World Health Organization

Strengthening Health Resilience to Climate Change

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Scope and purpose of the paper

This paper aims to providing the recent evidence related to health risks from climate change and the need to build health resilience to climate hazards. It briefly summarizes the relevant evidence and makes a series of proposals for actions.

Introduction

There is now a very large body of evidence that human actions, mainly the burning of fossil fuels, have caused significant changes in the global climate system, with effects that will persist for decades or longer. The degree and rate of future climate change will depend on amounts of emissions of greenhouse gases and other climate pollutants such as black carbon. The Intergovernmental Panel on Climate Change (IPCC) has defined four scenarios of future emissions that it considers equally plausible, in order to describe the range of possible future climate conditions (1). Emissions of greenhouse gases are currently following the higher end of this range. By the end of the Century, these are projected to lead to concentrations of greenhouse gases in the atmosphere that are almost four times pre-industrial levels. This would be expected to bring a 3.7°C – 4.8°C rise in global mean surface temperatures (with a range of 2.5°C to 7.8°C) and severe disruptions to precipitation patterns, as well as the frequency and intensity of extreme weather events. If greenhouse gas emissions can be reduced then climate change will be less severe. However, even with rapid reductions in emissions the world is committed to significant changes in the coming decades (Figure 1).

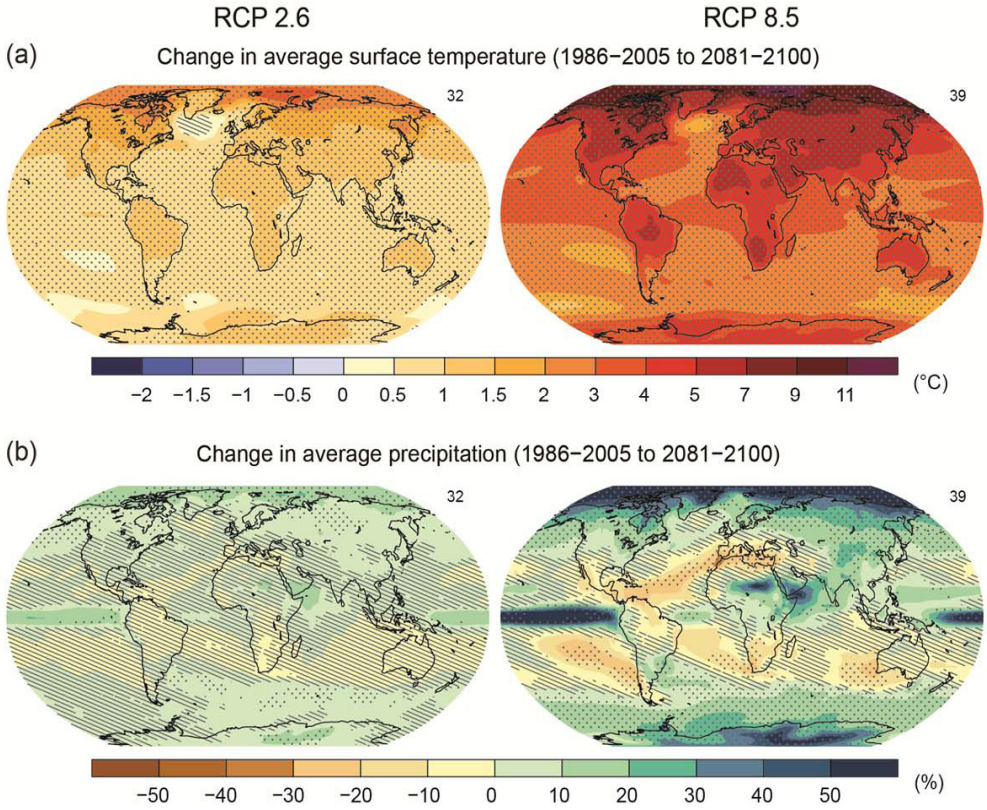

Figure 1 Projected changes in average temperature and precipitation by the end of the current century, under the lower (RCP 2.6) and higher (RCP 8.6) of the range of four scenarios of greenhouse gas emissions assessed by the Intergovernmental Panel on Climate Change (1).

This is already leading to important changes in weather conditions that are directly relevant to human health. If aggressive actions are not taken to limit carbon emissions, significant changes in human exposures to weather conditions are virtually certain by the end of the century (see Table 1).

Phenomenon and direction of trend	*Assessment that changes occurred (typically since 1950 unless otherwise indicated)*	*Assessment of a human contribution to observed changes*	*Likelihood of further changes (Early 21st Century)*	*Likelihood of further changes (Late 21st Century)*
Warmer and/or fewer cold days and nights over most land areas	Very likely	Very likely	Likely	Virtually certain
Warmer and/or more frequent hot days and nights over most land areas	Very likely	Very likely	Likely	Virtually certain
Warm spells/heat waves. Frequency and/or duration increases over most land areas	Medium confidence on a global scale Likely in large parts of Europe, Asia and Australia	Likely	Not formally assessed	Very likely
Heavy precipitation events. **Increase in the frequency, intensity, and/or amount of heavy precipitation**	Likely more land areas with increases than decreases	Medium confidence	Likely over many land areas	Very likely over most of the mid-latitude land masses and over wet tropical regions
Increases in intensity and/or duration of drought	Low confidence on a global scale Likely changes in some regions	Low confidence	Low confidence	Likely (medium confidence) on a regional to global scale
Increases in intense tropical cyclone activity	Low confidence in long term (centennial) changes Virtually certain in North Atlantic since 1970	Low confidence	Low confidence	More likely than not in the Western North Pacific and North Atlantic
Increased incidence and/or magnitude of extreme high sea level	Likely (since 1970)	Likely	Likely	Very likely

Table 1 Extreme weather and climate events: Global-scale assessment of recent observed changes, human contribution to the changes, and projected further changes for the early (2016–2035) and late (2081–2100) 21st century: Adapted from (1).

Health Impacts of Climate Change

Potential health impacts with confidence assessments

There are multiple connections between climate and health. The health chapter of the most recent report of the IPCC (2) – divides these into three main groups;

1. The direct impacts on human health, such as those which arise from damages and illness from increased frequency and severity of extreme weather events;
2. Indirect impacts which are mediated through other environmental systems. These include rising air pollution, and changing patterns of vector- food- and water-borne diseases;
3. Socially mediated effects which occur via climate change's interaction with social and human systems. These include health effects resulting from undernutrition, occupational heat stress and mental illness, as well as potential increases in population displacement and risks of violent conflict, and slowing of economic growth and poverty reduction.

Climate change therefore impacts health directly, undermines the social determinants of health and threatens the viability of a number of environmental services provided by natural systems. It can present multiple hazards which interact with pre-existing vulnerabilities, to cause substantially worse health outcomes. Importantly, almost all of the health impacts are moderated by the strength of the health system and its capacity to manage and adapt to climate-sensitive health risks.

The health risks of climate change occur both through gradual changes in average conditions, but also in variability, such as more frequent and/or severe heatwaves, floods and storms. These are of particular concern as they are often far less predictable than changes in mean conditions; they have the potential to cripple health facilities, social systems and key infrastructure; and they may result in irreversible shifts, for example through storm surges flooding both natural ecosystems and inhabited areas.

Table 2 summarises some of the most important expected impacts of climate change by the middle of the current Century. Some of these effects are being experienced today, will worsen as climate change continues unabated, and are truly global in reach, with no populations exempt. Due to the geographical distributions of climate hazards, the underlying socioeconomic determinants of vulnerability and weaknesses in government and community capacity to respond, the effects will be felt hardest in low- and middle-income countries and populations, including in sub-Saharan Africa, South Asia and Small Island Developing States. They will also disproportionately affect vulnerable groups within each country, including the poor, children, elderly, and those with pre-existing medical conditions.

	Exposures affected by climate change	*Health risks*	*Health impacts*	*Confidence rating*
Direct effects	Increased numbers of warm days and nights; Increase in frequency and intensity of heatwaves; Increased fire risk in low rainfall conditions	Excess heat related mortality; Increased incidence of heat exhaustion and heat stroke, particularly for outdoor labourers, athletes, elderly; Exacerbated circulatory, cardio-vascular, respiratory, and kidney diseases; Increased premature mortality related to ozone, and air pollution produced by fires, particularly during heat waves	Greater risk of injury, disease, and death due to more intense heat waves and fires	Very high
	Decreased numbers of cold days and nights	Lower cold-related mortality, reduced cardiovascular, and respiratory disease, particularly for the elderly in cold and temperate climates	Modest improvements in cold-related mortality and morbidity	Low
Effects mediated through natural systems	Higher temperatures and humidity, changing and increasingly variable precipitation, higher sea surface and freshwater temperatures	Accelerated microbial growth, survival, persistence, transmission, virulence of pathogens; Shifting geographic and seasonal distributions of e.g. cholera, schistosomiasis, and harmful algal blooms; Lack of water for hygiene; Flood damage to water and sanitation infrastructure, and contamination of water sources through overflow	Increased risks of food- and water-borne diseases	Very high
	Higher temperatures and humidity, changing and increasingly variable precipitation	Accelerated parasite replication and increased biting rates; Prolonged transmission seasons; Re-emergence of formerly prevalent diseases; Changing distribution and abundance of disease vectors; Reduced effectiveness of vector control interventions	Increased risks of vector-borne diseases	Medium
Effects heavily mediated by human systems	Higher temperatures and changes in precipitation	Lower food production in tropics; Lower access to food due to reduced supply and higher prices; Combined effects of undernutrition and infectious diseases; Chronic effects of stunting and wasting in children	Increased risk of under-nutrition resulting from diminished food production in poor regions	High
	Higher temperatures and humidity	Outdoor and unprotected workers obliged to work in physiologically unsafe conditions, or to lose income or livelihood opportunities	Consequences for health of lost work capacity and reduced labour productivity in vulnerable populations	High
Combined effect	Overall climate change	Combination and interactions of risks above	Negative health effects will outweigh positive effects worldwide	High

Table 2: Summary of the main expected health impacts of climate variability and climate change globally by the middle of the current Century. The final column refers to the level of confidence in the evidence for expected health impacts, as assessed in the 5th Assessment report of the IPCC (2). Other health impacts are possible (see text), but were not assigned an evidence grading by the IPCC.

WHO has carried out a quantitative estimate of the projected effects of climate change on mortality assuming continued economic growth and technological advances. Considering only a subset of climate-sensitive health outcomes, WHO estimates that by the 2030s, climate change can be expected to cause over 250,000 additional deaths a year (3). Other studies predict greater impacts of climate change, indicating that there could be 314,000- 736,000 deaths a year by 2050 (4) as a result of reduced food production.

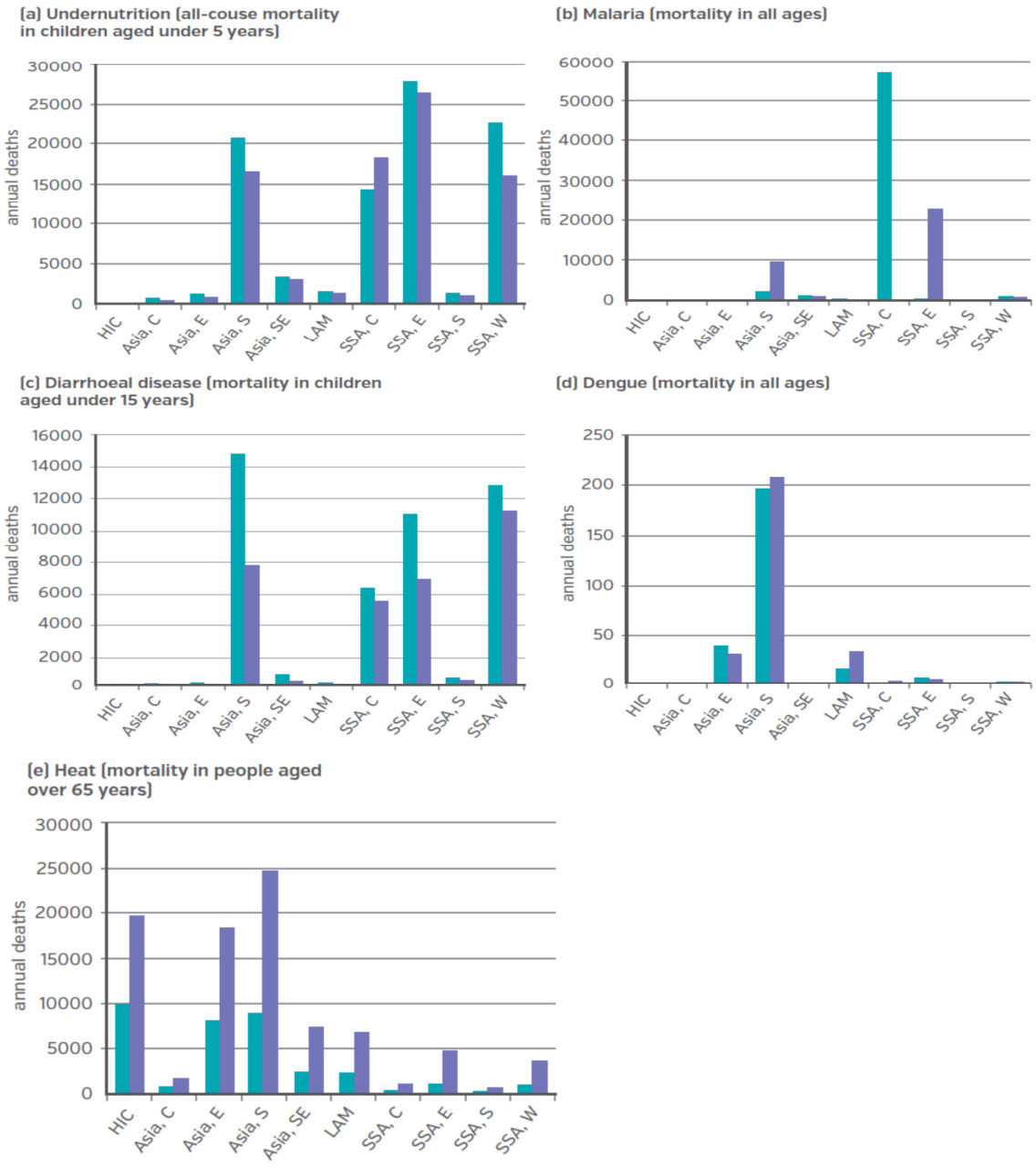

Figure 2 Estimated future mortality due to climate change in the 2030s (light blue bars) and the 2050s (purple bars), by health impact and region. For more details and regional groupings, see (3).

Additional Reasons for Concern

In addition to the main health impacts assigned an evidence grading by the IPCC, there is an emerging body of evidence for a range of other risks. Some of these have been highlighted in the IPCC 5th Assessment Report which outlines a number of key 'reasons for concern' – effects of climate change which are either particularly severe or irreversible(5). The health-relevant components of these include:

- The potential for increasing severity and frequency of extreme weather events including storms and floods, threatening the viability of the health system by damaging critical services and infrastructure networks;
- Mass displacement and disruption of livelihoods in low-lying coastal zones and small island states due to storm surges and sea-level rise;
- Inland flooding in particularly vulnerable urban centres, causing severe ill-health and adverse social outcomes;
- Breakdown in food systems from drought, flooding and extremes in precipitation, resulting in food-shortages and volatile prices, disproportionately affecting those in low and middle income countries;
- Potentially increased risk of violent conflict associated with resource scarcity and population movements.
- Slow-down in economic growth and exacerbation of poverty, with the IPCC concluding that "poor people in urban areas in low- and lower middle-income countries in Africa, Asia and Latin America may slip from transient to chronic poverty".
- Associated reversal of global health progress, including achievement of the Millennium Development Goals, and the objectives of the forthcoming post-2015 development agenda.

From a public health perspective, the lack of conclusive evidence is not a justification for ignoring the potential risks. Instead, it requires a risk management approach with an emphasis on "no regrets" measures, including inter-sectoral action to protect the environmental determinants of health such as availability of water and food, emergency and disaster risk management, or improved surveillance and response for infectious diseases. Such actions would both improve health now and reduce vulnerability to uncertain risks from future climate change.

Equity, Gender, and Vulnerable Populations

The impacts of climate change will disproportionately affect those who are already vulnerable to health effects due to other factors, such as socioeconomic status, age, gender, ethnicity, displacement, or disability. Those who are at the intersection of multiple vulnerabilities may be adversely affected by several exposures. For instance many rural internally displaced people (IDP), migrant or nomadic populations from low resource areas are very susceptible to changes in climate due to a greater dependency on natural cycles and resources. These individuals are often vulnerable not only to acute food shortages due to damage to crops and livestock, but are also susceptible to food price increases, precarious living situations and livelihoods, restricted mobility and violence. Rising rates of urban poverty are a particular reason for concern, due to the ongoing migration from rural areas, often to poor quality housing in high-risk, insecure, and physically exposed locations (e.g. at low elevation, in floodplains or on exposed slopes) in unplanned developments in cities. Many inhabitants are therefore at a disproportionately high risk of flooding, weather extremes, and poor sanitary conditions as well as social tension and discrimination. Climate change strains existing health systems and social structure and amplifies already existing social inequities (6).

Child Health and Climate Change

Children are at particularly high risk from climate change due to their developmental susceptibility and their anticipated long-term exposure to environmental changes. WHO's quantitative assessment of the health impacts of human-induced climate change for the year 2000, concluded that almost 90% of the deaths attributable to climate change at that time were children, overwhelmingly in developing countries, principally due to high pre-existing burdens of climate-sensitive health outcomes, including the effects of undernutrition, malaria and diarrhoea (7). Several important health outcomes were not included in the assessment and many of these also disproportionally affect children. These include, for example, heat stroke and dehydration, drowning and trauma from thermal extremes and natural disasters, malnutrition, growth retardation and developmental delays as well as increased risks of infectious disease, environmentally driven respiratory problems, immunosuppression and skin cancers due to air pollution and ultraviolet (UV) exposure. There is therefore a need for health adaptation programmes to place an emphasis on integrated approaches to protect and promote the health of children.

In addition, the combination of the long-term nature of climate change, and the long-life expectancy of children, presents an issue of intergenerational equity. Each generation of children will be subject throughout their lives to the environmental damage caused by previous generations. This presents a strong argument for engaging younger age groups in decisions on climate change policy.

Promoting Gender Equity while Responding to Climate Change

Women represent some 70% of the 1.3 billion people currently living in extreme poverty and are disproportionately affected by climate change, with many of its implications working to exacerbate existing gender disparities in health. This gender-gap is larger in situations where women are of low socio-economic status and where the environmental impact is more severe. There is evidence that in some of the poorest populations, female mortality associated with flooding events is several times higher and has a younger mean age, than equivalent statistics for men.

Women and girls are also more likely to have nutritional deficiencies from food insecurity and, in low-resource settings, are more likely to experience health problems associated with the burdens of traveling further to collect water. Similarly, pregnant women are particularly vulnerable to infectious diseases and pre-eclampsia which is influenced by seasonal variation and climate variability. Conversely, some climate-related conditions affect men more than women, such as in the case of rural farmers in Australia and India, who are more

susceptible to suicide in face of drought. It is therefore apparent that traditional and culturally influenced gender roles play a role in mediating the health effects of climate change.

This calls for a gender perspective to be mainstreamed into health and climate policy, including the systematic consideration of gender differences in vulnerability and adaptation assessments, routine monitoring of sex-disaggregated data for health outcomes, and inclusion of gender-responsive elements such as ensuring that activities and budgets engage both women and men in all levels of the decision-making process (8).

Unacceptable risks and limits to adaptation

Risk assessments for climate change often aim to provide the most conservative, quantitative estimates of health impacts, such as numbers of people who are likely to be exposed to, or die from, infectious diseases sensitive to meteorological conditions. As a complementary approach, specific outcomes considered as unacceptably hazardous are identified and their probability is assessed, depending on preventive measures undertaken. This approach is widely used to evaluate, inter alia, the risk of natural disasters or intentional or accidental incidents at nuclear facilities.

This approach is particularly relevant where there are clear thresholds that should be avoided. For example, human physiology dictates that it is unsafe, and very rapidly fatal, to carry out physical activity above specific levels of temperature and humidity. The limits vary with the level of exertion, and can be modified by acclimatization and behaviour change, but only to a limited extent. Using these well-studied limits, it is possible to evaluate the probability of climate change raising temperatures and humidity to levels where it would be impossible to carry out different levels of physical activity during daylight hours, for at least one month during the year, in different locations around the world. As shown in Figure 3, projected temperature change by the middle of the century is for example expected to increase the probability of passing a threshold associated with higher mortality in US cities, almost doubling in Atlanta, USA, and tripling in New York City.

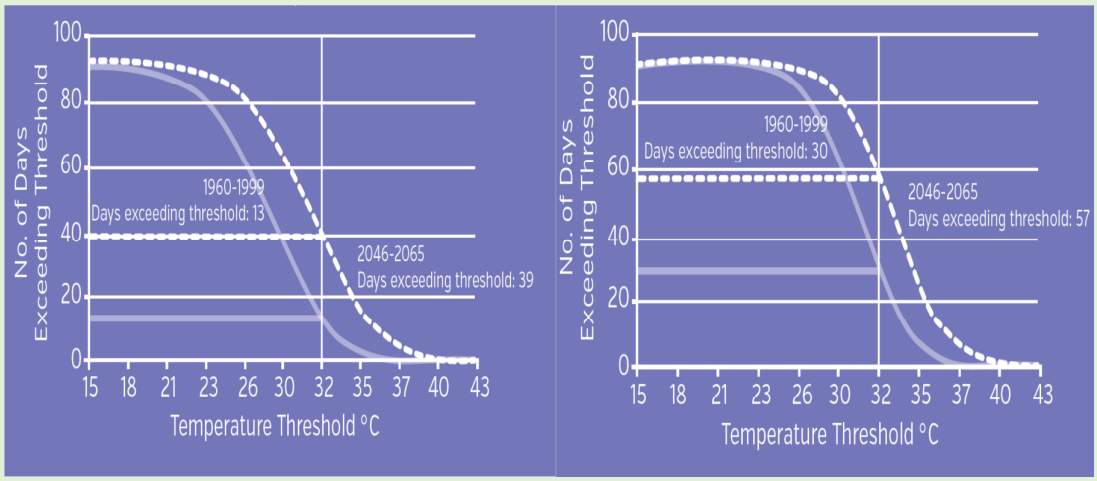

Figure 3 Probability of exceeding temperature thresholds of 32°C in US cities of New York (left panel), and Atlanta, Georgia (right hand panel), under the IPCC A1B emissions scenario, by the middle of the century, compared to a 1961-1990 reference period. Adapted from (9).

To take another example, a global mean temperature increase of about 4.5°C (within the likely range for the end of the century under current emissions paths) would have a 50% chance of completely precluding medium or heavy physical work outside in northern India in the hottest month of the year. Other kinds of physical activity would be impossible at even lower levels. For example, even a 1°C increase has a 40% chance of making sporting activity dangerous in northern India throughout the summer, and with a 4°C

warming this probability will have risen to approximately 80-90 % in northern India and south-eastern USA, and 50 % in South-Eastern China.

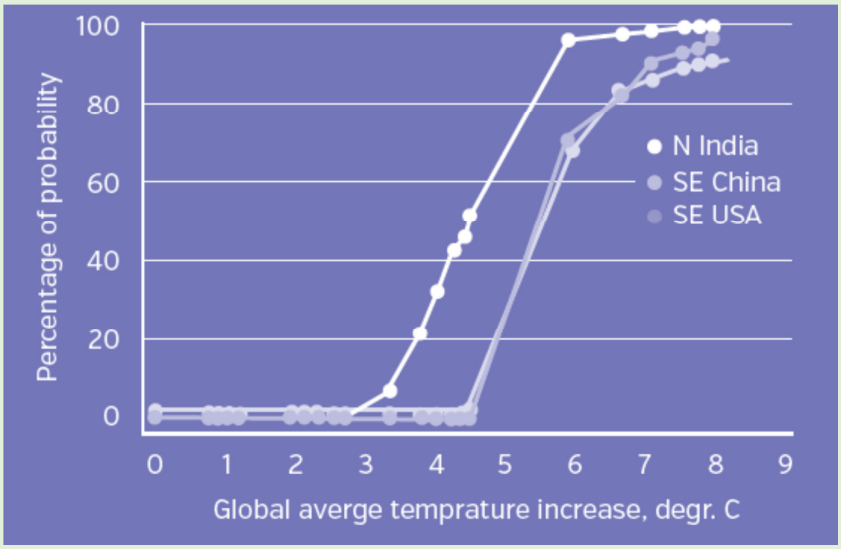

Figure 4 Probability that heat stress will preclude medium to heavy physical work outside during at least one month of the year, for different levels of global temperature increase, in different locations. More intense activity, such as active sport, would be made impossible at lower levels of warming (10).

Our degree of ambition and success in addressing global warming will therefore determine, among many other things, whether it will continue to be possible for people to live, work and play outside for significant parts of the year, in many regions of the world, calling their habitability into question.

Protecting Human Health in a Changing Climate – The Role of the Health Sector

The Sustainable Development Goals as the overall framework for health and climate action

Climate change is already presenting risks to health and these will continue in the future. However, much of the potential health burdens of climate change can be avoided; through acting on the environmental and social determinants of climate –sensitive diseases, strengthening the climate resilience of both preventive and curative aspects of health systems, and adapting to changing climate conditions.

Climate change also presents a requirement and an opportunity to work more closely with other health determining sectors such as water and sanitation and nutrition; and partners such as meteorological services to understand, monitor and manage risks. In most countries, responding to climate change is a cross-Government priority, requiring the health sector to work in a coordinated manner with other actors, often under a single climate change strategy and coordinating mechanism. It also presents an entry point to implement a "health in all policies" approach.

The agreement of the 2030 development agenda, and the adoption of the Sustainable Development Goals (SDGs) in 2015 provides the basis for the health community to work across not only within the formal health sector, but in partnership with others. While SDG 3 on 'Good Health and Well-being' provides the central reference for health, achievement of this goal depends on progress on all of the others, which relate to key environmental and social determinants of health. Some of the strongest connections are with SDG 1 'No Poverty', SDG 2 'Zero hunger', SDG 6 'Clean water and sanitation', SDG 7 'Affordable and clean energy', and SDG 11 'Sustainable cities and communities'. At the same time, progress on all of these aspects of sustainable development will be undermined if the world is not successful in SDG 13, on 'Climate Action'.

The SDGs therefore provide the comprehensive framework to make the transition from a more disease-based and curative focus, to a more integrated and preventive approach. It will also provide the reference for tracking development progress in the coming decades.

Figure 5 The Sustainable Development Goals provide the basis to ensure that actions to increase health resilience to climate change take place within a comprehensive and integrative approach to development.

A public health approach to protecting populations from climate change

Climate change differs from many traditional health issues, in that it acts over long periods, is subject to multiple uncertainties, is strongly mediated by social and economic determinants, and causes diverse and interacting health impacts. It therefore requires a response that builds on core health system functions, but also works with actors outside of the health sector to ensure coordination and synergies, and address the root causes of health risks.

Building resilience to climate risks and adapting to climate change, is therefore part of the wider effort to improve and sustain the social and environmental determinants of health. Progress towards alleviation of poverty; reduction of inequities in the social and environmental determinants of health, disaster risk reduction, and strengthening of public health systems to extend services for hard-to-reach populations are therefore critical to health protection from climate change, even though they are not specific to it. These broad-based responses enhance an individual and community's own capacity to respond to a changing climate, and improve their ability to respond to social and environmental shocks.

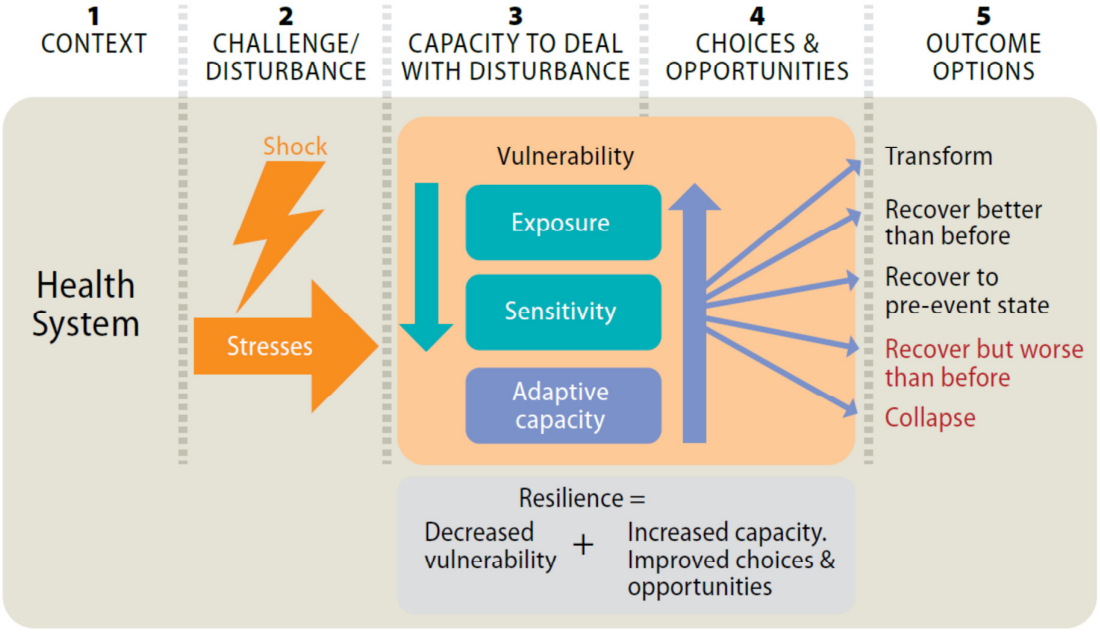

Figure 6 Climate change not only increases risks of disease, it will also bring acute shocks and long-term stresses to health systems. A systems based approach to decreasing vulnerability and increasing adaptive capacity can ensure continued health progress despite a changing climate (11).

Within the comprehensive approach, it is also necessary to be specific about the health systems functions that should be strengthened in order to increase resilience and adapt to a changing climate. These will vary between regions, countries and communities depending on local circumstances, but consultations with Member States, and the experience of pilot projects, suggest that there is a strong convergence on core set of functions. In order to support a comprehensive approach to Universal Health Coverage, and to ensure that efforts to address climate change are aligned as closely as possible with other activities of the health system, WHO proposes a framework that takes as a reference point the six "building blocks" used to describe the various functions of health systems (12).

Under these, the framework outlines a total of 10 functions that build on these pillars, adding the additional actions that are required specifically to increase health system resilience to climate variability and longer-term

change. Each of these are interdependent on the others as part of the overall strengthening of the climate resilience of the health system. It provides an organizing framework that is comprehensive at the level of functions and links to the pillars of the health system, and examples of interventions that may be adapted depending on local circumstances. Strengthening these functions can increase the capacity of the system to recognize climate risks and inform decisions, to monitor, anticipate, prevent, and respond to emergencies and changing risks, and over time to improve the system by adapting to new conditions and learning from successes and failures.

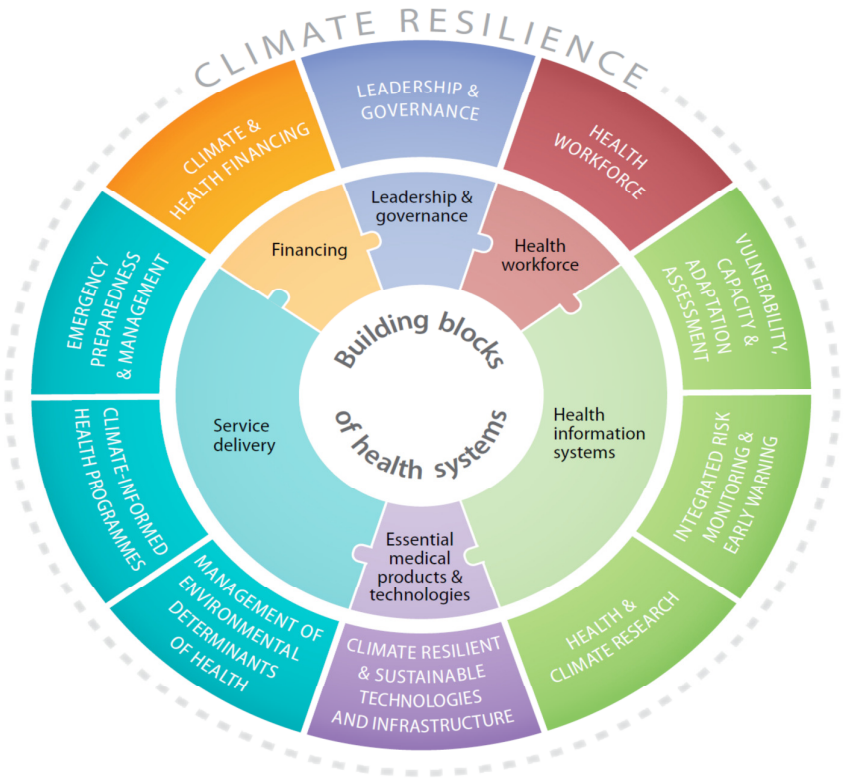

Figure 7 Reinforcement of the basic building blocks common to all health systems is essential to the provision of Universal Health Coverage, and will also contributes to climate resilience. A fully effective response, however, will also require the development of additional, more specific functions related to each to each of these building blocks (11)

Leadership and Governance: Health playing its role among others

Effective action to protect health from climate change will only occur if the health sector takes ownership, shows political leadership and ensures that climate risks are mainstreamed across all of its functions. This will require high level coordination of the relevant programmes within the formal health sector, such as environmental health; vector-control; water, sanitation and hygiene (WASH); disaster management; health information systems; policy and finance.

More fundamentally, an effective health response to climate change implies assessment, monitoring, regulation, and management of climate-related health risks that originate in other sectors, from water and sanitation, to agriculture and food, to labour and industry, and disaster management. At the national level, these sectors in most countries have active programming to respond to the impacts of climate change. With adequate coordination, investments in other sectors can be leveraged to also maximize health protection.

Proposed Objectives:

Governance: Focal points, definition of roles, and accountability mechanisms on climate established among health programmes within the Ministry of Health.

Policy: national climate and health policy strategies and plans developed, and climate variability and change considerations reflected, in main health policies and programmes.

Cross-sectoral collaboration: Health representation ensured in main climate change processes at national, regional and global levels; the main policies and strategies from health-determining sectors reflect climate change and health considerations (e.g. climate-resilient Water Safety Plans); Health Impact Assessments conducted for new mitigation and adaptation policies and programmes in all health determining sectors, in accordance with article 4.1.f of the UNFCCC.

Including health in National Adaptation Plans for climate change

Climate change affects all aspects of life. In contrast to more familiar risk factors that affect individual diseases in the short term, it instead presents both acute shocks and long-term stresses across all of the environmental and social conditions that maintain human wellbeing, from food and nutrition, to water and sanitation, to natural ecosystems.

For this reason, countries are taking action to strengthen resilience across socioeconomic sectors. To meet the challenges of climate change, such action needs to transform whole systems, and to be sustained over the long term. The United Nations Framework Convention on Climate Change (UNFCCC) therefore calls for the development of cross-sectoral National Adaptation Plans (NAPs), and is providing support initially for the most vulnerable countries.

NAPs or equivalent cross-sectoral planning processes provide the opportunity for the health sector both to take responsibility for organizing its own response to climate change. They also allow coordination with other health-determining sectors, such as food and agriculture, water and sanitation, and disaster preparedness, to ensure synergies and avoid actions taken in one sector undermining those in others.

WHO therefore provides guidance to national ministries of health on the process of preparing a comprehensive health adaptation plan (H-NAP), within the overall National Adaptation Plan. To promote cross-sectoral coordination, this is aligned with the generic NAP guidance provided by the UNFCCC, but in this case addressing the main decisions that need to be taken by the health community.

While the overall NAP process may proceed at a faster or slower pace in different countries or sectors, WHO encourages the health sector to take responsibility for planning its own response as quickly as possible. Early planning can provide a basis for comprehensive action by the health sector, promote health as a key objective of overall climate resilience, and ensure that health is well placed to receive political, technical and financial support.

Health workforce: Capacity building on climate change and health

Climate variability and change may increase local demand for services, thus potentially altering the numbers of health workers and staff required, the type of health workers, as well as their level of training. It is likely to require skills which are not currently common in the health workforce, including understanding and using climate information for health decision-making; engaging in cross-sectoral monitoring, managing changing risks to health and health system performance, and the ability to communicate climate risks to health actors and the public.

An effective health response to climate change also requires strengthening of organizational capacity; i.e. the mobilization and effective deployment and management of the financial, human and technical resources to enhance the resilience and adaptive capacity of a health system to address risks associated with climate. Finally, it requires institutional capacity development, including the ability to define and fulfil responsibilities in collaboration with other sectors, communicate with the public, and strengthen community engagement in building resilience to climate risks.

Proposed Objectives:

Human Resources: health workers sufficient in number and with the required technical capacity to understand and deal with the health risks posed by climate variability and change are available.

Organizational Capacity Development: resources, information, knowledge and processes employed by health organizations are used in an efficient and targeted manner taking account of current risks, and the additional risks posed by climate variability and change.

Communications and awareness raising: awareness on the links between climate variability and change and health outcomes raised among different target audiences (e.g. policy makers, senior staff, media, and communities).

Integrated Health Information Systems: Vulnerability and adaptation assessments; surveillance; and research

One of the primary functions of health systems is to provide accurate information to inform decisions over a range of timescales, from the immediate risk of outbreaks, to long term trends in risk factors and disease burdens. The WHO Operational Framework makes reference to three components with related functions.

Vulnerability, capacity and adaptation assessments (V&As) aim to assess which populations are most vulnerable to different kinds of health effects, to identify weaknesses in the systems that should protect them, and to specify interventions to respond. Assessments can also improve evidence and understanding of the linkages between climate and health, serve as a baseline analysis against which changes in disease risk and protective measures can be monitored, identify knowledge gaps, provide the opportunity for building capacity, and strengthen the case for investment in health protection.

Proposed Objectives:

Vulnerability: a sound understanding of the main population groups exposed to health risks posed by climate variability and change and of the most vulnerable populations groups, exists in the country or region.

Capacity: baseline information exists on capacities and gaps within the health system to anticipate, prepare for and face the challenges posed by extreme weather and long-term climate change.

Adaptation options: information on effective climate risk management and feasible adaptation options, including their comparative advantages, potential costs and efficiency, is available for selection by health system decision makers.

Integrated risk monitoring & early warning systems are an essential complement to established disease surveillance systems. Climate variability and change are altering the incidence and distribution of many important health risks including the occurrence of extreme weather events, and the transmission of vector, water and food--borne diseases. Health surveillance systems rely mainly on early detection of disease cases. Integrated risk monitoring can supplement this with information about influential climatic and environmental conditions. Analysing the relationships between health and environment in space and time, can allow the generation of risk maps for areas where environmental information is available but health information is not. Providing sufficient data are available, analysis of the temporal relationships can also allow the development of early warning systems, for example to forecast health risks of with imminent heatwaves, or outbreaks of water-borne disease associated with flooding.

Proposed Objectives:

> **Integrated Disease Surveillance and Early Warnings**: data on climate-sensitive environmental risks and epidemiological trends collected, analysed and interpreted on a continuous basis; and development of timely and actionable alerts and response to risks promoted.
>
> **Monitoring**: information on extreme weather and climate change impacts, vulnerability, response capacity, and emergency preparedness capacity is monitored and reported over time.
>
> **Communication**: evidence based risk information and timely warnings are communicated to health decision makers, the media and the public and translated into effective action to prevent negative health outcomes.

Strengthening information systems: Using climate information to support surveillance and response for Zika virus transmission.

From early 2015, Brazilian health officials began to report on an emerging cluster of microcephaly and other neurological disorders in children whose mothers had been infected with Zika virus during pregnancy. Further cases were later detected across South America and elsewhere, leading WHO to declare the outbreak a Public Health Emergency of International concern in February 2016. Since that time, the evidence of the link between Zika virus, microcephaly and other symptoms has further strengthened.

The fact that the disease is transmitted primarily by Aedes aegypti mosquitoes, and that other diseases with very similar transmission cycles, including dengue, have been shown to be highly sensitive to weather and climate conditions, have led to suggestions that the El Nino event of 2015 may have played a role in the outbreak.

Subsequent research has demonstrated that the period in which Zika virus was introduced and has spread in Latin America was indeed a period of both prolonged drought, and record high temperatures across the region, with 2014 and 2015 the warmest years on record, due to the combination of the strong 2015/2016 El Niño, and ongoing global warming.

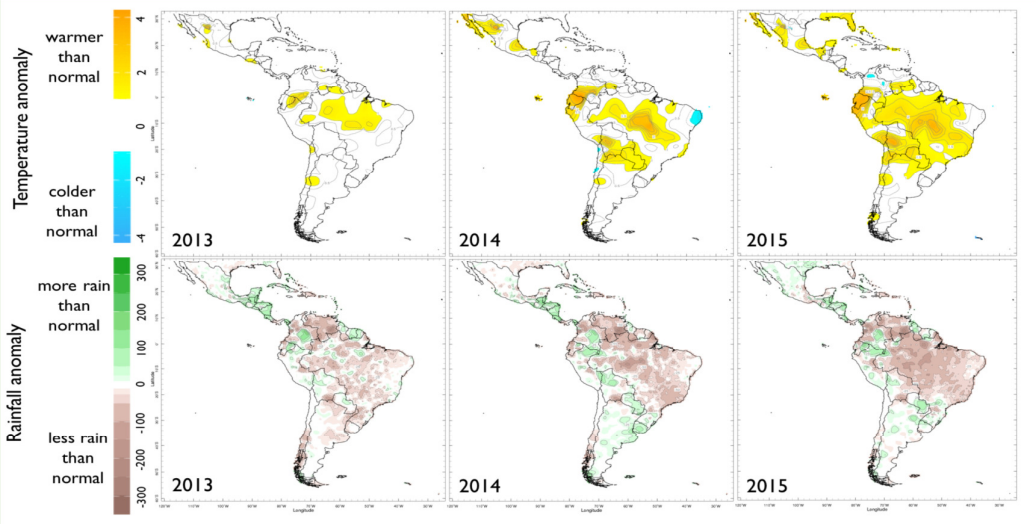

Figure 8 Map of the degree to which Annual temperature (upper row) and rainfall (lower row) in 2013-2015 departed from normal values (white). Units are ºC and mm, respectively. From (13).

Many factors contribute to disease transmission, so it is not possible to definitively attribute the current outbreak to climate change alone. However, the strong biological connections between meteorological conditions and transmission of mosquito-borne viral diseases, coupled with increases in other risk factors including urbanization and international travel, are a cause for concern for the spread of Zika virus, and potential outbreaks of other similar diseases in the future.

At the same time, these connections also provide a basis for targeting surveillance and response, Recent research has analysed the correlations between the distribution of Zika cases, climate, and other environmental factors. The resulting relationships have been used to generate predictive maps of environmental suitability for Zika virus, highlighting areas where the disease may be most likely to spread, and therefore giving a first indication of the areas in which surveillance should be most vigilant.

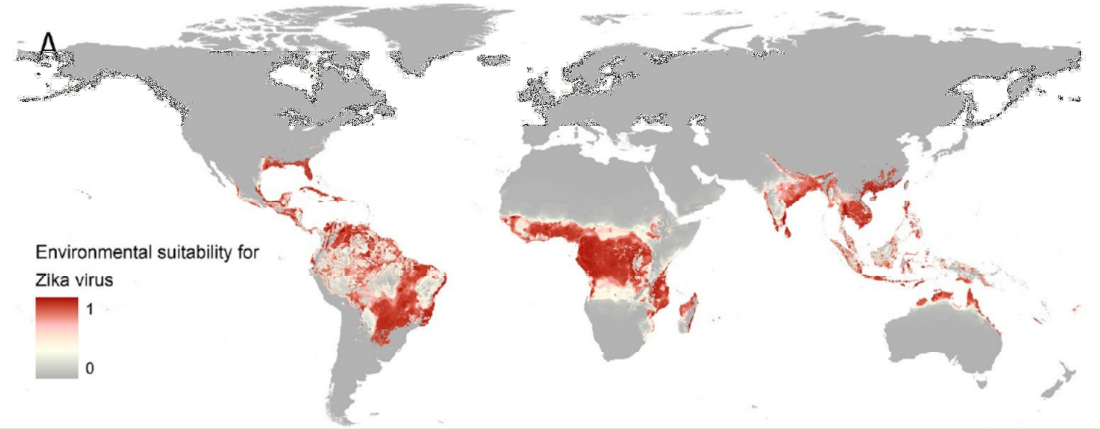

Figure 9 Map of global environmental suitability for Zika virus transmission, ranging from 0 (completely unsuitable, grey), to 1 (completely suitable, red). From (14).

The same approach also provides the basis for understanding how future trends in determinants such as a climate, urbanization and travel, may affect changing patterns of risk in the future, as one important component of strengthening health system resilience to climate-sensitive health risks.

Climate and health research is a particularly wide ranging and complex topic, and while evidence in this field is growing rapidly, investment in research lags far behind more familiar areas. There is a particular lack of evidence on the degree to which interventions which are known to protect health now, are also effective for health adaptation to climate change, especially in the poorest and most vulnerable countries (15).

Research from the global to the local level can be used to provide knowledge on climate risks to health, the modulating effect of social and environmental determinants; climate-sensitivity and seasonality of diseases and risks; how communities and health systems currently understand and cope with current and future climate risks, how local-conditions and vulnerabilities are connected to broader environmental and social health determinants; and the degree to which communities and local health services are prepared to cope with climate-related shocks and stresses. Applied research that can understand community risk perceptions, develop and test new technologies, data tools and instruments, and strategies for risk management are also critical to evidence-based decision-making.

Proposed Objectives:

Research agenda: Multi-disciplinary national research agenda on climate and health defined and endorsed by stakeholders.

Support research: Research capacity on climate and health built by supporting relevant multidisciplinary networks, making available financial resources and creating training opportunities.

Connect to policy: Research findings on climate and health disseminated to and used by policy makers.

Essential medical products and technologies: Climate resilient and sustainable technologies and infrastructure

Building health system resilience to climate risks clearly requires the provision of essential preventive and curative interventions – but can also be further enhanced through investment in specific technologies that can reduce vulnerability to climate risks.

Within the health sector, this includes the provision of climate resilient health infrastructure includes ensuring that the siting of health facilities, and the building codes that are applied to them, take account of climate risks, such as heatwaves, cyclones or storm surges. It also includes technology choices and management practices that ensure essential environmental services to health facilities, such as water and sanitation services, that are able to withstand flood or drought, and the use of renewable or other resilient electricity supplies, that will not be cut off during extreme weather events (16). Procurement of technologies with lower energy demand can simultaneously increase resilience and reduce the impact of health sector on the environment, including reduced emissions of climate altering pollutants associated with energy generation, contributing to overall sustainability.

Climate resilience can also be enhanced through the use of new technologies or approaches for better delivery of health interventions, particularly through the use of information technology. Satellite based remote sensing of meteorological and environmental conditions have improved the reliability of weather warnings, and contributed to monitoring, surveillance and risk mapping of suitability for transmission of water-borne and vector-borne diseases. Mobile communications and advances in information management have increased the speed and volume of health data collection, and vastly increased analytical capacity. Systematic integration of these technologies into disease surveillance systems can support vulnerability and adaptation assessment, surveillance and early warning.

Adaptation of current infrastructures, technologies and processes: future climate risks systematically considered with regard to revision or upgrading of technologies, products and procedures for health system service delivery.

Promotion of new technologies: new technologies, processes and products selected and deployed to increase climate resilience through enhanced health service delivery.

Sustainability of health operations: low environmental impact technologies procured and promoted by the health sector to enhance resilience to climate and contribute to long-term sustainability.

Service Delivery: Management of environmental determinants, climate informed health programming, and enhanced emergency preparedness and management.

The ultimate aim of building climate resilient health systems is to ensure provision of more effective and equitable preventive and curative services, despite external pressures posed by the climate. Three components cover this area of the health system: management of the environmental determinants of health; climate-informed health programmes; and emergency preparedness and management.

Management of environmental and social determinants of health, such as air and water quality, food and nutrition security, housing and waste management can avoid risks long before they affect human health. For this reason, some of the most effective actions that can be taken by health systems are in collaboration with other sectors such as water and sanitation, agriculture, transport, housing, and energy.

While the health sector does not usually have direct control over environmental determinants, they have essential roles to play in providing evidence and raising awareness, joint monitoring of environmental exposures and outcomes, defining regulatory standards which take account of climate influences, and

management of health risks, at both policy and programmatic levels. This requires active coordination and inter-sectoral planning.

Proposed Objectives:

> **Monitoring**: Monitoring of climate –sensitive environmental risks and impacts across sectors, against evidence-based standards.
>
> **Regulation**: Regulatory policies protecting populations against climate-sensitive environmental risks defined, revised and enforced.
>
> **Co-ordinated Management**: Environmental determinants of health jointly managed, with clear roles and responsibilities defined across sectors.

Ensuring that that health programmes are climate-informed, is more directly under the control of the health sector. National health agencies often implement or direct vertical programmes, for example for vector-borne and water-borne disease. Such programmes can become climate resilient by using information about current and projected future climate conditions, and their relationships to health outcomes and health system performance, to identify capacity gaps and inform policy, strategic investment and planning decisions.

Specific health programmes can use information gathered through the implementation of the component related to "information and early warning systems" (e.g. V&A assessments, research, Integrated Risk Monitoring and EWS) to improve their decision-making, and adjust the scale of intervention accordingly. For example, health programming informed by early warnings about a potential outbreak or heat wave, can use time wisely to prepare operations for increased patient loads and special needs. Climate-informed programming will continually review and adjust service delivery according to new information.

Proposed Objectives:

> **Health planning and programming:** Information on current and projected future climate conditions integrated into strategic planning of health system management and health programmes for climate-sensitive diseases.
>
> **Delivery of interventions**: Public health programmes revise their standard operating procedures so as to respond to climate risks in delivery of interventions.

Emergency preparedness and management associated with extreme weather are among the clearest dangers of climate variability and climate change. The Sendai Framework for Disaster Risk Reduction 2015-2030 provides the overarching structure for the global response to increasing disaster risks, including in the context of climate change, and with specific reference to health.

In addition to the usual focus on response capacity, health systems and communities should emphasize preparedness, and aim to holistically manage overall public health risks, through climate-informed preparedness plans, emergency systems, and community-based disaster and emergency management.

Health operations including healthcare and public health infrastructure should be prepared to address changing population catchments, service demands, increasing emergency events, and to operate under changing environmental conditions. For example, new facilities and service routes should be appropriately located and adequately robust to be safe and remain functional during the type of extreme weather events projected for a particular area. This includes infrastructure for water supplies, drainage, waste disposal and sanitation, as well as telecommunications, energy supplies, and medical transport. Another example is that pharmacies should have protocols and practices for safe storage and transport of pharmaceuticals, vaccines, and medical equipment in extreme heat conditions.

At least as important as the formal health sector, community based actions are at the forefront of protecting health in emergencies. The health sector can support this through providing and receiving information on local risks and vulnerable groups, and supporting the engagement, empowerment and organization of the community to reduce risks, save lives, and minimize the impact of emergencies.

Proposed Objectives:

Policies and protocols: Emergency and disaster risk management protocols and policies are adequately informed by current and likely future climatic conditions

Risk management: Strengthened health system's capacity to manage risks so that overall vulnerability and exposure to hazards are reduced and residual risks and uncertainties are effectively managed.

Empowerment of communities: Communities are empowered so as to effectively prevent and respond to the health risks posed by extreme weather events.

Financing

Effectively protecting health from climate change will incur financial costs for health systems. Health systems may need to expend resources to expand the geographic or seasonal range or population coverage of surveillance and control programmes for climate-sensitive infectious diseases, or to retrofit health facilities to withstand more extreme weather events. Additional investment may also be needed in other sectors in order to achieve health goals, such as implementing climate resilient water safety plans, or enhanced food security forecasting and nutritional screening during droughts.

A comprehensive approach to financing health protection from climate change will first build on core investments in the health sector, such as investments to an ensure adequate numbers of trained health personnel, and basic health infrastructure and services, which also help to address climate change risks.

Resources can also be mobilized through mainstreaming climate change and health considerations in investments in key health determining sectors. For example, national governments and donors make very large investments in water and sanitation, which improve health and generally reduce climate vulnerability. Adding criteria for climate resilience and health promotion to investment strategies can ensure that these investments bring the greatest possible benefit in terms of human health, climate adaptation and social return on investment, over the long term.

Opportunities are now becoming available to mobilize additional resources specifically to address additional risks presented by climate change, including for health. The Paris Climate agreement commits to raise US$100 billion a year in climate finance by the year 2020, with the Green Climate Fund, the funds of the Global Environmental Facility and the Adaptation Fund as the main multilateral financing mechanisms (17), alongside bilateral and regional channels.

The development of a clear action agenda will be fundamental to accessing climate finance for health resilience.

Proposed Objectives:

Health-specific funding mechanisms: Climate change considerations included in proposals related to climate-sensitive diseases submitted to and funded by health funding mechanisms.

Funding for sectors influencing health: Health and climate change considerations incorporated in projects and programmes funded through development funding available for main health determining sectors.

Climate change funding streams: Climate change funding mechanisms available at national level accessed.

Proposals for an action agenda on health resilience to climate change

Despite growing knowledge and experience on climate change and health, the scale of the response is currently inadequate to address the challenges posed. Common issues across countries include (i) lack of sufficient awareness and understanding and weaknesses in inter-sectoral governance mechanisms to address the links between climate change and health; (ii) limited technical, organizational and institutional capacity to develop strategies and plans to protect health from climate risks; and (iii) limited availability of financial resources, particularly from the public sector, to make the necessary long-term investments to address health and climate change, either separately, or as overlapping and synergistic priorities.

The following are proposed as priorities for action.

1. **Adopt a comprehensive approach to mainstreaming climate risks into health systems**: This action would encompass public health interventions within the formal health sector, and cross-sectoral action to improve the environmental and social determinants of health, ranging from improved air quality and wider access to clean water and sanitation to enhanced disaster preparedness.

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2. **Show leadership and engage in inter-sectoral governance**: The health sector has the ultimate responsibility for protecting health from climate risks, but cannot accomplish this task alone. The health community should engage fully in the inter-sectoral mechanisms for adaptation climate change adaptation, including contributing to the development of the health components of National Adaptation Plans, of Nationally Determined Contributions to the UNFCCC, and of the Sustainable Development Goals.

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3. **Develop the capacity of the health workforce to address climate risks.** Support capacity-building through the setting of norms and standards, development of technical guidance and training courses and mainstreaming climate change and health topics into medical and public health training. This action will include the use of information on potential climate change threats to health to improve disease surveillance and early warning and enhanced health preparedness for and response to extreme weather events.

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4. **Awareness and understanding of health risks from climate change** is growing fast within the health community, but is not yet a core part of training and career development. The health community can support capacity-building through the setting of norms and standards, development of technical guidance and training courses, and mainstreaming the issues into medical and public health training. This action will include key areas such as the use of information on climate to improve disease surveillance, diagnostics, and early warning; and enhanced health preparedness for and response to extreme weather events.

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5. **Enhance health information systems**: Risk assessment, surveillance and research are well-established health functions – and are particularly important in relation to the emerging threats of climate. The health community can use its considerable capacity and expertise to assess future health risks and necessary responses, to enhance disease surveillance and develop early warning systems for emerging risks, and to invest in research on risks and responses to protect health from climate change

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6. **Promote climate resilient and sustainable infrastructure and technologies**: Health facilities, and the services they provide, are at the front line in protecting health. It is therefore essential to ensure that they are able to withstand climate risks, and have access to essential services such as energy, water and sanitation, including during extreme weather events. In many countries healthcare provision is also a large part of the economy, and a significant contributor to greenhouse gas emissions. Wherever possible, the health sector should take the opportunity to decrease its environmental impact at the same time as enhancing health service provision.

7. **Strengthen the management of environmental determinants of health**; climate-informed health programming, and emergency preparedness. Full protection of health from climate risks ultimately requires a comprehensive set of interventions along the causal chain from exposures to disease outcomes. Primary prevention can be achieved through management of the environmental risks exacerbated by climate change, such as threats to air quality, water and sanitation, and nutrition security. It can also be enhanced by integrating climate into vertical health programmes, for example for vector-born or water-borne disease. It is also necessary to further strengthen disaster preparedness and response for extreme weather events that are likely to become more frequent and intense with ongoing climate change.

8. **Scale up finance for health resilience to climate change**: Building health resilience will require investment in all of the functions described above. The health sector can increase investment through ensuring that the large investments that are already made in health systems take account of climate risks; guiding investment in health-determining sectors, such as water and sanitation systems, to ensure that they are climate resilient, and where necessary, drawing on the specific climate funds to meet the additional costs incurred by impacts of climate variability and change.

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