World Health Organization
Pan American Health Organization

Protecting Health from Climate Change
Vulnerability and Adaptation Assessment

DRAFT FOR DISCUSSION

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Introduction

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; WHO, 2009). Impacts can arise from:

- The effects of climate change on natural and physical systems that, in turn alter the number of people at risk of malnutrition, the geographic range and incidence of vectorborne, 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 worth of economic losses. The frequency and intensity of some types of extreme weather events are expected to continue to increase over coming decades as a consequence of climate change (IPCC, 2007b), suggesting that the associated health impacts could increase without additional prevention actions.

- Climate change can affect population health through climate-induced economic dislocation and environmental decline, as well as through development setbacks incurred by damage to critical public health infrastructure and 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, policies need to explicitly consider these risks in order to maintain and improve current levels of population health. In most cases, the primary response will be to modify current health risk management activities to address the additional risks of climate change.

However, implementing policies and programmes that only address current vulnerabilities is not sufficient 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 and/or change their geographic range. Therefore, capacity needs to be built within public health and health care organizations and institutions to prepare for and identify changing risks and to evaluate the effectiveness of current and proposed programmes, both within and outside the health sector, in a changing climate. These evaluations should consider rapid climate change over the next few decades and longer-term changes in the means of meteorological variables. Policies and programmes to address the health risks from climate change also should explicitly consider how to avoid large 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 changes with changing climate, demographics, technologies, and socioeconomic development, 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 geographic range and incidence of a range of adverse health outcomes, policies and measured designed to address the health risks of climate change need to be incorporated into existing and planned programmes designed to address these risks.

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). Policy 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 enhancement of current policies and programmes, or the development of new policies and programmes.

This document is designed to provide basic and flexible guidance on conducting a national or sub-national assessment 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 possible priority policies and programmes to prevent and reduce the severity of future impacts.\(^1\) The proposed steps may be implemented completely in the order presented, or only selected steps may be undertaken to meet the needs of a community, region, or country.\(^2\) For example, an assessment might focus on identifying populations and regions vulnerable to current and possible future changes in the geographic range of climate-sensitive infectious diseases. The assessment could be quantitative, 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, please refer to the WHO Methods for Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change (Kovats et al., 2003) and the WHO Environmental Burden of Disease guidance for quantifying the health impacts of climate change at national and local levels (Campbell-Lendrum and Woodruff, 2007).

Before the assessment is initiated, the scope of the assessment needs to be determined, including the decision and information needs, the timing and budget, the geographic areas included, the health outcomes of most interest, how the assessment will be managed, and the communication plan for informing decision makers, stakeholders, and the public of the progress and results of the assessment. Once the scope is determined, it is important to decide on the stakeholders who should be involved in the various steps of the assessment.

An assessment typically has three overlapping components; one more focused on vulnerability, another more focused on estimating current and projecting future impacts, and

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1 The guidance will 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.

2 The term "assessment" is used to indicate a "vulnerability and adaptation assessment."
a third more focused on increasing the effectiveness of policies and programmes to manage the health risks of climate change.

The vulnerability component identifies populations and regions most likely to suffer adverse health effects of climate change, such as the impacts of current extreme weather events (e.g. floods, droughts, and heatwaves) on those most susceptible to harm. This includes estimating the current burden of climate-sensitive health outcomes and the effectiveness of current policies and programmes to manage these health burdens.

The impact component aims to qualitatively or quantitatively characterize how health risks may evolve over time with and without climate change, and to estimate future health burdens associated with climate change. The assessment also could evaluate the health impacts of measures implemented in other sectors to address climate change risks (e.g. health impacts resulting from changes in transportation policies). This component should identify risks factors and indicators to be monitored over time, to improve management of health risks in a changing climate.

The adaptation component identifies, evaluates, and prioritizes possible policies and programmes to enhance management of climate change health risks by reducing vulnerability to climate-related hazards (e.g. by implementing early warning systems to inform older adults and others vulnerable to high temperatures on actions to take to reduce their risks) and/or by reducing exposures (e.g. by reducing the higher temperatures in urban areas). Understanding plans for adjusting current policies and programmes irrespective of climate change provides a baseline for identifying and prioritizing modifications to policies and programmes to increase health protection, and for estimating the costs and benefits of additional programmes to reduce climate change-related risks.

Finally, because managing the health risks of climate change will be an iterative process, there should be a plan for communicating the results, applying and integrating information into decisions, and regular re-evaluations of vulnerability, current and projected impacts, and the effectiveness of adaptation measure to determine if another assessment cycle should be started.
Climate change is one of many determinants of health

Climate is not the only factor affecting the geographic 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 full causal pathway from climate change through to health outcome, in order to identify opportunities to manage the environmental determinants of health.

The DPSEEA (driving force, pressure, state, exposure, effect, action) 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 behavioral conditions. It displays the various levels of actions that can be taken to reduce health impacts (Corvalan et al., 2000). The driving forces (D) refer to the key factors that generate the environmental processes involved, such as population growth and economic development. These driving forces result in pressures (P) on the environment. In response, the state of the environment (S) is altered, with changes that may be complex and wide-ranging. These changes in the state of the environment may operate at markedly different geographic scales, from local to international. Risks to health may occur when people are exposed to these environmental hazards (E1) that can then lead to health effects (E2); these hazards may vary in type, intensity, and magnitude. The following figure applies the DPSEEA framework to climate change.

![Figure 1 DPSEE Framework](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 and health vulnerability assessment.
SECTION 1: STEPS IN CONDUCTING A VULNERABILITY, IMPACT, 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 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 means that assessment is an iterative process, with the results of one assessment providing a baseline of current vulnerability, impacts, adaptation policies and programmes, and identifying actions to inform future assessments. Future vulnerabilities may be different than 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 changing vulnerabilities, as well as with environmental changes. Public health policies, programmes, and interventions to address vulnerabilities and impacts will need to be regularly revisited to ensure continuing effectiveness in a changing climate.

The basic components of an assessment are:

1. Frame and Scope the Assessment
   - Define the geographic region and health outcomes of interest
   - Identify the questions to be addressed
   - Identify the context for the assessment
   - Establish a project team and a management plan
   - Develop a communications plan
   - Establish a stakeholder process

Vulnerability Assessment

2. 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 (2.1)
   - Describing the current capacity of health and other sectors to address the risks of climate-sensitive health outcomes (2.2)

Impact Assessment

3. 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 (3.1)
   - Estimating the possible additional burden of adverse health outcomes due to climate change (3.2)

Adaptation Assessment

4. Identify and prioritize policies and programmes to address current and projected health risks. This includes:
Identifying additional public health and health care policies and programmes to prevent likely future health burdens (4.1)

Prioritizing public health and health care policies and programmes to reduce likely future health burdens (4.2)

Identifying human and financial resources needed for implementation, and potential challenges to be addressed (4.3)

Estimating the costs of action and of inaction (4.4)

Identifying possible policies and programmes to reduce the potential health risks of adaptation and greenhouse gas mitigation policies and programmes implemented in other sectors (4.5)

5. Establish an iterative process for managing the health risks of climate change

These steps are shown in the following figure.

Figure 2 Vulnerability and Adaptation Assessment Process
1.0 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 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 geographic region and health outcomes of interest
- Identifying the questions to be addressed
- Identifying the context for the assessment
- Establishing a project team and a management plan
- Developing a communications plan
- Establishing a stakeholder plan

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

1.1 Define the geographic range and health outcomes of interest

The first step is to determine the health outcomes of interest on which to focus and the geographic 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. In some cases, all climate-sensitive health outcomes will be considered in the assessment; in others, 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 geographic scale could be national or sub-national.
Box 1 Assessment scoping: experience from Russia

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 happen in the Arctic, it was decided to select one of the Russian circumpolar areas --- Arkhangelsk region --- for a climate change and health vulnerability 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 to mainstream climate change considerations within existing risk management services or systems

The Arkhangelsk region is located in the north-western part of Russia with a territory of 587.4 thousand sq km 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 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 that 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 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 population in the Nenets Autonomous Area (indigenous population)
- 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, contribute to the increase in overall mortality over the last 20 years. The region has a well-developed system for infectious disease surveillance that covers more than 40 diseases. Some Russian studies suggested 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, as well as areas where they have not been reported, providing a unique opportunity for studying the migration of ticks to the North.

Contributed by A M Grjibovski
1.2 Identify the questions to be addressed

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 will be addressed include:

- Which regions and populations in a country are the most vulnerable to climate variability and climate change?
- What is the current burden of climate-sensitive health outcomes?
- What factors other than weather and climate determine vulnerability of populations and health systems?
- How effective are current 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 geographic distribution, incidence, or timing of climate-sensitive health outcomes?
- What additional public health policies and programmes will likely be needed?
- 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?

1.3 Identify the context for the assessment

The context and purpose for conducting the assessment should be described, including existing policies and programmes relevant to climate change and health. 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.
Box 2 Integrating climate change with other environmental health processes: the Ghana Situation Analysis and Needs Assessment for the Libreville Declaration

The Libreville Declaration is a commitment by African Ministers of Health and Ministers of Environment to address health and environment inter-linkages 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 (SANA) that establishes baseline information on where a country stands in relation to eleven action points within the Declaration, and to identify what is needed to achieve their objectives and targets in the National Joint Plans of Action for Health and the Environment. The SANA goal 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 SANA 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
- An inventory of national institutions whose missions 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 (MEAs) 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

Contributed Edith Clarke, Ghana Health Service Ministry of Health, based on (UNEP/WHO, 2010)

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. There is a thorough discussion of how to establish a management plan in (Kovats et al., 2003).

1.5 Develop a communications plan

Plans for communicating the assessment results should be formulated at the start of the process. Decisions need to be taken on the audience for the assessment – the Ministry of Health at the national or sub-national level, the team responsible for the National Communication to the UNFCCC, others – and the mechanisms for communicating the results. 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 communication activities are needed to ensure the findings of a vulnerability and adaptation assessment are relevant to decision-makers, which will increase the chance that they will be used. Approaches to communication are summarized in (Kovats et al., 2003). In general, it is helpful for communications to include a summary of the process, stakeholders included, description of the deliberations, and summary of priority policies and programmes recommended.

**Box 3 Communicating health risks of heat in Canada: tool kit for health professionals**

Extreme heat events pose a growing public health risk in many regions of Canada, as a result of a changing climate. An increase in these events is a concern in this country that is experiencing rapid growth in the population of seniors, a group that has been identified as particularly vulnerable to the health impacts of extreme heat. Gosselin et al. (2008) project that in the absence of further adaptations there will be an increase of 250 excess heat related deaths annually by 2020 in the province of Quebec, 500 excess deaths by 2050, and 1400 by 2080. Communities in Canada are adapting by implementing heat alert and response systems (HARS) that are designed to prevent mortality and morbidity during extreme heat events by delivering timely warnings and interventions.

However, to ensure the effectiveness of efforts to protect populations most at risk from extreme heat and to improve the capacity of health and social services to provide assistance to those in distress, information is needed on individual and community level vulnerability.

Drawing from the PAHO/WHO climate change and health assessment guidelines, Health Canada is completing four extreme heat and health vulnerability assessments in partnering communities - Winnipeg (Manitoba), the Assiniboine Health Authority Region (Manitoba), Windsor (Ontario), and Fredericton (New Brunswick). Literature reviews, community workshops, climate modeling, and expert consultation are being used to obtain and analyze information on historic weather and future climate trends (e.g. daily maximum temperatures, urban heat island effect), population sensitivity to extreme heat (e.g., seniors, infants and young children, occupational groups), the capacity of individuals to adapt (e.g. socially disadvantaged groups, people living alone, levels of literacy and educational attainment) and community capacity to take protective actions (e.g. public transit services, cooling options, health and social services).

The assessments of heat health vulnerabilities will provide health officials, emergency managers, city planners, and social service organizations with information on existing vulnerabilities so that public health policies and programmes can be developed and implemented to protect citizens. Community programs and outreach strategies based on the findings of the assessments will empower individual Canadians with the knowledge they need, to take the measures necessary to protect themselves and their family members from heat-health risks.
Box 4 Communication of the Tunisian assessment

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 exchange of information among assessment leads, 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 lead by the health sector that provided input to the assessment process; the committee included 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 communication activities are planned to disseminate results from the assessment and 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.

Contributed by Mazouzi Raja (Ministry of Public Health - Tunisia)

1.6 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, non-governmental organizations (NGOs), national and regional emergency preparedness committees, and those affected by climate change. Community, regional, and national climate change initiatives and initiatives 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, conduct, evaluation and monitoring, and communication of the assessment. 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 as the needed experience and expertise change from assessing current health burdens to projecting future burdens to identifying modifications to policies and programmes to reduce health risks. 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.
Possible stakeholders to include in an assessment

Stakeholders include policy- and decision-makers, scientists, programme managers (from ministries, departments, and NGOs in the areas of health, agriculture, water resources, urban planning, transport, development, and others), and those most likely to be affected by the health risks from climate change. Including their expertise and experience during the assessment will help ensure that key issues are identified. Depending on the scope of the assessment, it may be important to link with emergency preparedness programmes and activities.

Two stages of stakeholder involvement may be required. At the initial stages of project scoping, the stakeholder group will probably be small in order to enable the quick development of objectives and to identify additional stakeholders. Following initial stakeholder scoping activities, the full project team and a broad, diverse group of stakeholders should be engaged throughout the assessment, including representatives of those who will implement the identified policies and programmes and those who may be affected by them or by climate change impacts. The roles and responsibilities of the stakeholders should be clear to all participants. Consideration should be given to using the assessment 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 relevant ministries, NGOs, universities, and others. The assessment goals are presented and discussed, and input is sought on priority issues that need to be addressed (including geographic 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 policymakers; and the most vulnerable groups. For example, if water-borne diseases are a priority issue, stakeholders could include representatives from the ministry of health, the ministry of the environment (assuming it deals with climate change), the 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, as well as 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 the facilitators, and principles of effective consultation. See, for example, the UNDP Adaptation Policy Framework (UNDP, 2003).
Box 5 Application of the WHO/EURO stakeholder engagement tool: experience from Macedonia

The Ministry of Health in the 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. List the stakeholders. Steering Committee members listed all stakeholders that could be engaged in the assessment and in developing a national health adaptation strategy.
2. Analyze the stakeholders. The list was analyzed to identify the existing level of interest from each stakeholder in the project and their level of expected influence in helping develop a national climate change and health adaptation strategy.
3. Categorize the stakeholders. The stakeholders were categorized into those with whom the project should partner, those who should be involved directly, those who should be consulted, and 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 email bulletins were sent to those to be informed.
5. Update the Stakeholder Categorization and Engagement Plan. The stakeholder categorization and engagement plan were regularly updated to ensure all relevant groups were being engaged.

Contributed by Vladimir Kendrovski and Margarita Spasenovska, based on (WHO-EURO, 2010).

Box 6 Criteria for stakeholder selection, informing decisions in Costa Rica

The assessment of climate change risks in Costa Rica was approached from the perspective of understanding how health determinants could be affected by future climatic patterns. The process was highly participative, including intersectoral and multidisciplinary representation, qualitative expert assessments, and open information exchanges to ensure broad participation and input. The Costa Rica team identified stakeholders to meet 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 in which the stakeholder can influence political decisions at the national level
- **Strategic importance**: degree in which involvement of stakeholders facilitate achieving the strategic objectives of the assessment
- **Relation with the topic**: degree to which the stakeholder is directly affected by the issue
- **Representation**: degree in which involvement of the stakeholder guarantees representation and equitable social participation

Contributed by: L Navarro
Section 2: Conducting the Vulnerability Assessment

2.0 Describe 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 exposure(s) 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 geographic range of climate-sensitive health outcomes. Therefore, the severity of impacts is determined by changes in climate as well as concurrent changes in non-climatic factors. Exposures include changes in the frequency and intensity of extreme weather events, as well as 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 just of heavy precipitation, but also of infrastructure and land use choices over previous decades, the effectiveness of emergency response programmes, and other factors. In another example, malnutrition is a consequence not just of local and regional crop yields that are affected by temperature and precipitation patterns, but also 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 and 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 geographic circumstances, such as coastal or urban settings. Population vulnerability also is a function of the effectiveness of the public health and related institutions, such as the quality of surveillance and control programmes, as well as the demographic structure of a population, the prevalence of pre-existing medical conditions; acquired factors (such as immunity); and genetic factors (Balbus and Malina, 2009). Socioeconomic factors, including social capital and the distribution of resources also play a critical role in determining vulnerability, by interacting with biological factors that mediate risk (such as nutritional status) and/or 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 to consider not just 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 and/or precipitation, and how associated changes in food production could affect malnutrition.
2.1 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 and/or for the local community.

2.1.1 Identify Vulnerable Populations and Regions

Although climate change will affect all populations and regions, some are more vulnerable to climatic exposures and could, therefore, suffer greater harm. This step should identify populations and regions with increased or decreased vulnerability to weather, current climate variability, and recent climate change. A few examples include:

- All persons 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 and the infirm, and those 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.
- Populations living in areas where land-use change may create conditions that facilitate disease transmission, such as deforestation, coastal development, or dense urbanization. Land-use may be one of the drivers of the distribution of a particular disease vector.

Table 1 Categories of Vulnerable Populations

<table>
<thead>
<tr>
<th>Vulnerability due to demographic factors</th>
<th>Vulnerability due to health status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of children</td>
<td>HIV/AIDS affected populations</td>
</tr>
<tr>
<td>Proportion of women</td>
<td>TB affected populations</td>
</tr>
<tr>
<td>Proportion of elderly</td>
<td>Undernourished populations</td>
</tr>
<tr>
<td></td>
<td>Infectious disease burdened</td>
</tr>
<tr>
<td></td>
<td>Chronic disease burdened populations</td>
</tr>
<tr>
<td></td>
<td>Mentally or physically disabled</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vulnerability due to culture or life condition</th>
<th>Vulnerability due to geographic location of populations in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impoverished</td>
<td>Unplanned urban housing</td>
</tr>
<tr>
<td>Nomadic and semi-nomadic peoples</td>
<td>Flood risk zones</td>
</tr>
<tr>
<td>Subsistence farmers &amp; fisherfolk</td>
<td>Drought risk zones</td>
</tr>
<tr>
<td>Ethnic minorities</td>
<td>Coastal storm and cyclone risk zones</td>
</tr>
<tr>
<td>Indentured laborers</td>
<td>Conflict zones</td>
</tr>
<tr>
<td>Displaced populations</td>
<td>Water stressed zones</td>
</tr>
<tr>
<td></td>
<td>Food insecure zones</td>
</tr>
</tbody>
</table>

Vulnerability due to limited access to adequate:

- Health care
- Potable water
- Sanitation
- Shelter
- Economic opportunities

Provided by: Joy Guillemot (WHO/HQ)
### Table 2 Summary of Vulnerability to Climate-Sensitive Health Outcomes by Subpopulation

<table>
<thead>
<tr>
<th>Groups with Increased Vulnerability</th>
<th>Climate-Related Vulnerabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants and Children</td>
<td>Heat stress, ozone air pollution, waterborne and foodborne illnesses, malaria, malnutrition</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>Heat stress, extreme weather events, water and foodborne illnesses, malaria</td>
</tr>
<tr>
<td>Elderly / chronic medical conditions</td>
<td>Heat stress, air pollution, extreme weather events, water and foodborne illnesses, dengue</td>
</tr>
<tr>
<td>Impoverished / low socioeconomic status</td>
<td>Heat stress, extreme weather events, air pollution, vector-borne infectious diseases, waterborne diseases</td>
</tr>
<tr>
<td>Outdoor workers</td>
<td>Heat stress, ozone air pollution, Lyme disease, other vector-borne infectious diseases, UV exposure.</td>
</tr>
</tbody>
</table>

Source: Adapted from (Balbus and Malina, 2009)

Spatial mapping is a valuable approach for describing current or projected future vulnerability. The increasing use of Geographic Information Systems (GIS) offers opportunities to show current distributions of, for example, vulnerable populations, and the spatial relationship to disease vectors, river basins prone to flooding, and other important variables of interest to public health officials. Boxes 8 and 13 provide examples of how a spatial analysis can reveal linkages, illustrating how population risks factors may evolve over time and space. Maps also serve as important communication tools for explaining assessment results. Several GIS software packages are available in the public domain, and a variety of potentially relevant environmental, climate, and socio-demographic data are available through web-based sources, such as the ones provided below.

- EPI-INFO: [http://www.cdc.gov/epiinfo/maps.htm](http://www.cdc.gov/epiinfo/maps.htm)
- UNEP Environmental Information & Mapping: [http://maps.grida.no/](http://maps.grida.no/)
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 tools allow for the identification of 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 analyze health, environmental, and socio-demographic 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 allowed health managers to identify areas of high malaria prevalence, as well as environmental risk factors that may be exacerbated by climate change, assisting in the planning of prevention programmes.

Contributed by: C. Barcellos, FIOCRUZ Brazil
Box 8 Using landscape epidemiology to identify geographic boundaries of disease risk: example of high altitude malaria in 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 between 2600 and 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 semiarid 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.

LANDSAT and GIS images, shows the unusual mountain ecosystem location of the community where the majority of malaria cases were registered; Tuntunani in yellow, Mollebamba in blue, and Sehuenquera in gray.

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 1997-1998 was a contributing factor.

Contributed by Marilyn Aparicio
2.1.2 Analyze the Relationships Between Weather/Climate and Health Outcomes

A clear understanding of the relationships and sensitivity of health outcomes and determinants to weather and climate patterns is essential when determining the risks that climate change poses to population health. These analyses, often referred to as sensitivity analyses, should describe current vulnerability at the geographic 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 needed to describe these relationships. The burden of the chosen health outcome can be estimated using expert judgment 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). Observed seasonal epidemiological trends and disease outbreaks associated with weather anomalies over time also can be good indications of the sensitivity of the outcome to meteorological conditions (e.g. incidence of disease during dry or wet seasons).

Approaches for quantitatively analyzing relationships between weather variables and climate-sensitive health outcomes are detailed in (Campbell-Lendrum and Woodruff, 2007; Kovats et al., 2003). Data availability and its reliability, cost, spatial and temporal resolution, and comparability are issues that will likely need to be addressed during an assessment. At a minimum, analyses should be conducted of the relationship(s) 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 the Ministry of Health, and weather data from the national meteorological and hydrological services. However, in some countries, data access can be challenging because some meteorological services and other data sources charge for data, which can limit the scope of the analyses. Stakeholder participation from the data owners can help facilitate access.

Sources of current and historical meteorological data relevant for the health decisions can be found at: http://www.who.int/globalchange/links/data_resources/en/index.html

The time periods, and geographic 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 geographic regions, there should be caution when analyzing 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. Generally, it is often the health data that are available for only a few years, rarely for decades or more. Because climate change occurs over decades and longer, analyses over shorter time scales can provide information on possible risks associated with climatic conditions, but cannot attribute how climate change has affected the geographic range and/or incidence of a particular outcome. Where data are available over several decades, a valuable analysis is to try to detect a trend in a health

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3 National and sub-national data, when 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 http://www.who.int/gho/en/. Information also may be available from climate-health risk maps and surveys conducted by NGOs and other organizations.
outcome and assess whether some or all of the change can be attributed to climate change; this requires that other drivers of the health outcome be included in the analysis.

**Box 9 Climate and health observatory innovations in data sharing, communications, and partnership building, from 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 socio-demographic 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 undertakes the following functions:

- Gathering available data on climate, environment, society, and health
- Conducting situation analyses, as well as 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 the Pan American Health Organization and is coordinated by the Oswaldo Cruz Foundation. Through workshops, participants developed institutional agreements for sharing data, and identified specific data formats, time-scales, 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 vectorborne diseases; the vulnerability of water supply and sanitation systems, and the increasing risk of water-related diseases; and the interaction between climate change impacts on air pollutants that increase the risks of respiratory diseases.

Contributed by: C. Barcellos
2.1.3 Identify Trends in Climate Change-Related Exposures

Climate change and non-climate change-related exposures are important to human health. Assessments should consider how health determinants could be affected by climate change, such as availability and quality of water and food, poverty, and population density. Analyses should focus on understanding these trends scaled to the area of interest.

**Box 10 Health determinants sensitive to climate change: IPCC projected trends**

Heat waves, floods, droughts and other extreme events: Heat waves 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 events). 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 geographic 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 risk of hunger, with potentially large negative health effects in sub-Saharan Africa.

Source: (IPCC, 2007a)

**Identifying particularly vulnerable populations**

Particularly vulnerable populations and regions were highlighted in the Human Health chapter of the IPCC 4th 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 tend to 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 heat waves, 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. These include 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; loss of property such as crop land because of floods, droughts, and a rise in sea level; and increased rates of associated climate-sensitive health outcomes.

**Food insecurity:** Expert assessments of future food security are generally pessimistic over the medium term. Indications are that it will take approximately 35 additional years to reach the World Food Summit 2002 target of reducing world hunger by half by 2015 (Rosegrant and Cline, 2003); (UN, 2006). Projecting current and future climate change-related malnutrition burdens is problematic because the determinants of malnutrition are complex. Nevertheless, malnutrition linked to extreme climatic events could be one of the most important consequences of climate change because of the very large number of people that could be affected. Overall, climate change is projected to increase the number of people at risk of hunger (FAO, 2005).

**Populations in coastal and low-lying areas:** Climate change could affect coastal areas through an accelerated rise in sea level, 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 through coastal flooding and damaged coastal infrastructure; saltwater intrusion into coastal 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 diarrheal diseases (WHO, 2006).

**Populations in mountain regions:** Little published information is available on the possible health consequences of climate change in mountain regions. However, it is likely that vector-borne pathogens could take advantage of new habitats in altitudes that were formerly unsuitable, and that diarrheal 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 11 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 generating this information. Expert judgment 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 (Table 3).

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

<table>
<thead>
<tr>
<th>Country</th>
<th>Afghanistan</th>
<th>Bangladesh</th>
<th>Bhutan</th>
<th>China</th>
<th>Nepal</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat waves</td>
<td>M-P</td>
<td>P</td>
<td>–</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Flood deaths/morbidity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glacial lake floods</td>
<td>M-P</td>
<td>–</td>
<td>M-P</td>
<td>M-P</td>
<td>M-P</td>
<td>M-P</td>
</tr>
<tr>
<td>Flash</td>
<td>M-P</td>
<td>P</td>
<td>M-P</td>
<td>M-P</td>
<td>M-P</td>
<td>M-P</td>
</tr>
<tr>
<td>Riverine (plain)</td>
<td>P</td>
<td>P</td>
<td>–</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Vector-borne disease</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Malaria</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>M-P</td>
<td>P</td>
</tr>
<tr>
<td>Japanese encephalitis</td>
<td>–</td>
<td>P</td>
<td>–</td>
<td>P</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Kala-azar</td>
<td>P</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>P</td>
<td>P</td>
</tr>
<tr>
<td>Dengue</td>
<td>–</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td>–</td>
<td>P</td>
</tr>
<tr>
<td>Water-borne diseases</td>
<td>M-P</td>
<td>P</td>
<td>M-P</td>
<td>M-P</td>
<td>M-P</td>
<td>M-P</td>
</tr>
<tr>
<td>Water scarcity, quality</td>
<td>M-P</td>
<td>P</td>
<td>P</td>
<td>M-P</td>
<td>M-P</td>
<td>M-P</td>
</tr>
<tr>
<td>Drought-related food insecurity</td>
<td>M-P</td>
<td>P</td>
<td>–</td>
<td>M-P</td>
<td>–</td>
<td>M-P</td>
</tr>
</tbody>
</table>

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

2.2 Describe the Current Capacity of Health and Other Sectors to Address 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 diarrheal diseases, malaria, and dengue; and injuries and deaths due to extreme weather events. A wide range of policies and programmes exist to control these health burdens. It is important to understand the strengths and weaknesses of these programmes under current conditions of climate variability and recent climate change, to provide information on possible alterations to increase their capacity to address the additional health risks due to climate change in the future.

The health sector, comprised of a health ministry, non-governmental organizations (NGOs), private sector, 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, such as the International Federation of Red Cross and Red
Crescent Societies. 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 geographic range of the health outcomes of concern.

It is also important to account for planned changes to existing policies and programmes. Ministries of health often have 5- and 10-year plans prioritizing areas of investment for health protection. These plans detail proposed changes that could affect the coverage and effectiveness of programmes. Understanding these proposed changes is necessary when developing modifications to address the health risks of climate change.

The following questions could be asked for each programme to be assessed:

- 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, and in relation to particularly 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 weak points that may be stressed 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?

The exact policies and programmes to be included will depend on the scope of the assessment. 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:

- 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
- Vectorborne, rodent-borne, and zoonotic diseases
  - Early warning systems
  - Surveillance and monitoring programmes for malaria and other vectorborne 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 foodborne diseases and contaminants
- Programmes to increase access to and use of safe water and improved sanitation
- Surveillance and monitoring programmes for water- and food-borne 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, 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
  - 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

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 geographic 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 exist to identify programmatic strengths and weaknesses, such as those for disaster and emergency preparedness described in Boxes 14 and 15.
Box 12 Tool to evaluate health sector disaster risk management effectiveness and preparedness

It is essential to measure the effectiveness of policies and programmes designed to address the health risks of climate change against current and likely future climates, including extreme weather events. The WHO/PAHO Self-Assessment Tool for Evaluating the Effectiveness of Disaster Risk Reduction Plans can be used to assess the level of preparedness of the health sector disaster management program 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, and measure progress over time. The tool is comprised of:

- Standards and health sector indicators for preparedness, mitigation, response/recovery, and partnerships
- Checklists with questions that can be used by the assessor to evaluate the status of the indicators

The tool is designed to be self-administered and can be adapted to local circumstances, including adding items to the checklist that are specific to a country. Professionals from health and disaster management fields, and monitoring and evaluation specialists provided the knowledge to develop this tool, which was then piloted in several locations. This tool is one example of how to measure the effectiveness of policies and programs and can provide the basis for designing similar tools that evaluate strategies for reducing the health risks of climate change.


Contributed by: Jill Ceitlin and Ciro Ugarte (PAHO-AMRO), based on (PAHO, 2010a)

Box 13 Tool to evaluate the resilience of health services and facilities to extreme events and emergencies: the Hospital Safety Index

The Hospital Safety Index (PAHO, 2010b) is used to assess the safety of health facilities and provides an evaluation of the overall probability that a hospital or health facility will continue to function in major emergencies. It evaluates structural, nonstructural, and functional factors, including the environment and the health services network to which it 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 both a guide for evaluators and evaluation forms as well as the Safe Hospitals Checklist that is used to assess the level of safety in 145 areas of the hospital. For example, within the non-structural section, electric and water systems are
evaluated. One functional factor that is assessed is if 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.

Online Reference
temid=884&test=true

Contributed by: Jill Ceitlin and Ciro Ugarte, based on (PAHO, 2010b)

The resilience of the health system, related infrastructure, and specific policies and
programmes to climate risks reflects the degree of flexibility and adaptive management
incorporated. 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 control programmes, were designed
assuming a stable climate. Further, the institutions that administer these policies and
programmes may have structures that enhance or restrict adaptability. As climate change
accelerates, some policies and programmes will need to be modified to explicitly incorporate
consideration of climate change. Inflexible programmes will mean that populations are less
protected in the face of differing weather patterns. Understanding the strengths and
weaknesses of programmes to respond to changes and surprises is of critical importance to
facilitate discussions of modifications needed to increase resilience in a changing climate.
Section 3: Understanding Future Impacts on Health

3.0 Project Future Health Risks and Impacts Under Climate Change

The health impacts that may occur in a particular location over a particular future time period 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 vectorborne disease surveillance and control programmes are partially determined by choices made in other sectors that affect access to safe water, and the ability of infrastructure to withstand flooding events.

3.1 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

Climate is not the only factor that will change over coming decades; there will be changes in demographics, socioeconomic development, urbanization, and other important determinants. Many of these other factors are also associated with increases or decreases in the incidence and geographic range of climate-sensitive health outcomes. Estimating how these factors are likely to change is needed to put into context the risks attributable to climate change.

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 bed nets, 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.

3.2 Estimate the Possible Additional Burden of Adverse Health Outcomes due to Climate Change

3.2.1 Select qualitative and/or quantitative methods for projecting future health risks

The possible additional burden of climate-sensitive health outcomes can be estimated qualitatively or quantitatively, depending upon the data, resources, and capacity available. Quantitative methods can be used for modeling relationships and extrapolating future burdens and risks. Qualitatively, expert judgment and development of qualitative scenarios can be used to estimate future impacts.

Qualitative projections of possible changes in health risks also can be based on simple scenarios of climate change, such as a 1 \( ^\circ \)C increase in average temperature within 20 years, with a 10\% increase in precipitation variability. Climate projections used in the National Communication to the UNFCCC or other assessments should inform the scenario used. Based on the results of previous steps, 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 diarrheal diseases. The implication of this projected increase for the control of these diseases depends on the
effectiveness and geographic 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 14 Using expert judgment to estimate future health impacts of climate change

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 vectorborne diseases, including malaria, West Nile virus, schistosomiasis, Mediterranean Spotted Fever, and leishmaniasis; the latter two are endemic to Portugal. Although human cases of vectorborne 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).

(Casimiro et al., 2006)
Box 15 Using Qualitative Health Scenarios to exploring potential future health risks in Tashkent, Uzbekistan 2030

Professionals from health and other sectors developed a qualitative storyline of future health 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 further explored with additional studies and data.

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

- 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 populations increases could contribute to more solid waste, with associated contamination of soil and water; this would pressure social and public services that manage waste and pollution. The quality and quantity of the water supply would likely be stressed.
- Expanding urban geographic boundaries into current agricultural land could reduce production capacity of locally produced food, 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 health concerns include cardiovascular and cardio-pulmonary disorders, allergies, upper respiratory tract complications, and infections. An urbanized and polluted environment could 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 hard to anticipate, but possible, that universal health insurance will be available by that time, increasing access to essential health services.

Contributed by: Joy Guillemot (WHO-HQ) as prepared by Uzbekistan Working group on climate change and health, WHO/Ministry of health meeting on climate change and health July, 2010

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. 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 group(s) negative health outcomes could occur. Risk managers can use the identification of vulnerable populations and regions to facilitate developing and implementing adaptation policies and measures to reduce projected negative impacts. Policymakers also can 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 and Burton, 2008). Models developed for other sectors, such as emergency response or 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. Modeling is 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 built through training courses and other mechanisms. A goal of the assessment could be to include building research capacity and increasing the availability of models to project health impacts in future studies.

3.2.2. 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 chosen need to balance the needs of decision-makers, who are often focused on the next five to ten 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 socio-economic 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, then a longer time period would be of interest because new buildings typically last for many decades and it would be helpful to know if possible locations may experience increased vulnerability to future extreme weather events such as floods. The choice of time periods also will depend on availability of data on projected changes.4

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 SRES (Specialized Reference Emission Scenarios; 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 2060/70s and 2100. Any time period(s) chosen must be relevant for policymakers and decision makers. These scenarios can be qualitative, quantitative, or include elements of both; for example, scenarios can be constructed with quantitative projections of demographic change combined with descriptions of possible pathways for development of the public health infrastructure and health care delivery in a particular region.

4 For example, Projections of changes in climate and other factors are available from the IPCC Data Distribution Centre (http://www.ipcc-data.org/), the United Nations Population Division has national level demographic projections to 2050 for all countries at http://esa.un.org/unpp/, and WHO has current estimates and projections of expected disease burdens at http://www.who.int/healthinfo/global_burden_disease/en/
Box 16 Standardized Reference Emission Scenarios (SRES)

The 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 greenhouse gas emission driving forces and their evolution. 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 vs. 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 modeling 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.

Source Nakicenovic, 2000
Box 17 Developing quantitative projections of the health impacts of climate change in Oceania

WHO and collaborators developed methods for quantitative estimation of the burden of disease from climate change (Campbell-Lendrum and Woodruff, 2007). The methods involve a) identifying health outcomes sensitive to climatic influences and obtaining estimates of their current burdens; b) quantifying the relationships between climate and non-climate variables, and the selected health outcomes; c) defining future scenarios of both climate and other determinants; and d) 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 the following table.

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Health impact estimated</th>
<th>Baseline health impact</th>
<th>Future health impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature extremes (cold and heat)</td>
<td>Attributable mortality in &gt; 65-year-old age group</td>
<td>1,100 deaths per year (across 10 cities); temperate cities have higher rates of heat deaths than tropical cities</td>
<td>Annual mortality range from 1,400 to 2,090, depending on scenario, increase in heat deaths will significantly outweigh decrease in cold deaths</td>
</tr>
<tr>
<td>Rainfall (inland)</td>
<td>Annual incidence of deaths and injuries</td>
<td>Average annual death rate in Australia (1970–2001) was 0.61/million (state rates varied from 0.06 to 3.1); the injury rate was 1.9/million (range, 0.1–8.7)</td>
<td>Predicted annual death rate of 0.53–0.61/million (state rates vary from 0.08 to 4.9); the injury rate was 1.9/million (range, 0.22–3.77)</td>
</tr>
<tr>
<td>Temperature and rainfall</td>
<td>Population living in a potential malaria transmission zone</td>
<td>Imported cases only</td>
<td>Substantial southeastern expansion of the malaria zone</td>
</tr>
<tr>
<td>Vapor pressure</td>
<td>Population living in a potential dengue transmission zone</td>
<td>Dengue not established, but local outbreaks from infected travelers occur in far northeast Australia in most years</td>
<td>Substantial southeastern and westward expansion of the dengue zone</td>
</tr>
<tr>
<td>Temperature</td>
<td>Annual incidence of diarrheal disease</td>
<td>Aboriginal people living in remote arid communities have high levels of diarrheal disease</td>
<td>A 10% (5–18%) increase in the annual number of diarrheal hospital admissions among Aboriginal children</td>
</tr>
</tbody>
</table>

The method also can illustrate the relative importance of climate and non-climate influences. For example, the Oceania assessment 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 (who are more sensitive to extreme heat) is expected to increase vulnerability by an even greater degree. Health authorities will, of course, need to plan for the overall increase in risk from both climate and non-climate factors.

Effect of a gradual increase in temperature and ageing effects on the estimated annual number of deaths from heat stress in Brisbane, Australia in 2050, as shown in the following figure.

![Figure 3 Estimated Heat attributable deaths in 2050](image-url)
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 also can 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 freshwater for large population groups. This method should therefore ideally be used alongside other qualitative approaches, to provide a more comprehensive vulnerability assessment.
Section 4: Adaptation to Climate Change: Identifying and Monitoring Health protection

4.0 Identify and Prioritize Policies 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 managing the risks of climate change, including:

- Health Sector Self Assessment tool for Disaster Risk Reduction (WHO/PAHO) http://new.paho.org/disasters/index.php?option=com_content&task=view&id=1375&Itemid=1
- Climate Adaptation: Risk, Uncertainty, and Decision Making Framework and Toolset (Climate Impacts Programme, UK) http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=62
- Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments (Climate Impacts Group, University of Washington; King County (State of Washington); ICLEI (US)). http://www.cses.washington.edu/db/pdf/snoveretalgb574.pdf

This section discusses how to identify possible adaptation options (4.1), evaluate and prioritize options to address identified risks (4.2); identify needed resources and potential barriers to implementation (4.3); estimate the costs of action and inaction (4.4); and identify possible policies and programmes to reduce health damages from decisions in other sectors (4.5).
4.1 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 and evaluate modifications to current and planned policies and programmes, and to identify 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 with 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.

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 and that are specific to a region or population. 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 socio-economic 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 geographic 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 favor 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 irrespective of how the climate changes.

Because surveillance and response are a cornerstone 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 vectorborne, 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 vulnerability and adaptation assessments to set priorities for additional funding, highlighting the additional burden of climate change on surveillance and response programmes may offer a possibility of 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 could 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 and/or large change in weather. Policies and programmes also may 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 and Diaz, 2004; Stott et al., 2004).

**Box 18 Strengthening health systems to prepare for climate change**

Strengthening health systems\(^5\) to address the additional health risks of climate change would improve current and future health burdens. Some health system actions to prepare for climate change include:

- **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, the incidence and geographic range of climate-sensitive health outcomes, including 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 to address climate-sensitive health outcomes.

- **Ensure adequate human and financial resources** to protect individuals and communities from the effects of climate change. This includes providing training and capacity building on all aspects of climate change and health for professionals and the public, and providing for effective service delivery during crises and disasters.

Contributed by B Menne

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\(^5\) Health systems comprise all the organizations, institutions, and resources that are devoted to producing actions principally aimed at improving, maintaining, or restoring health.
Box 19 Setting priorities for adaptation in the 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 governmentally approved working group. The Ministry of Health also works 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 multi-criteria analysis to set priorities. The participants identified the size of the population at risk and the likelihood of harm, scaled from (0 = lowest to 10 = highest). In addition, the timescale for risk [short (S), medium (M) or long-term (L)] was determined.

Priorities for Health Adaptation Plan

<table>
<thead>
<tr>
<th>Health risks</th>
<th>Size of the Population at Risk (low) 0 - 10 (high)</th>
<th>Likelihood of Harm (low) 0 - 10 (high)</th>
<th>Total</th>
<th>Time S/M/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heatwaves and cold spells</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>M</td>
</tr>
<tr>
<td>Mudflows</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>M</td>
</tr>
<tr>
<td>Food security and food safety</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>S</td>
</tr>
<tr>
<td>Quality of water</td>
<td>6</td>
<td>4</td>
<td>10</td>
<td>S</td>
</tr>
<tr>
<td>Infectious diseases</td>
<td>7</td>
<td>7</td>
<td>14</td>
<td>L</td>
</tr>
<tr>
<td>Migration</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>S</td>
</tr>
<tr>
<td>Quality of air</td>
<td>4</td>
<td>5</td>
<td>9</td>
<td>M</td>
</tr>
<tr>
<td>Cardiovascular diseases</td>
<td>6</td>
<td>7</td>
<td>13</td>
<td>L</td>
</tr>
<tr>
<td>Respiratory diseases</td>
<td>4</td>
<td>5</td>
<td>9</td>
<td>M</td>
</tr>
</tbody>
</table>

Further scoring was then 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

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

Contributed by A. Sharshenova.

4.1.1 Identify all possible adaptation policies and programmes

In the process of identifying specific policies and programmes to suggest to decision makers to implement, 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 and Burton, 2008). This theoretical range of choice (White, 1986) includes currently implemented interventions, new or untried interventions, plus 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 policy 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.

4.1.2 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 policy and decision makers can choose. Criteria that can be used to determine which choices are practical include:

1. Technical feasibility. Is the choice technically viable and available? For example, although a possible programme to address possible changes in the geographic range of malaria is vaccination, this option is not currently available.

2. 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.

3. 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.

4. 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 they in fact be used by those exposed (or sold to neighboring communities to supplement income)? What would the benefits be in terms of the reduced incidence of malaria?

5. 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 and/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.
4.1.3 Possible additional analyses

Once the policies and programmes have been narrowed to practical choices, additional analysis can identify and prioritize these choices for consideration by policy makers (Ebi and Burton, 2008). Analyses can be conducted through quantitative assessment, solicitation of expert judgment and/or stakeholder groups. Additional criteria may be needed to facilitate selection of practical policies and programmes, and to aid prioritization. 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 policy and 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 so land use practices in one country could affect flooding in another. In this case, transboundary cooperation and collaboration may be needed.

4.2 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. 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.

Box 20 Prioritizing Adaptation Options in Cambodia

The Cambodian Vulnerability and Adaptation Assessment focused on vectorborne diseases (malaria, dengue fever), food security, water- and foodborne diseases, and the health consequences of extreme weather events. Priority adaptation options were identified using problem trees based on answers to the following questions. Is, or does, the adaption 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 potential adverse public health outcome?

Cambodia Assessment Problem Trees Identifying different causal linkages and opportunities for health protection

Contributed by Piseth Raingsey Prak, Ministry of Health of Cambodia
Because there is no such thing as absolute safety, policy and decision makers seek to understand “how safe is safe enough?” The answer depends upon the criteria that have been established and the social norm 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 is 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: evaluates 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.
- Multi-criteria assessment: ranks how well each adaptation meets established criteria such as effectiveness, feasibility, and cost (Whyte and 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, policy 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 4.4 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 illness and human life (USEPA, 2010).

Multi-criteria analysis (MCA) 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. MCA allows decision makers to include a full range of social, environmental, technical, economic, and financial criteria (UNFCCC, 2010). An advantage of multi-criteria assessment is that criteria do not need to be measured in common metrics, and criteria can be weighted to reflect relative importance.

4.3 Identify Human and Financial Resources Needed for Implementation and Potential Challenges to be Addressed

For each priority policy and programme, it is helpful to write a brief description that includes the benefits and effectiveness for reducing current and future vulnerability, the human and financial resources required, feasibility, and constraints to implementation. 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, 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 also can 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 is 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 its implementation and continued support.

4.4 Estimate the Costs of Action and of Inaction to Protect Health

Decision makers are interested in the costs of the impacts 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 cost of inaction) and of the costs of policies and programmes to address these risks (e.g. the cost of action) can contribute to health policies and resourcing decisions. 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 care givers and lost productivity time. WHO has published a guide to estimating the economic consequences of disease and injury\(^6\). 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 cost 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 has guidance on estimating the costs of interventions through a tool 'Cost-It' (WHO, 2010c). 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).

It should be noted that because of the adaptation deficit 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 and their 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 disease such as malaria (WHO, 2010a) and water and sanitation (WHO, 2010b).

**Box 21 Estimating the costs of addressing the possible additional health burdens of climate change in 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 diarrheal diseases); vectorborne 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 rise and after disasters. The Government of Bangladesh estimated the additional costs to control diseases attributable to climate change. The total costs were estimated to be $2.8 billion United States Dollars, or 3% of GDP, consisting of malnutrition (26% of costs), chronic obstructive pulmonary disease (22%), injuries and drowning (22%), dengue, malaria, and chikungunya (11%), kalazar (6%), diarrhea (4%), filariasis (2%), and other diseases and events (8%). 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>
<thead>
<tr>
<th>Disease</th>
<th>Estimate in US $ (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diarrhea (3.5 episode/person/year @ BDT 50/episode. Source: ICDDR,B)</td>
<td>102.94</td>
</tr>
<tr>
<td>Kalazar</td>
<td>161.76</td>
</tr>
<tr>
<td>Filariasis</td>
<td>51.47</td>
</tr>
<tr>
<td>Dengue, Malaria, Chikungunya</td>
<td>308.82</td>
</tr>
<tr>
<td>Chronic Obstructive Pulmonary Disease</td>
<td>617.65</td>
</tr>
<tr>
<td>Injuries, drowning</td>
<td>602.94</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>735.29</td>
</tr>
<tr>
<td>Other diseases and events</td>
<td>220.59</td>
</tr>
</tbody>
</table>

Contributed by Iqbal Kabir, Ministry of Health and Family Welfare - Bangladesh

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\(^7\) In other words, that countries are underprepared for current climate conditions, much less for future climate change.
4.5 Identifying 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 identifying modifications to climate adaptation and greenhouse gas mitigation choices that would promote health.

For example, the IPCC stated that the "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" (IPCC, 2007). 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 also can bring health benefits. In addition to harm from exposure to air pollution, patterns of energy use and transportation may contribute to accidents and unhealthy changes in physical activity. Development and promotion of active modes of transport that will reduce greenhouse gas emissions also could 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 waste water, will likely have implications for human health and well-being by increasing or decreasing risks from vectorborne diseases and other health risks associated with water resources management.

Health Impact Assessment (HIA) is one approach to assessing the potential health impacts of policies and programmes in other sectors. 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 and 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. A HIA can identify and communicate potentially significant health impacts that are under-recognized 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 (http://www.who.int/hia/en/)

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

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 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 multi-sectoral discussion to reduce health risks from programmes in other sectors to counter the impacts of climate change.

Contributed by Edith Clarke Ghana Health Service Ministry of Health

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

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, Jordon’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 systems 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 by the food and drug administration policies and programmes aimed at reducing the impacts of climate change.

Contributed by Hamed Bakir  WHO Regional Centre for Environmental Health Activities (CEHA)

Box 24 Managing the links between water storage and dengue vectors in 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 fifty-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 has required that each newly constructed house 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 sector 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 them 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.

Contributed by Winfred Austin Greaves Ministry of Health, Barbados

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, the IPCC concluded that the number of people at risk from increasing water stress due to population growth and climate change is projected to be between 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 on the estimated number of people at risk than differences in emission scenarios. 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, and others expensive and complex, such as desalination. A Cochrane review of interventions to improve water quality from source to use to prevent diarrhea 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, diarrheal 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).

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. 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).
Section 5.0 Establish an Iterative Process for Managing the Health Risks of Climate Change

Management of climate change-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, 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 and/or sudden changes in weather, climate, and other factors. Not only will policy responses change, but 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 geographic range of climate-sensitive health outcomes, relevant environmental variables (e.g., changes in temperature, precipitation, ozone concentrations, land use change), and possible confounding variables associated with the environmental variables and the outcomes; this includes factors such as demographic change, status of the 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 also are needed that evaluate the outcomes of programmes designed to increase resilience to 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 policies and programmes, 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).
Conclusion

Conducting a health vulnerability and climate 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 context 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 vectorborne disease surveillance systems that legally require individuals to clean up vector breeding sites within their living areas; 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. Policy 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, policy makers need to know the range of available 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 modifications to maintain or improve the control of the health burdens of climate change. Stakeholder engagement is integral to the process. At each step, there are opportunities to communicate findings to stakeholders, policy 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 the health sector to demonstrate leadership within and outside the sector on adaptation and mitigation. Maximizing opportunities to engage with other sectors in designing climate resilient pathways would bring benefits to all.
DEFinitions

Key terms used in this guidance are defined here for a common understanding.8

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 (i.e. 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 in is 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. The United Nations Framework Convention on Climate Change 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’.

Climate Variability describes variations in the mean state and other statistics (e.g. standard deviations, the occurrence of extreme events, etc.) 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.

Climate-Sensitive Health Outcome is any health outcome whose geographic range, incidence, or intensity of transmission is directly or indirectly associated with weather or climate.

Co-benefits – 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.

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

Mitigation refers to policies and measures to reduce greenhouse gas emissions and/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 (i.e. climate-related risk) is a product of the likelihood of exposure and the consequence(s) of that exposure. It arises from the interaction of a physically defined hazard

8 For a full glossary of terms, refer to:  
http://www.who.int/globalchange/publications/climatechangeglos.pdf
(i.e. floods and 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 (such as immunity), and genetic factors (Balbus and Malina, 2009). Socioeconomic factors also play a critical role in altering vulnerability and sensitivity, by interacting with biological factors that mediate risk (such as nutritional status) and/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). 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 and Malina, 2009). Characteristics of a region, such as baseline climate, abundance of natural resources (i.e. access to freshwater), elevation, infrastructure, and other factors can alter vulnerability.
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