climate-sensitive health outcomes. Therefore, to maintain and improve current levels of population health, it will be necessary not only to continue to strengthen core functions of health systems, but also to explicitly consider the risks posed by a changing climate and to modify current health risk management activities to respond.

Policies and programmes will need to go beyond addressing current vulnerabilities, to protect against health risks from future and possibly more severe climate change. Because of the inherent inertia in the climate system and the length of time required for carbon dioxide to come to equilibrium in the atmosphere, the world is committed to three to five decades of climate change, no matter how quickly greenhouse gas emissions are reduced (IPCC, 2007b).

The future health impacts of climate change will vary over spatial and temporal scales, and will depend on changing socioeconomic and environmental conditions, with possibilities for diseases to increase in incidence or change their geographical range. Therefore, capacity needs to be built within and outside the health sector to identify increased risks and then prepare and then manage them by evaluating the effectiveness of current and proposed programes. These evaluations should consider both rapid climate change over the next few decades and longer-term changes in the averages of meteorological variables. Policies and programmes to address the health risks from climate change should explicitly consider how to avoid severe health impacts from cumulative or catastrophic events.

Reducing current and projected health risks attributable to climate change is a risk management issue. The primary responses to managing the health risks of climate change are mitigation, or reduction of human influence on the climate system, and adaptation, or policies and programmes designed to prevent avoidable impacts and minimize resulting health burdens (prevention). Mitigation and adaptation policies are not mutually exclusive; for example, co-benefits to human health can result from actions to reduce greenhouse gas emissions (Haines et al., 2009), and adaptation measures can lead to reduced emissions. As the context for adaptation continues to change with changing demographics, technologies, socioeconomic development and climate conditions, an iterative risk management approach is likely to be most effective. At the same time, because climate change is one of many factors associated with the geographical range and incidence of many adverse health outcomes, policies and measures designed to address the health risks of climate change need to be incorporated into existing programmes designed to address these risks and strengthen health systems.

Although there are uncertainties about the rate and magnitude of future climate change, failure to invest in adaptation and mitigation may leave communities and nations poorly prepared, thus increasing the probability of severe adverse consequences (WHO, 2009). Decision-makers need to understand the potential health impacts of climate change, the effectiveness of current adaptation and mitigation policies, and the range of choices available for enhanced or new policies and programmes.

This document is designed to provide basic and flexible guidance on conducting a national or subnational assessment[1] of current and future vulnerability (i.e. the susceptibility of a population or region to harm) to the health risks of climate change, and of policies and programmes that could increase resilience, taking into account the multiple determinants of climate-sensitive health outcomes. The assessment outcome will provide information for decision-makers on the extent and magnitude of likely health risks attributable to climate change, and priority policies and programmes to prevent and reduce the severity of future impacts.[2] The steps may be implemented in the order presented, or only selected steps may be undertaken to meet the needs of the population being considered. For example, an assessment might focus on identifying populations and regions vulnerable to current and possible future changes in the geographical range of climate-sensitive infectious diseases. The assessment could be quantitative or qualitative, or a mixture of both. Because data limitations can make quantitative assessments difficult, this guidance focuses on qualitative approaches. For more information on quantitative approaches, see Kovats et al. (2003) and Campbell-Lendrum & Woodruff (2007).

1 The term "assessment" is used to indicate a vulnerability and adaptation assessment.

2 The guidance does not address the tasks required to conduct an assessment of the positive and negative health effects associated with climate change mitigation measures, although this is as important as conducting a vulnerability and adaptation assessment.

Photo credit: **UN Photo/Martine Perret.**

Ecosystem services to health: Boys in wooden goggles catch fish off Atauro Island, Timor-Leste.

1.1 Climate change is one of many determinants of health

Climate is not the only factor affecting the geographical range and incidence of climate-sensitive health outcomes. Non-climatic factors can have a strong or even dominant effect, either independently or by modifying climate effects. It is also important to understand the various causal pathways from climate change through to health outcomes, in order to identify opportunities to address the environmental determinants of poor health outcomes.

The Driving Force, Pressure, State, Exposure, Effect, Action (DPSEEA) Framework was designed to provide a hierarchical model to describe the actions of various causes that act, more or less directly, on health outcomes from environmental or related behavioural conditions. It describes the various levels of actions that can be taken to reduce health impacts (Corvalan et al., 2000). The driving forces refer to the key factors that generate the environmental processes involved, such as population growth and economic development. These driving forces result in pressures on the environment. In response, the state of the environment is altered, with changes that may be complex and wide-ranging. These changes in the state of the environment may operate at markedly different geographical scales, from local to international. Risks to health may occur when people are exposed to these environmental hazards, which can then lead to health effects; these hazards may vary in type, intensity and magnitude. Figure 1 applies the DPSEEA Framework to climate change.

Figure 1 Driving Force, Pressure, State, Exposure, Effect, Action (DPSEEA) Framework

	Actions
Driving forces Energy, agriculture, transport policies; demographic change; land-use change; urbanization process	**International agreements (e.g., UN Conventions: UNFCCC, CBD, CCD)**
Pressures Greenhouse gas emissions	**National mitigation policies**
State Climate change	**Adaptation policies and programmes to manage risks**
Exposure Extreme weather events (droughts, floods, heatwaves); ecosystem changes; water scarcity; food availability; changes in vector distribution	**Indicators; monitoring; surveillance systems; public health policies; environmental protection**
Effect Climate-sensitive diseases including cardiovascular; acute and chronic respiratory; acute diarrhoeal; mental; vector-borne; malnutrition; injuries	**Diagnosis and treatment**

Based on Kovats et al. (2005).

The DPSEEA Framework can help public health officials identify the range of factors that should be considered when conducting a climate change vulnerability and adaptation assessment.

2.0 Steps in conducting a vulnerability and adaptation assessment

The steps conducted in a particular assessment will depend on the interests of the users. For example, the primary concern may be to enhance preparedness for extreme weather events, in which case the focus would likely be on describing current vulnerability and on identifying policies and programmes to improve health sector preparedness and increase community resilience (i.e. the ability to adapt). Other assessments may be broader in scope and investigate a range of health concerns associated with climate change, and may project health impacts under different climate and socioeconomic scenarios.

Ongoing climate change and changes in vulnerability conditions mean that assessment is an iterative process. The results of one assessment should provide a baseline of current vulnerability, impacts, adaptation policies and programmes, and identify actions to inform future assessments. Future vulnerabilities may be different from current vulnerabilities because of changes in public health and health-care policies, governance and institutions, socioeconomic development, availability of human and financial resources, and other factors. Impacts can change with both changing vulnerabilities and environmental changes. Public health policies, programmes and interventions to address vulnerabilities and impacts will need to be revisited regularly to ensure continuing effectiveness in a changing climate.

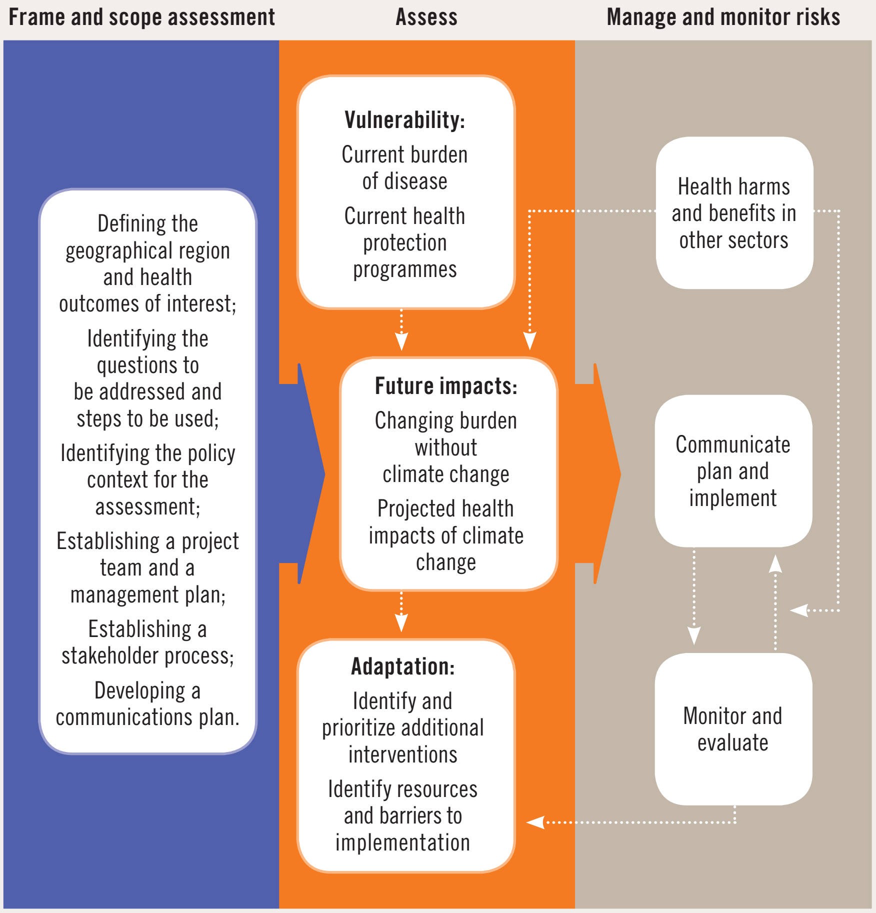
The basic steps of an assessment are:

1. Frame and scope the assessment:
   - define the geographical region and health outcomes of interest;
   - identify the questions to be addressed and steps to be included;
   - identify the policy context for the assessment;
   - establish a project team and management plan;
   - establish a stakeholder process;
   - develop a communications plan.
2. Vulnerability assessment: Describe the human health risks of current climate variability and recent climate change, and the public health policies and programmes to address the risks. This includes:
   - describing the current risks of climate-sensitive health outcomes, including the most vulnerable populations and regions (2.2.2);
   - describing the current capacity of health and other sectors to address the risks of climate-sensitive health outcomes (2.2.6).

3. Impact assessment: Project future health risks and impacts under climate change. This includes:
   - describing how the risks of climate-sensitive health outcomes, including the most vulnerable populations and regions, may change over coming decades, irrespective of climate change (2.3.2);
   - estimating the possible additional burden of adverse health outcomes due to climate change (2.3.3).
4. Adaptation assessment: Identify and prioritize policies and programmes to address current and projected health risks. This includes:
   - Identify and prioritize polices and programmes to address current and projected health risks (2.4.1);
   - Identify additional public health and health-care policies and programmes to prevent likely future health burdens (2.4.2);
   - Identify resources for implementation and potential barriers to be addressed (2.4.4);
   - Estimate the costs of action and of inaction to protect health (2.4.5);
   - Identify possible actions to reduce the potential health risks of adaptation and greenhouse gas mitigation policies and programmes implemented in other sectors (2.4.6).
5. Establish an iterative process for monitoring and managing the health risks of climate change.

   These steps are shown in Figure 2.

Figure 2 Vulnerability and adaptation assessment



2.1 Frame and scope the assessment

The mandate for the assessment, and the time and resources available to the project team, will inform the scope of the assessment. Assessments can take from several months to more than a year, can involve a few to many scientists and stakeholders, and can have small or large budgets. The process of scoping and designing an assessment involves:

- defining the geographical region and health outcomes of interest;
- identifying the questions to be addressed and steps to be used;
- identifying the policy context for the assessment;
- establishing a project team and a management plan;
- establishing a stakeholder process;
- developing a communications plan.

The national climate change team, the Ministry of Health or another entity may call for the assessment.

2.1.1 Define the geographical range and health outcomes of interest

The first step is to determine the health outcomes of interest on which to focus and the geographical range for the assessment, as these choices determine the expertise and experience needed in the project team, the types of stakeholders to be involved, and the key audience for the results (see Box 1). In some cases, all climate-sensitive health outcomes will be considered in the assessment; in other cases, the focus will be on specific outcomes such as infectious diseases or the health impacts of extreme weather events. The assessment can start from the perspective of specific climatic changes (i.e. exposure) and determine their possible consequences, or from the perspective of current climate-sensitive health risks and determine how they could change with climate change. The geographical scale could be national or subnational.

Box 1 Assessment scoping: Experience from the Russian Federation

By Andrej M Grjibovski, Norwegian Institute of Public Health

The Russian Federation has regions with climate ranging from arctic to subtropical, raising different adaptation challenges for different regions of the country. Given that a substantial proportion of the country is located in the circumpolar areas and that the most pronounced climatic changes are expected to occur in the Arctic, it was decided to select one of the Russian circumpolar areas – Arkhangelsk region – for a climate change and health vulnerability and adaptation assessment. The main criteria applied in choosing a region were:

- size of the population at risk;
- burden of disease from climate-sensitive health outcomes;
- climate sensitivity of the health problems selected;
- data availability and quality;
- human resources available to conduct the assessment;
- feasibility of reversing impacts and availability of preventive measures;
- feasibility of mainstreaming climate change considerations within existing risk management services or systems.

The Arkhangelsk region is located in the north-western part of the Russian Federation. It has a territory of 587 400 km^2 and a population of 1.26 million. The city of Arkhangelsk is an industrial, cultural and research centre of the region, with a population of about 350 000. Together with the neighbouring towns of Severodvinsk and Novodvinsk, there is a total population of 600 000, ensuring enough data for a quantitative estimation of exposure–response relationships. The combination of a large urban agglomeration at high latitude provides unique opportunities for analysing associations between climatic factors and health-related outcomes. The region also includes the Nenets Autonomous Area, which has a high proportion of indigenous people, whose traditional lifestyle is based on reindeer herding and fishing. This provides an opportunity to compare the vulnerability of this population with ethnic Russians and with ethnic minorities in other circumpolar areas.

The vulnerability assessment focused on:

- all-cause mortality in the city of Arkhangelsk;
- cardiovascular and respiratory morbidity in the Arkhangelsk region;
- associations between climatic factors and selected infectious diseases in the Arkhangelsk region, particularly tick-borne encephalitis and salmonellosis;
- the health of the indigenous population in the Nenets Autonomous Area;
- impacts associated with extreme weather events and disasters.

Cardiovascular diseases are among the main killers in the region, accounting for more than two-thirds of all deaths and, along with injuries and accidents, contributing to the increase in overall mortality over the past 20 years. The region has a well-developed system for infectious disease surveillance, which covers more than 40 diseases. Some Russian studies suggest a recent increase in the incidence of tick-borne encephalitis and tick bites. The Arkhangelsk region covers areas where tick bites were reported many decades ago, and areas where tick bites have not been reported, providing a unique opportunity for studying the migration of ticks to the north.

2.1.2 Identify the questions to be addressed and steps to be used

Clearly stating the goals for the assessment, in terms of the questions to be addressed, is critical for defining the rest of the process. Lack of clarity on the assessment goals puts the assessment at risk of not providing the information needed by decision-makers.

Questions that may be addressed include the following:

- Which regions and populations in a country are the most vulnerable to climate variability and climate change?
- What is the current burden and distribution of climate-sensitive health outcomes?
- What factors other than weather and climate determine vulnerability of populations and health systems?
- How effective are current health or other sector policies and programmes in managing climate-sensitive health outcomes?
- How is the burden of climate-sensitive health outcomes likely to change over the coming decades, irrespective of climate change?
- What are the likely health impacts of climate change over the next several decades and over the longer term?
- How well is the health system prepared for changes in demand due to changes in the geographical distribution, incidence or timing of climate-sensitive health outcomes?
- What additional public health policies and programmes will likely be needed for effective health management?
- What policies and programmes are needed in other sectors to protect health?
- What are the estimated costs and benefits of the proposed policies and programmes?
- How will special vulnerabilities of groups such as indigenous communities or women be considered in the assessment?

2.1.3 Identify the policy context for the assessment

The policy context and purpose for conducting the assessment should be described, including existing policies and programmes relevant to climate change, health and critical health determinants, such as water or land management. In many low-income countries, assessments are conducted as part of the national communications to the United Nations Framework Convention on Climate Change (UNFCCC). All countries that are signatories to the UNFCCC are required to produce regular national communications that include a section on vulnerability and adaptation. Non-Annex 1 countries are provided with funding to conduct their national assessment, which is supposed to cover all sectors vulnerable to the impacts of climate change. In addition, some regions and countries have policy processes that overlap with, or encompass, the links between climate change and health, such as regional health and environment ministerial processes (see Box 2) or national environmental health action plans. The policy context for the assessment can also include the influence of civil society and nongovernmental organizations (NGOs), often in reaction to experienced impacts of extreme events such as floods or droughts, that can prompt concern over the effects of longer-term climate change.

Photo credit: Maria Pia Valdivia/Photoshare.

A physician meets with a group of rural clients in the Puno region of Peru.

Box 2 Integrating climate change into other environmental health processes: The Ghana situation analysis and needs assessment for the Libreville Declaration

By Edith Clarke, Ghana Health Service Ministry of Health, based on UNEP & WHO (2010)

The Libreville Declaration is a commitment by African ministers of health and ministers of environment to address health and environment interlinkages and derive synergies from intensified collaboration through the development of national plans of joint actions in African countries. The national plans are based on evidence from a situation analysis and needs assessment that establishes baseline information on where a country stands in relation to 11 action points within the Declaration, and identify what is needed to achieve their objectives and targets in the National Joint Plans of Action for Health and the Environment. The goal of the situation analysis and needs assessment is to help national authorities establish milestones on health and environment, particularly to achieve the Millennium Development Goals. Climate change risks and responses can be mainstreamed into this process of environment and health management.

In Ghana, the situation analysis and needs assessment completed in 2009–2010 provides information on:

- natural and man-made risk factors interacting with the effects of climate change, such as conditions that could increase malaria transmission;
- national institutions whose mandates include some aspect of the health risks of climate change;
- national regulations covering the health risks of climate change, such as the Community Water and Sanitation Agency Act (Act 564);
- multilateral environmental agreements with relevance for climate change, including the status of implementation;
- national frameworks with relevance to the health risks of climate change, such as the Growth and Poverty Reduction Strategy;
- health development plans, such as annual programmes of work;
- specific programmes addressing climate-sensitive health outcomes, such as the malaria control programme, including monitoring and surveillance programmes.

2.1.4 Establish a project team and a management plan

Members of the project team need relevant expertise and experience for assessing the risks of climate change for the health outcomes of interest in the chosen region. If the focus is on vector-borne diseases in a particular region, then the project team could include entomologists, public health specialists, representatives of the health-care system, meteorologists and officials in related areas.

The management plan should include the assessment timeline, roles and responsibilities, and budget. For a thorough discussion of how to establish a management plan, see Kovats et al. (2003).

Photo credit: UN Photo/Isaac Billy.

Strong partnership with all stakeholders is an essential first step.

2.1.5 Establish a stakeholder process

Assessing the health risks of climate change and identifying possible policies and programmes to increase resilience needs to be informed by all groups engaged in or concerned with the prevention and management of the health impacts of climate change, including within the ministry of health, universities, NGOs, national and regional emergency preparedness committees, and those affected by climate change. Community, regional and national climate change initiatives and those focused on managing climate-sensitive health risks may be helpful in identifying appropriate stakeholders.

At the beginning of the assessment, the project team will need to establish a process for generating stakeholder input to the design, implementation and conduct of the assessment and communication of the results. When identifying possible stakeholders, consideration should be given to those who will be involved with public health and health-care policies and programmes. Stakeholders may change during the course of an assessment because the needed experience and expertise for assessing current health burdens, projecting future burdens and identifying modifications to policies and programmes to reduce health risks will differ. For example, stakeholders with an understanding of the vulnerability of specific populations may differ from those with information on the effectiveness of different public health and health-care programmes to address a particular health outcome.

2.1.5.1 Possible stakeholders to include in an assessment

Stakeholders include decision-makers, scientists, programme managers (from ministries, departments and NGOs in the areas of health, emergency preparedness, agriculture, water resources, urban planning, transport, development and others) and those most likely to be affected by climate change. Including their expertise and experience during the assessment will help ensure that key issues are identified and addressed (see Boxes 3 and 4).

Two stages of stakeholder involvement may be required. At the initial stages of project scoping, the stakeholder group will probably be small to enable the efficient identification of objectives and additional stakeholders needed. Following initial scoping activities, the full project team and a broad, diverse group of stakeholders should be engaged throughout the assessment. It will be important to include representatives of institutions who are important contributors of data or analytical skills, who will implement the identified policies and programmes, and who may be affected by such policies or by climate change impacts. The roles and responsibilities of the stakeholders should be clear to all participants. The assessment process is an opportunity to develop an ongoing network of partners engaged in or concerned about the health impacts of climate change.

For national assessments, countries typically hold at least one stakeholder meeting with representatives from all ministries, NGOs, universities and other relevant groups. The assessment goals are presented and discussed, and input is sought on high-priority issues that need to be addressed (including geographical regions and vulnerable populations). Ideally, stakeholders should represent the programmes that deal with the health outcomes; organizations and institutions that are knowledgeable about climate change and development plans; local, regional and national decision-makers; and the most vulnerable groups. For example, if waterborne diseases are a high-priority issue, stakeholders could include representatives from the country's ministry of health, ministry of the environment (assuming it deals with climate change), ministry of finance (assuming it oversees infrastructure development and planning), water managers, scientists involved in water-related issues, and community leaders and others who understand patterns of water use and misuse in their communities. The output from an initial stakeholder meeting will include further specification of the content and process of the assessment, and details of how to ensure active and sustained stakeholder dialogue throughout the assessment.

A substantial literature exists on stakeholder engagement, including planning approaches, the role of facilitators and principles of effective consultation. See, for example, UNDP (2003).

Box 3 Application of the WHO Regional Office for Europe (WHO/EURO) stakeholder engagement tool: Experience from the former Yugoslav Republic of Macedonia

By Vladimir Kendrovski and Margarita Spasenovska, based on WHO/EURO (2010)

The Ministry of Health in the former Yugoslav Republic of Macedonia selected a steering committee on climate change and health to identify key stakeholders and develop an engagement plan for the project Protecting Health from Climate Change in Southeast Europe, Central Asia and the Northern Russian Federation. The following steps were followed to identify and organize stakeholders for the project:

1. Identify the stakeholders. Steering Committee members listed all stakeholders that could be engaged in the assessment and in developing a national climate change and health adaptation strategy.
2. Analyse the stakeholders. The list was analysed to identify the interest from each stakeholder in the project and their expected influence in helping develop a national climate change and health adaptation strategy.
3. Categorize the stakeholders. The stakeholders were categorized into four groups:
   (1) those with whom the project should partner;
   (2) those who should be involved directly;
   (3) those who should be consulted; and
   (4) those who should be regularly informed.
4. Develop a stakeholder engagement plan. A stakeholder engagement plan was developed according to the level of desired engagement, stakeholder concerns and interests, and operational requirements to complete the project. For example, stakeholders who were critical to involve were assigned to be representatives on project boards. Briefings and workshops were organized to inform those to be consulted, and e-mail bulletins were sent to those to be informed.
5. Update the stakeholder categorization and engagement plan. The stakeholder categorization and engagement plan was regularly updated to ensure all relevant groups were engaged.

Box 4 Criteria for stakeholder selection: Informing adaptation decisions in Costa Rica

By L Navarro, Ministry of Health, Costa Rica

The assessment of health risks from climate change in Costa Rica was approached from the perspective of understanding how health determinants could be affected by future climatic patterns. The process was highly participatory through the inclusion of intersectoral and multidisciplinary representatives, qualitative expert assessments, and open information exchanges to ensure broad engagement and input. The Costa Rica team identified stakeholders based upon five criteria proposed by the Ministry of Health:

- Legal importance: Degree to which the participation of the stakeholder is needed as a legal requirement for addressing this issue.
- Political importance: Degree to which the stakeholder can influence political decisions at the national level.
- Strategic importance: Degree to which involvement of the stakeholder facilitates achieving the strategic objectives of the assessment.
- Relation with the topic: Degree to which the stakeholder is directly affected by the issue.
- Representation: Degree to which involvement of the stakeholder guarantees representation and equitable social participation.

2.1.6 Develop a communications plan

Plans for communicating the assessment process and results should be formulated at the start of the process. The credibility and legitimacy of the assessment results will be increased if stakeholders and the intended end-users have been informed of and included in discussions throughout. The audience for the assessment – such as the ministry of health at the national or subnational level, and the team responsible for the national communication to UNFCCC – and the mechanisms for communicating the results need to be identified. For example, the results could be presented in a report aimed at the appropriate officials and programmes within the ministry of health, with an executive summary that will inform the national communication.

Well-developed and implemented communications activities are needed to ensure the inputs and findings of a vulnerability and adaptation assessment are relevant to decision-makers, which will increase the chance that they will be used (see Boxes 5 and 6). Approaches to communication are summarized in Kovats et al. (2003). In general, it is helpful for communications plans to include a summary of the assessment process, stakeholders included, description of the deliberations, and summary of priority policies and programmes recommended.

Box 5 Assessing and communicating the vulnerability of Canadians to the health impacts of extreme heat events

By Peter Berry, Health Canada

As the number, intensity and duration of extreme heat events are very likely to increase, heat poses a growing public health risk in many regions of Canada. Temperature projections indicate that the number of hot days (above 30 °C) in some Canadian cities is expected to almost double by 2041–2070 (Casati, 2010). To prepare for the projected increase in extreme heat events some Canadian communities are implementing heat alert and response systems (HARS). Knowledge derived from vulnerability and adaptation assessment allows for the development of effective HARS and other interventions (e.g. public health programmes, transportation services, urban heat island mitigation). It also supports efforts by public health and emergency management officials to target population groups needing assistance and to develop effective communications strategies and health protection messages.

Drawing from the WHO/AMRO assessment guidelines, Health Canada developed a guidance document to assess extreme heat and health vulnerability, *Adapting to extreme heat events: Guidelines for assessing health vulnerability*. The guidelines are being tested through the completion of vulnerability assessments in Winnipeg (Manitoba), the Assiniboine Regional Health Authority (Manitoba), Windsor (Ontario) and Fredericton (New Brunswick). The assessments are using a broad range of health data and methods, such as literature reviews, stakeholder consultations, epidemiological studies, expert judgement, climate models and climate scenarios. They will provide information to decision-makers on historical weather and future climate trends, (e.g. daily maximum and minimum temperatures), the urban heat island effect, population sensitivity to extreme heat (e.g. older adults, people on certain medications, outdoor workers, athletes, infants and young children), the capacity of individuals to adapt (e.g. socioeconomic conditions, the strength of social networks, literacy and educational attainment) and community capacity to take protective actions (e.g. available social services, cooling options, public transit services).

Broad communication of the assessment findings, especially findings relating to heat-vulnerable groups, is critical in order to prepare for extreme heat events. To help communicate with people most at risk during, before and after extreme heat events and thereby reduce health impacts, Health Canada has developed *Communicating the health risks of extreme heat events: Toolkit for public health and emergency management officials.* The Toolkit provides guidance on delivering a successful heat-health communications campaign and scientifically sound messages that can be tailored to meet audience needs.

The publications can be accessed at *http://www.hc-sc.gc.ca/ewh-semt/pubs/climat/index-eng.php*

Box 6 Communication of the Tunisian assessment

By Mazouzi Raja, Ministry of Public Health, Tunisia

Over the period 2007–2010, Tunisia carried out an intersectoral assessment of vulnerability and adaptation to climate change, including human health. The resulting experience demonstrates that the exchange of information among assessment leaders, researchers, stakeholders, decision-makers and civil society needs to occur throughout the process and after completion of the assessment. Effective communications were supported by:

- an intersectoral committee led by the health sector, and including representatives from other sectors. The committee facilitated engagement in the assessment by concerned stakeholders and ensured access to information by all parties;
- training workshops undertaken by the committee to build capacity and increase the knowledge of all members about issues relevant to the assessment;
- the celebration of World Health Day, Protecting Health from Climate Change, that was used as an opportunity to increase awareness of the assessment.

A number of communications activities are planned to disseminate results from the assessment and the adaptation strategy that will be developed. A survey will be conducted of the current knowledge of climate change issues among health officials and professionals. This will be followed by sessions to raise awareness of climate change and health issues. The adaptation strategy will be translated into English, French and Arabic to ensure that it is accessible to the widest possible audience, and will be disseminated through outreach workshops at local and regional levels.

Photo credit: WHO/Jim Holme.

A child collects potable water from a tank at the Internally Displaced Persons (IDP) Camp near Banda Aceh.

2.2 Conducting the vulnerability and adaptation assessment

2.2.1 Establish baseline conditions by describing the human health risks of current climate variability and recent climate change, and the public health policies and programmes to address the risks

The magnitude and extent of health impacts of climate change are a function of the interactions between exposures to climate change-related alterations in weather patterns, and the vulnerabilities of the exposed human and natural systems that are relevant for the incidence and geographical range of climate-sensitive health outcomes. Therefore, the severity of impacts is determined by changes in climate and concurrent changes in non-climatic factors. Exposures include changes in the frequency and intensity of extreme weather events, and changes in mean temperature, precipitation and other weather variables that have consequences for health determinants, such as food and water security, and for disease transmission pathways. Vulnerabilities are the consequence of a range of factors, which need to be investigated and understood within the context of the multiple determinants of health outcomes. Adverse health outcomes from flooding, for example, are a consequence not only of heavy precipitation but also of infrastructure and land use choices over previous decades, the effectiveness of emergency risk management programmes, and other factors. In another example, malnutrition is a consequence not only of local and regional crop yields that are affected by temperature and precipitation patterns, but also of the vulnerability of the food production system to trade policies, access to an adequate and diverse diet, and other pressures.

The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability to climate change as the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate variability and change (IPCC, 2007a). Vulnerability of a population or a location is the summation of all risk and protective factors that ultimately determine whether a subpopulation or region experiences adverse health outcomes (Balbus & Malina, 2009). The vulnerability of a location can be due to factors such as the baseline climate, including the expected magnitude and frequency of extreme weather events, and geographical circumstances, such as coastal or urban settings that expose populations differentially to hazards. Population vulnerability is also a function of the effectiveness and coverage of the public health system and related institutions, reflected in the quality of surveillance and control programmes, and baseline morbidity and mortality conditions. Population characteristics such as the demographic structure of a population, the prevalence of pre-existing medical conditions; acquired factors such as immunity and genetic factors are important baseline vulnerability conditions (Balbus & Malina, 2009). Demographic and socioeconomic factors, including population density, social capital and the distribution of resources, also play a critical role in determining vulnerability, often interacting with biological factors such as nutritional status that lead to differences in the ability to adapt or respond to exposures or early phases of illness.

These multiple sources of vulnerability need to be considered when assessing current and likely future vulnerabilities. When considering where to focus the assessment, it may be important not only to consider current vulnerabilities and the current burden of specific health outcomes, but also to consider systems that are or could be affected by climate change, such as the vulnerability of food production systems to changes in temperature or precipitation, and how associated changes in food production could affect malnutrition.

2.2.2 Describe current risks of climate-sensitive health outcomes, including the most vulnerable populations and regions

The vulnerability baseline includes a qualitative or quantitative description of the current distribution and burden of climate-sensitive health outcomes by vulnerable population or region. The health outcomes included should reflect the priorities for the ministry of health or the local community.

Table 1 Categories of populations vulnerable to the health impacts of climate change

Vulnerability due to demographic factors	Proportion of children Proportion of women Proportion of elderly people Population density
Vulnerability due to health status	Populations with human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS) and immunocompromised populations Populations with tuberculosis (TB) Undernourished populations Populations with infectious disease burden Populations with chronic disease burden Mentally or physically disabled people
Vulnerability due to culture or life condition	Impoverished Nomadic and semi-nomadic peoples Subsistence farmers and fisherfolk Ethnic minorities Indentured labourers Displaced populations
Vulnerability due to limited access to adequate resources and services	Unplanned urban housing Flood risk zones Drought risk zones Coastal storm and cyclone risk zones Conflict zones Water-stressed zones Food-insecure zones Urban, remote, rural areas
Vulnerability due to limited access to adequate	Health care Potable water Sanitation Education Shelter Economic opportunities
Vulnerability due to sociopolitical conditions	Political stability Existence of complex emergencies or conflict Freedom of speech and information Types of civil rights and civil society

Source: Joy Guillemot, WHO.

2.2.2.1 Identify vulnerable populations and regions

Although climate change affects all populations and regions, some populations and regions are more vulnerable to climatic exposures and could, therefore, suffer greater harm if not prepared. This step should identify populations and regions with increased or decreased vulnerability to weather, current climate variability and recent climate change. Table 1 provides broad categories of vulnerable populations; a few examples include the following:

- All people living in a flood plain are at risk during a flood, but those with less ability to escape floodwaters and their consequences (such as children, infirm people, and people living in substandard housing along riverbanks) are at higher risk.
- Adults with chronic respiratory disease, people with asthma, children and outdoor workers are at increased risk during episodes of poor air quality.
- People living in areas where land-use changes such as deforestation, coastal development and urbanization may affect the distribution of infectious diseases.

Certain health conditions affect specific subpopulations to a greater or lesser extent, as a result of differences in both exposures and sensitivity. Examples of some of the most important relationships are shown in Table 2.

Photo credit: UN Photo/UNICEF/ZAK.

Children are among the worst affected by extreme weather events like the 2010 Pakistan floods.

Table 2 Vulnerability to climate-sensitive health outcomes by subpopulation

Groups with increased vulnerability	Climate-related vulnerabilities
Infants and children	Heat stress, air pollution, waterborne/foodborne diseases, vector-borne diseases, malnutrition
Pregnant women	Heat stress, extreme weather events, waterborne/foodborne diseases, vector-borne diseases
Elderly people and people with chronic medical conditions	Heat stress, air pollution, extreme weather events, waterborne/foodborne diseases, vector-borne diseases
Impoverished/low socioeconomic status	Heat stress, air pollution, extreme weather events, waterborne/foodborne diseases, vector-borne diseases
Outdoor workers	Heat stress, air pollution, vector-borne diseases, ultraviolet light (UV) exposure

2.2.2.2 Describe risk distribution using spatial mapping

Spatial mapping is a valuable approach for describing the geographical distribution of current or projected future vulnerabilities and hazards. A geographical perspective of risks is valuable as it offers a neutral platform for the integration, visualization and analysis of the various health and environmental data used or produced during the assessment. Maps also serve as important communication tools for explaining assessment results (see Box 7).

A geographical perspective and the use of geographical information systems (GIS) offer opportunities to show current distributions of, for example, vulnerable populations and the spatial relationship to disease vectors, river basins prone to flooding, health facilities, and other important variables of interest to public health officials. Various vulnerability and risk identification programmes, such as WHO Vulnerability and Risk Analysis and Mapping (VRAM) and the United Nations Development Programme (UNDP) Global Risk Identification Programme (GRIP), use GIS as one of their principal tools. Boxes 7 and 8 provide examples of how a spatial analysis can reveal linkages, illustrating how population risks factors may evolve over time and space.

Several GIS software packages are available in the public domain, and a variety of potentially relevant environmental, climate and sociodemographic data are available through web-based sources, including:

- HealthMapper
- EPI INFO: *http://www.cdc.gov/epiinfo/maps.htm*
- SIG-EPI: *http://www.paho.org/English/DD/AIS/sigepi_web2003en.htm*
- GRIP: *http://www.gripweb.org/grip.php?ido=1000*
- United Nations Environment Programme (UNEP) Environmental Information Mapping: *http://maps.grida.no/*

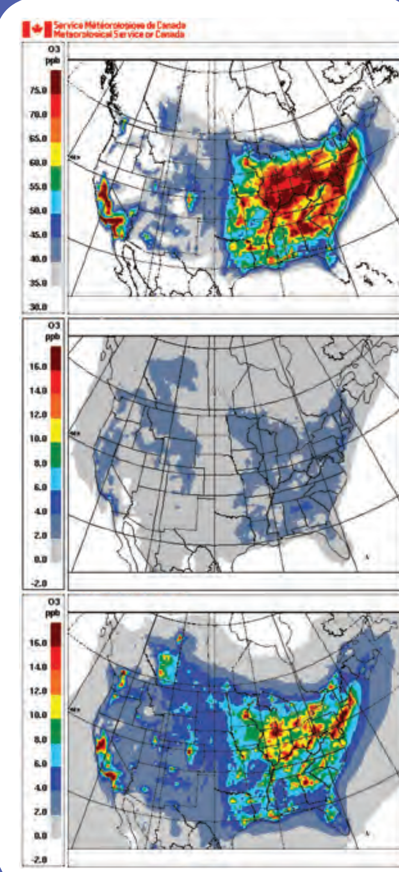


Photo credit: **Health Canada, 2008.**

Projected increase in air pollution under a changing climate.

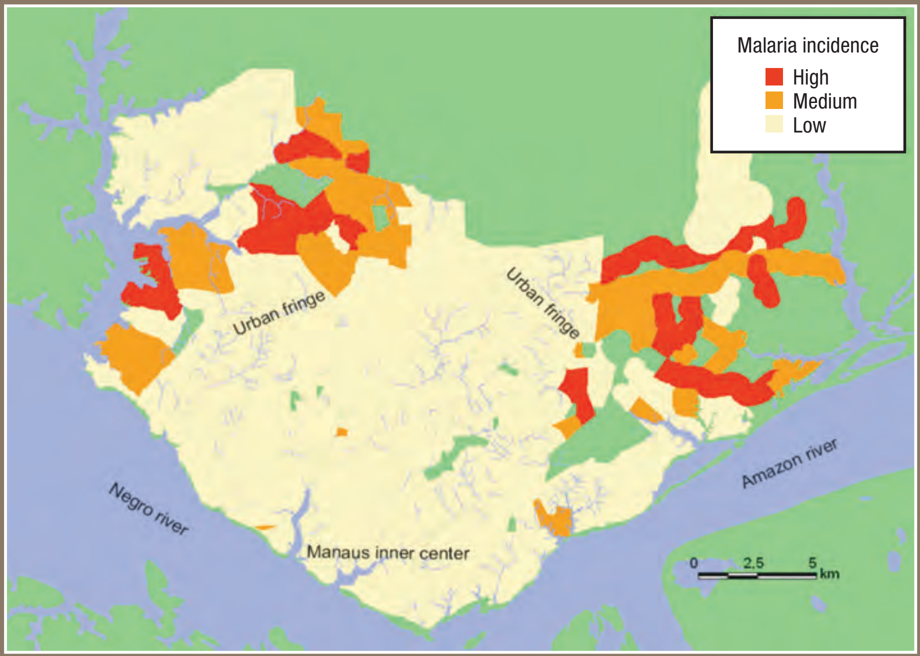
Box 7 Using GIS to identify vulnerable populations in Brazil

By Cristovam Barcellos, FIOCRUZ Brazil

Disease transmission during outbreaks is a consequence of close associations between humans and the environment, social organizations within communities, and existing health services. Spatial analysis using GIS can characterize the human and ecological landscape in which disease is transmitted to identify vulnerabilities and possible interventions. For example, vulnerability to flooding may be investigated by combining information on elevation, sanitation conditions, population density, disease incidence and the presence of basic health services. GIS can be used to identify clusters of disease and the proximity of vulnerable populations to risk sources.

In Manaus, Brazil (in the Amazon basin), GIS was used to gather and analyse health, environmental and sociodemographic data to assess the risks of climate change affecting malaria incidence along the urban fringe. Deforestation, the presence of creeks and recent settlement explain the high incidence of malaria in this area. The pace of deforestation and the extent of floodable creeks could increase considerably during the next decades due to river water-level variation and land-use pressures. The map (Figure 3) allowed health managers to identify areas of high malaria prevalence and environmental risk factors that may be exacerbated by climate change, assisting in the planning of prevention programmes.

Figure 3 Classification of districts of Manaus, Brazil, by malaria incidence



Box 8 Using landscape epidemiology to identify geographical boundaries of disease risk: Example of high-altitude malaria in Bolivia

By Marilyn Aparicio Effen, Facultad de Medicina, Universidad Mayor de San Andres, La Paz, Bolivia

Recent outbreaks of high-altitude malaria in the Andean regions of Bolivia may be related to climate change, as evidenced by an outbreak in eight communities of Carabuco and Mocomoco counties, situated 2600–3590 m above sea level and about 50 km from Titicaca Lake. The disease affected non-endemic communities during the rainy season (January to May) in 1998. The cold climate and high-altitude semi-arid ecosystems were assumed to preclude development of disease-carrying *Anopheles* mosquitoes as neither malaria nor other vector-transmissible disease antecedents were previously recorded in the area.

The results of the assessment of the 1998 malaria outbreak include climate analyses; comprehensive ecosystem evaluation; biodiversity changes; vector habitat modification; entomological, social, clinical and laboratory examinations; and landscape level epidemiology carried out by LANDSAT satellite images and GIS. These analyses provided evidence of a temperature increase of 0.8 °C between 1960–1990 and 1991–2007, ecosystem changes, positive blood samples of Vivax malaria parasites in the population, and the presence of the vector *Anopheles pseudopuntipennis*. The strong El Niño of 1997–1998 was a contributing factor.

2.2.3 Analyse the relationships between current and past weather/climate conditions and health outcomes

A clear understanding of the relationships of health outcomes and weather and climate patterns is essential when assessing the risks that climate change poses to population health. These analyses, often referred to as sensitivity analyses, should describe current vulnerability at the geographical scale and level of detail that is most suitable for decision-makers, taking into consideration the type and quality of evidence.

In some cases, quantitative data are not available or even necessary to describe these relationships. The burden of the chosen health outcome can be estimated using expert judgement and described in relative terms (e.g. there is a high burden of endemic malaria in a particular district, or there is a medium risk of epidemic malaria in another).[3] Observed seasonal epidemiological trends and disease outbreaks associated with weather anomalies over time can also be good indications of the sensitivity of the outcome to meteorological conditions (e.g. incidence of disease during dry or wet seasons).

[3] National and subnational data, if available, can be used to quantify the burden. National data are available from WHO at *http://apps.who.int/whosis/data/Search.jsp* and in the Global Health Observatory at *http://www.who.int/gho/en/*. Information may also be available from climate-health risk maps and surveys conducted by NGOs and other organizations.

Approaches for quantitatively analysing relationships between weather variables and climate-sensitive health outcomes are detailed in Campbell-Lendrum & Woodruff (2007) and Kovats et al. (2003). Data availability, and the reliability, cost, spatial and temporal resolution and comparability of data, are issues that will need to be addressed during an assessment. At a minimum, analyses should be conducted of the relationships between health data and core weather variables, such as temperature, precipitation, relative humidity and extreme weather events and patterns. Health data are generally available from ministries of health, and weather data from national meteorological and hydrological services. However, in some countries, accessing data is challenging because some agencies charge for data, which can limit the scope of the analyses. Stakeholder participation from the data owners can help facilitate access (see Box 9).

Some sources of current and historical meteorological data relevant for the health decisions can be found at:

- World Climate Applications and Services Programm (WCASP): *http://www.wmo.int/pages/prog/wcp/wcasp/wcasp_home_en.html*
- Humanitarian Early Warning Service: *http://www.hewsweb.org/*
- Climate Prediction Center: *http://www.cpc.ncep.noaa.gov/*
- National Climate Services: *http://www.climate.gov/*
- International Research Institute for Climate and Society (IRI)/Earth Institute's Lamont-Doherty Earth Observatory (LDEO) Climate Data Library: *http://iridl.ldeo.columbia.edu/*
- IRI Climate and Health Resource Room: *http://iridl.ldeo.columbia.edu/maproom/.Health/*

The time periods and geographical and temporal resolution of weather and health data will often not match perfectly. There should be consultations with relevant disciplinary experts on the choices for the scale of analysis. If, for example, health data are available at the hospital level or the level of a census tract, and the catchment area includes several weather stations, then the weather data may need to be aggregated to the level of the health data. Because weather patterns can change over geographical regions, there should be caution when analysing health outcomes if the weather data have been measured at some distance and with a difference in altitude from the population being described.

There should be consideration of the robustness of conclusions that can be drawn if the time series for either the health or weather data are short. Often, health data are available for only a few years, and they are rarely available for decades or longer. Because climate change occurs over decades and longer, analyses over shorter timescales can provide information on possible risks associated with climatic conditions but cannot attribute how climate change has affected the geographical range or incidence of a particular health outcome. Where data are available over several decades, a valuable analysis is to try to detect a trend in a health outcome and assess whether some or all of the change can be attributed to climate change; this requires other drivers of the health outcome to be included in the analysis.

Box 9 Climate and health observatory: Innovations in data sharing, communications and partnership building in Brazil

By Christovam Barcellos, FIOCRUZ Brazil

Given the complexity of processes that drive climate change impacts on human health, it is necessary to gather data from different institutions in order to understand, monitor and project these outcomes. These data include not only climatic and human health variables but also trends in sociodemographic and environmental factors and institutional capacity.

The experience of the Brazilian Climate and Health Observatory demonstrates how to bring multiple institutions and stakeholders together to support actions to decrease human health vulnerability to climate change. The observatory has the following functions:

- gathering available data on climate, environment, society and health;
- conducting situation analyses and identifying trends and patterns related to climate change impacts on health (e.g. semi-qualitative graphs and maps);
- providing information to national alert systems and for monitoring health emergencies associated with extreme weather events;
- supporting research and development on climate and environmental changes and associated health impacts;
- promoting the active participation of civil society and citizens on issues related to climate change, environmental degradation and health impacts (e.g. news reports, commentaries, photographs).

The observatory project is supported by the Brazilian Ministry of Health and is coordinated by the Oswaldo Cruz Foundation. Through workshops, participants developed institutional agreements for sharing data and identified specific data formats, timescales and spatial resolution to be used at the observatory. Climate change and health impacts to be addressed first include direct impacts from heatwaves, floods and droughts; the expansion of vector-borne diseases; the vulnerability of water supply and sanitation systems, and the increasing risk of water-related diseases; and the interaction between climate change and impacts on air pollutants that increase the risks of respiratory diseases.

2.2.4 Identify trends in climate change-related exposures

Climate change and non-climate change-related exposures are important to human health. Assessments should consider how key health determinants such as poverty, the availability and quality of water and food, and population density could be affected by climate change. Analyses should focus on understanding these trends scaled to the area of interest. Below are the IPCC (2007a) conclusions for global trends in selected health determinants:

Health determinants sensitive to climate change: IPCC global projected trends

- *Heatwaves, floods, droughts and other extreme events:* Heatwaves are projected to increase, cold days to decrease over mid- to low latitudes, and the proportion of heavy precipitation events to increase, with differences in the spatial distribution of the changes (although there will be a few areas with projected decreases in absolute numbers of heavy precipitation events). Climate change is projected to significantly increase the frequency and duration of extreme droughts and the land area affected by these events over the next century.
- *Water availability* will be affected by changes in runoff due to alterations in the rainy and dry seasons. Changing temperature and precipitation patterns could affect the geographical distribution and abundance of vectors and pathogens.
- *Air quality:* Climate change may cause significant degradation in air quality by changing the formation of tropospheric ozone, the chemistry and transport of pollutants, aerosol generation, aeroallergen formation and dispersion, and the strength of emissions from the biosphere, fires and dust sources. The extent to which these changes are positive or negative, and their magnitude, are highly uncertain; changes also will vary regionally.
- *Crop yields:* Crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1–3 °C, depending on the crop, and then decrease beyond that in some regions. At lower latitudes, especially seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1–2 °C); this would increase the risk of hunger, with potentially large negative health effects in sub-Saharan Africa.

2.2.5 Take account of interactions between environmental and socioeconomic determinants of health

Particularly vulnerable populations and regions were highlighted in the Human Health chapter of the IPCC Fourth Assessment Report (Confalonieri et al., 2007). A source of vulnerability for many population groups is an inequitable distribution of resources that affects the ability to adapt. In many situations, climate change will increase inequity (Patz et al., 2007):

- *Vulnerable urban populations:* Urbanization and climate change may work synergistically to increase disease burdens. Urbanization can positively influence population health, for example by making it easier to provide safe water and improved sanitation. However, rapid and unplanned urbanization is often associated with adverse health outcomes. Urban slums and squatter settlements are often located in areas subject to landslides, floods and other natural hazards. Lack of water and sanitation in these settlements increases the difficulty of controlling disease reservoirs and vectors and facilitates the emergence and re-emergence of infectious diseases. Populations in high-density urban areas with poor housing will be more susceptible to the effects of increasingly frequent and intense climate-related natural hazards such as heatwaves, exacerbated in part by the interaction between increasing temperatures and urban heat island effects.
- *Vulnerable rural populations:* Climate change could have a range of adverse effects on some rural populations and regions. One example is increased food insecurity because of geographical shifts in optimum crop-growing conditions and decreases in crop yields; reduced water resources for agriculture and for human consumption; and loss of property such as crop land because of floods, droughts and a rise in sea level. Overall, the world is considered to be several decades behind agreed international targets on reducing hunger (Rosegrant & Cline, 2003; UN, 2006), and climate change is projected to increase the number of people at risk (FAO, 2005). Given the large number of people currently and potentially affected by malnutrition, this may be one of the most important determinants of health outcomes.
- *Populations in coastal and low-lying areas:* Climate change could affect coastal areas through an accelerated rise in sea level, a further rise in sea-surface temperatures, intensification of tropical cyclones, changes in wave and storm-surge characteristics, altered precipitation and runoff, and ocean acidification. All these changes could affect human health in these areas through flooding and damaged infrastructure; saltwater intrusion into freshwater resources; damage to coastal ecosystems, coral reefs and coastal fisheries; population displacement; and changes in the range and prevalence of climate-sensitive health outcomes, such as malaria, dengue and diarrhoeal diseases (WHO, 2006).

Photo credit: **UN Photo/Albert Gonzalez Farran.**

Sudanese women from Kassab Internally Displaced Persons (IDP) Camp in Kutum, North Darfur, venture out to collect firewood.

- *Populations in mountain regions:* Little published information is available on the possible health consequences of climate change in mountain regions (see Box 10). However, it is likely that vector-borne pathogens could take advantage of new habitats in altitudes that were formerly unsuitable, and diarrhoeal diseases could become more prevalent with changes in freshwater quality and availability (Ebi et al., 2007). More extreme rainfall events are likely to increase the number of floods and landslides. Glacier-lake outburst floods are a risk unique to mountain regions; these are associated with high morbidity and mortality and are projected to increase as the rate of glacier melting increases. Changes in the depth of mountain snow packs and glaciers, and in their seasonal melting, can have significant impacts on mountain and downstream communities that rely on freshwater runoff.
- *Other populations:* Other populations will be at increased risk, such as those living in fragile ecosystems (e.g. forests and deserts). Ecosystem services are indispensable to human health and well-being by providing food, safe water, clean air, shelter and other life-sustaining products or services. Changes in their availability affect livelihoods, income, migration and, on occasion, political conflict. The resulting impacts have wide-ranging impacts on health and well-being (Millennium Ecosystem Assessment, 2005).

Box 10 Exercise to plot climate-sensitive diseases in geographically defined populations

Because of concerns about health vulnerabilities related to climate change, a joint WHO/WMO/UNEP/UNDP workshop was conducted in the Hindu Kush–Himalaya regions (Ebi et al., 2007). Only crude estimates of the current burden of climate-sensitive diseases were available because of the lack of health surveillance data at the local level. Therefore, a qualitative assessment was conducted as a first step to generate this information. Expert judgement was used to determine the extent to which climate-sensitive diseases could be a concern in populations in mountainous and non-mountainous regions of six countries (see Table 3).

Table 3 Current climate-related health determinants and outcomes in the Hindu Kush–Himalaya regions

Country	Afghanistan	Bangladesh	Bhutan	China	Nepal	India
Heatwaves	M-P	P	–	P	P	P
Flood deaths/morbidity						
Glacial lake floods	M-P	–	M-P	M-P	M-P	M-P
Flash floods	M-P	P	M-P	M-P	M-P	M-P
Riverine floods	P	P	–	P	P	P
Vector-borne disease	P	P	P	P	P	P
Malaria	P	P	P	P	M-P	P
Japanese encephalitis	–	P	–	P	P	P
Kala-azar	P	–	–	–	P	P
Dengue	–	P	P	P	–	P
Waterborne diseases	M-P	P	M-P	M-P	M-P	M-P
Water scarcity, quality	M-P	P	P	M-P	M-P	M-P
Drought-related food insecurity	M-P	P	–	M-P	–	M-P

M-P health determinant or outcome occurs in mountainous and non-mountainous (i.e. plains) areas;
P health determinant or outcome occurs only in non-mountainous areas;
– health determinant or outcome is not present in the country (WHO/SEARO, 2006).

2.2.6 Describe the current capacity of health and other sectors to manage the risks of climate-sensitive health outcomes

Climate-sensitive health outcomes are among the leading causes globally of current morbidity and mortality. Every year there are millions of cases of malnutrition; climate-sensitive infectious diseases, such as diarrhoeal diseases, malaria and dengue; and injuries, disability and deaths due to extreme weather events. A wide range of policies and programmes exists to control these health burdens. However, it must be recognized that many countries are underprepared for the health effects of current climate variability and often suffer damages and health system setbacks when health burdens increase, for example during heatwaves or epidemics. Thus, it is very important to understand the effectiveness, strengths and weaknesses of these programmes under current conditions of climate variability and recent climate change. This assessment is needed to identify possible alterations to existing programmes and measures to increase capacity and address the additional health risks due to climate change.

The health sector, comprised of a health ministry, NGOs, private-sector actors and others, may have individual or joint responsibility for these programmes. For example, ministries of health typically have responsibility for vector-borne disease surveillance and control programmes. Other programmes, such as disaster risk management activities, may be joint activities across ministries (including health, emergency management and others) and include NGOs and local organizations, such as national societies of the International Federation of Red Cross and Red Crescent. Representatives from all relevant organizations and institutions should be consulted to find out what is working well, what could be improved, and the capacity of the programmes to address possible increases in the incidence or changes in the geographical range of the health outcomes of concern.

It is important to account for planned changes to existing policies and programmes, and any changes expected in levels of health-sector financing. Ministries of health often have 5- and 10-year plans that prioritize areas of investment for health promotion and protection. These plans detail proposed changes that could affect the coverage and effectiveness of health programmes. Taking account of proposed changes is necessary when developing adaptation plans to address the health risks of climate change.

The exact policies and programmes to be included will depend on the scope of the assessment, and may include measures from the health sector and other sectors. Engaging a wide range of stakeholders will help ensure that all relevant policies, programmes and interventions are assessed. Examples of interventions for specific climate-sensitive health outcomes include the following:

- Health outcomes related to extreme weather events:
  - early warning systems and emergency response plans;
  - programmes to monitor adverse health outcomes during and after an extreme weather event;

  - educational programmes for individuals, communities, responders and health-care workers on the risks of and appropriate responses to extreme weather events;
  - building design and infrastructure codes and standards;
  - laws and regulations on land use and land use planning.
- Vector-borne, rodent-borne and zoonotic diseases:
  - early warning systems;
  - surveillance and monitoring programmes for malaria and other vector-borne and zoonotic diseases;
  - maternal and child health programmes, including vaccination campaigns;
  - integrated vector management and environmental hygiene programmes;
  - educational programmes for individuals, communities and health-care workers on identifying and treating diseases.
- Water- and foodborne diseases:
  - regulations to control water- and foodborne diseases and contaminants;
  - programmes to increase access to and use of safe water and improved sanitation;
  - surveillance and monitoring programmes for water- and foodborne diseases;
  - educational programmes on food handling and safety;
  - water quality regulations;
  - watershed protection laws.
- Health outcomes related to air quality:
  - programmes to alert the population and health-care providers on days with poor air quality or fires and appropriate personal protection measures to undertake;
  - monitoring programmes for air quality and its health consequences;
  - educational programmes for individuals, communities and health-care workers on the risks of poor air quality and appropriate protection measures to adopt;
  - air quality regulations to control emissions of contaminants from traffic, industry and other sources.
- Malnutrition:
  - monitoring programmes for malnutrition in vulnerable populations;
  - programmes to support local food production and sustainable food sources;
  - emergency response plans to increase food security;
  - nutrition education for individuals and communities.

To assess the capacity and performance of current programmes, the following questions could be asked:

- What is the management structure for the programme? This information is necessary to identify constraints and opportunities for modifying the programme.
- What human and financial resources are available? Cataloguing these assets is important when planning additional policies and programmes.
- How effective is the programme in controlling the current health burden? Less than optimal effectiveness may be the result of limited human and financial resources, limited laboratory and material supplies, limited coordination among partners, administrative inefficiencies, and other factors. Addressing this question should include evaluations of overall effectiveness, particularly of programmes serving vulnerable populations and regions.
- How robust are core health system functions (such as human resource planning, disease surveillance, and emergency preparedness and response) to extreme weather events? This is important for identifying existing gaps that may be exacerbated by a more variable climate.
- How might proposed changes to the programme in the next 5–10 years affect its ability to address relevant climate-sensitive health outcomes?

There are many metrics that can be used to measure the effectiveness of these programmes, including trends in reductions in the number of injuries, illnesses or deaths; coverage of appropriate geographical regions and vulnerable groups; and the extent to which planned changes are likely to increase the ability of the programme or activity to further reduce current health burdens. Specific tools and checklists that exist to help identify programmatic strengths and weaknesses, such as those for evaluating disaster and emergency preparedness, are described in Boxes 11 and 12.

Box 11 Tool to evaluate health sector disaster risk management effectiveness and preparedness

By Jill Ceitlin and Ciro Ugarte, PAHO, based on PAHO (2010a)

It is essential to measure the effectiveness of policies and programmes designed to address the health risks of extreme weather events. The WHO/PAHO Health Sector Self-Assessment Tool for Disaster Risk Reduction[4] can be used to assess the level of preparedness of a health sector disaster management programme to handle weather-related and public health emergencies. Health disaster coordinators or other relevant stakeholders can apply this tool to get a snapshot of the status of preparedness, identify priorities for action to address gaps, and measure progress over time. The tool comprises:

- standards and health sector indicators for preparedness, mitigation, response/recovery functions, and establishing and sustaining partnerships;
- checklists with questions that can be used by the assessor to evaluate status against the indicators.

[4] See *http://new.paho.org/disasters/index.php?option=com_content&task=view&id=1375&Itemid=1.*

Box 12 Tool to evaluate the resilience of health services and facilities to extreme events and emergencies: the Hospital Safety Index

By Jill Ceitlin and Ciro Ugarte, based on PAHO (2010b)

The Hospital Safety Index[5] (PAHO, 2010b) is used to assess the safety of health facilities and the overall probability that a hospital or health facility will continue to function in major emergencies. It evaluates structural, non-structural and functional factors, including the environment and the health services network to which the facility belongs. The Hospital Safety Index is a rapid, reliable and low-cost diagnostic tool. It is easy to apply by a trained team of engineers, architects and health professionals. It can help countries begin to prioritize investments in hospital safety to address growing risks from climate change.

The Hospital Safety Index includes a guide for evaluators and a Safe Hospitals Checklist that is used to assess the level of safety in 145 areas of the hospital. For example, one functional factor that is assessed is whether a committee has been formally established to respond to major disasters. Evaluation teams have used the results of hospital safety studies to encourage risk managers from other sectors to contribute to disaster reduction actions, and to influence political agendas in this regard.

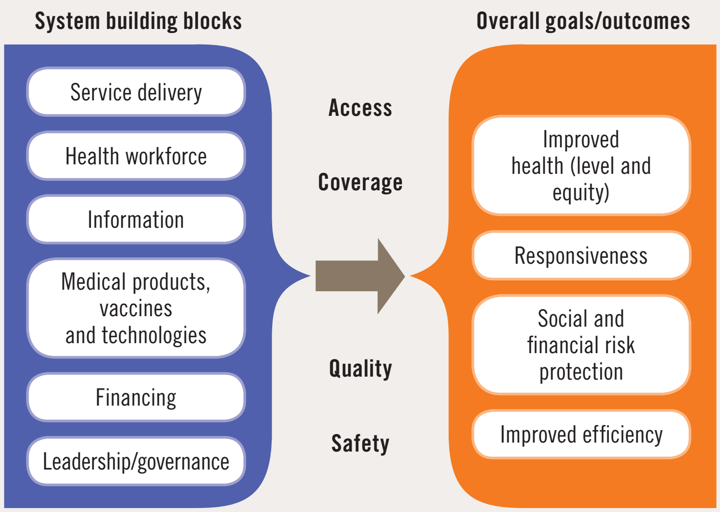
[5] See *http://new.paho.org/disasters/index.php?option=com_content&task=blogcategory&id=907&Itemid=884&test=true.*

2.2.6.1 Considering health system adaptive capacity and resilience

The resilience of a health system-related infrastructure, and specific policies and programmes to address climate risks, reflects the degree of flexibility and adaptive management incorporated within it. Today, few health policies and programmes are tailored to take into consideration weather conditions and seasonal trends, current climate variability and recent climate change. Most, such as surveillance and disease control programmes, were designed assuming a stable climate. Furthermore, the institutions that administer these policies and programmes may have structures that enhance or restrict their flexibility to integrate new information and respond to new conditions. As climate change accelerates, some policies and programmes will need to be modified to explicitly incorporate consideration of climate change. The effectiveness of a programme depends upon the functioning of the health system as a whole. Core health system components such as governance, financing, workforce management, information management and health service delivery will influence the capacity of actors to reduce climate-related health risks. These aspects should be considered to ensure climate risk management measures are integrated into the health system, and are adequately protective, cost-efficient and responsive to different needs and conditions in a changing climate (see Boxes 13 and 14).

Understanding the strengths and weaknesses of the health system and specific programmes to respond to changes and surprises is of critical importance to plan modifications needed to increase health system resilience. Figure 4 highlights important components and resources necessary to ensure health system functioning and resilience (see also Table 6 on page 46).

Figure 4 WHO Health System Framework



Source: *http://www.who.int/entity/healthsystems/HSSkeycomponents.pdf.*

Box 13 Strengthening health systems to prepare for climate change

By Bettina Menne, WHO/EURO

Strengthening health systems to address the additional health risks of climate change would reduce current and future health burdens. Health system actions to prepare for climate change include the following:

- Provide leadership and governance in advocating health in all policies. The health sector has a challenge – and an opportunity – to demonstrate its leadership and responsibility in dealing with climate change through its own actions, through leadership in developing national health adaptation plans that consider how climate change-related actions in other sectors could affect current and future population health, and through promoting equity and good governance in national and regional policies.
- Establish information systems that collect timely and relevant data on vulnerable populations and regions, and the incidence and geographical range of climate-sensitive health outcomes. This includes collaborations with national meteorological and hydrological services to ensure that appropriate environmental data are collected on the same scale as health data, and that policies and programmes are effective in addressing climate-sensitive health outcomes.
- Ensure adequate human and financial resources to protect individuals and communities from the health impacts of climate change. This includes providing training and capacity building for professionals and the public to support efforts to reduce health risks and providing effective service delivery during crises and disasters.

Box 14 Is a health system adequately prepared for crises?

By Gerard Rockenschaub, WHO/EURO

Preparing for and preventing a health crisis is becoming more complex in a changing global environment. The increasing number of weather-related events (e.g. heatwaves, floods, droughts, windstorms) and the increasing threat of a human influenza pandemic have underpinned the need for worldwide cooperation in strengthening public health defences to respond to emerging international health problems. WHO/EURO, in consultation with many partners and countries, has developed a tool that presents an overview of the essential attributes considered vital if a nation is to meet its national and international obligations in health crisis preparedness. Its objective is to minimize the health impact of future emergencies and crises by addressing the gaps in the resilience of health systems to respond to all threats. It does not provide technical detail; nor is it intended to replace the health system planning process. Rather, it helps to reduce the complexity of the crisis preparedness process into manageable units enabling the ministry of health to:

- identify tasks that need to be performed;
- establish responsibilities for undertaking specific tasks;
- determine how a task is interrelated with other partners, sectors and disciplines to realize synergies in resources;
- verify that the task is completed;
- evaluate the current status of health systems emergency and crisis preparedness planning.

This tool uses the six building blocks of the WHO Health System Framework (Figure 4) and underlines key elements inherent in it to separate and classify the different components that are essential to a comprehensive and effective health crisis preparedness process.

This tool is designed for use by ministry of health experts and officials from any other organizations (national institutes, NGOs, United Nations organizations, etc.) involved in health system crisis preparedness, and some of the elements can be used by officials at all levels of the health system whose task is to coordinate activities related to health crisis preparedness. Because health systems and supporting infrastructures vary from country to country, any planning must be tailored to fit the national context. Users are advised, therefore, to adapt this resource to suit their needs at the national and local level.

Photo credit: **WHO/Jim Holme.**

Climate change impacts on water and sanitation, increasing the vulnerability of families.

2.3 Understanding future impacts on health

2.3.1 Future health risks and impacts under climate change

The health impacts that may occur in a particular location will depend on the actual climate change experienced and the vulnerability of the community and region. Actual impacts will also be determined by the actions taken within and outside the health sector to address the projected risks and vulnerabilities, to prevent negative health outcomes. For example, the effectiveness of vector-borne disease surveillance and control programmes is determined partly by choices made in other sectors that affect access to safe water, and the ability of infrastructure to withstand flooding events.

2.3.2 Describe how the risks of climate-sensitive health outcomes, including the most vulnerable populations and regions, may change over coming decades, irrespective of climate change

Changes in demographics, socioeconomic development, urbanization and other important determinants are associated with increases or decreases in the incidence and geographical range of climate-sensitive health outcomes. Estimating how these factors are likely to increase or decrease in the future is required to accurately apportion increased health risks to climate change.

2.3.3 Estimate the possible additional burden of adverse health outcomes due to climate change

2.3.3.1 Select qualitative or quantitative methods for projecting future health risks

The possible additional burden of climate-sensitive health outcomes can be estimated qualitatively or quantitatively, depending on the data, resources and capacity available. Quantitative methods can be used for modelling relationships and extrapolating future burdens and risks. Qualitatively, expert judgement and development of scenarios can be used to estimate future impacts (see Boxes 15 and 16).

2.3.3.2 Qualitative approaches

Qualitative analysis is possible for estimating changes over shorter time periods. For example, *n* cases of malaria are currently occurring in a particular region. A new programme is planned to reduce the burden by 20%, taking into account population growth, distribution of insecticide-treated bednets, and integrated vector management programmes. Therefore, the future burden of malaria would reasonably be expected to be between the current burden and 80% of the current burden. In another region, control programmes are not expected to change, but demographic growth is expected to increase the number of cases by 10%. This description is the baseline against which the possible additional health burdens of climate change will be assessed.

Qualitative projections of possible changes in health risks also can be based on simple scenarios of climate change, such as a 1 °C increase in average temperature within 20 years, with a 10% increase in precipitation variability. Climate projections used in a country's national communication to UNFCCC or other assessments should inform the scenario used. Based on the results of previous assessment steps (see Section 2.2), possible future health burdens can be estimated by public health officials and other experts. For example, in rural areas in tropical countries with limited access to safe water and adequate sanitation, increasing average temperatures and precipitation variability will likely increase the burden of diarrhoeal diseases. The implication of this projected increase for the control of these diseases depends on the effectiveness and geographical coverage of current programmes. When possible, future health burdens should be estimated at the scale (i.e. community, city or region) where policies and programmes are implemented.

Box 15 Qualitative estimates of future health impacts of climate change using expert judgement

During the assessment of health risks and responses in the first Portuguese national assessment, a qualitative assessment was conducted of the possible impacts of climate change on vector-borne diseases, including malaria, West Nile virus, schistosomiasis, Mediterranean spotted fever and leishmaniasis; the latter two are endemic to Portugal. Although human cases of vector-borne diseases have generally decreased over recent decades, many competent vectors are still present in Portugal. Disease transmission risk was categorized qualitatively based on vector distribution and abundance and pathogen prevalence. Four brief storylines of plausible future conditions were constructed based on current climate and projected climate change, and assuming either the current distribution and prevalence of vectors and parasites, or the introduction of focal populations of parasite infected vectors. These storylines were discussed with experts to estimate transmission risk levels. For Mediterranean spotted fever, the risk of transmission was high under all storylines, suggesting that climate change is likely to have a limited impact. For the other diseases, the risk level varied across the storylines. For example, the risk of leishmaniasis varied from medium under current climate to high under both climate change storylines. The risk of schistosomiasis varied from very low (current climate and current vector distributions) to medium (climate change and focal introduction).

Source: Based on Casimiro et al. (2006).

Box 16 Qualitative health storylines help explore potential future health risks in Tashkent, Uzbekistan

By Joy Guillemot, WHO, as prepared by the Uzbekistan Working Group on Climate Change and Health, WHO/Ministry of Health Meeting on Climate Change and Health, July, 2010

Professionals from health and other sectors developed a qualitative storyline to describe future health outcomes during a vulnerability and adaptation assessment planning workshop. The exercise aimed to identify health determinants and exposures sensitive to climate change and imagine the possible kinds of future health impacts that could develop over the coming 20 years in Uzbekistan. This scenario exercise was used for brainstorming assessment design and to identify which health determinants and outcomes could be explored further with additional studies and data.

In 2030, Tashkent is projected to be composed of a larger proportion of its population under the age of 14 years and over the age of 55 years, increasing the number of individuals vulnerable to health risks. If rural livelihoods and industry grow slower than urban opportunities, then migratory pressures into urban areas will continue to increase to 2030. Key changes that could affect exposure and vulnerability include the following:

- Increased greenhouse gas emissions could result from increases in traffic volume and industrial and commercial activity. These activities also would increase air pollution and ground level ozone.
- Continued rapid urbanization and population increases could contribute to more solid waste production, with associated contamination of soil and water; this would increase pressure on social and public services that manage waste and pollution. The quality and quantity of the water supply would likely be stressed.
- Continued expansion of urban centres that reduces agricultural land could lower the capacity to produce local foods, particularly fruits, vegetables and grains.
- Warmer temperatures could increase the demand for energy for air conditioning.

If social and environmental conditions resemble this scenario, then risks associated with cardiovascular and cardiopulmonary disorders, allergies, upper respiratory tract complications and infections are expected to increase. Greater urbanization and pollution could also increase mental health concerns, cancer, and increased accidents and injuries from more traffic. Acute intestinal infections and diseases linked to malnutrition may increase in children. Food and water availability and quality were not addressed. New or emergent pathogens and vectors are likely. Such a health scenario will place increased demand on the current health system in multiple ways. It is possible that universal health insurance will be available by that time, increasing access to essential health services.

2.3.3.3 Quantitative approaches

Farmer checking temperature inside greenhouse in Wangdi, Buhtan.

Models are generally used to quantitatively estimate how the health risks of climate change could increase or decrease over time, particularly for longer time periods (see Box 17). Health models can explore the range of potential impacts of a changing climate in the context of other drivers of population health to better understand where, when and in what population groups negative health outcomes could occur. Risk managers can use the identification of vulnerable populations and regions to facilitate development and implementation of adaptation policies and measures to reduce projected negative impacts. Decision-makers can also use model results to "climate-proof" decisions, to better ensure that the policies and programmes implemented will be resilient to changing weather patterns and trends (Ebi & Burton, 2008). Models developed for other sectors, such as emergency management and in agriculture, may be used as the basis for, or in addition to, health models to facilitate understanding of how vulnerability to health impacts might change.

A word of caution is in order when models are used to project the health risks of climate change. Modelling can be a complex undertaking requiring highly technical expertise and specific data inputs that take time and effort to acquire. The capacity to design and run models to project health impacts can be developed through training courses and other mechanisms. A goal of the assessment could be to build research capacity and increase the availability of models to project health impacts in future studies.

Box 17 Developing quantitative projections of the health impacts of climate change in Oceania

By Diarmid Campbell-Lendrum, WHO

WHO and collaborators developed methods for quantitative estimation of the burden of disease from climate change (Campbell-Lendrum & Woodruff, 2007). The methods involve:

- identifying health outcomes sensitive to climatic influences and obtaining estimates of their current burdens;
- quantifying the relationships between climate and non-climate variables, and the selected health outcomes;
- defining future scenarios based upon both climate and other determinants;
- linking these relationships to estimate the burden of disease that is likely to be attributable to both climate and non-climate risk factors in the future.

This method was used to produce a quantitative risk assessment of health impacts from climate change for the Oceania region (McMichael et al., 2003b). The range of health impacts assessed and the main findings are shown in Table 4.

Table 4 Summary of the main findings of the risk assessment for climate change impacts on health in Oceania, for the year 2050

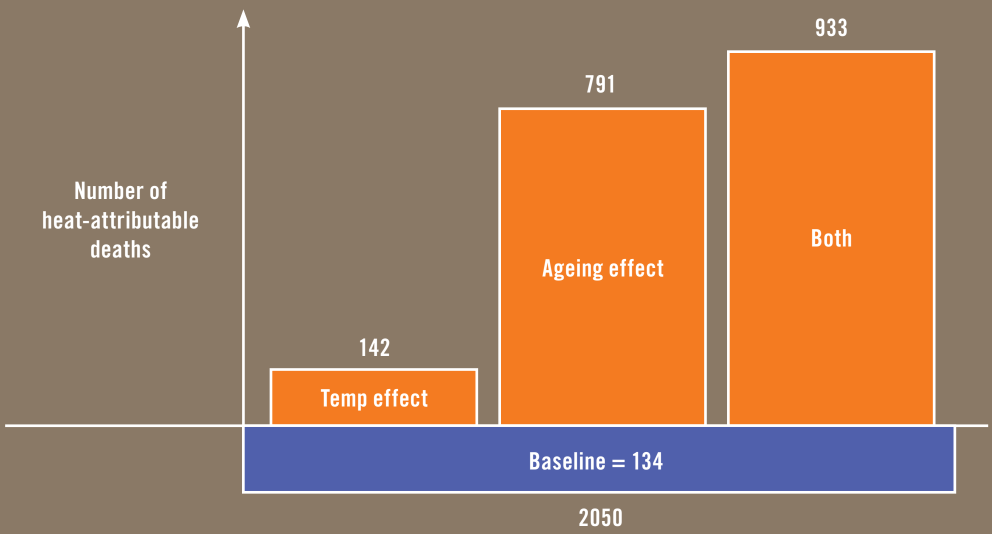
Exposure	Health impact estimated	Baseline health impact	Future health impact
Temperature extremes (cold and heat)	Attributable mortality in >65 year old age group	1100 deaths per year (across 10 cities); temperate cities have higher rates of heat deaths than tropical cities	Annual mortality range from 1400 to 2000, depending on scenario: increase in heat deaths will significantly outweigh decrease in cold deaths
Rainfall (inland)	Annual incidence of deaths and injuries	Average annual death rate in Australia (1970–2001) was 0.41/million (state rates varied from 0.05 to 3.1): the injury rate was 1.9/million (range 0.1–8.7)	Predicted annual death rate of 0.53–0.61/million (state rates vary from 0.06 to 4.8); the injury rate was 1.99/million (range 0.22–13.77)
Temperature and rainfall	Population living in a potential malaria transmission zone	Imported cases only	Substantial south-eastern expansion of the malaria zone
Vapour pressure	Population living in a potential dengue transmission zone	Dengue not established, but local outbreaks from infected travelers occur in far north-east Australia in most years	Substantial south-eastern and westward expansion of the dengue zone
Temperature	Annual incidence of diarrhoeal disease	Aboriginal people living in remote arid communities have high level of diarrhoeal disease	A 10% (5–18%) increase in the annual number of diarrhoeal hospital admissions among Aboriginal children

Box 17 Continued

The assessment findings illustrated the relative importance of climate and non-climate influences. For example, they showed that although increasing temperatures are likely to cause a significant increase in number of heat-attributable deaths in Australian cities, the trend towards a more elderly population (more sensitive to extreme heat) is expected to increase community and individual vulnerability by an even greater degree. Health authorities will need to plan for the overall increase in risk from both climate and non-climate factors.

The effect of a gradual increase in temperature and of ageing trends on the estimated annual number of deaths from heat stress in Brisbane, Australia in 2050, is shown in Figure 6.

Figure 5 Estimated heat-attributable deaths in Brisbane, Australia in 2050



The advantages of this method are that it can take into account both the size of the underlying burden of disease and the size of the proportional change. It can also be used to produce an aggregate estimate of the effect of climate change across a wide range of impact pathways, and provide some indication of the relative importance of different health impacts (e.g. whether changes in flood frequency may be more or less of a health problem than increasing malaria).

The main limitation is that it can only be usefully applied for health impact pathways where there are sufficient input data to build quantitative models. For example, although it may be possible to produce reasonable estimates of the effect of climate change on the burden of diarrhoea, there are currently no models to assess the possible health effects of more frequent drought, or of the gradual disappearance of glaciers that supply fresh water for large population groups. This method may therefore need to be used alongside other qualitative approaches to provide a more comprehensive vulnerability assessment.

2.3.3.4 Identify time periods for analysis

The assessment team will need to decide on the time periods to be considered in the assessment. The time periods used need to balance the needs of decision-makers, who are often focused on the next 5–10 years, with the need to understand how climate change could affect health risks over decades or longer. A particular challenge is considering how other factors are likely to change over time, such as demographics, urbanization and socioeconomic development. The longer the projection, the more uncertain are changes in these and other factors. The choice of time periods will depend on the focus of the assessment. For example, if one goal of the assessment is to determine health-care infrastructure needs and vulnerabilities, then a longer time period would be of interest. New buildings typically last for many decades and it would be helpful to know whether possible locations may experience increased impacts from future extreme weather events such as floods. The choice of time periods will also depend on availability of data on projected changes.[6]

Because of the inertia in the climate system, current atmospheric concentrations of carbon dioxide and other greenhouse gases have committed earth to several decades of climate change, irrespective of the rate and extent of reductions in greenhouse gas emissions. Therefore, projections for the next several decades do not need to take into account emissions of greenhouse gases under different scenarios, such as the specialized reference emission scenarios (SRES; see Box 18). Projecting possible health impacts of temperature and precipitation changes in these time periods should, however, take into account changes in demographics, economic growth and other confounding factors.

Longer-term projections need to take into account different emission scenarios in addition to other factors; possible time periods for projections are the 2060s/2070s and 2100. Any time periods chosen must be relevant for decision-makers. These scenarios can be qualitative or quantitative, or may include elements of both; for example, scenarios can be constructed with quantitative projections of demographic changes combined with descriptions of possible pathways for development of the public health infrastructure and health-care delivery in a particular region.

[6] Projections of changes in climate and other factors are available from the IPCC Data Distribution Centre at *http://www.ipcc-data.org/.* The United Nations Population Division has national-level demographic projections to 2050 for all countries at *http://www.un.org/popin/wdtrends.htm.* WHO has current estimates and projections of expected disease burdens at *http://www.who.int/healthinfo/global_burden_disease/en/.*

Box 18 Standardized reference emission scenarios (SRES)

SRES were developed as alternative images of how the future might unfold (Nakicenovic, 2000). Four different narrative storylines were developed to describe the relationships between driving forces such as population and economic growth, and their effects on greenhouse gas emissions (Figure 6). Probabilities or likelihood were not assigned to the individual scenarios. There is no single most likely or best-guess scenario. None of the scenarios represents an estimate of a central tendency for all driving forces or emissions.

Each SRES storyline assumes a distinctly different direction for future development, such that the four storylines differ in increasingly irreversible ways. The storylines were created along two dimensions – global versus regional development patterns and whether economic or environmental concerns would be primary. It is important to note that the scenarios do not cover all possible future worlds. For example, there is no SRES world in which absolute incomes are constant or falling. The A2 and B2 storylines are frequently used when modelling health impacts.

The A2 storyline describes a very heterogeneous world with an underlying theme of self-reliance and preservation of local identities. Fertility patterns across regions vary slowly, resulting in continuously increasing global population. Economic development is primarily regionally oriented, and per capita economic growth and technological change are fragmented and slower compared with the other scenarios.

The B2 storyline describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population (at a rate slower than A2), intermediate levels of economic development, and less rapid and more diverse technological change than A1/B1.

Figure 6 Alternative socioeconomic development scenarios described by the IPCC Special Report on Emissions Scenarios (SRES)

Economic emphasis →

Global integration ↑

Regional emphasis ↓

A1 storyline

World: market-oriented
Economy: fastest per capita growth
Population: 2050 peak, then decline
Governance: strong regional interactions; income convergence
Technology: three scenario groups:
- A1FI: fossil-intensive
- A1T: non-fossil energy sources
- A1B: balanced across all sources

A2 storyline

World: differentiated
Economy: regional oriented; lowest per capita growth
Population: continuously increasing
Governance: self-reliance with preservation of local identities
Technology: slowest and most fragmented development

B1 storyline

World: convergent
Economy: service and information based; lower growth than A1
Population: same as A1
Governance: global solutions to economic, social and environmental sustainability
Technology: clean and resource-efficient

B2 storyline

World: local solutions
Economy: intermediate growth
Population: continuously increasing at lower rate than A2
Governance: local and regional solutions to environmental protection and social equity
Technology: more rapid than A2; less rapid, more diverse than A1/B1

← Environmental emphasis

2.4 Adaptation to climate change: Prioritizing and implementing health protection

2.4.1 Identify and prioritize polices and programmes to address current and projected health risks

Adapting to the health risks of climate change is essentially a risk management process. A number of guidance documents not specific to the health sector describe approaches for identifying and managing the risks of climate change, including the following:

- Adaptation Policy Framework: *http://www.undp.org/climatechange/adapt/apf.html*.
- Climate Change Impacts and Risk Management: A Guide for Business and Government (Department of Climate Change, Australia): *http://www.climatechange.gov.au/en/what-you-can-do/community/local-government/risk-management.aspx*.
- Climate Adaptation: Risk, Uncertainty, and Decision Making Framework and Toolset (Climate Impacts Programme, United Kingdom): *http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=62*.
- Adapting to Climate Variability and Change: A Guidance Manual for Development Planning (United States Agency for International Development): *http://www.usaid.gov/our_work/environment/climate/docs/reports/cc_vamanual.pdf*.
- Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments (Climate Impacts Group, University of Washington, King County, WA; ICLEI, United States): *http://www.cses.washington.edu/db/pdf/snoveretalgb574.pdf*.
- Changing Climate, Changing Communities Guide and Workbook for Municipal Climate Adaptation: *http://www.iclei.org/index.php?id=8708*.
- Climate Vulnerability and Capacity Analysis (CARE): *http://www.careclimatechange.org/cvca/CARE_CVCAHandbook.pdf*.

2.4.2 Identify additional public health and health-care policies and programmes to prevent likely future health burdens

A previous step in the assessment evaluated the effectiveness of current policies and programmes to identify, prevent and control the occurrence of health outcomes associated with current climate variability and change. This part of the assessment discusses how to identify potential modifications to current policies and programmes and develop new policies and measures that may be needed to prepare for and respond to current and emerging health risks associated with climate change. Typically, public health officials and stakeholders involved in the design and operation of current programmes are best placed to identify appropriate modifications, as they have the detailed understanding of what works (and why), where improvements are needed, and the issues that should be addressed for effective implementation of the policies and programmes, including the human and financial resources, and approaches to overcome any institutional barriers (see Box 19).

The design and implementation of policies and programmes in a specific region take place within the context of slowly changing factors that are partial determinants of the extent of impacts experienced. These may include population and regional vulnerabilities, social and cultural factors, and the status of the public health infrastructure and health-care services. Successful efforts to reduce the impacts of climate change on health will require actions to address underlying vulnerabilities within and outside the formal health sector, such as improving the resilience of health-care facilities and services, reducing socioeconomic disparities, and providing services to vulnerable populations.

Many interventions recommended by stakeholders will likely be modifications to address weaknesses in current policies and programmes to address shifts in the incidence and geographical range of diseases. For example, the level of success of programmes designed to prevent foodborne diseases, such as salmonella, varies across developed countries (Kovats et al., 2004). The design and implementation of incremental policy changes should be grounded in an understanding of the adequacy of existing policies and programmes and how their effectiveness could change under different climate change scenarios. Because the risk of salmonella food poisoning may increase with warmer ambient temperatures that favour the growth and spread of the bacteria, enhancing current salmonella control programmes and improving measures to encourage adherence to proper food-handling guidelines can lower current and future disease burdens, no matter the future changes in climate.

Because surveillance and response activities are cornerstones of infectious disease control, modifications to incorporate the risks of climate change will likely be needed in many regions, for example by expanding current surveillance programmes to areas where changes in weather and climate may facilitate the spread of vector-borne, foodborne and waterborne diseases. A challenge in many low-income countries is meeting the ongoing financial and human capital commitments needed for surveillance programmes. Because many bilateral and international donors and organizations are using the results of climate change vulnerability and adaptation assessments to set priorities for additional funding, highlighting the implications of climate change for surveillance and response programmes may offer a possibility for obtaining needed resources.

For some climate-sensitive health outcomes, data collected from surveillance programmes can be the basis of early warning systems to reduce the magnitude or extent of a disease outbreak (WHO, 2005). If appropriately designed, early warning systems can be adjusted to incorporate projected increases in climate variability and change, thus preventing increasing burdens of adverse health outcomes.

Policies and programmes may be needed to address situations where thresholds could be crossed, leading to large increases in negative health outcomes, either because some aspect of disease transmission is close to its boundary conditions or because there is a sudden or large change in weather. Policies and programmes may also be needed to address new risks. The 2003 European heatwave could be categorized as a new threat because its strength and duration were outside the range of recorded historical experience (Beniston & Diaz, 2004; Stott et al., 2004).

Box 19 Setting priorities for adaptation in the Kyrgyz Republic

By Ainash Sharshenova, Scientific and Production Centre for Preventive Medicine, Ministry of Health, Bishkek, Kyrgyz Republic

To develop a national adaptation plan for health systems, the Ministry of Health of the Kyrgyz Republic involved interested ministries and multidisciplinary experts within a Government-approved working group. The Ministry of Health also worked with the Inter-Agency Group on Development of the National Strategy and Climate Change Adaptation Plan for the Kyrgyz Republic. A workshop was held to define the elements of the health plan, using a tiered approach that included comparative risk assessment and a multicriteria analysis to set priorities. The participants used a qualitative approach to identify the size of the population at risk and the perceived likelihood of harm; in addition, the timescale for risk was determined (see Table 5).

Table 5 Health adaptation plan priority issues

Health risk	Size of population at risk: 0=low, 10=high	Likelihood of harm: 0=low, 10=high	Total	Time
Heatwaves and cold spells	6	6	12	M
Mudflows	3	4	7	M
Food security and food safety	4	3	7	S
Quality of water	6	4	10	S
Infectious diseases	7	7	14	L
Migration	2	3	5	S
Quality of air	4	5	9	M
Cardiovascular diseases	6	7	13	L
Respiratory diseases	4	5	9	M

S short-term **M** medium-term **L** long-term

Further scoring was carried out to determine adaptation priorities to reduce health burdens, based on the following criteria:

- approximate costs of the intervention;
- benefits to health and other sectors from intervening;
- feasibility to implement within existing services or systems;
- potential harm from any intervention;
- potential barriers or obstacles;
- opportunities for implementation.

Stakeholder groups (health sector, professionals from outside the health sector, NGOs) ranked priorities somewhat differently. The highest priorities were eventually identified as interventions to address water quality, food security and food safety.

2.4.2.1 Identify all possible adaptation policies and programmes

In the process of identifying specific policies and programmes to suggest to decision-makers for implementation, it can be useful to begin by generating a list of all potential choices, without regard to technical feasibility, cost or other limiting criteria (Ebi & Burton, 2008). This range of choice (White, 1986) includes currently implemented interventions, new or untried interventions, and other interventions that are theoretically possible. The list may be compiled from a canvass of current policies, practice and experience, from a search for policies and programmes used in other jurisdictions and in other societies, and from a brainstorming session with scientists, practitioners and affected stakeholders. Listing the full range of potential adaptation policies and programmes provides decision-makers with greater choice and flexibility regarding the programmes that could be implemented to reduce the health burden of climate-related risks. It also provides information about which choices are constrained because of a lack of technology, information or resources, or as a consequence of other policies and programmes.

2.4.2.2 Evaluate policies and programmes to determine those that can be implemented in the near term

The next step is to evaluate the identified policies and programmes to determine which measures are practical for a particular situation, within existing technological, financial and human capital constraints. This step generates a list of policies and programmes from which decision-makers can choose. Criteria that can be used to determine which choices are practical include the following:

- Technical feasibility: Is the choice technically viable and available? For example, although a possible programme to address potential changes in the geographical range of malaria is vaccination, this option is not currently available.
- Operationally feasibility: Does the health system have an adequate workforce, sustainable financial resources, service delivery mechanisms, and technical knowledge and capacity to deliver the interventions or programmes?
- Degree of effectiveness: How effective is the proposed policy or programme in reducing the incidence of the adverse health outcome? For example, not all malaria prophylactics are effective in all regions because of the development of drug resistance.
- Environmental acceptability: Does the proposed policy or programme have environmental consequences that are unacceptable? For example, the draining of wetlands may decrease the number of vector breeding sites but also has adverse ecological consequences. Vector resistance to some insecticides has resulted from poor management of their use in agriculture and public health applications.
- Economic efficiency: How costly is the policy or programme in relation to the expected benefits? For example, if insecticide-treated bednets are too costly for people in exposed areas to purchase, would it be cost-effective to supply bednets free or at a subsidized rate? How much would this cost, and who would pay? Would bednets be used by those exposed or sold to neighbouring communities to supplement income? What would be the benefits in terms of the reduced incidence of malaria?
- Social and legal acceptability: Is the proposed policy or programme in accordance with the laws and social customs and conventions of the community or country? For example, the spraying of mosquito breeding sites with chemicals may need to be regulated or people may object to spraying.

After this evaluation, some policies and programmes will remain viable and others will be eliminated or deemed infeasible in the immediate term. This does not mean that they will be unavailable in the future; the fact that a theoretical programme is not considered feasible may be an incentive to find ways of removing the existing obstacles through research, changing laws, or educating the public about the benefits of a practice. Those choices that are "open" comprise the currently available practical range of adaptation policies and programmes.

2.4.2.3 Possible additional analyses to inform adaptation decision-making

Once the policies and programmes have been narrowed to practical choices, additional analysis can identify and prioritize these choices for consideration by decision-makers (Ebi & Burton, 2008). Analyses can be conducted through quantitative assessment, solicitation of expert judgement or stakeholder groups. Additional criteria may be needed to facilitate selection of practical policies and programmes. Examples include:

- intensity of the exposure (e.g. projected magnitude and extent of flooding) and the implications of exposure for the programme;
- requirements for implementation;
- availability of human and financial resources;
- compatibility with current policy;
- target of opportunity for implementation;
- actions needed to reduce possible negative consequences of the programme.

It can be useful to summarize the state of knowledge that underlies the evaluation of each criterion to help decision-makers create the necessary environment for implementation. For example, some vaccines need to remain cold at all times to ensure their effectiveness. Therefore, if vaccination is the most effective programme to deal with an outbreak, then provisions to ensure vaccine doses remain below a certain temperature need to be put in place. A longer-term solution is development of alternative vaccine delivery systems that do not require refrigeration.

This list of criteria is not comprehensive. There may be other criteria that the assessment may wish to take into account. For example, river basins often cross national boundaries, and so land-use practices in one country could affect flooding in another. In this case, transboundary cooperation and collaboration may be needed.

2.4.3 Prioritize public health and health-care policies and programmes to reduce likely future health burdens

Prioritizing which health risk should be addressed first, where the greatest benefits and reduction of harm will result, or which health concern merits the greatest resource allocation is not an easy decision process. The process should involve relevant stakeholders. Multiple criteria can be used to set priorities; they commonly include significance, benefits and effectiveness, costs, and feasibility. There may be other criteria of importance to stakeholders, such as maintaining cultural and social institutions (see Box 20). The actual criteria used to set priorities will depend on the goals of the assessment (i.e. reducing vulnerability to heatwaves, or increasing resilience to flooding events):

- Significance is used to assess the relative importance of the anticipated impact, such as the possible burden of additional adverse health outcomes.
- Benefits and effectiveness are used to assess the degree to which the programme would likely reduce vulnerability to the anticipated health impact. The benefits of the proposed programme should exceed their cost, given consideration of what stakeholders have agreed upon for measuring benefits. The flexibility of the programme to be modified in a changing climate must also be considered.
- The costs of the programme should be estimated. This includes operation and maintenance, administration and staffing, equipment and other requirements.
- Feasibility is used to evaluate whether the programme can realistically be implemented in the context of current and planned policies and programmes.

Stakeholders may identify additional criteria to apply, such as the extent to which proposed programmes reduce social inequities.

Healthcare worker checks the blood pressure of a woman in Kolkata, India.

Box 20 Prioritizing adaptation options in Cambodia

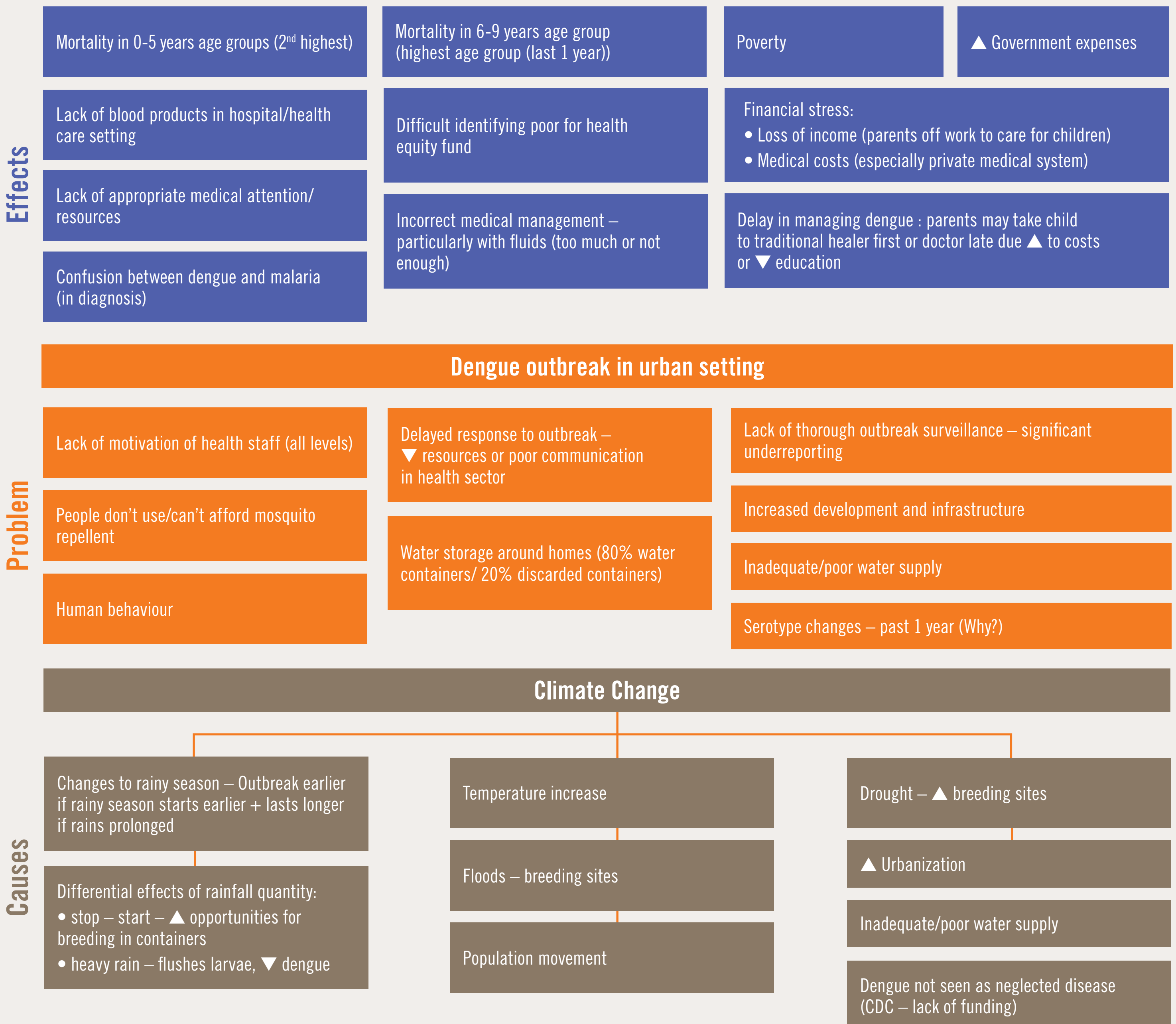
By Piseth Raingsey Prak, Ministry of Health of Cambodia

The Cambodian Vulnerability and Adaptation Assessment focused on addressing risks of vector-borne diseases (malaria, dengue fever), food security, waterborne and foodborne diseases, and the health consequences of extreme weather events. Once a list of potential actions had been identified, priority adaptation options were narrowed down using problem trees (see Figure 7) based on answers to the following questions:

Is, or does, the adaptation option:

- effectively address a current and future climate change-related public health issue?
- technically feasible given current resources and expertise?
- satisfy local community (and cultural) needs and preferences?
- integrate with, or complement, other programmes and national priorities?
- sustainable over time? Can it be scaled up?
- contribute to capacity building of the community, health sector or research capability?
- able to be monitored and evaluated?
- cost-effective? In the short-, medium- and long-term?
- have any potentially adverse public health outcome?

Figure 7 Cambodia assessment: Problem trees identifying different causal linkages and opportunities for health protection



Because there is no such thing as absolute safety, decision-makers seek to understand the question "how safe is safe enough?" The answer depends on the criteria that have been established and the social norms in a given society. Because a small elevation in risk may be manageable within existing policies and programmes, decision-makers should focus on approaches to manage larger increases in risk. Approaches for evaluating whether the risks associated with an exposure or activity are acceptable to society and leaders, or whether the threshold of risk requires action, include:

- an assessment of how much increased (or decreased) health burden will occur;
- comparative risk assessment to evaluate whether alternatives have comparable levels of risk. Comparative risk refers to the notion that all risks should be approximately equal to each other following risk-reduction strategies;
- benefit–risk assessment to evaluate the costs and benefits of risk reduction;
- multicriteria assessment to rank how well each adaptation meets established criteria such as effectiveness, feasibility and cost (Whyte & Burton, 1980). An advantage of this approach is that criteria do not need to be measured in common metrics, and criteria can be weighted to reflect relative importance.

Benefit–risk assessments compare the benefits to be gained from a particular policy or programme with the amount of risk reduction to be achieved. One underlying assumption is that society should not invest in policies and programmes for which there will be little gain. This is particularly relevant for risks that have been reduced to a fairly low level. Given that risks cannot be reduced to zero, decision-makers need to decide whether the effort required for further reduction in risk is an appropriate allocation of scarce public health resources.

Benefit–risk assessments may use cost–effectiveness or benefit-cost analyses (see Section 2.4.3 for further discussion). Cost–effectiveness analyses typically involve comparing the relative costs of different policies and programmes that achieve the same or similar outcomes. Benefit–cost analysis requires expression of benefits (e.g. avoided adverse impacts from an adaptation) and costs in a common metric, to allow benefits and costs to be compared to estimate whether the benefits exceed the costs. This is often done by expressing benefits in monetary terms. This is not straightforward for benefits that are not bought and sold in markets, such as avoided illness and extended human life (USEPA, 2010).

Multicriteria analysis is a type of decision tool particularly useful in cases where a single-criterion approach (such as cost–benefit analysis) falls short, especially where significant environmental and social impacts cannot be assigned monetary values. Multicriteria analysis allows decision-makers to include a full range of social, environmental, technical, economic and financial criteria (UNFCCC, 2010). An advantage of multicriteria assessment is that criteria do not need to be measured in common metrics, and criteria can be weighted to reflect relative importance.

Table 6 Health system resources for climate resilience

Financial resources	Adequate funds are needed to maintain core health system functions, including in the case of a crisis. In addition to providing funds for core health and public health services (water/sanitation/environmental hygiene/disaster and health emergency preparedness), it is necessary to plan for insurance or replacement costs for health facilities and equipment lost or damaged due to extreme weather events.
Human resources and capacity	A well-performing health workforce is needed to achieve the best health outcomes possible. This includes sufficient numbers and a mix of qualified, competent and productive staff to deliver health promotion and protection and take account of location and seasonal demands for staff (e.g. the cyclone season may demand higher numbers of staff in coastal zones). It also includes capacity development to build skills, ranging from health policy and management to newer disciplines such as application of meteorological information to health policy.
Service delivery mechanisms	Health service delivery should combine inputs to provide effective, safe, good-quality health interventions in an efficient and equitable manner. Health services may need to prepare for shifts or additional burdens, requiring revisions of organizational and management processes and the timing and location of service delivery.
Technology, pharmaceuticals or goods required	A range of medical products and technologies are needed to protect populations from climate-sensitive health conditions. These include medical equipment and supplies for emergency response, permanent and emergency health facility services, and technologies in health-supporting sectors such as water and sanitation and environmental hygiene.
Information resources	Health information systems that ensure the production and application of reliable and timely information on health determinants, health systems performance and health status, are essential for managing climate-related health risks. Health information system resources and functions include data collection, analysis, communication and reporting, hazard and vulnerability assessments, early warning systems, overall information infrastructure (hardware and networks), and the coordination mechanisms to link relevant information, (e.g. from meteorological or hydrological services), to inform health decisions.
Leadership and governance	Political will to take action to address the health risks of climate change is essential. This includes developing strategic policy frameworks, implementing adaptation plans, and ensuring effective monitoring and management. It is also necessary to build coalitions between relevant sectors and partners, including national and international climate policy mechanisms. It also requires public advocacy and risk communication to ensure public understanding and support.
Health partnerships and community engagement	The delivery of public health depends upon individual and community use of public health services and acquisition of public health education. Partnerships across stakeholder groups and levels are necessary to engage members of society as actors in their own health protection.

Source: Joy Guillemot, WHO, developed for climate change using the WHO/EURO Health Systems Crisis Preparedness Assessment Tool.

2.4.4 Identify resources for implementation and potential barriers to be addressed

For each priority policy and programme identified, it is helpful to write a brief description of the requirements that would be needed to implement it over the expected timeframe. Useful elements to describe include the estimated benefits and effectiveness for reducing current and future vulnerability to the health risk, the resources required, feasibility and constraints to implementation.

Health system resources needed for the implementation of climate-informed policy and programmes should consider the aspects included in Table 6. There should be a discussion of the current policies and programmes designed to address the health outcome, and where and when modifications are needed to increase their effectiveness to respond to current and projected climate variability and climate change. This discussion should consider how to ensure active and continued stakeholder engagement and financial sustainability; how to address changes in climate and population and health system vulnerability over time; and how uncertainties in climate projections and development pathways can be incorporated. Possible barriers, constraints and limits also should be addressed. Typical barriers to effective risk management include lack of leadership or political will, limited human and financial resources, limited or incorrect information and communication, lack of authority or jurisdiction to act, lack of coordination and partnerships, and social and cultural factors. There can also be barriers internal to the decision-makers, such as attitudes and beliefs. Options for overcoming institutional barriers are important to identify, evaluate and incorporate into adaptive management processes.

It is helpful to have a summary of the costs and benefits of each programme, including how the programme has been planned to reduce the burden of climate-sensitive health outcomes, the possible consequences for population health if the programme is not implemented, and estimates of the costs over time for implementation and continued support of the programme.

2.4.5 Estimate the costs of action and of inaction to protect health

Decision-makers are interested in the costs of measures to adapt to or avert climate change, and in the efficacy of policies and programmes. Estimates of the costs of current and projected impacts without additional policies and programmes (e.g. the costs of inaction) and of the costs of policies and programmes to address these risks (e.g. the costs of action) can contribute to health policies and resourcing decisions (see Box 21). The costs of inaction, or "damage" costs, include the costs of treating additional health burdens resulting from climate change, the costs associated with premature mortality, and other non-health-care costs associated with illness, such as time and costs of informal caregivers and lost productivity time. WHO has published a guide to estimating the economic consequences of disease and injury.[7] The costs of policies and programmes include all health promotion, preventive and curative interventions, including early warning systems and emergency response.

Once decision-makers are convinced they have to act, they need to know the costs of alternative courses of action and their relative merits (e.g. effectiveness and efficiency) in order to decide on a course of action. Many health actions are "no regrets" measures that are relevant even in the absence of climate change or under future climate uncertainty, as they aim to strengthen responses to existing health risks.

Given that health policies and programmes are rarely 100% effective, there are likely to be excess disease burdens, or "residual health damages", from non-avoided impacts. This may be because some health impacts are very difficult to mitigate (e.g. from natural disasters) or – more often – the marginal costs of avoiding some impacts are higher than households or governments are willing to pay. These residual health damages can be estimated and valued.

There is, of course, high uncertainty with estimating future costs in a changing environment. WHO (2010c) has published guidance on estimating the costs of interventions through the tool Cost-It. A simple approach to estimating the costs of adaptation is to estimate current or future cases of a health outcome attributable to climate change (with or without adaptation programmes) and to multiple that by the cost of prevention or, for non-avoided cases, by the cost of treatment – see Ebi (2008) for an example.

[7] See *http://www.who.int/choice/publications/d_economic_impact_guide.pdf.*

It should be noted that because of the adaptation deficit[8] in many communities, regions and nations, climate change-motivated investments in improving health-sector policies have the potential to address the larger burden of disease not attributed to climate change. In other words, under certain conditions, using adaptation funds to strengthen policies and response capacity can lead to net health gains.

The cost-effectiveness of individual or combined programmes can be assessed, providing estimates of the cost per case or death averted, as can the cost–benefit ratio, when health and other benefits are valued in monetary terms. Cost-effectiveness guidance is available from the WHO-CHOICE model (WHO, 2010c) and from Tan-Torres Edejer et al. (2003). Tools are available for costing specific diseases such as malaria (WHO, 2010a) and water and sanitation (WHO, 2010b).

[8] The "adaptation deficit" suggests that countries are underprepared for current climate conditions, and even less for future climate change.

Box 21 Estimating the costs of addressing the possible additional health burdens of climate change in Bangladesh

By Iqbal Kabir, Ministry of Health and Family Welfare, Bangladesh

Bangladesh is at very high risk from climate change impacts, including those related to human health. It is estimated that the lives and livelihoods of 36 million people in the southern coastal regions will be affected by climate change, including heat stress from extreme heat events; water- and foodborne diseases (e.g. cholera and other diarrhoeal diseases); vector-borne diseases (e.g. dengue and malaria); respiratory diseases due to increases in air pollution and aeroallergens; impacts on food and water security (e.g. malnutrition); and psychosocial concerns from the displacement of populations through sea-level rises and after disasters. The Government of Bangladesh estimated the additional costs to control diseases attributable to climate change for the next 10 years to 2021. The total costs were estimated to be US$ 2.8 billion, or 3% of gross domestic product, consisting of malnutrition (26% of costs), chronic obstructive pulmonary disease (22%), injuries and drowning (22%), dengue, malaria, chikungunya (11%), kala-azar (6%), diarrhoea (4%), filariasis (2%), and other diseases and events (8%) (see Table 7). To prepare for these impacts, the Government of Bangladesh is establishing a model health-care delivery service based on the development of new community health clinics and through the revitalization of primary health care services to reduce population vulnerabilities.

Table 7: Estimated costs of controlling additional health impacts of climate change in Bangladesh

Disease	Estimated cost (US$ million)
Diarrhoea (3.5 episodes/person/year @ BDT 50/episode[9])	102.94
Kala-azar	161.76
Filariasis	51.47
Dengue, malaria, chikungunya	308.82
Chronic obstructive pulmonary disease	617.65
Injuries, drowning	602.94
Malnutrition	735.29
Other diseases and events	220.59

[9] Source: The International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B).

2.4.6 Identify possible actions to reduce the potential health risks of adaptation and greenhouse gas mitigation policies and programmes implemented in other sectors

Because climate change adaptation and greenhouse gas mitigation decisions taken in other sectors can have important implications for public health, it is incumbent on public health officials to engage with these sectors to identify possible health consequences from adaptation and mitigation plans, and to identify and recommend actions for minimizing health risks and maximizing any potential health gains. Many countries have climate change programmes, often within ministries of the environment, that coordinate climate change activities, including development of the national communications and applications to international and bilateral donors for adaptation funds. Health sector engagement with these programmes can facilitate the identification of modifications to climate adaptation and greenhouse gas mitigation choices that would promote health.

For example, IPCC (2007a, page 481) stated that "there is general agreement that health co-benefits from reduced air pollution as a result of actions to reduce greenhouse gas emissions can be substantial and may offset a substantial fraction of mitigation costs". Co-benefits, or ancillary benefits, of greenhouse gas mitigation policies have been defined as health improvements other than those caused by changes in greenhouse gas emissions, arising as a consequence of mitigation policies (Bell et al., 2008). Emissions from energy production and use are associated with significant premature morbidity and mortality; therefore, reducing current emissions for the purpose of mitigation can also bring health benefits. In addition to harm from exposure to air pollution, patterns of energy use and transportation may contribute to unhealthy changes in physical activity. Development and promotion of active modes of transport that will reduce greenhouse gas emissions, if well planned, could also reduce some of the millions of annual deaths associated with physical inactivity and road traffic accidents (WHO, 2008). Therefore, assessments of the costs and benefits of policies to reduce greenhouse gas emissions should include the health co-benefits to more accurately reflect the full range of possible consequences (Haines et al., 2009).

Another example is that the use of biofuels can affect food availability and prices, which in turn is associated with the 3.5 million annual deaths globally from undernutrition (Black et al., 2008). Also, adaptations implemented in the water sector, including infrastructure development, irrigation, and use of treated wastewater, will likely have implications for human health and well-being by increasing or decreasing risks from vector-borne diseases and other health risks associated with water resources management (see Boxes 22 – 24).

Box 22 Identifying and preventing health risks from adaptation choices in other sectors: Potential for resurgence in risks of guinea worm transmission due to water conservation practices in Ghana

By Edith Clarke, Ghana Health Service Ministry of Health

Long periods of drought reduce crop and animal production in areas such as the northern part of Ghana, where rainfall tends to be sparse. An adaptation measure being considered to address projections of increased drought due to climate change is the use of water conservation practices, such as storage in surface facilities (e.g. dams, ponds, dugouts and small reservoirs) for use during the dry months. Guinea-worm transmission is known to increase during the dry season because of infection of surface water sources. Over the past few years, intensification of control efforts drastically reduced cases of guinea-worm disease to near elimination. However, creating dams and ponds in guinea-worm endemic areas has the potential to undo the successes achieved. This example stresses the importance of multisectoral discussion to reduce health risks from programmes in other sectors to counter the impacts of climate change.

Box 23 Assessing and managing the health risks of using treated wastewater in Jordan

By Hamed Bakir, WHO Regional Centre for Environmental Health Activities

Jordan is one of the most water-scarce countries in the world. To address concerns over water scarcity and to increase resilience to climate change impacts, Jordan's water sector policy requires the use of wastewater in food production. Using recycled wastewater carries risks to the health of agricultural workers, their families and communities, and the consumers of food. To minimize these risks, health authorities are developing a national management system for safe wastewater use. This system involves multiple components and actors:

- regulations, health surveillance and health services by the health ministry;
- wastewater treatment and management by the water sector;
- farming practices management by the agriculture sector;
- monitoring of food quality through food and drug administration programmes which also aim at reducing the impacts of climate change.

Box 24 Managing the links between water storage and dengue vectors in Barbados

By Winfred Austin Greaves, Ministry of Health, Barbados

In Barbados, *Aedes aegypti* mosquito is the vector for dengue fever. Traditional and modern water storage practices to counter water shortages provide breeding grounds for *Aedes* mosquitoes. The traditional method of storing potable water was in 50-gallon metal cans, often uncovered. Small-scale water-intensive agriculture often involved water storage in plastic buckets or other smaller containers, which were also uncovered. The advent of piped water, now into more than 90% of households, should have reduced the need to store water. However, climate change has begun to exacerbate water stress in Barbados. To address inadequate water supplies, the Government of Barbados requires each newly constructed house to have an underground rainwater storage tank. Without adequate public health education on maintenance of these tanks, there was an explosion of *Aedes* mosquitoes that were breeding in underground cisterns. In response, a programme was developed to train ancillary staff in the public and private sectors to find, inspect and eliminate mosquito breeding sites. In addition, it was found that utility companies have large manholes used for underground cables and *Aedes* breeds in the water there. With guidance from the Ministry of Health, the companies initiated an inspection protocol, hired private contractors to pump water from these manholes, and inspected the manholes in conjunction with the vector control unit. This programme significantly reduced infestation and is now an ongoing partnership between the Ministry of Health and the utility companies.

Assessment of the possible health harms of actions taken in other sectors can be accomplished by an expert review of the policies proposed to determine the nature and magnitude of possible health impacts. These auxiliary health effects are generally unintended and can range from none to highly significant. Assessment of possible health harms can be done within the framework of a health impacts assessment to identify where impacts are unlikely, minor or more significant (see Box 25). Such an evaluation would facilitate the design and implementation of necessary additional programmes, including monitoring, to maximize benefits and to reduce potential likely and significant adverse effects. Assessment of the health implications of decisions across multiple sectors can also be supported by integrated settings-based approaches such as the Healthy Cities process that is based on establishing priorities and strategic plans, soliciting political support, taking local action, and evaluating progress to meet community needs (Flynn, 1996).

Box 25 Tools for evaluating health impacts of other sectors

Health impact assessment (HIA) is one approach used to assess the potential health impacts of adaptation and/or mitigation policies and programmes in other sectors, such as housing, water and agriculture. HIA refers to the procedures, methods and tools used to formally evaluate the potential health effects of a policy, programme or project and the distribution of those effects within the population (Cole & Fielding, 2007). There are five generally accepted key characteristics of HIA:

- a focus on specific policy or project proposals;
- a comprehensive consideration of potential health impacts;
- a broad, population-based perspective that incorporates multiple determinants and dimensions of health;
- a multidisciplinary systems-based analytical approach;
- a process that is highly structured but maintains flexibility.

By bringing consideration of health issues into decision-making in other sectors whose actions affect population health, HIA can provide a practical means for facilitating cross-sectoral action for health protection. HIA can identify and communicate potentially significant health impacts that are underrecognized or unexpected, such as the potential health impacts of promoting biofuels. HIA encourages analysis of synergistic pressures on population health through a multi-stakeholder process.

Source: *http://www.who.int/hia/en/.*

The results of studies conducted by the health sector can provide valuable input into decisions on possible policies and programmes to reduce the risks of climate change. For example, IPCC concluded that the number of people at risk from increasing water stress due to population growth and climate change is projected to be 2.8–6.9 billion people by the 2050s (from a baseline of 1.3–1.6 billion in 1995) (Kundzewicz et al., 2007). For the 2050s, population projections have a greater impact than differences in emission scenarios on the estimated number of people at risk. General programmes for increasing access to safe water include increasing supply and decreasing demand. Some programmes are relatively simple, such as promoting indigenous practices for sustainable water use, but others are expensive and complex, such as desalination. A Cochrane Review of interventions to improve water quality from source to use to prevent diarrhoea concluded that household interventions are more effective than interventions at the water source (Clasen et al., 2006). This is because water users in many developing countries rely on self-provision, informal exchanges to obtain water, and local community institutions. Overall, diarrhoeal disease episodes can be reduced by 25% by improving water supply, 32% by improving sanitation, 45% by hand-washing, and 39% by household water treatment and safe storage (Fewtrell et al., 2005).

2.4.7 Developand propose health adaptation plans

Deciding on the most appropriate, effective, cost-efficient and high-priority actions needed to protect health from the current and future impacts of climate change is a complex and iterative process.

The development of adaptation plans and programmes for the health sector will vary, depending on the strategic policy and specific programmatic needs identified at the beginning of the assessment process. However, the vulnerability and adaptation assessment process itself can be an important instrument for learning and building cooperation between key stakeholders, who will apply the information jointly generated to adaptation planning and programme design decisions. Once current and future health risks are better understood, and potential adjustments and adaptation options are evaluated, next steps should include further stakeholder consultation, communication, and discussions with health and other sector leadership on applying this new information about risks to health. The stakeholder engagement and communication plans are vital for gaining understanding, legitimacy and credibility for the recommendations that may result from a vulnerability and adaptation assessment.

2.5 Establish an iterative process for managing and monitoring the health risks of climate change

Management of climate-related health risks will evolve as the climate changes and as more is understood about the relationships between weather/climate and health determinants and outcomes. Thus, the policy process will benefit from continual learning, recognizing that knowledge will never be sufficient, that there will always be uncertainties, and that experience (learning by doing) will inform policy development (Scheraga et al., 2003). There is one important difference from other public health policies and programmes – those implemented should be designed with greater flexibility so that they can be adjusted as climate and other factors change. In addition, continuing research is needed to understand changing conditions and their implications for the management of health outcomes, including the costs of impacts and adaptations. Funding is needed for monitoring and evaluation programmes to measure key indicators of disease burdens and the effectiveness of interventions. In particular, funding will be needed for low- and middle-income countries to develop and maintain such programmes. Flexibility is needed for handling large or sudden changes in weather, climate and other factors. Not only will policy responses change, but also the public health institutions themselves will change in response to changes in the social, economic and political paradigms and power structures that direct and limit the policy context.

Key components of an iterative risk management process are monitoring and evaluation programmes to ensure the policies and programmes implemented continue to be effective in a changing climate. Effective monitoring programmes include indicators that track changes in vulnerability, the incidence and geographical range of climate-sensitive health outcomes, relevant environmental variables (e.g. changes in temperature, precipitation, ozone concentrations and land use), and possible confounding variables associated with the environmental variables and the outcomes; this includes factors such as demographic change, the status of public health infrastructure, and economic development. For example, English et al. (2009) identified climate change and health indicators for the United States that were chosen to describe elements of environmental sources, hazards, exposures, health effects, and intervention and prevention activities. Some indicators are measures of environmental variables that can directly or indirectly affect human health, such as maximum and minimum temperature extremes, while others can be used to project future health impacts based on changes in exposure, assuming exposure–response relationships remain constant. Indicators were categorized into four areas: environmental, morbidity and mortality, vulnerability, and policy responses related to adaptation and greenhouse gas mitigation.

Indicators are also needed that evaluate the outcomes of programmes designed to increase resilience and the health risks of climate change, to identify where additional modifications may be needed as the climate and other factors continue to change. These indicators are similar to those used to monitor the effectiveness of any public health policy or programme that as been adjusted to take into account a changing environment that could alter their effectiveness.

Effective monitoring and evaluation programmes require sustained commitments of human and financial resources. Monitoring and tracking climate risks to human health is likely to require building institutional awareness, partnerships and capacity. There may be opportunities to link climate change policies and programmes with related activities, such as the Healthy Cities projects (Awofeso, 2003).

Changing patterns of disease require increased surveillance in Thailand's National Institute of Health.

3.0 Conclusion

Photo credit: **Lars Bødker Madsen.**

Conducting a climate change vulnerability and adaptation assessment is a similar process for all nations and regions: The goal remains to better understand how climate variability and climate change can and do affect health risks today and in the future, in order to better inform policies and programmes that can protect public health. However, the context, structure and content of the assessment will vary, depending on local circumstances, socioeconomic conditions, legal and regulatory frameworks, and other factors that reflect local decision needs. All policies and programmes identified to protect health through the assessment process need to take into account the evolving social, economic, environmental and political contexts within which they will be implemented. Differences among communities and among nations will affect the structure and implementation of policies and programmes. Local policy-making processes, institutions and resources will influence the choices of which policies and programmes to implement to address the current and likely future health risks from climate change. For example, some communities and nations have vector-borne disease surveillance systems that legally require individuals to clean up vector breeding sites within their living areas, but most nations do not have this option for improving vector control.

The ability of a nation or community to identify and implement effective adaptation policies and programmes depends on a range of factors. Decision-makers and the public must have sufficient knowledge of the health risks from climate change and the range of responses needed to reduce current and projected adverse health impacts. Once there is motivation for action, decision-makers need to know the magnitude of potential risks and identify a range of options (including their feasibility, benefits, acceptability, effectiveness and costs); the availability of resources and their distribution across the population; and the structure of critical institutions, including the allocation of decision-making authority. A carefully conducted assessment can be a major contribution to protecting health from climate change.

Managing the health risks of climate change involves an iterative management process that starts with assessing the current and likely future vulnerability of the target community or region; qualitatively or quantitatively estimating the extent of future health burdens due to climate change; designing and implementing policies and programmes to reduce current and future health risks due to climate change; and then monitoring and evaluating these policies and programmes to identify necessary modifications. Stakeholder engagement is integral to the process. At each step, there are opportunities to communicate findings to stakeholders, decision-makers, researchers and the public to enhance understanding of the risks of, and adaptation policies and programmes to address, the health impacts of climate change.

The risks of climate change provide an opportunity and a challenge to health authorities to demonstrate leadership within and outside the sector on adaptation and greenhouse gas mitigation. Maximizing opportunities to engage with other sectors in designing climate resilient pathways would bring benefits to all.

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5.0 Definitions

Key terms used in this guidance are defined here for a common understanding.[10]

Adaptation is a process by which strategies and measures to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, implemented and monitored (UNDP, 2003). In public health, the analogous term is "prevention". Various types of adaptation exist, including anticipatory and reactive, private and public, autonomous and planned.

Adaptive capacity is the general ability of individuals, communities and institutions to effectively prepare for and cope with the consequences of climate variability and change.

Climate is the "average weather" in a particular place over a particular time period. It is the statistical description of the mean and variability of weather variables (e.g. temperature, precipitation) over a period of time ranging from months to thousands or millions of years; the typical time period is 30 years.

Climate change refers to a statistically significant variation in either the mean state of the climate or its variability, persisting for an extended period (typically decades or longer). Climate change is due to natural internal processes or external forcings, and to persistent anthropogenic changes in the composition of the atmosphere. UNFCCC defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods".

A ***climate-sensitive health outcome*** is any health outcome whose geographical range, incidence or intensity of transmission is directly or indirectly associated with weather or climate.

Climate variability describes variations in the mean state and other statistics (e.g. standard deviations, the occurrence of extreme events) of climate on all temporal and spatial scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system or to variations in natural or anthropogenic external forcing.

Co-benefits are benefits (often health benefits) associated with reductions in greenhouse gas emissions. For example, reduced emissions of air pollutants can have immediate health benefits. In addition, there can be co-benefits of adaptation measures, such as new surveillance systems that monitor climate-related and non-climate-related infectious diseases.

Exposure is the amount of a factor to which a group or individual was exposed; sometimes contrasted with dose (the amount that enters or interacts with the organism). Exposures may be either beneficial or harmful.

10 For a full glossary of terms, see *http://www.who.int/globalchange/publications/climatechangeglos.pdf.*

Health is a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity.

Health systems comprise all the organizations, institutions and resources that are devoted to producing actions principally aimed at improving, maintaining or restoring health.

Mitigation refers to policies and measures to reduce greenhouse gas emissions or enhance sinks.

Resilience is the ability of a natural or human system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

Risk (e.g. climate-related risk) is a product of the likelihood of exposure and the consequences of that exposure. It arises from the interaction of a physically defined hazard (e.g. floods, other extreme weather events, increasing temperature) with the properties of the exposed system (its vulnerability) (UNDP, 2003). System vulnerability is a critical determinant of the risk a region or subpopulation faces when exposed to a particular hazard. This means that programmes to decrease vulnerability will decrease risk.

Sensitivity describes an individual's or subpopulation's increased responsiveness, primarily for biological reasons, to a particular exposure. Biological sensitivity may be related to developmental stage, pre-existing medical conditions, acquired factors (e.g. immunity) and genetic factors (Balbus & Malina, 2009). Socioeconomic factors also play a critical role in altering vulnerability and sensitivity, by interacting with biological factors that mediate risk (e.g. nutritional status) or lead to differences in the ability to adapt or respond to exposures or early phases of illness and injury.

Vulnerability is the susceptibility to harm, which can be defined in terms of a population or a location. "Vulnerability to climate change is the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate variability and change" (IPCC, 2007a – page 21). Vulnerability is dynamic and may itself be influenced by climate change (e.g. extreme weather events affecting health infrastructure). From a health perspective, vulnerability can be defined as the summation of all risk and protective factors that ultimately determine whether a subpopulation or region experiences adverse health outcomes due to climate change (Balbus & Malina, 2009). Characteristics of a region, such as baseline climate, abundance of natural resources (e.g. access to fresh water), elevation, infrastructure and other factors can alter vulnerability.

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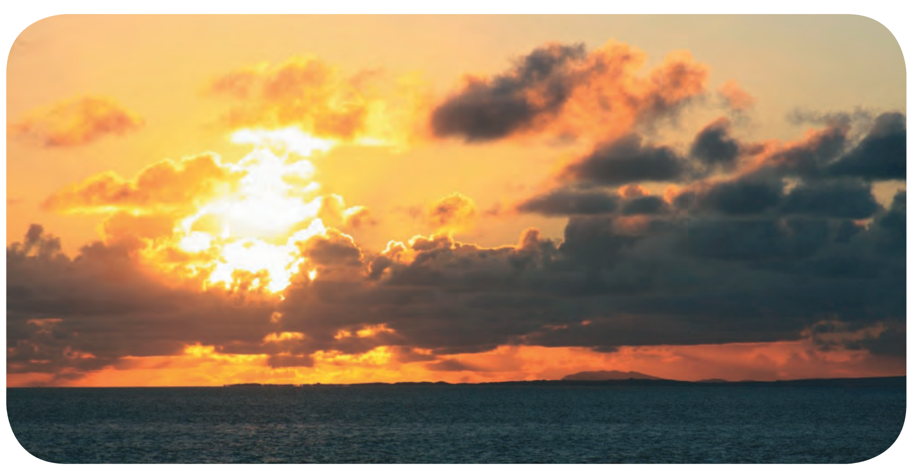

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