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THE ADAPTATION GAP

HEALTH REPORT



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REPORT

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GLOSSARY

The entries in this glossary are adapted from definitions provided by authoritative sources, such as the Intergovernmental Panel on Climate Change (IPCC) and the World Health Organization (WHO).

Adaptation	In human systems, the process of adjustment to actual or expected climate and its effects in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.
Adaptive capacity	The combination of the strengths, attributes and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities.
Burden of Disease	The burden of disease can be thought of as the measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability.
Disability adjusted life years	Disability Adjusted Life Year (DALY) can be thought of as a year of 'healthy' life lost. The sum of these DALYs across the population constitutes the burden of disease.
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
Hazard	The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. In this report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.
Resilience	The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation.
Stunting	Stunting is the impaired growth and development that children experience from poor nutrition, repeated infection, and inadequate psychosocial stimulation. Children are defined as stunted if their height-for-age is more than two standard deviations below the WHO Child Growth Standards median.
Vulnerability	Here understood as the propensity or predisposition to be adversely affected by climate impacts.

Wasting	Wasting is the impaired growth and development that children experience from poor nutrition, repeated infection, and inadequate psychosocial stimulation. Children are defined as wasted if their weight-for-height is more than two standard deviations below the WHO Child Growth Standards median.
Vector-borne disease	Illnesses caused by parasites, viruses and bacteria that are transmitted by mosquitoes, sandflies, triatomine bugs, blackflies, ticks, tsetse flies, mites, snails and lice.
Water-borne disease	Illnesses that are transmitted through contact with or consumption of unsafe or contaminated water.
Food-borne disease	Illnesses that are transmitted through consumption of unsafe or contaminated food.

ACRONYMS

COP	Conference of Parties
FBD	Food-borne Disease
IPCC	Intergovernmental Panel on Climate Change
MDB	Multilateral Development Bank
NAP	National Adaptation Plan
NDC	Nationally Determined Contribution
OECD	Organisation for Economic Co-operation and Development
SDG	Sustainable Development Goal
UNFCCC	United Nations Framework Convention on Climate Change
VBD	Vector-borne disease
WASH	Water, sanitation and hygiene
WFB	Water and Food-borne diseases
WBD	Water-borne disease
WHO	World Health Organization

FOREWORD

Economic losses from weather and climate-related disasters made 2017 the costliest year on record, and the the record high temperatures, heatwaves, and wildfires of 2018 illustrate that the impacts of climate change are being felt across the world. The potential future health impacts of climate change are particularly staggering. The heatwave of the summer of 2010 caused 55,000 deaths in Eastern Europe alone. According to the World Health Organization, climate change is expected to cause approximately 250,000 additional deaths per year between 2030 and 2050, due to heat exposure, diarrhea, malaria, and childhood undernutrition. These figures show that societies and economies across the world are increasingly vulnerable.

The 2018 Adaptation Gap Report has two parts. First, it provides an overview of the status and trends of the adaptation gap in terms of vulnerability to climate change, adaptation costs and finance, and countries' adaptation commitments and actions. Second, the report undertakes an in-depth assessment of the adaptation gap in health.

The report underscores that adaptation to climate change is strongly linked to sustainable development. If done right, adaptation actions can grow our economies, create jobs and lead to better health outcomes. Given these multiple benefits, adaptation is an integral part of good, climate resilient development. In the health sector, many of the most important actions to bridge the adaptation gap are related to improving basic sanitation, improving access to safe water, and reducing food and nutrition insecurity. The recommendations in this report aim to make this a reality.

We hope this report will help to identify and design the actions required to bridge the adaptation gap – whether in terms of vulnerability, finance or health. We are delighted to the continued collaboration between UN Environment and the Global Center on Adaptation. This report will provide important input to the work of the newly-launched Global Commission on Adaptation in its ambitious mission of accelerating adaptation action at scale and at speed.

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Deputy Executive Director of UN Environment

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Chief Executive Officer of the Global Center on Adaptation

EXECUTIVE SUMMARY

This is the fourth edition of the UN Environment Adaptation Gap Reports. Since 2014, these reports have focused on exploring adaptation gaps, characterized as the difference between the actual level of adaptation and the level required to achieve a societal goal. The adoption of the Paris Agreement established a global goal on adaptation of "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the temperature goal". As the Paris Agreement is now being implemented, important decisions are about to be made on how to report on, and take stock of, progress towards this global goal. The Adaptation Gap Reports focus on providing policy-relevant information to support such efforts.

The focus of the 2018 report is dual: **The first part** examines the gaps that exist in a number of areas that are central to taking stock and assessing progress on adaptation, namely the enabling environment as expressed through laws and policies, key development aspects of adaptive capacity, and the costs of and finance needed for adaptation. **The second part** of the report focuses on the adaptation gap in one particular sector, namely **health.** Based on the available scientific evidence on climate impacts and health outcomes, the second part provides an overview of the global adaptation gap in health, followed by a specific focus on three key areas of climate-related health risks: heat and extreme events, climate-sensitive infectious diseases, and food and nutritional security.

PART ONE: STATUS AND TRENDS IN THE ENABLING ENVIRONMENT, ADAPTIVE CAPACITY AND FINANCING FOR ADAPTATION

ADAPTATION IS INCREASINGLY ADDRESSED IN LAWS AND POLICIES, BUT MORE NEEDS TO BE DONE TO ENABLE EFFECTIVE AND EFFICIENT ADAPTATION

There is a divergence between what countries report under the United Nations Framework Convention on Climate Change (UNFCCC) and what studies tell us about the laws and policy frameworks being implemented at the national level. Under the UNFCCC, countries use multiple reporting instruments to provide information on how they enable adaptation, including information on their plans and policies. As at November 2018, adaptation information from developing countries included 132 adaptation components of NDCs and 11 National Adaptation Plans, whereas 40 developed countries reported on adaptation in their seventh National Communications. In comparison, independent studies show that at least 162 countries explicitly address adaptation at national level through a total of 110 laws and 330 policies. Although only 68 of these countries use legislation, nearly all of them have executive policies. However, several countries are in the process of developing adaptation legislation, which is more difficult to reverse than policies. Less than half of countries provide integrated frameworks to address climate change adaptation in a holistic way. Most address adaptation through development plans or sectoral policies alone, while a handful have been specifically designed to create financial instruments or to focus on disaster risk management.

Only 40 developing countries have quantifiable adaptation targets in their current NDCs, while 49 include quantifiable targets in their national laws and policies. Some countries include quantified adaptation targets in their international reporting, but have not yet codified them in national legislation, whereas others have targets codified in national law that are not currently reported to the UNFCCC. Most of the quantifiable targets in national laws and policies are relevant to adaptation in disaster risk management, coastal protection, flood-proofing, land preservation, water management, climate-resilient buildings and more. The low levels of quantifiable targets present a risk both to the signal that the NDCs provide to the required national policy-making efforts, and to the ability to measure progress and increase ambition over time. Furthermore, many existing targets are relatively short-term and do not look beyond 2020. This challenges the ability to address anticipated future climate impacts. Finally, lacking systematic recording at subnational levels, it is not possible to capture all adaptation-relevant actions and to assess status and progress on adaptation governance structures.

INDICATORS OF ADAPTIVE CAPACITY SHOW THAT THE GAP BETWEEN LOWER-INCOME AND HIGHER-INCOME COUNTRIES IS CLOSING, BUT PROGRESS IS GENERALLY TOO SLOW

Indicators of adaptive capacity, along with indicators of exposure and sensitivity, are central to assessing reduced vulnerability and enhanced resilience. Focusing on adaptive capacity, the report examines existing frameworks and indices of vulnerability and distilled common indicators of adaptive capacity across them for which sufficient data are available. Measures of progress in adaptive capacity have much in common with measures of progress in development more generally and are likely to yield benefits irrespective of future climate regimes while addressing aspects relevant to increased exposure to climate hazards. The emphasis has also been on selecting indicators relevant to health, as this is the focus of the second part of the report.

Over the past twenty years low- and middle-income countries have shown consistent progress in many indicators relevant to adaptive capacity. Most of these indicators, identified on the basis of existing frameworks and indices of vulnerability, overlap with development indicators. They include access to basic sanitation, clean water and electricity, as well as immunization rates, child mortality, food deficits and the prevalence of stunting. However, progress has been slow and there is no sign of acceleration, so that catching up with wealthier countries to bridge the gap in adaptive capacity will take many decades under current rates of improvement. For example, average access to basic sanitation in low-income countries is currently at around 30 percent, but at rates of between 2 and 8 percent increase in access per year it will take several decades to reach lower-middle income country levels.

Progress in other indicators of adaptive capacity is mixed. For instance, the number of physicians in low-income countries has been stagnating at very low levels (less than 0.5 per 1,000 people), whereas in upper-middle to high-income countries numbers have continued to climb and are currently between 2 and 3 per 1,000 people. On the other hand, access to mobile phone technology in low and lower-middle income countries is catching up quickly with the rest of the world and will have attained full coverage within a decade, providing many opportunities for development and income generation, as well as access to information that can be important for adaptation.

Access to resources and information, technological capacity and a conducive enabling environment are necessary elements of building adaptive capacity. A good example where this has been shown to be successful is the reduction of deaths from tropical cyclones in Bangladesh. Storm risk hazards have been strongly mitigated since the 1990s by adopting an integrated approach that coordinates actions across ministries and other stakeholders at the national to local levels, empowers communities, and provides effective early warning and access to protective infrastructure.

THERE IS A CONSIDERABLE ADAPTATION FINANCE GAP TODAY, WHICH IS ESTIMATED TO INCREASE SIGNIFICANTLY IN THE FUTURE

The 2016 Adaptation Finance Gap Report significantly increased previous estimates of adaptation costs. The annual costs of adaptation could range from US$140 billion to US$300 billion by 2030 and from US$280 billion to US$500 billion by 2050. However, major information gaps continue to persist across sectors and for different impacts, most notably with the omission of adaptation cost estimates for biodiversity and ecosystem services, which are likely to raise the costs of adaptation further. New information strengthens and adds detail to the previous findings:

Climate-risk screening by the multilateral development banks suggests that including costs to build resilience to future climate risks over the lifetime of a given investment will significantly increase costs. In the road sector, for example, the uplift required to deliver resilience varies from 0.5 to 10 percent of the total project investment cost. Given the latest estimates of the global investments in new infrastructure, which range from US$57 trillion to US$95 trillion between now and 2030, cost uplifts of this level imply very large global adaptation costs.

The programming and implementation costs of adaptation are significant. For international climate finance, the additional costs of design (including safeguards) and implementation (capacity building, project management, reporting, monitoring and evaluation, and oversight) typically range between 10 and 20 percent of the total costs. These need to be included in adaptation cost estimates and financing needs to reflect the realistic costs of delivering adaptation.

There is also more evidence of the short-term economic and financial costs of extreme events, which are poorly captured. Economic losses from weather events were the highest on record in 2017. Total estimated economic losses stood at US$330 billion in 2017, of which US$136 billion was insured losses. Climate attribution is starting to tease out the influence of climate change on large weather extremes, and these indicate earlier and larger impacts than previously estimated.

Overall, a major adaptation finance gap persists. New information shows that global public finance flows have remained stable and were estimated at US$23 billion in 2016. Approximately 64 percent of this went to developing countries via bilateral climate finance, multilateral climate funds and multilateral development banks. Other sources of adaptation finance, such as through development finance institutions, domestic public finance and private-sector finance, are available but difficult to assess. While substantial, the available adaptation finance is significantly lower than the needs expressed in the NDCs, which have been estimated at over US$50 billion per year for fifty non-Annex I countries for the period 2020 to 2030, and much lower than the estimated costs of adaptation.

PART TWO: THE ADAPTATION GAP IN HEALTH

The adaptation gap in health can be characterized as the difference between the climate-related health outcomes under actual adaptation efforts and the climate-related health outcomes that would occur under desirable levels of health adaptation efforts, consistent with the societally set goal for adaptation. While a global societal goal for adaptation in health does not exist, an implicit objective is to avoid the highest possible proportion of climate-related health impacts now and in the future by increasing adaptation efforts implemented in the highest-quality manner that knowledge can support. Because even successfully implemented full adaptation cannot be a hundred percent effective in protecting health from climate impacts, there will still be some residual health impacts on populations.

THERE IS A SIGNIFICANT GLOBAL ADAPTATION GAP IN HEALTH, AS EFFORTS ARE WELL BELOW THE LEVEL REQUIRED TO MINIMIZE NEGATIVE HEALTH OUTCOMES

There is a significant global health adaptation gap today. While progress has been made in reducing climate-sensitive diseases and injuries, current adaptation efforts are well below the level required to avoid or minimize negative health impacts. Acknowledging the diversity of national circumstances with great variation both across and within countries and regions, a substantial proportion of the current climate-related impacts on mortality, illness and decrements in the quality of life is preventable. However, current funding for climate change adaptation in health is negligible and, while health is a priority sector in 54 percent of NDCs featuring adaptation, there are few quantitative targets against which progress can be measured.

Unless adaptation efforts are strengthened considerably, heat and extreme event-related morbidity and mortality will continue to rise. The impacts of heatwaves and extreme events on human health are significant. Current climate variability already threatens vulnerable populations in many regions. Projected increases in heat and extreme weather events and changing socio-demographic trends will further increase exposure and risks. Thus, while largely preventable with appropriate adaptation measures, heat-related annual mortality of the elderly could rise by over 90,000 in 2030 and over 250,000 by 2050, particularly in sub-Saharan Africa, Latin America and Southeast Asia.

Without appropriate action, infectious diseases will rise significantly due to climate change, particularly in Africa and Asia. Infectious diseases are climate-sensitive and represent a large share of the current global burden of disease, mainly through water- and foodborne diseases and vector-borne diseases. For instance, as heavy rains and floods increase with climate change, outbreaks of water-borne diseases will rise due to the contamination of drinking water supplies, which typically hit people living in precarious conditions, especially women, children and the elderly, the hardest. Without adaptation, 48,000 additional deaths in children aged under fifteen are projected due to diarrheal disease for 2030, as well as 60,000 additional deaths from malaria.

Unabated, nutrition-related morbidity and mortality are expected to rise significantly in the future, even under moderate warming scenarios. Sub-Saharan Africa and southern Asia remain the regions that are most vulnerable to chronic and acute undernutrition, which typically hits the rural poor, women and children the hardest. For instance, stunting in children, a key indicator of food insecurity and nutrition, shows slow rates of decline and is expected to miss the target of a 40 percent reduction by 2025 compared with 2012 by a significant margin. As a risk multiplier, climate change will increasingly threaten health related to food and nutritional security through its direct and indirect impacts on food systems. Without adaptation, climate change will cause 7.5 million additional cases of stunted children by 2030, and 10.1 million by 2050.

There are few robust global estimates of the health impacts caused by weather extremes, climate-sensitive infectious diseases and undernutrition. Estimates of the health burden of climate change probably underestimate the actual impacts due to the complexity of the causal pathways between exposure and attributable health outcomes, and the inability of existing monitoring and surveillance systems to capture accurate information. For instance, studies reveal substantial gaps in knowledge and data coverage that need to be overcome in order to improve assessments of progress on adaptation efforts, although improvements can be expected as tracking the SDG and Sendai Framework targets gets underway.

There is limited information on the costs of adaptation in health. A lack of global studies on the costs of the health impacts of climate change and the costs of health adaptation is hindering better global estimates of current and future costs and the financial needs of health adaptation. Ill health and premature mortality related to climate variability and change incur significant economic costs to health systems and society, which are expected to rise in the future. While the costs of climate-related health impacts, particularly weather extremes, vary considerably, the benefits of preventing impacts can be high. For instance, the benefit-to-cost ratios for heatwave warning systems have been estimated at 11 for London, 308 for Prague, and 913 for Madrid, with increasing benefits under a changing climate.

International climate finance for health has been negligible. In principle, most of the financing mechanisms and funds for adaptation apply to health adaptation as well. However, so far the overall presence of health-sector activities in international climate adaptation finance stands at less than one percent. Additional resources are needed to increase the resilience of health systems, including health facilities, and to build the capacities of health professionals to deal with climate-related impacts, particularly in developing countries.

BRIDGING THE ADAPTATION GAP IN HEALTH

Many of the actions that can contribute to bridging the adaptation gap in health are low or no-regret measures that provide immediate health benefits, reduce the risks from future climate change and support the SDGs. Among these actions three categories are key: 1) efforts to enhance the climate resilience of health systems; 2) efforts related to broader development action; and 3) efforts related to early warning, monitoring and building the evidence base.

Efforts related to enhancing the climate resilience of health systems are fundamental if health systems are to perform their core functions and maintain their structures under climate-related shocks and stresses, thus creating sustained improvements in population health, even in a changing climate. Important efforts include:

- **Climate proofing health systems.** This includes inter-sectoral actions to enhance the climate resilience of health facilities, as well as organizational measures to maintain essential functions and structure of health systems after extreme weather events, both currently and under the more frequent and severe events that are expected from climate change.

- **Investing in capacity-building and preparedness.** Carrying out climate change health vulnerability and adaptation assessments, developing climate change and health action plans and enhancing health workforce preparedness to climate impacts would deliver immediate and long-lasting results that would improve adaptive capacity in health and strengthen the resilience of health systems.

- **Integration of health into broader policy frameworks.** Health adaptation is most effective when it is integrated into broader national policies and programmes, notably by evaluating and ensuring the health benefits of sectoral adaptation activities in agriculture, water and sanitation, infrastructure, transport, energy and urban planning, as well as by creating synergies with complementary initiatives such as the Sendai Framework and the SDGs, the Paris Agreement and the International Health Regulations, among others.

Efforts related to broader development action. The prevention of many of the climate-related impacts on health will depend greatly on development efforts that address key social and environmental determinants of health such as basic sanitation, clean water supply, and food and nutritional security. Important efforts include:

- **Improving basic measures in water, sanitation and hygiene.** Development-related measures in water, sanitation and hygiene, as well as in food safety, can prevent many of the additional deaths due to climate-sensitive infectious diseases.

- **Scaling up proven interventions to avoid malnutrition.** Prevention, early detection and treatment of malnutrition in all its forms can be achieved by scaling up proven interventions that build capacity and knowledge in women and by providing food supplements to overcome deficiencies, particularly in the areas of food insecure climate hotspots.

Efforts related to early warning, monitoring and building the evidence base. Early warning, monitoring and improved scientific understanding are key to reducing the impacts of weather extremes and enhancing the prediction and management of future burdens of climate-sensitive health impacts. Important efforts include:

- **Building effective early warning and monitoring systems.** This includes the development and implementation of multi-hazard early warning systems along with effective planning and risk management in line with the global targets of the Sendai Framework and the SDGs. However, progress is hindered by several factors, including widely varying surveillance capacity among countries and regions, and a lack of clear, standardized definitions of extreme events.

- **Expanding the evidence base for climate-related health risks.** Better models are crucial to our understanding and management of climate-related risks. For instance, challenges exist in quantifying the magnitude of weather extremes and in predicting the occurrence, distribution and incidence, at different spatial scales, of the future burden of infectious diseases and undernutrition due to their often extremely complex causal pathways.

HOW WELL ARE WE DOING OVERALL?

Overall, we need more efforts and resources to scale up actions to narrow the gap. Based on what we know, there is a significant global adaptation gap in health, current efforts being well below the level required to significantly reduce negative health outcomes. We also know that health impacts will strongly increase in the future due to climate change unless adaptation action is scaled up and accelerated. At the same time, there has been progress in bridging the gap in some areas, although with great variability both within and across countries and regions. For instance, the average death toll from floods and droughts has declined compared with similar events in the past. What is urgently needed to further narrow the adaptation gap in health, both today and in the future, is mainly political will and the necessary financial resources to implement the most important actions related to climate resilient health systems, early warning systems and a broader development agenda aimed at reducing vulnerability to climate-sensitive health risks, particularly infectious diseases and food and nutritional insecurity.

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CHAPTER 1

INTRODUCTION

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This is the fourth edition of the UN Environment Adaptation Gap Reports, which aim at exploring key adaptation gaps, characterized as the difference between the actual level of adaptation and the level required to achieve a societal goal. It comes at a time of mounting evidence on the increase in the number and devastating effects of climate variability and extreme events that we already experience, and where the scientific understanding of what we can expect in the future under different global temperature scenarios underlines the urgency of unprecedented and accelerated mitigation and adaptation ambition and action.

The recently published Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5°C underscores the challenges ahead as climate change intensifies. It details how climate variability and extreme events will escalate with increased global temperatures and stipulates that many impacts will be irreversible, particularly on ecosystems and biodiversity, or difficult to manage above +1.5°C (IPCC, 2018). For instance, at +1.5°C over 350 million additional people will be exposed to deadly heat stress by 2050 (Ebi *et al.*, 2018).

The UN Environment Emissions Gap Report 2018 amplifies the reasons for concern. The report assesses that, despite progress being made in reducing greenhouse gas emissions, the mitigation ambition is still far from sufficient to limit global warming to the targets of the Paris Agreement (UNEP, 2018). Continuation of mitigation efforts in line with the current Nationally Determined Contributions (NDCs) would lead to a global mean temperature rise of about 3.0°C to 3.2°C above preindustrial levels by the end of the century. The ambition must be to roughly triple current efforts to get the world on track towards achieving the goal of the Paris Agreement of limiting global warming to well below 2°C and increased around fivefold for a 1.5°C scenario (UNEP, 2018).

Next to urgent and unprecedented mitigation, the ambition to adapt to the intensifying climate-related impacts also needs to be strengthened and accelerated. While limiting global warming through mitigation will be the most critical factor in keeping the future adaptation challenge manageable, the adaptation efforts needed even under the 1.5°C global warming scenario far surpass current levels and are set to affect the poor and vulnerable most, particularly in developing countries. In fact, previous Adaptation Gap Reports have illustrated that global adaptation gaps prevail already today (see box 1.1) and that they are intrinsically linked with development gaps. Current adaptation gaps are set to widen substantially in the future, unless adaptation efforts are scaled up both locally and globally and are accompanied by sound development progress. Therefore, progress towards the United Nations Sustainable Development Goals (UN, n.d.) and the targets set out in the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015) among other development agreements generally also contribute to adaptation progress.

Box 1.1: The Adaptation Gap Reports

Since 2014, UN Environment has produced global reports that explore key adaptation gaps, characterized as the difference between the actual level of adaptation and the level required to achieve a societal goal at a given point in time (UNEP, 2014). The Adaptation Gap Reports present ways to assess these gaps and options for bridging them. In 2014, the first Adaptation Gap Report provided a framework for defining adaptation gaps with a preliminary assessments in three key areas: finance, technology and knowledge. It highlighted the need for a global framework for adaptation action defined by clear goals, targets and metrics (UNEP, 2014).

The 2016 Adaptation Finance Gap Report utilized the framework to assess the difference between the costs of meeting climate change adaptation needs in developing countries and the finance currently available. The report outlined the importance of up-to-date estimates of adaptation needs and costs, suggesting that adaptation costs in developing countries were significantly higher than previously estimated, and arguing for improved tracking of finance flows in order to support the operationalization of the global goal on adaptation (UNEP, 2016).

Rather than assessing a specific adaptation gap, the 2017 Adaptation Gap Report looked at the status and ways forward for assessing and tracking progress on adaptation at a global level to support the post-Paris process. The report provided insights into the current state of knowledge on methodologies, indicators and metrics for adaptation tracking and evaluation of progress at a global level. It highlighted the opportunities to learn from efforts countries are currently undertaking in implementing national Monitoring and Evaluation systems for adaptation and the necessity to develop indicators that capture context-specific aspects and support evaluative metrics for qualitative assessment (UNEP, 2017).

The 2015 Paris Agreement established the global goal on adaptation of "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the temperature goal" (UNFCCC, 2015). As the implementation of the Paris Agreement is under way, countries are expected to reach final agreement on important adaptation-related aspects of the Paris Agreement work programme during the 24th session of the Conference of the Parties (COP 24) of the United Nations Framework Convention on Climate Change (UNFCCC). These aspects include the development of further guidance in relation to adaptation communications, methodologies for assessing adaptation needs and for reviewing the adequacy and effectiveness of adaptation and associated support, identification and recommendations on the sources of input for the global stocktake, and the development of modalities for the latter.

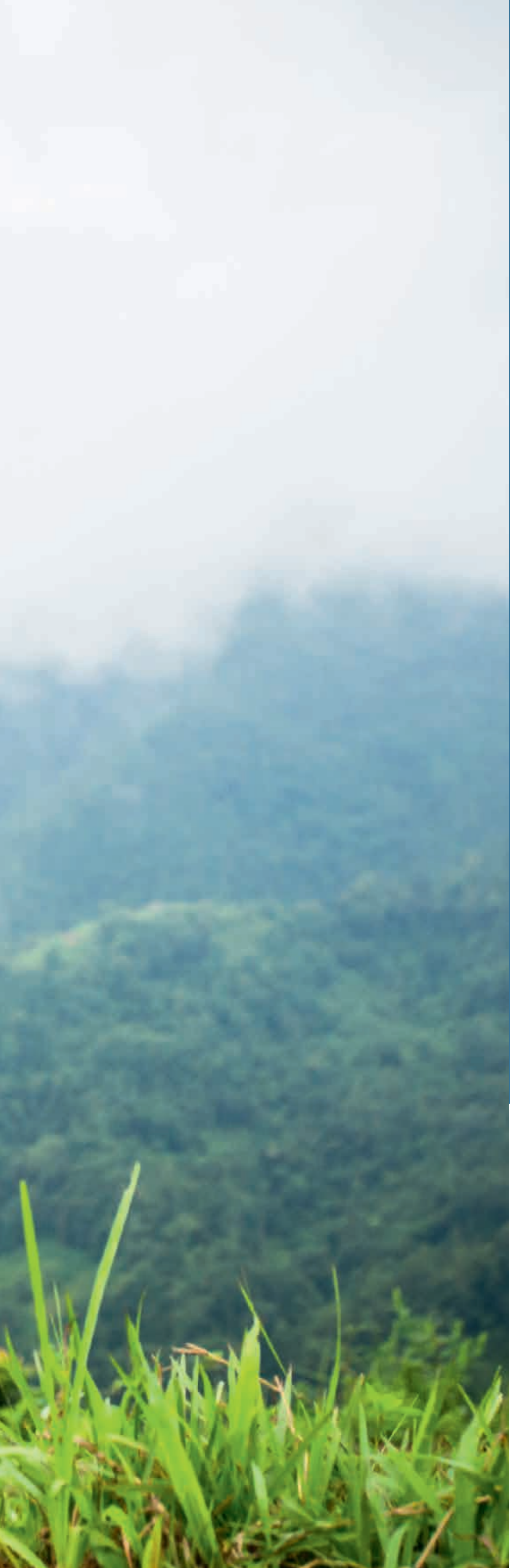
Within this political and scientific landscape, this fourth Adaptation Gap Report is structured into two parts. The first part builds on the 2017 report by providing practical examples of the status of and trends in adaptation gaps that are central to enhancing resilience and reducing vulnerability in the face of increased exposure to climate risks: enabling environment, adaptive capacity and finance. These will need to feature in any effort to take stock of status and progress in achieving both national and global adaptation goals. The report also examines the status of national governance structures to enable climate change adaptation as expressed through laws and policies (chapter 2), identifies key aspects of describing and building adaptive capacity (chapter 3), and provides an updated assessment of the costs and finance needs for adaptation both now and in the future (chapter 4).

In its second part, the report assesses the adaptation gap in one particular sector, namely health. Given the strong linkages between the impacts of climate variability and change and health-related outcomes, it is no wonder that health features among the most prioritized sectors in the adaptation components of NDCs. In 2014, the IPCC concluded with very high confidence that projected climate change would mostly affect human health by exacerbating existing health problems (IPCC, 2014). Climate change is also expected to exacerbate the vulnerability of health systems facilities (WHO, 2015). Current estimates of these future health impacts portray alarming numbers: according to the World Health Organization (WHO), projected climate change would cause approximately 250,000 additional deaths a year by 2030 (WHO, 2014). This contrasts with the limited amount of attention and funding allocated to adaptation for health (Watts et al., 2018). The existing shortage of investments in addressing health risks aggravates the potential reach of climate change effects on health. The challenge is global but bears particular relevance for developing countries, where health systems often face large deficits in capacities and resources to meet current demands and are even less prepared for future challenges than those of developed countries (WHO, 2013; Watts *et al.*, 2018).

The second part of the report begins by providing a global overview of and introduction to the adaptation gaps in health based on the availability of scientific evidence on impacts and adaptation measures (chapter 5). Following this, it focuses on three key areas of climate-related health risks and discusses the potential for bridging the health adaptation gap: heat and extreme events (chapter 6), climate-sensitive infectious diseases (chapter 7) and food and nutritional security (chapter 8).

The report has been written by an international team of experts affiliated with seventeen institutions. The process was overseen by a steering committee, and all chapters have undergone extensive external review. It is our collective hope that this report provides a useful contribution to increasing levels of ambition in relation to adaptation by enhancing understanding of the adaptation gap in key areas of society, with a particular focus on health.

02



CHAPTER 2

STATUS AND TRENDS: ENABLING ADAPTATION

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2.1 INTRODUCTION

The 2015 Paris Agreement established a global goal of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of holding the increase in global average temperatures to well below 2°C above pre-industrial levels. Each country is to engage in developing or enhancing relevant plans, policies and/or contributions and to make progress over time, while recognizing the need to support developing countries, including through finance, technology and capacity-building (UNFCCC, 2016).

Meeting the global goal on adaptation relies heavily on action by national governments. Governments have multiple roles in regulating, incentivising and providing public good services, and in overcoming structural, informational and economic barriers to adaptation. They play a pivotal role in planning, implementing, mainstreaming and supporting climate adaptation efforts by both state and non-state actors. Through national laws, policies, strategies and plans, governments are putting in place governance and financial structures to address adaptation and are implementing a wide range of policy measures in multiple sectors.

Governments have been reporting their commitments and actions on adaptation to the United Nations Framework Convention on Climate Change (UNFCCC) through their Nationally Determined Contributions (NDCs), their National Communications and their National Adaptation Plans (NAPs). These reports contain information on existing adaptation efforts, implemented through national laws and policies, as well as forward-looking national goals contributing towards the global goal on adaptation. This chapter provides an overview of (1) national adaptation efforts as reflected in national laws and policies, and (2) internationally communicated goals and actions, offering observations on the relationships and gaps between them.

The analysis presented in the chapter faces a number of challenges:

The first challenge is the vast and complex landscape of adaptation legislation and policy, where certain areas of policy are more easily associated with climate change – for example, measures to protect coastal communities from sea-level rises – while others, including health, see adaptation and development blending into each other without clear-cut boundaries. At the national level, policies are outcome-oriented, regardless of whether they are framed as adaptation policies or not, and therefore it is difficult to identify all adaptation-relevant policies. However, when communicating adaptation efforts to the UNFCCC, countries often report on a large variety of adaptation-relevant policy measures, creating a challenge for the analysis.

Second, no detailed analysis of the content of national laws and policies is as yet available, although such is planned (Nachmany *et al.*, forthcoming).

Third, while acknowledging the critical role of sub-national and local governments in addressing adaptation, here we encounter an empirical challenge, as there is currently no comprehensive and systematic recording of adaptation action on the regional or city levels.

Fourth, in the absence of robust quantifiable metrics and measures with which to measure the outcomes of adaptation means, we cannot provide an analysis of the implemented legislation.

2.2 ENABLING ADAPTATION UNDER THE UNFCCC

The 1992 Convention commits countries to cooperate in preparing and planning for adaptation to the impacts of climate change (UNFCCC, 1992). As countries started to experience such impacts, in 2010 they agreed to enhance action on adaptation and to strengthen institutional capacities and enabling environments for adaptation. As developing countries are affected most and have fewer capacities for adaptation, countries also established a process to formulate and implement NAPs with a view to (1) reducing vulnerability to climate change, and (2) facilitating the integration of climate change adaptation into national development planning processes (UNFCCC, 2011). The 2015 Paris Agreement established a global goal on adaptation and committed each country to engage in developing or enhancing relevant plans, policies and/or contributions, and to make progress over time, while recognizing the need to support developing countries, including through finance, technology and capacity-building (UNFCCC, 2016).

Box 2.1: Enabling adaptation in the Philippines

The Philippines has put in place comprehensive adaptation legislation, starting with the Climate Change Act of 2009 (amended in 2012), which established the Philippine Climate Change Commission to lead the development of policy and to coordinate, monitor and evaluate the climate response. In addition, the Cabinet Cluster on Climate Change Adaptation and Mitigation was created to enhance coordination and coherence across government agencies with key roles in adaptation and mitigation. The 2010 National Framework Strategy on Climate Change provided a road-map for addressing climate change and led to the 2011 National Climate Change Action Plan, which seeks to implement short-, medium- and long-term actions in seven thematic areas, among them food security, water sufficiency and human security. The ultimate goal is to build the adaptive capacities of women and men in their communities and increase the resilience of vulnerable sectors and natural ecosystems to climate change. While the National Climate Change Action Plan does not include quantified targets, it includes expected outputs, outcomes, and indicators. For example, the expected outcome of ensuring that "health and social protection delivery systems are responsive to climate change risks" is being measured by the "number of local government units with trained health personnel trained on climate change health adaptation and disaster risk reduction". To ensure that adaptation and disaster risk reduction are mainstreamed and integrated into the country's plans and programmes at all levels, the Philippines plans to roll out science-based climate/disaster risk and vulnerability assessment processes as the basis for mainstreaming climate and disaster risk reduction and to submit its NAP to the UNFCCC by November 2018 (Government of the Philippines, 2015).

Countries provide information on how they are enabling adaptation, including information on their plans and policies, through multiple reporting instruments. As at the 13th of November 2018, adaptation information from developing countries was included in 132 adaptation components of 180 NDCs[1] (see the examples of Brazil (box 2.1), Burkina Faso (box 2.2) and the Philippines (box 2.3)) and 11 NAPs[2] (see the examples of Brazil and Burkina Faso), and from developed countries in 40 seventh national communications[3] (see the example of the Netherlands (box 2.4)).

The majority of countries have defined a national long-term goal or vision for adaptation – which are aspirational, qualitative, quantitative or a combination of all three – to be attained by 2030, with some going up to 2050. According to the reports, some of these goals and visions are contained in national laws, strategies and plans. However, only around forty developing countries have quantifiable targets in their NDCs, a fact which presents a risk both to the signal NDCs provide to the required national policy-making efforts, and to the ability to measure progress and increase ambition over time (Nachmany and Mangan, 2018).

Countries also reported that they have, or are establishing, national adaptation planning and implementation processes, and that they are planning or already implementing adaptation measures as a contribution to their national vision and goals in virtually every sector and area of the economy, with water, agriculture and health being the top three. Often countries start by formulating a national adaptation strategy and follow it up with more detailed national and sectoral adaptation plans. The portfolio of adaptation measures being implemented is growing and diversifying from discrete stand-alone projects to comprehensive integrated programmes.

Regarding health, countries are seeking to achieve the overall integration of climate impacts and/or the identification of priority actions in the health sector; an enhanced understanding of the links between climate and health and changing disease patterns; and enhanced management systems or contingency plans for public health to improve the adaptive capacity of public medical services. In order for countries to reach their reported ambitions, it is important that these goals and visions are codified in national legislation.

1 Available at: https://unfccc.int/process/the-paris-agreement/nationally-determined-contributions/ndc-registry.

2 Available at: http://www4.unfccc.int/nap/Pages/Home.aspx.

3 Available at: https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/national-communications-and-biennial-reports-annex-i-parties/seventh-national-communications-annex-i.

2.3 ENABLING ADAPTATION NATIONALLY: STATUS OF LEGISLATION AND POLICIES TO ADDRESS ADAPTATION

This section draws on the Grantham Research Institute's 'Climate Change Laws of the World' global database, which contains over 1,500 climate change laws and policies (CCLW, 2018). The database includes laws passed by national legislative branches (parliaments, national assemblies and so forth), and decrees, policies, strategies and plans (collectively referred to as 'policies') issued by national executive branches. It also includes a detailed analysis of the quantified targets set out in the laws and policies.

The above-mentioned database contains 110 laws and 330 policies related to adaptation from 162 countries (CCLW, 2018). Only 68 of these countries address adaptation through legislation, while nearly all of these countries have adaptation-relevant executive policies. Less than half of these laws and policies consist of holistic frameworks for addressing climate change nationally (for example, climate change laws and strategies). A handful are specifically designed to create financial instruments, such as Bangladesh's Climate Change Trust Fund Act, which establishes an instrument to allocate funds to adaptation projects and to serve as a disaster recovery fund. Other laws and policies address adaptation through a framework of development plans, for example, the Cook Islands' National Sustainable Development Plan (Government of Cook Islands, 2016), or through sectoral policies, such as Madagascar's National Strategy to Face Climate Change in Agriculture-Livestock-Fishery, 2013, or Tanzania's Health National Adaptation Plan, 2018 (Government of Madagascar, 2013; Government of Tanzania, 2018).

Finally, some laws and policies focus on disaster risk management, which is closely linked to adaptation. While adaptive capacities and resilience also depend on multiple factors (for example, infrastructure, health and emergency services, water and education), the plethora of laws and policies that govern these policy areas do not necessarily explicitly address climate adaptation, and therefore they were not always included in the Grantham Research Institute's 'Climate Change Laws of the World' database. For example, health policies were not surveyed systematically for this analysis.

There could be a number of reasons why adaptation is addressed more frequently in (executive) policies than in laws. First, laws will often serve as central governance frameworks, establishing institutions and mandating multiple subsequent sectoral policies and actions. For example, Kenya's Climate Change Act of 2016 establishes a National Climate Change Council and mandates the preparation of climate change action plans, strategies and policies (Government of Kenya, 2016). The United Kingdom Climate Change Act of 2008 requires the government to periodically assess the risks and opportunities of climate change for the United Kingdom, requires the United Kingdom government to produce a NAP and grants the government power to require certain organizations to report on their adaptations

Box 2.2: Enabling adaptation in the Netherlands

The Netherlands prepared its first national adaptation strategy in 2007, followed by the 2010 Dutch Delta Programme, which focused on flood protection, fresh water availability and spatial adaptation. A 2012 audit of the adaptation policy by the Dutch Court of Audit concluded that the adaptation policy as a whole was not being coordinated, monitored or evaluated, that it had never been translated into concrete actions, milestones or an allocation of responsibilities, and that it did not cover all the risks and vulnerabilities facing the Netherlands. In response, in 2016 the Dutch government adopted a National Climate Adaptation Strategy, 'Adapting with Ambition', which broadened the scope of adaptation planning beyond the original three themes to include also agriculture, health and welfare, among others. In addition, the strategy is currently being translated into a Climate Adaptation Implementation Programme, which seeks to mainstream adaptation into all policies and in their subsequent implementation (Government of the Netherlands, 2017).

to climate change (Government of United Kingdom, 2016). Furthermore, the process of formulating policies is often shorter and less complicated than that required to pass legislative instruments. It can also point to a relative weakness of adaptation legislation, as policies are generally (though not always) easier to reverse and harder to be held accountable for than laws. At the same time, legislation takes longer than policies to formulate and pass, and there are several countries that are in the process of developing legislation.

To date, there has been no systematic review of the content of adaptation elements in laws and policies. A detailed analysis of adaptation laws and policies globally is currently underway (Nachmany *et al*., forthcoming).

Setting quantified targets is an important step in addressing a policy issue, as it provides a clear trajectory that allows progress to be tracked and therefore improves the effectiveness of policy measures. Setting robust targets in national laws and policies is also crucial for the credibility of countries' commitments with regard to the Paris Agreement (Nachmany and Mangan, 2018). However, much progress still needs to be made in developing globally comparable metrics that track progress towards the global goal on adaptation based on country-level information. Combined with the fact that this goal is outcome-oriented and qualitative, countries face a challenge in setting clear and quantifiable adaptation targets (UNEP, 2017).

As at October 2018, 49 countries have included quantifiable targets relevant to adaptation in their national laws and policies, covering disaster risk management, coastal protection, flood-proofing, land preservation, water management, climate-resilient buildings, forestry and other areas. Examples of targets set can be found in table 2.1 below. Many of these targets are relatively short-term, with the vast majority of quantified targets being set for 2020 or earlier, and only fifteen countries have set target for 2030 and beyond.

When examining the alignment between targets communicated internationally and those in national laws and policies, gaps become evident. For example, China and Malaysia set national targets on coastal protection (in China's 13th Five Year Plan of 2016 and Malaysia's 11th Malay Plan of 2016), but do not mention them in their NDCs (Government of China, 2016; Government of Malaysia, 2016). In its National Strategy on Climate Change of 2012 Ecuador sets a target for reducing climate-change related malaria and a target for climate-resilient buildings that are not reflected in its NDC (Government of Ecuador, 2012). Samoa sets a target to have 100 percent climate-resilient new buildings by 2020 (Government of Samoa, 2016), which is not mentioned in its NDC. Similarly, many quantified targets are stated in countries' NDCs but not identified in the body of climate laws and policies. This does not necessarily mean that the targets have not been specified in sectoral or non-climate-specific laws and policies, but it emphasizes the governance challenge of climate adaptation: in order to track progress towards a global goal, to hold governments accountable for their commitments and to be able to allocate adaptation funding effectively and efficiently, national laws and policies and international commitments need to reflect each other clearly and transparently.

Table 2.1: Examples of quantified adaptation targets in legislation, laws and policies

Target focus	Targets in national laws and policies
Coastal protection	**China:** ensure that the natural shoreline does not fall below 35% by 2020 **Malaysia:** 10 % coastal and marine areas to be gazetted as protected areas by 2020 **Tonga:** all coastal communities to be protected by 2035
Disaster risk management	**Malaysia:** two million people to be protected through flood mitigation projects by 2020 **Peru:** 50% reduction in the loss and damage index from disasters by 2021 **Tanzania:** 60% of districts to have climate change and risk-reduction strategies by 2020
Health	**Ecuador:** 40% fewer cases of malaria derived in large part from climate change by 2013 against a 2009 baseline
Water	**Singapore:** tenfold increase in desalination capacity to meet 30% long term water needs by 2060 **Dominican Republic:** increase effective use of distributed water in irrigation to 45% of distributed volume by 2030
Agriculture	**China:** improve training in agricultural adaptation technology, to reach a 70% penetration rate of practical adaptive technical training for rural labour by 2020

Source: CCLW, 2018.

2.4 CHALLENGES AND OPPORTUNITIES IN ENABLING ADAPTATION

Countries are facing a number of challenges in seeking to enable adaptation through legislation and policies. Developing countries in particular are reporting to the UNFCCC that they require adequate financial, technological, and capacity-building support not only to assess, plan, implement, monitor and evaluate adaptation, but to also create the necessary enabling environment with appropriate institutional arrangements and legislation. Besides financial and human resources, countries have reported that setting up institutional frameworks and legislation depends on short- to mid-term political and economic priorities and circumstances.

Another challenging aspect is the question of who 'owns' adaptation and is thus ultimately responsible and accountable for enabling it, as the scope of actions that can be classified under the umbrella term "adaptation" remains blurred, some residing within the realm of climate change, while others are not explicitly climate-related. The diffused focus of adaptation creates coordination challenges – vertically, between levels of government (international-national; national-sub-national-local), horizontally (for example, between line ministries) and between multiple relevant actors types (state, non-state, international and transnational actors). In addition, there are information gaps and often issues of limited capacity and resources, especially in the most vulnerable countries, which are often those with the greatest adaptation needs.

Countries have recognized these governance challenges and have reported on opportunities and ways to overcome them, including through improving coordination and clarity in the mandates across different government departments that pursue different or potentially conflicting policy goals, between different economic sectors, and between national and subnational authorities. In a survey of 100 countries (Averchenkova and Nachmany, forthcoming), it was reported that approximately 70 percent of countries have a function which is in charge of coordinating adaptation action, mostly government ministries or departments, alongside a handful of inter-ministerial bodies (see the example of the Philippines (box 2.3)). In most cases, these ministries are the ones overseeing climate change action in general (mitigation and adaptation), but it is difficult to determine how and to what extent adaptation is being addressed.

In order to enable adaptation more widely across different sectors, many countries undertake activities to support the integration of adaptation into national, subnational and sectoral development planning and regulatory processes at various levels of government, including by:

- Incorporating consideration of climate change into the design of priority programmes, as well as investment and business plans;
- Public expenditure reviews to determine the amount spent by the national government on adaptation;
- National budget codes to track budget allocations to national climate-change activities.

Box 2.3: Enabling adaptation in Brazil

In 2008, Brazil enacted a Climate Change National Plan, with vulnerability and adaptation being one of its seven areas. The Brazilian Federal Court of Accounts subsequently audited the extent to which the actions of the Federal Public Administration were in fact promoting successful adaptation of the livestock and agricultural sector and of coastal zones. The audit concluded that the national plan lacked adaptation goals, that there was a need to review the policies of specific sectors to incorporate consideration of adaptation, and that conflicts of jurisdiction and a lack of coordination between federal and state managers prevented an adequate adaptation response (INTOSAI, 2010; Arifa, 2017). As a response to the audit, the Brazilian government launched plans for sector adaptation, such as the health-sector plan, which led to the 2010 Sectoral Plans for Mitigation and Adaptation and culminated in the 2016 NAP. Brazil's NAP seeks to strengthen the country's adaptation capacity, assess climate risks and manage vulnerabilities at the national, state and municipal levels, to integrate vulnerabilities and climate risk management into public policies and strategies, and to enhance the coherence of national and local development strategies with adaptation measures. The NAP is divided into eleven strategies for sectors and themes, among them agriculture, cities, water and health, with associated goals, indicators and responsible institutions (Government of Brazil, 2016).

Box 2.4: Enabling adaptation in Burkina Faso

Building on its 2007 national adaptation programme of action, which focused on short-term and immediate adaptation priorities, Burkina Faso submitted its NAP in 2015 with the aim of managing its economic and social development more efficiently by taking into account resilience and adaptation to climate change between now and 2050. The NAP listed short-, medium- and long-term adaptation objectives for seven sectors and themes, including agriculture, water and health (Government of Burkina Faso, 2015). Implementation of the NAP is to be steered and coordinated by the National Council for the Environment and Sustainable Development and its Permanent Secretariat. The NAP is complemented by a Strategic Framework for Investment in Sustainable Land Management, which has defined quantitative goals for the country at the 2025 horizon. It can thus be regarded as an operational action plan for adaptation in the sectors of agriculture, animal husbandry, forests and land use, water management and biomass energy. Some of these quantified goals and targets are reflected in Burkina Faso's NDC.

For example, Burkina Faso's NAP has been mainstreamed into its Strategic Framework for Investment in Sustainable Land Management, which serves as the implementation vehicle.

As with tracking budget allocations and expenditure, there is a need to monitor and evaluate the outputs, outcomes and, most importantly, impacts of adaptation plans and legislation. Many countries report that they are putting such monitoring and evaluation systems in place, though most of the systems are still in the earlier stages of implementation and are focused mainly on monitoring the adaptation policy process rather than the outcomes and impacts of plans and legislation (UNEP, 2017).

Finally, as governments are increasing their spending on addressing and averting climate change impacts, public adaptation actions have become the focus of auditing, often by Supreme Audit Institutions. These assessments provide national parliaments with objective information to help them examine their government's public spending and performance. Brazil and the Netherlands greatly benefitted from an audit of their adaptation policies (see boxes 2.2 and 2.4) and concluded that audits provide opportunities to enable adaptation, including by raising awareness among public policy-makers, identifying good practices and undertaking impact analyses, even when there are no clear targets for adaptation plans (INTOSAI, 2010; Arifa, 2017). The Dutch audit concluded that auditing adaptation is also relevant because there is a risk that government expenditure on climate policy may place greater pressure on public finances in the future (Algemene Rekenkamer, 2012).


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CHAPTER 3

STATUS AND TRENDS: ENHANCING ADAPTIVE CAPACITY TO CLIMATE CHANGE

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3.1 INTRODUCTION

The Paris Agreement established a global goal of enhancing adaptive capacity in relation to adaptation by strengthening resilience and reducing vulnerability to climate change (UNFCCC, 2015). However, the specifics regarding the implementation of the global goal are yet to be set, in particular how to measure and assess adaptation (Adaptation Committee, 2018). Unlike mitigation, where an encompassing metric enables global progress to be assessed, the task is not straightforward given the local and context-specific nature of adaptation and the strong links and overlaps with development.

The 2017 Adaptation Gap Report stressed that vulnerability, resilience and adaptive capacity can be conceptualized in different ways and offer no uniform, objective opportunities for measurement (UNEP, 2017). However, there is consensus that vulnerability and resilience are dependent on three key elements and their interaction: exposure, sensitivity and adaptive capacity (see box 3.1). In this chapter, we focus on adaptive capacity as one of the important determinants of both vulnerability and resilience. Other things being equal, enhanced adaptive capacity will reduce vulnerability and strengthen resilience, thereby narrowing the adaptation gap.

The chapter takes up the question of whether there are feasible and robust indicators, based on the aggregation of existing national data, for measuring the status of and collective progress with adaptive capacity over periods consistent with the five-year stocktakes provided for under the Paris Agreement. It is not the intention to suggest a particular framework for assessing progress, nor to provide a final selection of the indicators for any such framework, this being a challenge facing the adaptation community as a whole. The aim is simply to illustrate how future stocktakes can build on selected indicators and data included in established adaptation-related indices and frameworks to minimize the additional burden of reporting.

In contrast to indicators of exposure that provide information about the status and projected changes in climate-related areas, such as flood hazards, extreme heat events, sea level rises, reduced crop yields or deaths from climate-induced diseases, indicators of adaptive capacity are closely interlinked with development. Fankhauser and Burton (2011) asked what would constitute good adaptation practice in developing countries and concluded that building adaptive capacity is central to efficient, effective and equitable adaptation, being likely to yield benefits irrespective of future climate regimes. This is taken up further by Brooks *et al.* (2011), who argue that successful adaptation should be based on inclusive development and that measures of progress in adaptation will have much in common with measures of development progress, but with the added requirement that the measures encompass the changing and longer-term context within which adaptation takes place. They see successful adaptation as keeping development 'on track', not only in shorter-term business-as-usual activities, but also in preparing communities for eventual transformative changes. This is similar to the 'adaptive development' approach suggested by Agrawal and Lemos (2015).

In the subsequent sections of the chapter, we first provide a brief rationale for the selection of some of the indicators that are relevant in assessing changes in adaptive capacity and progress in bridging the adaptation gap. We focus particularly on health-related metrics, given this report's emphasis on the health sector. We then assess the changes in adaptive capacity suggested by selected indicators, focusing on groups of countries classified by income bracket. Finally, we provide a short description of the elements needed to build adaptive capacity and show how they have been introduced in the case of Bangladesh's successful management of cyclone threats. In the background annex[4], which is available online, we set out a much more complete justification for the selection of indicators as a basis for assessing progress in enhancing adaptive capacity to climate change.

Box 3.1: Adaptation Terminology

The many discussions about the semantics of various terms used in discussing adaptation, such as vulnerability, resilience and adaptive capacity, have been reviewed in previous Adaptation Gap Reports (UNEP, 2014), as well as the Intergovernmental Panel on Climate Change (IPCC) fifth assessment report (Noble *et al.*, 2014) and many other publications (Brooks *et al.*, 2011; Hinkel, 2011; Jones, 2017). Here we use terminology consistent with the Intergovernmental Panel on Climate Change (IPCC, 2012; Noble *et al.*, 2014) by accepting that most adaptation actions seek to reduce the exposure of people, ecosystems and physical assets to climate-related hazards and to reduce their vulnerability to harm if they are affected by climate-related events. While recognizing the subtle but often important differences between vulnerability and resilience (Nelson *et al.*, 2007), in this chapter we will tend to treat the terms as synonyms.

4 All annexes are available at: http://www.unenvironment.org/resources/adaptation-gap-report.

3.2 LESSONS FROM MEASURING ADAPTATION

While there are many examples of frameworks for selecting indicators both locally and nationally (Adger *et al.,* 2007; Nelson *et al.,* 2007; Tol and Yohe, 2007; Hinkel, 2011; Engle *et al.,* 2014; Agrawal and Lemos, 2015; Miola *et al.* 2015), the Adaptation Gap Report for 2017 focused on frameworks for adaptation methodologies and data suitable for aggregating multiple indicators to assess progress on adaptation both nationally and globally (UNEP, 2017). The report concluded that there "are currently no existing frameworks that fulfill all of the criteria for an assessment of progress towards the global goal on adaptation." This arises mainly from a trade-off between finding metrics that are meaningful proxies for progress in adaptation and the need to be able to aggregate indicators nationally to track progress towards a global goal on adaptation. Ideally, indicators of adaptation should measure actual outcomes of actions, but most often the proxies used to measure adaptation results rely on value judgments and assumptions. Indicators to track progress can be based on inputs and actions, but it is frequently difficult to assess their relationship to outcomes (UNEP, 2017).

Indices that rank countries in relation to exposure, vulnerability, adaptive capacity and other aspects connected with adaptation already exist (see annex). There is broad agreement between these indices, but only in the sense that high-income countries, including the Organisation for Economic Co-operation and Development (OECD), are usually the most resilient, whereas sub-Saharan African and many Small Island Developing States are the least resilient. Countries vary enormously in rank from one index to another, making the use of these indices in tracking progress under the Paris Agreement contentious (Leiter *et al.,* 2017). However, rather than ranking countries based on indices, the purpose of this chapter is to look at underlying indicators of adaptive capacity in order to measure status and progress, or the lack of it, by groups of countries over time.

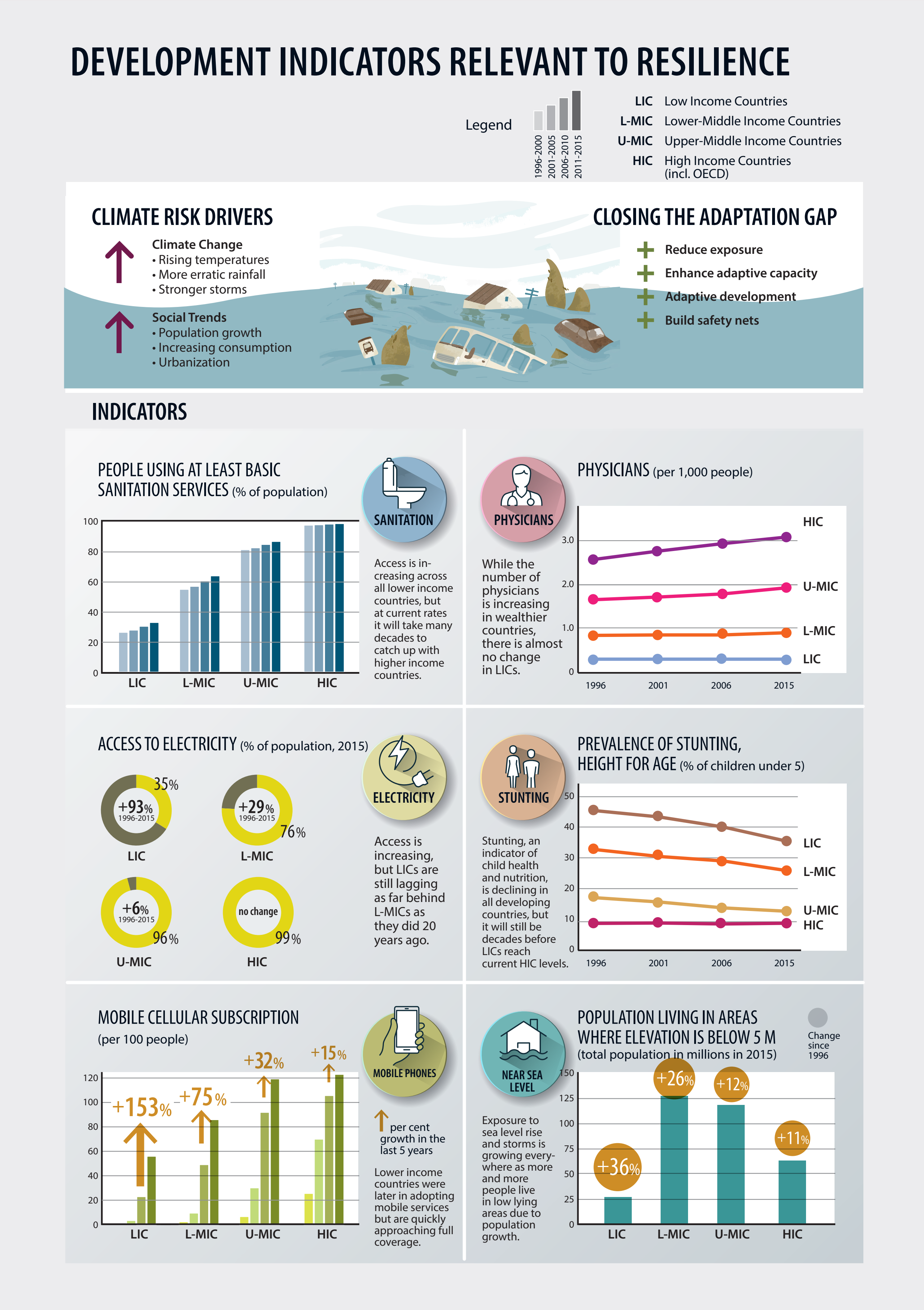
The background annex describes the rationale for and process of identifying an exploratory set of indicators of adaptive capacity. We sought longitudinal data sets with a time series of data from 1996 to 2015, which can represent a baseline equivalent to four Paris Agreement stocktaking periods. Thus, they provide information not only on the current state of adaptive capacity, but also on trends in the recent past. We also sought to identify a mix of indicators to track both near-term objectives, such as achieving better health-related goals, and longer-term drivers of vulnerability, such as urbanization, population shifts, rising consumption and age dependency. Thus, the focus of this chapter is the immediate past and present. All indicators are already well established (for example, in the World Development Indicators (World Bank, 2018a)), so they will not impose an additional reporting burden, and most are also used as indicators of the Sustainable Development Goals (SDGs). In the past, some frequently recommended indicators, such as literacy rates and gender equity ratios, have been measured too infrequently and not inclusively for all countries and are therefore not considered here. This should improve in the future with the support for tracking the SDG indicators. The final set of indicators selected is described in the annex. Although the data would allow the tracking of individual countries, here we examine only whether the indicators appear to be suitable for differentiating progress between the major income groups of countries, that is, Low, Lower-Middle, Upper-Middle and High-Income (World Bank, 2018b).

3.3 GAPS IN ADAPTIVE CAPACITY AS REFLECTED IN THE EXPLORATORY INDICATORS

The results of the assessment in the annex suggest that many indicators that are widely considered to be suitable proxies for adaptive capacity are also appropriate for assessing progress within the time-frames set by the five-year global stocktakes of the Paris Agreement. Table 3.1 provides a full overview of the explorative set of indicators, while figure 3.1 illustrates trends in selected indicators across income groups and over time.

As illustrated in table 3.1 and in figure 3.1, low and lower-middle income countries show consistent growth in the proportion of the population using at least basic sanitation and access to electricity, while the number of stunted children under five years – a good indicator of long-term food and nutritional insecurity (see chapter 8) – is falling. Similar improvements are seen in the percentages of populations having access to clean water

Figure 3.1: Selected development indicators with relevance for adaptive capacity to climate change



Note: See the online annex for a description of the indicators and the rationale for their selection.

and immunization rates. Finally, child mortality and food deficit rates are also declining, as are indicators of inequality.

While low and lower-middle income countries are showing improvements in most of the indicators analysed, the number of physicians per thousand people in low and lower-middle income countries has barely changed since 1996 from a very low base, while numbers have grown in upper-middle and high income countries. These are worrying trends pointing to areas in which the adaptation gap has widened and might do so further in the future.

Another cause for concern is that the low and lower-middle income countries remain well behind higher income countries and for many indicators have not reached the level where the next higher income group was twenty years ago. Although they are progressing, the rates are too slow and many do not show any signs of acceleration. Thus, bridging the gap in adaptive capacity will take many decades at current rates of change.

An example is access to improved sanitation, which is commonly used as a proxy for the ability of the government to deliver basic services that are likely to be affected by climate events. All income groups show improvements, with poorer countries showing consistent and greater rates of progress over the twenty-year period than higher income countries. The changes are two percent to eight percent per five-year period, which shows that they would make suitable indicators for the Paris stocktakes in tracking progress. The more sombre observation is that, at current rates of progress, it will take several decades for low-income countries as a whole to reach the current level of service in lower-middle income countries and almost a century to reach those of high-income countries.

A different example is access to mobile phones. This is seen as a measure of increased opportunity in livelihoods (for example, information on markets) and in providing warnings and advice about extreme events. Here low-income countries were late in gaining access to this technology, but their rate of uptake has matched or exceeded that of the earlier uptake in wealthier countries. It seems likely that even low-income countries will reach levels equivalent to high-income countries within five to ten years, thus providing a wide range of opportunities, for development, job creation and capacity-building through access to information and technology.

Although adaptive capacity in the high-income country group is high overall, exposure to climate hazards is growing everywhere, as exemplified by the number of people living less than five meters above sea level who will experience more storm surges and flooding in the future (see figure 3.1). While this indicator is used frequently and captures infrastructure in the immediate vicinity of the coastline at a high risk of damage from storm surge and sea level rises, a supplementary proxy for exposure to winds and heavy rain associated with storms might be distance from the coastline (Torresan *et al.,* 2012). A more complete set of indicators would include other metrics of exposure and sensitivity to climate hazards in order to identify countries' climate risks and vulnerability trajectories.

As mentioned in the introduction, it is not the purpose of this chapter to suggest a particular framework for tracking change, nor to select the indicators for any such framework. This is a challenge facing the adaptation community as a whole – social, physical and biological scientists, policy-makers, practitioners, the people most affected by climate impacts and, ultimately, negotiators. As Magnan and Ribera (2016) have suggested, a process similar to the IPCC or the SDG may be needed to take a significant step forward in resolving this challenge. However, within the context of the negotiations, despite the fact that adaptation lacks a single common metric similar to that used for greenhouse gas emission reductions for mitigation, progress towards an adaptation goal will need to be and probably can be tracked on the basis of a small number of agreed indicators.

3.4 BUILDING ADAPTIVE CAPACITY

The adaptation literature points to several key factors that are necessary for building adaptive capacity, which typically include access to resources, technological capacity, access to information, governance and institutional mechanisms (Adger, 2003; Brooks *et al.,* 2005; Jones *et al.,*2010; Cinner *et al.,* 2011; Eakin *et al.,* 2014; Williams *et al.,* 2015). For instance, Cinner *et al.* (2011) describe five domains of adaptive capacity (assets, flexibility, social organization, knowledge and learning, and agency) and note that, while there are interactions and trade-offs between the different domains, successfully building adaptive capacity entails addressing all of them. Thus, variations across these domains result in different outcomes of adaptive capacity. For example, while greater financial and technological assets, knowledge resources and learning favour adaptive capacity, the flexibility to adjust measures, the agency to mobilize those assets and skills, and the social organization to implement the changes are all essential to achieving increases in adaptive capacity (Cinner *et al.*, 2011). This is also evident from a case study on progress in storm risk

Table 3.1: A summary of each of the twelve indicators of adaptive capacity included in the exploratory set with a particular focus on the health-related aspects

Indicator	Description	Suitability, usage and links to SDGs
Percent population with access to improved water sources and improved sanitation respectively	These two indicators provide similar information, and both show how much the LICs, and to a lesser extent the L-MICs, are lagging other countries. When grouped by vulnerability classes, SSA is seen to lag behind other low-income countries, including the SIDS, especially on improved sanitation services. These remain strong indicators of progress in two areas that are vulnerable to disruption by climate events and important to maintaining public health.	Effective and widely used in indices. SDG 6.1.1
Number of physicians (per 1,000 people)	Show similar information as the indicators on access to improved water and sanitation. Again SSA is lagging well behind other LICs, but in this case the SIDS are also lagging behind. They have almost four times the numbers of physicians per population than in SSA, but they still have only half the number that other LICs & MICs do.	Effective and widely used in indices. SDG 6.2.1
Immunization, measles (% of children ages 12-23 months)	These data show the value of focused effort in improving health outcomes. LICs, MICs and SSA are all approaching the vaccination levels of HICs. There are signs that rates of increase are falling and that vaccination rates have tended to stabilize over the past five to ten years. There are similar trends in Hep B and DPT vaccinations. These are important to monitor, but they may not be good long-term indicators of progress in adaptive capacity.	Effective, but approaching saturation (for example, little room will remain to improve further). SDG 3.b.1
Mortality rate, under-5 (per 1,000 live births)	The LICs, MICs and SSA countries are performing similarly in having reduced child mortality by 40% to 50% over the past twenty years. However, they still have mortality rates ten to twenty times those of OECD countries. SSA has mortality rates that are double other developing country groups.	Effective. SDG 3.2.1
Prevalence of stunting, height for age (% of children < five years old)	Similar to the child mortality indicators above, with LICs, MICs and SSA countries reducing the prevalence of stunting by about 20% over the past twenty years. However, countries with poor child health outcomes vary significantly on both measures.	Effective and commonly used in indices. SDG 2.2.1
Depth of the food deficit (kilocalories per person per day)	All groups have reduced their food deficits by about 30% to 50% over twenty years. However, the LICs have not reached the average of L-MICs of twenty years ago, and similarly L-MICs have not reached the levels of U-MICs. This indicator suggests that there is progress but at a rate much slower than desired.	Effective and commonly used in indices. SDG 2.1.2
Dependency ratio (here ratio of 0-14 yr & over 65 year olds to 15-65 year olds)	Dependency ratios are falling across all developing countries. This is probably due to lower birth rates and is a positive indication that they are in a better position to support education and have fewer dependent people needing help in extreme events etc. This indicator is available separately for the dependency of young and elderly, and probably a more nuanced assessment could be made.	Effective and commonly used; a breakdown into dependent young and older people may increase its value.
Income share held by bottom 10th percentile of income earners	There are small improvements in all developing countries, but there is still greater inequality than in higher income countries where inequality has increased slightly. There are different interpretations of how well inequality is measured by such broad-brush economic indicators. The Gini coefficient, which measures across all income groups, is often used to measure inequality. The indicators are strongly correlated (r^2 =0.8).	Widely used but less effective; more socially based indicators of inequality might be better. SDG 10
Percent population with access to electricity	Electricity access is increasing everywhere, although HICs and even U-MICs are close to full coverage. However, in 1996-2000 LICs had 41% fewer people connected than the L-MICs. Fifteen years later they have more people connected but are still 42% behind U-MICs.	Effective and commonly used. SDG 7.1.1
Mobile phone users (per 100 people)	Low income countries were slow to adopt this technology, but over the past decade or so their rates of uptake have been very rapid. They will reach levels equivalent to high-income countries within a decade. Internet usage may give a clearer measure of progress and probably better captures access to modern information services.	Effective and commonly used; likely to reach saturatation over the next decade. SDG 16.6.2
Population living in areas where elevation is below 5 metres (in millions)	A commonly used indicator of an important component of exposure, but not effective for tracking progress as currently collected. Only two estimates have been made over the past 20 twenty years, with very little change in terms of the estimated percentage of the population exposed. The number of people exposed has increased along with population increase.	Widely used but less effective due to low granularity and frequency; other indicators might be more useful. SDG 11

Note: The income categories are abbreviated as follows: LIC = Low Income Countries. L-MIC = Lower-Middle Income Countries. U-MIC = Upper-Middle Income Countries. HIC = High Income Countries. SSA = sub-Saharan African countries. SIDS =Small Island Developing States.

management in Bangladesh that has been successful in significantly reducing the risk of casualties during the tropical cyclones that frequently hit the country (see box 3.2). This achievement has been made possible because of an integrated approach that coordinates actions across ministries and other national stakeholders all the way down to the community level, while providing relevant early warning information and protective infrastructure.

Box 3.2: Bangladesh: a success story of cyclone disaster management

Since the 1980s, Bangladesh has experienced more than two hundred natural disasters with nearly 200,000 fatalities and an economic loss of about US$17 billion. The country's 700 km coastline is exposed to, and often battered by, deadly cyclones. Two severe cyclones occurred in 1970 and 1991, causing approximately 500,000 and 140,000 deaths, respectively (Haque *et al.*, 2012). However, during the past twenty years Bangladesh has managed to reduce deaths and injuries from cyclones significantly. For example, the most recent severe cyclone of similar power as the two mentioned above, cyclone Sidr in 2007, caused 4,234 deaths (Haque *et al.*, 2012). The recent cyclone Mora, which struck the coasts at around 120 km/h, registered six deaths, and government agencies successfully evacuated nearly one million people. This dramatic transformation and enhancement of the system's resilience is the result of multiple integrated initiatives having been taken by the government and other stakeholders after a paradigm shift in disaster management. After 1991, the country went from a conventional response and relief scheme to a more comprehensive risk reduction culture, which includes prevention and mitigation, preparedness, response, recovery and rehabilitation and builds on the following elements related to enhancing adaptive capacity:

A STRONG INSTITUTIONAL FRAMEWORK AND COMMITMENT FROM THE GOVERNMENT

The legal framework for disaster management is enshrined in the Disaster Management Act of 2012, which assigns accountability and provides mandatory legal provisions (Government of Bangladesh, 2012). The government recognized that disaster management cannot be the work of one agency only, and hence it has been mainstreamed to ensure the participation of departments and institutions from the cabinet to the village level. Overall coordination resides with the National Disaster Management Council overseen by the Prime Minister. It is led by the Ministry of Disaster Management and Relief Works as the central agency for training, implementing and coordinating disaster management activities, and it functions through a network of over two thousand village disaster committees, forty district Disaster Management Committees, twelve line ministries and six donor partners (UNDP, n.d.).

EARLY WARNING PROGRAMME, CYCLONE SHELTERS AND MANGROVE FORESTS

Bangladesh drew up its Cyclone Preparedness Program in 1970, a volunteer organization responsible for disseminating early warning signals to nearly fifty thousand cyclone preparedness volunteers (BRCS, n.d.). But despite having more than two thousand cyclone shelters (CEGIS, 2009), this is still not enough for the entire population at risk. During cyclone Sidr, mangrove forests helped to protect the southwestern part of the country so that, to mitigate future storm risks, the country has restored approximately 1,200km^2 of mangrove forests.

ENGAGING COMMUNITIES AND CIVIL-SOCIETY ORGANIZATIONS

The government engages with community members, the private sector and civil society in both risk preparedness and disaster relief. Community-based disaster risk-reduction strategies, in collaboration with different international, government and non-governmental organizations, have helped build the capacity of local communities to prepare for and respond to cyclone disasters. Building upon lessons learned from cyclone Sidr, community-based groups have restored 1,200 km^2 of mangrove forests to reduce cyclone risks. These programmes also empower women and other marginal groups that are more vulnerable to cyclone disasters.


04

CHAPTER 4

STATUS AND TRENDS: THE ADAPTATION FINANCE GAP

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4.1 INTRODUCTION

The report 'Adaptation Finance Gap Update with Insights from the Intended Nationally Determined Contributions' suggests that the adaptation finance gap can be defined and measured as the difference between the costs of meeting a given adaptation target and the amount of finance available to do so (UNEP, 2015a). While the adaptation finance gap is facilitated by a common monetary metric, it stresses that finance is a means rather than an end: the availability of funds does not guarantee that they will be used efficiently and effectively.

Previous Adaptation Gap Reports reviewed the evidence base for the costs of adaptation, concluding that there is no definitive estimate for the (global) costs of adaptation, not least because there is no agreed (quantitative) adaptation target (UNEP, 2014; 2016). In addition, there are differing views on how to set such a target, as this involves complex ethical and technical issues. In light of this, the report stressed that providing a definitive estimate of the costs of adaptation is challenging. The wide range of estimates reflects major differences in targets, future scenarios, methods, assumptions, coverage (sectors and impacts), uncertainty and the costs of implementation.

- A key challenge is uncertainty. Future climate change varies with the future emissions scenario (for example, a 2°C or a 4°C world) and the climate model output for a particular scenario (for example, wetter or drier regions). Different scenarios and models lead to different costs of adaptation. This causes further challenges for proactive adaptation, as it requires decision-making under conditions of uncertainty and changes the options and costs compared to analyses of adaptation for a single defined future.

- A further issue is whether the adaptation deficit is included in the estimated cost of adaptation. This deficit relates to the adverse impacts of current climate variability and extremes, which many countries have not incorporated in their adaptation management plans and strategies or done so efficiently. While this adaptation deficit is not caused primarily by climate change, future adaptation will be less effective if the adaptation deficit is not first addressed.

Key findings of the reports are summarized in box 4.1.

This chapter complements previous Adaptation Gap reports by providing an update on the literature concerning the estimated costs of adaptation, as well as the current situation regarding international adaptation finance, and thus the potential adaptation finance gap. It also provides an update on the opportunities to bridge the gap and discusses new insights since the last report.

Box 4.1: Key Findings on the Costs of Adaptation from the Previous Adaptation Finance Gap Reports

The 2016 Adaptation Finance Gap report presented the following conclusions with regard to estimates of the costs of adaptation (UNEP, 2016).

- The costs of adaptation in developing countries will be significant, and earlier global estimates of the costs of adaptation are likely to be underestimates. The Adaptation Gap Report (2014) indicated that by 2030 the estimated costs of adaptation could be two to three times higher than the range cited in the Intergovernmental Panel on Climate Change (IPCC) (which reported a value of US$70 billion to US$100 billion per year, and plausibly four to five times higher by 2050 (UNEP, 2014). The 2016 Report reinforced the validity of these estimates (UNEP, 2016).
- These adaptation costs will vary across regions: there will be higher relative adaptation costs (compared to Gross Domestic Product) in many of the world's poorest countries.
- The focus to date has been on the estimated costs of planned, proactive adaptation, primarily undertaken by the public sector. For some sectors, there has been less consideration of household and private adaptation (sometimes called autonomous adaptation). These additional categories will increase the estimated costs of adaptation, potentially significantly.
- Most current cost estimates are based on technical (engineering) costs. As these omit opportunity costs, transaction costs and implementation costs, adaptation costs are likely to be higher in practice. However, countering this, non-technical options, learning and innovation all have the potential to reduce future adaptation costs compared to hard engineering options.

4.2 THE COSTS OF ADAPTATION

Since the Adaptation Finance Gap Report (UNEP, 2016) there have been additional studies, but no new global adaptation cost assessments or new global reviews and syntheses have been produced. The literature that has been published generally reinforces the messages of the Adaptation Finance Gap Report (UNEP, 2016) (see box 4.1) while adding new insights. There are new publications on the estimated global and regional economic costs of climate change, with updates to previous studies, as well as new approaches. Many studies report higher economic costs than earlier studies, especially later in the century under higher warming scenarios (see annex 4.1 for further information)[5]. There have also been updates and new publications on adaptation costs, although it is difficult to aggregate these findings to produce revised estimates of global adaptation costs (see annex 4.2). As a general trend, the updated estimates of the global costs of adaptation in key sectors indicate higher costs than earlier studies and Reinforce the Adaptation Finance Gap Report findings from 2016. However, many of the key gaps remain. There is still only partial coverage of private (household) adaptation, though early evidence indicates high additional adaptation costs: an example is the additional demand for cooling (autonomous adaptation) in warm countries. There are also still major gaps across sectors and impacts, most notably the omission of adaptation cost estimates for biodiversity and ecosystem services.

Complementing these updates, new evidence has emerged since the last report. First, multilateral development banks (MDBs) have introduced climate-risk screening processes and are now tracking resilience spending in their portfolios, thus providing information on the marginal costs of enhancing the climate resilience of planned infrastructure investments[6] (MDB, 2017). The latest figures show spending of US$7.4 billion on adaptation in 2017 (MDB, 2017). This involves up-front costs, incurred today, to build resilience to future climate risks over the lifetime of the investment. In the road sector, for example, the uplift required to deliver resilience varies from 0.5 to 10 percent of the total project investment cost (ADB, 2015). Given the latest estimates of the global investment in new infrastructure in the coming decades,[7] cost uplifts on this level imply very large global adaptation costs.

Second, information is emerging on the programming and implementation costs of adaptation, due to the increased flows of international climate finance. An analysis of the Adaptation Fund and Green Climate Fund portfolios, included in this report, concludes that the additional costs of design (including safeguards) and implementation (capacity-building, project management, reporting, monitoring and evaluation, and oversight) are significant, typically ranging between 10 percent and 20 percent of the total finance. These additional costs need to be included in adaptation cost estimates and financing needs[8] to reflect realistic costs of delivering adaptation.

Third, there is an updated evidence base on adaptation financing needs, namely countries' Nationally Determined Contributions (NDCs). These set out country plans for domestic climate actions, funded either through international or domestic finance. A review of NDCs for this study concluded that around fifty non-Annex I countries have included estimates of adaptation financing needs. These are not generally based on detailed technical analyses and use a range of methods, making them difficult to aggregate. Nonetheless, the indicative financing needs for these fifty countries in the period from 2020 to 2030 are approximately US$500 billion,[9] and the annual average costs are just over US$50 billion per year. This indicates higher estimates of the costs of adaptation than the climate adaptation literature (see annex 4.2), as the time period is earlier (2020 to 2030), and only fifty countries are included, though they do not clearly separate financing the adaptation deficit from future climate change. Similarly, a number of the submitted National Adaptation Plans include cost estimates, although many of these estimates are included in the NDC submission.

Finally, today we have more evidence of the short-term economic and financial costs of extreme events associated with climate change. This is important because many global estimates assume a slow onset of change and therefore do not capture these early changes in variability. Economic losses from weather events were the highest on record in 2017 (Munich Re, 2018), and this was also the year with the highest insured losses from natural catastrophes. Swiss Re (2018) estimated total economic losses at US$330 billion in 2017, of which US$136 billion was insured losses. Climate attribution studies are starting to tease out the influence of climate change on large-scale weather extremes, and these indicate earlier and larger impacts than previously included in global modelling studies. This implies higher costs, either through higher insurance premiums (which can be considered higher residual damage or adaptation costs) or increased investment in disaster risk response and reduction (higher adaptation costs).

5 All annexes are available at: http://www.unenvironment.org/resources/adaptation-gap-report.

6 This is sometimes called climate proofing, but this term is incorrect because it is often not possible, and certainly not economically efficient, to climate-proof infrastructure completely against all risks over all time periods.

7 Several recent studies have assessed the global demand for new infrastructure, with estimates of US$57 trillion (New Climate Economy, 2016) to US$95 trillion (OECD, 2017a) by 2030 (the latter equivalent to US$6.3 trillion/year over the next decade).

8 These levels are for international climate finance: for example, the costs of domestic programming could be lower.

9 40 percent of this is from a single country, India.

4.3 ADAPTATION FINANCE

In 2009, developed countries committed themselves to mobilizing US$100 billion a year from public and private sources for climate action in developing countries. The 2015 Paris Agreement reaffirmed this commitment. While the US$100 billion is not a target for public finance alone, public finance is critical. However, there are different positions regarding what counts towards the goal, with international public finance that is concessional in nature (that is, grants of less than market rate loans) being acceptable to most (Bodnar *et al.,* 2015).

Public finance serves to strengthen the capacities of various stakeholders, create incentives for institutions and investors, and to take on risks that would otherwise disincentivize private flows of adaptation finance. Private finance for adaptation, on the other hand, remains essential given the nature and scale of the challenges posed by a changing climate.

PUBLIC-SECTOR ADAPTATION FINANCE

Adaptation is often needed in non-market sectors or is focused on public goods that benefit many. It is also often local and diffuse, involving many actors and targeting future benefits, often making rates of return unattractive for the private sector (UNEP, 2014). This is compounded by the lower risk appetite for private investments in developing countries because of their less developed legal, economic and regulatory frameworks, immature financial markets and currency exchange, and political and governance risks (UNEP, 2016). Overcoming these barriers and unlocking private finance flows for adaptation is therefore an important role for public finance for adaptation.

In 2016, global public finance flows for adaptation were estimated at US$23 billion.[10] Although these flows have fallen from US$26 billion in 2014, the change is partly due to differences in how development finance institutions are reporting on adaptation finance (CPI, 2017). Table 4.1 summarizes the provision of public finance from developed countries for adaptation in developing countries through core channels, comprising up to roughly 64 percent of global public adaptation finance. It considers bilateral and multilateral concessional finance, with bilateral data reliant on government reporting of Official Development Assistance that has some climate objectives (OECD, 2017b), multilateral provision of adaptation finance sourced from the MDBs[11] and multilateral climate change funds (see annex).[12]

Despite mitigation finance continuing to dominate international public finance flows for climate action,[13] there have been increases in adaptation finance through both bilateral routes and the MDBs. In 2016 adaptation finance represented 27 percent of bilateral public finance (with climate change objectives) provided by the members of the Organisation

Table 4.1: Public concessional adaptation finance

	2014		2016	
	Share going towards adaptation	Amount going to adaptation (US$ billion)	Share going towards adaptation	Amount going to adaptation (US$ billion)
Bilateral climate finance	27%	6.2	27%	8.5
Multilateral climate funds	24%	0.6	19%	0.4
Multilateral development banks	18%	4.6	23%	5.9

Note: Bilateral climate finance data is sourced from the OECD Development Assistance Committee data, which refer only to concessional flows of climate-related development assistance reported by OECD Development Assistance Committee members. While only MDBs' own resources are reported here, the annex 4.2 covers multilateral climate funds.

Source: (MDB, 2017; OECD, 2018; CFU, 2018).

10 This global figure includes finance from a number of development finance institutions beyond the MDBs. In the case of a number of developing country financial institutions included here, this amount is not to be judged in light of the US$100 billion commitment. In contrast, global public climate finance flows for mitigation were estimated at US$112 billion, with a further US$6 billion that contributed to both mitigation and adaptation simultaneously. (These figures are not to be confused with the US$100 billion commitment, which is for developing countries only.)

11 It is recognized that MDB contributions are not all received by developed countries, nor is all finance programmed in developing countries. Developing countries have also contributed to the multilateral climate change funds on a voluntary basis. The figures presented here, therefore, should not be directly compared to the US$100 billion commitment under the United Nations Framework Convention on Climate Change (UNFCCC).

12 OECD Development Assistance Committee members also report multilateral contributions via the creditor reporting system. These are additionally available through MDBs' own reporting and independent reporting initiatives, such as the Climate Funds Update that reports on flows via the multilateral climate funds. As such, the OECD Development Assistance Committee data focus on official bilateral development assistance contributions so as to avoid double counting.

13 Comparisons between the volumes of adaptation and mitigation finance are made complex by the fact that contributions are measured using different approaches. While mitigation finance is coded on an activity basis (accounting total project costs), adaptation activities are considered in relation to the proportion of the project or investment that covers climate change adaptation activities only.

for Economic Co-operation and Development's (OECD) Development Assistance Committee, 19 percent[14] of multilateral climate change fund project approvals and 23 percent of MDB contributions[15] (MDB, 2017; OECD, 2018; CFU, 2018). In contrast, adaptation finance flowing through the multilateral climate change funds has slowed. However, as the Green Climate Fund continues to ramp up its activities, this is likely to increase again.

OTHER SOURCES OF ADAPTATION FINANCE

The international flows of public concessional adaption finance listed in table 4.1 are not enough on their own to meet the scale of adaptation finance needed. Data availability, however, often challenges our ability to make quantitative estimates of domestic public finance or private investments in adaptation beyond what the MDBs tell us.

A number of development finance institutions are relevant to adaptation action, alongside the MDBs. The International Development Finance Corporation, a group of 23 regional and national development finance institutions, budgeted US$5 billion towards adaptation in 2016. Unfortunately, the data available is not disaggregated enough to allow for detailed analyses (IDFC, 2017). Given the number of developing country development finance institutions within the International Development Finance Corporation, this amount is not comparable to the US$100 billion commitment, though important more broadly in mobilizing adaptation finance. The Asia Infrastructure Investment Bank and the New Development Bank, both relatively new development finance institutions led by developing countries, with mixed shareholdings between developed and developing countries in the case of the Asia Infrastructure Investment Bank, will be important sources of adaptation finance going forward (Nassiry and Nakhooda, 2016).

Domestic public finance for adaptation is difficult to attribute within national or local budgets. Budget lines will often serve other purposes and may have been approved on developmental grounds (UNEP, 2016). Data remains largely case study-based, with very few examples of systematic tracking of domestic finance for adaptation. The Overseas Development Institute analyzed national budget spending by four African countries, Ethiopia, Ghana, Kenya and Uganda, finding between 1 percent and 10 percent of government expenditure, for example between US$25 million and US$440 million per annum, relevant to climate change, with adaptation accounting for 66 percent of spend across countries (Bird *et al.,* 2016). The United Nations Development Programme has a database with findings from its climate public expenditure and institutional reviews,[16] while the Climate Finance Group for Latin America and the Caribbean and the United Nations Development Programme report draw together information on a number of countries, illustrating how divergent methods, years of analysis and reporting are (GFLAC, 2018).

Similarly, very little data are available on private-sector financing for adaptation. The private sector is a very heterogeneous grouping with no obligations to report on climate finance. It includes businesses (domestic and international, in all sectors), private finance institutions and insurance companies, as well as major institutional investors such as pension funds, but also household spendings (UNEP, 2016). Private-sector climate-resilience activities are often integrated into business activities and are therefore rarely stand-alone activities or among those called 'adaptation', making them hard to track or monitor (Averchenkova *et al.,* 2015). Similarly, investment databases lack the contextual information needed to identify whether an investment has any relevance to adaptation (UNEP, 2016) or may be too sensitive to release.

Overall, information on current flows of adaptation finance cannot be directly related to future adaptation costs and needs. In particular, the lack of data on domestic public and private finance means that estimates reported are likely to be significant underestimates. Furthermore, it is important to note the quality as well as the quantity of adaptation finance. Climate finance effectiveness goes beyond a traditional understanding of effectiveness, capturing how it is accessed, managed, used and delivered (see, for example, Nakhooda *et al.,* 2014). However, these estimated flows do give an indication of the amount of adaptation finance mobilised, which is showing a positive trend while still considerably below the needs indicated in the NDCs.

4.4 NEW CONSIDERATIONS ON THE COSTS AND FINANCING OF ADAPTATION

The adaptation landscape continues to evolve. A number of new considerations have emerged since the latest Adaptation Finance Gap report (UNEP, 2016), and these are summarized below.

14 In 2016, 25 percent of approved funding from the multilateral climate funds targeted both adaptation and mitigation, significantly obscuring the performance of the climate funds in addressing the adaptation, mitigation bias: in 2016, 53 percent of approved funding went to mitigation only (CFU, 2018).

15 This figure includes the MDBs' own resources, thus excluding external resources for climate action programmed by the MDBs, but including all contributors and all recipients due to a lack of data disaggregation by the MDBs.

16 Available at: https://www.climatefinance-developmenteffectiveness.org/CPEIR-Database.

A number of methodological challenges remain in estimating adaptation finance flows, such as the lack of an internationally agreed definition, though efforts have been made to harmonize approaches across development finance actors.[17] A better understanding of the balance between adaptation and mitigation finance could emerge in 2019, as the OECD Development Assistance Committee starts to measure Official Development Assistance disbursements in grant equivalents (OECD, 2015). This would no longer mean that a US$100 grant and a US$100 concessional loan are reported as the same amount, despite the latter having to be paid back with interest, albeit at below market rates. However, the measurement and tracking of adaptation costs and finance does not need to be perfect or harmonized globally in order to develop better systems and mechanisms to mobilize finance for adaptation.

The Paris Agreement urges all countries to "make finance flows consistent with a pathway towards low GHG emissions and climate resilient development" (UNFCCC, 2015). A number of initiatives have engaged the capital and financial markets to promote greater consistency with this target (UNEP 2015b). The Task Force on Climate-related Financial Disclosure,[18] established by the G20's Financial Stability Board, is advancing the understanding that climate risks are financial risks, which will help ensure the appropriate allocation of capital due to knowledge about exposure to climate-related risks (CISL, 2018). Rating agencies and risk analysts are also starting to consider climate risk in credit worthiness assessments, portfolio management and environmental disclosure guidance (Climate Transparency, 2017). These initiatives are positive and will improve the integration of climate-related risk into private-sector decisions, and there are policy and market responses that can build resilience for financial benefit (UNEP Inquiry, 2018). However, by drawing attention to higher climate impact risks in more vulnerable countries, they may have some unintended consequences, thus reducing investments or increasing borrowing costs.

Much of the current MDB finance on adaptation has gone to funding the marginal costs of making existing infrastructure resilient. This has entailed more decision-making under conditions of uncertainty. However, while these approaches offer benefits in terms of good adaptation programming, they are time- and resource-intensive to implement, which is leading to a greater emphasis on light touch approaches (Watkiss, 2018). Looking outside the MDBs, it is likely that a greater focus will be needed on extending standards and norms beyond the public sector to incentivize private-sector resilience. This is being taken forward through the emerging development of adaptation standards that help to deliver climate resilience.[19] In the medium-term there is likely to be a greater focus on adaptation programming, for example, where the main objective is adaptation. This will provide more evidence on early adaptation costs at scale.

Redoubled efforts have been made to enhance the reach of insurance. Although insurance is a method to transfer risks (not to reduce them per se), it can build resilience through a more efficient allocation of resources by targeting high-impact, probabilistic events and supporting rapid recovery after climate-related extremes. Public finance can be used to support the establishment of new insurance schemes, help existing initiatives scale up or contribute to an enabling regulatory environment. This can include local initiatives (for example, index-based insurance) as well as national and regional ones (for example, risk pooling, such as the African Risk Capacity). There is less understanding, however, of the role of public finance (domestic or international) in subsidizing premiums as a form of adaptation or of the insurance industry itself. It is also stressed that insurance is a complementary tool to adaptation, spreading the financial risks of probabilistic extreme events, but not addressing slow onset change (trends) because premiums become unaffordable. Initiatives also need to be carefully designed to incentivize further adaptation and avoid maladaptation (including moral hazard). Finally, it is highly likely that increasing risks due to climate change will be factored into premiums by insurance companies, which will lead to pressure to start differential pricing and make it harder to obtain low-cost insurance for more vulnerable individuals and places.

4.5 OPPORTUNITIES AND CHALLENGES IN BRIDGING THE ADAPTATION FINANCE GAP

This chapter reinforces the messages of the previous Adaptation Gap Reports. The key finding is that we face a major gap in adaptation finance. Enhanced emissions reductions can reduce its size, but significant scaling up of both public and private sources of finance is required to bridge it.

17 For example, the joint MDB Methodology for Tracking Climate Change Adaptation Finance uses a context- and location-specific approach to capture finance associated with activities directly linked to climate change vulnerability. The internatinal development finance club has embraced this guidance on the measurement of adaptation finance, while the OECD worked in collaboration in their review of adaptation marker eligibility, illustrating clear efforts towards the harmonization of approaches (MDB, 2017).

18 Available at: https://www.fsb-tcfd.org.

19 For example, both the International Orgazisation for Standards and British Standards are developing standards in this area.

The MDBs have committed themselves to increasing adaptation finance through the 2020 Roadmap to US$100 billion (DFAT, 2015), though these commitments fall far short of the needs expressed in the NDCs (from 2020 onwards). Alongside the commitments to scale up adaptation finance, development finance institutions, MDBs and country governments could increase the mainstreaming of climate-resilient development. This might include upstream targets, goals and strategic direction, as well as downstream structuring and appraisal (Cochran and Deheza, 2017).

International public finance could also go further in supporting micro, small and medium enterprises as key private-sector actors for adaptation. Locally embedded formal and informal micro, small and medium enterprises often have a 'social licence' to operate, disseminating vital climate information to others (Terpstra and Ofstedahl, 2013), but they generally lack access to climate finance (Schaer and Kuruppu, 2018). Climate action by such enterprises is increasingly supported through the multilateral climate funds, though the focus remains on mitigation. The Green Climate Fund's pilot micro, small and medium enterprises programme, which has US$200 million to spend, could increase flows to this type of businesses (Watson and Patel, 2018).

There remains a need to look beyond official development assistance and highly concessional public finance to support adaptation, while recognizing that public finance will remain critical for proactive planned adaptation for the most vulnerable and for non-market sectors, as well as creating the enabling conditions for the private sector. Regarding the so-called Other Official Flows motivated by commercial and foreign-policy objectives rather than development reported to the OECD Development Assistance Committee, climate focus reporting is not mandatory, despite US$0.96 billion having been earmarked for climate issues in 2016. Further efforts should be made to ensure that these flows, and wider public finance flows in particular, are aligned with climate objectives.

Other initiatives may offer new approaches. Climate bond issuance is increasing rapidly and, though bonds are largely a refinancing instrument, they could realize greater flows for adaptation (such as through social impact bonds, catastrophe bonds or for water investments that are better able to deliver returns) (MMC, 2018). Similarly, more guidance on what constitutes sustainable investment will drive investment towards adaptation and away from maladaptive investments. The European Union, for example, is working towards this through its Sustainable Finance package of measures presented in 2018. This demonstrates that the role of domestic policy and regulation should not be underestimated in increasing investments in resilience. Shifts in fiscal policy[20] could also incentivize adaptation actions. Whereas fossil fuel subsidy reform to reduce emissions and increase the fiscal space for other development needs has good traction in the G7 and G20, similar reforms in respect of water supply or agriculture are merely nascent (Canales Trujillo *et al.,* 2015; Norman *et al.,* 2016). Underlying policy reforms can drive adaptation actions, which may or may not be underpinned by flows of public finance.

Some literature (for example, De Cian *et al.,* 2016) suggests that a global emissions trading scheme could help finance adaptation internationally by allocating allowances for adaptation costs and residual damage as well as mitigation. Highly impacted countries would thus be entitled to additional emissions allowances, which could generate large flows for adaptation by mid-century. There has also been a renewed focus on global carbon taxes (CPLC, 2017). However, the current climate policy landscape makes it extremely unlikely that a global emissions trading system or carbon tax is a realistic proposition in the short term.

As adaptation programming is scaled up, a number of other issues will emerge. There will be a need to understand how best to implement adaptation effectively, efficiently and equitably. This includes better information on the costs and benefits of individual adaptation options. It also includes improved knowledge of how technical, non-technical and capacity-building options perform, whether implemented individually or as part of a portfolio. In addition, there is a gap in how to programme adaptation, for example, to learn the best ways to address various barriers (whether market, policy or information failures) and to find out which programming modalities work well for particular risks or sectors. This evidence base will help maximize the impact of adaptation with the resources available.

There is also a need to consider the distributional differences in climate risks and adaptation costs between countries, sectors and groups in society, as well as their needs and access to finance. Perhaps more importantly, there is a need for more decisive action to shift the adaptation finance system to deal with these distributional differences. There also remains a critical information and implementation gap regarding adaptation costs and finance flows for biodiversity and ecosystem services. This is a particular priority given that these sectors are among the most vulnerable to climate change and risk major losses even under a 1.5°C scenario (IPCC, 2018). Furthermore, there is very little information currently on the potential costs of transformational adaptation, that is, going beyond incremental changes to system changes, which will be needed in some places and areas.

Finally, as highlighted in this chapter, while evidence is improving, there remain many key gaps. A key recommendation is for a more detailed evidence-based analysis to be undertaken of adaptation costs and adaptation finance, especially to inform the 2023 global stocktake.

20 Raising public revenues and directing public resources, fiscal policy instruments include taxes and pricing mechanisms.

05

CHAPTER 5

THE ADAPTATION HEALTH GAP: A GLOBAL OVERVIEW

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5.1 INTRODUCTION

Weather and climate strongly affect human health and well-being. Every year, several million deaths are caused by environmental factors, many of which are aggravated by climate change or its drivers (WHO, 2016). Comprehensive studies project increased health impacts from climate-sensitive exposure and hazards, posing a severe threat to the improvements in global health witnessed in recent decades (WMO, 2012; Smith *et al.*, 2014; Watts *et al.*, 2015; Hoegh-Guldberg *et al.*, 2018).

Climate change most often acts as a multiplier of global health threats, compounding many of the health issues communities already face, disproportionately affecting the health of vulnerable groups, particularly in lower income countries, and exacerbating inequalities. The direct and indirect impacts of climate change on human health and well-being are complex and far-reaching, and have been extensively researched (McMichael, 1994; McMichael *et al.,* 2003; Confalonieri *et al.,* 2007; Smith *et al.,* 2014). These effects, and in particular the population health effects of current climate variability and extremes, are increasingly being observed. As a result, protecting health and well-being is frequently highlighted as a central objective of national and international climate policies. For example, it is a priority sector in 54 percent of Nationally Determined Contributions (NDCs) featuring adaptation (Pauw *et al.,* 2016). Evidence shows that progress has been made in reducing climate-sensitive diseases and injuries (Smith *et al.,* 2014), but globally we are well below the required level of action in health adaptation to protect health from both climate variability and climate change (Watts *et al.,* 2015).

This chapter provides an overview of the current and projected global adaptation gap in efforts to protect health from climate change. It also serves as a cross-cutting introduction to chapters 6, 7 and 8, which provide assessments of health adaptation gaps for key categories of risk, respectively extreme weather (including heat waves), climate-sensitive infectious diseases and climate-related food insecurity.[21] The impacts on which these chapters focus were selected on the basis of the amount of scientific evidence available regarding impacts and adaptation measures, confidence in projections under climate-change scenarios, and the expected magnitude of health outcomes.

5.2 WHAT IS HEALTH ADAPTATION TO CLIMATE CHANGE?

Increasing the resilience of individuals, communities and health systems – a main goal of adaptation – can reduce the adverse health effects of climate change (Woodward *et al.,* 2011 in Smith *et al.,* 2014; Smith *et al.,* 2014; Campbell-Lendrum *et al.,* 2015). Health adaptation is the process of "designing, implementing, monitoring and evaluating strategies, policies and programmes to manage the risks of climate-relevant health outcomes" (WHO, 2014). It may be spontaneous or planned, the latter being characterized by actions that are informed by knowledge of relevant health risks and vulnerabilities with the specific aim of reducing climate change impacts. This would include actions taken by health sector officials in collaboration with those in related sectors to enhance the resilience of health systems so they can maintain their essential functions and structure after an extreme weather event, disaster or public health emergency, as well as confer the ability to withstand the even more frequent and severe events that are expected from climate change in the future (WHO, 2015a).

Public health officials have decades of experience in assessing and managing environmental health threats, and there is generally widespread agreement about how to protect health from climate-related impacts (McMichael *et al.,* 1994, 2001, 2013; WHO, 2008). Protecting the health of populations from climate change requires strengthening key health system functions and improving the management of current climate-sensitive risks (WHO, 2013). Health-system adaptation actions include those critical for strengthening key functions and improving the management of current climate-sensitive risks, many of which relate to providing adequate resources, technologies and information or knowledge to health decision-makers (WHO, 2015a). Some of the key areas of action to increase health systems resilience are highlighted in Figure 5.1.

21 Other potentially important climate-sensitive health outcomes that are not presented in this report include risks to health from air pollution, which are related to the drivers of climate change (for example, the burning of fossil fuels), projected increases in ground-level ozone and a range of eco-system impacts (for example, increased forest fires, aeroallergens, and molds from flooding), as well as impacts that are heavily mediated by human activity and systems, such as effects on labour productivity or climate-induced migration.

Beyond health systems, particularly in developing-country settings, the prevention of much of the impact on health from climate change will depend largely on basic development activities that address key social and environmental determinants of health. For example, potentially harmful exposure to temperature extremes and challenging hydro-climatic conditions are more frequent among the world's poorest populations (Byers *et al.,* 2018), as are a number of climate-sensitive diseases and impacts from extreme weather events and disasters (WHO and WMO, 2012; WHO, 2018a). In addition, for many people the basic requirements for achieving resilience to health impacts, such as a safe energy supply, are not being met. For instance, in 2016 an estimated 1.2 billion people did not have access to electricity, while 2.7 billion relied on burning unsafe, unsustainable and inefficient solid fuels (WB, 2018). Moreover, climate change could result in an increase of more than 100 million people living in extreme poverty, reversing past progress with development and exposing them to additional health risks (Hoegh-Guldberg *et al,* 2018).

Recognizing the importance of health adaptation, there are important limits to its ability to protect health from climate impacts, particularly under warming scenarios above 2°C. The physiological limits to endure high temperatures, explored in chapter 6, constitute a good example where planned adaptation may have limited effectiveness in scenarios of extremely high temperatures. In general, further warming of the globe reduces adaptation opportunities and increases the risks of unavoidable damage, particularly in vulnerable regions, including small islands and least developed countries, as well as among vulnerable populations (Smith *et al.,* 2014). The limits of potential health adaptation underscore the urgent need to adopt adequate measures.

A range of relevant metrics can be used in order to understand whether prevention of impacts and health adaptation work. A frequently used metric is the 'burden of disease', which can be understood roughly as a "measurement of the gap between the current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability".[22] This metric has been applied to many types of risks, including current and projected health impacts of weather, climate variability and climate change. In addition to premature mortality and the incidence (new cases) of disease, the burden of disease caused by climate variability and climate change can be estimated in terms of disability-adjusted life years lost and other metrics that capture both years of life lost due to premature death and decrements in the quality of life lived with certain health conditions (Murray *et al.,* 2012). Large donors and governments increasingly rely on burden-of-disease estimates to direct investments (Boerma *et al.,* 2018).

Figure 5.1: Ten components for building climate resilient health systems and the main connections to the building blocks of health systems

Source: WHO, 2015a.

22 Available at: http://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/.

5.3 THE HEALTH ADAPTATION GAP

CHARACTERIZING THE GAP

The first Adaptation Gap Report provided a generic definition of the adaptation gap as "the difference between actually implemented adaptation and a societally set goal, determined largely by preferences related to tolerated climate change impacts, and reflecting resource limitations and competing priorities" (UNEP, 2014). In line with this generic definition, the adaptation gap in health can be characterized and measured - at any given point in time - as the difference between the climate-related health outcomes under actual adaptation efforts and the outcomes that would occur under implementation of efforts at the individual, community and health-system levels consistent with a given adaptation goal, including shortcomings related to knowledge and implementation. While a global societal goal for adaptation in health does not exist, an implicit objective is to avoid the highest possible proportion of climate-related health impacts now and in the future by maximizing adaptation efforts implemented in the highest-quality manner that knowledge can support. Because even successfully implemented full adaptation cannot be 100 percent effective in protecting health from climate impacts, there will still be some residual health impacts on populations (WHO, 2014).

To understand the possible adaptation gap in the future, it is important to recognize that climate actions over the coming decades, including mitigation and health adaptation efforts, and other important trends in social and economic development outcomes (for example, demographics, education, socio-economic status, health status) will have major implications on climate change outcomes (O'Neill *et al.,* 2017; Sellers and Ebi, 2018). Under favourable conditions, with governments pursuing sustainable futures in a coordinated way, robust and proactive measures to enhance health-system preparedness for climate change impacts can be expected, resulting in greater adaptation. In contrast, under conditions lacking coordinated multinational action, more severe climate-related impacts would result in a much larger adaptation gap and greater residual impacts. Weaker health system performance in response to climate change would be expected to result in higher childhood mortality associated with illnesses such as diarrheal disease and undernutrition, with attendant implications for achieving the Sustainable Development Goals (SDGs), particularly Goal 3 on 'Good Health and Well-Being' (Sellers and Ebi, 2018). In all instances, as climate-change impacts increase, without sufficient measures to protect health the adaptation gap and residual impacts will increase with them.

Investigations of the current and possible future health adaptation gap based upon key healthsystem metrics such as burden of disease can be used by health authorities to plan for climate change. However, data availability, coverage and the quality of the evidence varies greatly among countries and regions, as well as for different health issues of concern. Data on the current adaptation gap, along with evidence on the current impacts of climate-sensitive risks, are much scarcer in low-resource settings.

EVIDENCE FOR THE CURRENT AND FUTURE ADAPTATION GAP IN HEALTH

Globally, the current level of effort to protect the health of populations and communities from most climate-sensitive risks is insufficient, although there is great variability both across and within countries and regions. The starting point is thus characterized by a clear current adaptation gap, based on the inability to deal with present-day climatic conditions (Noble *et al.,* 2014). This adaptation gap is illustrated by the global magnitude of climate-induced mortality and morbidity, and the scarcity of available or allocated resources, capacities and programs for their prevention. Furthermore, it is also characterized by the unequal distribution of impacts within and between countries. Most of the exposures and health outcomes caused or aggravated by climate impacts disproportionately affect vulnerable groups, including children, the elderly, women, people with chronic diseases, poor labourers and outdoor workers, people with low socio-economic status, indigenous peoples and people in the Arctic and Small Island Developing States (WHO, 2013; Hoegh-Guldberg *et al.*, 2018).

CURRENT AND PROJECTED CLIMATE-SENSITIVE HEALTH IMPACTS

The burden of mortality and illness related to, or aggravated by, weather and climatic drivers is significant. A selection of highlights and estimates from chapters 6, 7 and 8 is presented for illustrative purposes in table 5.1.

THE COSTS OF THE HEALTH IMPACTS OF CLIMATE CHANGE AND OF HEALTH ADAPTATION

Currently, there is a lack of global and comparative studies on the costs of the health impacts of climate change and of health adaptation. This prevents robust global assessments of current and future costs and financial needs for health adaptation, as well as of the benefit-cost ratios of health adaptation measures. However, the available information indicates that these are considerable. Besides their costs in terms of pain and suffering, ill health and premature mortality related to climate variability and change incur, and are expected to increase, tangible and significant economic costs for both health systems and society generally (Watkiss *et al.,* 2009, Kovats *et al.,* 2011; Watkiss, 2015). For instance, the health costs of six climate-related events that struck the United States between 2000 and 2009 (ozone pollution, heat waves, hurricanes, outbreaks of infectious diseases, river flooding and

Table 5.1: Selected facts and figures on current and projected health impacts of climate variability and change

Exposure/ outcome	Current impacts	Projected impacts
Heat waves	• The 2003 heatwave in Western Europe resulted in over 70,000 excess deaths (Robine *et al.*, 2008). • In 2010, many Eastern European cities recorded extremely high temperatures, particularly in Russia, where attributable deaths were estimated at around 55,000 (Barriopedro *et al.*, 2011). • In summer 2018 around 22,000 people were reported to have been taken to hospital with symptoms of heat stroke during a heatwave in Japan (Lancet, 2018).	• Large net increases in temperature-related excess mortality from around 3% in Central America to around 13% in Southeast Asia at the end of the century under high-emission scenarios (Gasparrini *et al.*, 2017). Global projections* (WHO, 2014): • With no adaptation,** additional annual deaths aged 65 and older estimated at over 92,000 in 2030 and around 255,000 in 2050. • With 50% adaptation, additional annual mortality estimated at around 38,000 in 2030 and 95,000 in 2050. • With 100% adaptation, attributable mortality drops to near zero. • Relative increases from 2030 to 2050 are largest in sub-Saharan Africa, Latin America, and South and Southeast Asia.
Flooding	• Affected 2 billion people in the last two decades (UNISDR, 2018). • Caused almost 53,000 deaths in the years 2002-2012, with a ratio of 23:1 low- versus high-income countries (Alderman *et al.*, 2012). • Psychological morbidity may represent up to 80% of the longer term attributable health burden (Hajat *et al.*, 2005).	• Projections are highly uncertain.
Windstorms, including cyclones	• Affected over 700 million people in the last two decades (UNISDR, 2018). • Caused at least 230,000 direct deaths in the last two decades (UNISDR, 2018). • Severely underestimated and under-reported (Kishore *et al.*, 2018).	• Projections are highly uncertain.
Water- and food-borne disease	• In 2016, diarrhea caused around 1.7 million deaths, including almost 450,000 in children younger than five years (Troeger *et al.*, 2017). • 600 million food-borne illnesses and 420,000 associated deaths in 2010 (WHO, 2015b). • In Europe, the most prevalent water- and food-borne disease is campylobacteriosis, which is highly sensitive to climate (ECDC, 2012).	• Global projections (WHO, 2014);* 48,000 additional deaths per year in children aged under 15 years are projected due to diarrheal disease for the year 2030 and 33,000 deaths for 2050. • In Europe in the 2080s, climate change could induce an additional 40,000 cases of salmonella annually (Watkiss *et al.*, 2009).
Vector-borne diseases	Estimated or reported annual cases of selected vector-borne diseases (WHO, 2017c): • Malaria: 212 million. • Schistosomiasis: 207 million. • Dengue: 96 million. • Lymphatic filariasis: 38.5 million. • Onchocerciasis: 15.5 million.	• Global projections (WHO, 2014):* 60,000 additional deaths per year from malaria for the year 2030 and 33,000 deaths for 2050. • Climate change will continue to increase the risk of tick-borne diseases (Stone *et al.*, 2017).
Undernutrition in children under five	• 150 million in 2016 (IFPRI, 2017).	• Additional 4.8 million climate-attributable cases in 2050.***
Stunting in children under five	• 155 million, or 22.2% of children under five (UNICEF *et al.*, 2018).	• Global projections (WHO, 2014):* 7.5 million additional stunted children per year by 2030, and 10.1 million by 2050.

Note: * Under the SRES A1b climate scenario and, in the selected highlights in this table, a base case economic scenario (based on current projections by the World Bank, Organisation for Economic Co-operation and Development, International Monetary Fund and International Futures), which assumes that recent trends in socioeconomic development, education and technology will continue for the next fifteen years, resulting in a continued decline in mortality from infectious diseases and under-nutrition. This assumption is highly contested – see chapter 7. ** Assumed adaptation: 50 percent or 100 percent improved heat health protection measures; early warning systems. *** NCAR climate model A2 Scenario.

wildfires) were estimated at US$14 billion, including healthcare costs of US$740 million (Knowlton *et al.,* 2011). While in general there is a scarcity of evidence and projections of the potential costs and benefits of specific health adaptation activities, the economic impacts of heat-related mortality and morbidity are comparatively well studied, as are the costs and benefits of the prevention of heat-related health effects (Chiabai *et al.,* 2018). In particular, early warning systems for heat waves yield high benefits compared to their economic costs. For example, benefit-to-cost ratios for heat-wave warning systems were estimated at 11 for London, 308 for Prague and 913 for Madrid, increasing much further in the near future under all climate scenarios (Hunt *et al.,* 2017). Globally, using future scenarios, various studies have attempted to calculate the projected costs of health impacts of climate change, as well as the costs of the required adaptation. The World Health Organization (WHO) estimated that the direct damage costs to health would amount to US$2-4 billion a year by 2030 (WHO, 2018b). However, these reported global costs are likely severe underestimates, since they cover only a small set of health outcomes and do not include indirect damages or costs in other sectors. Including other outcomes and indirect costs suggests that the costs of health impacts for the period 2041-2070 could be between 9 billion and 106 billion Euros in the European Union countries alone (Ciscar *et al.,* 2014). Global cost estimates of health adaptation are also partial and incomplete. The World Bank (2010) estimated the global costs of adaptation to climate-driven diarrhea, malnutrition and malaria at US$1.5 to 2 billion a year globally, with most of this incurred by African countries. This, however, does not include adaptation required in other sectors that affect health, including the cost of reducing additional cases of malnutrition (agriculture) and those associated with reducing risks from extreme weather (for example, floods and droughts).

PROGRESS AND THE ADAPTATION GAP IN HEALTH FOR CURRENT AND PROJECTED IMPACTS

Acknowledging the diversity of baselines and national circumstances, a substantial proportion of the burden of disease (mortality and illnesses) due to climate-related impacts is preventable. To a large extent these efforts and progress to reduce this burden of disease are directly linked to advances towards globally agreed goals like the Paris Agreement, the Sendai Framework for Disaster Risk Reduction and the Sustainable Development Goals within the 2030 Agenda for Sustainable Development.

For example, the Sendai Framework's global targets directly address reductions of the mortality (target A) and exposure (target B) of populations to disasters, including climate-related extremes, by 2030. In this case, the ongoing first cycle of the monitoring of progress will be completed in 2019. A recent review found that data were available for several countries to report on Targets A (83 percent of 87 reporting countries) and B (66 percent), with between 50 percent and 60 percent being able to establish baselines (UNISDR, 2017). Regarding heat waves specifically, a recent stocktaking exercise revealed that fewer than a quarter (23 percent) of countries, 75 percent of which are in the European region, have national or sub-national structured prevention activities in place, generally known as Heat-Health Action Plans (GHHIN, 2018). Moreover, the knowledge, data coverage and research gaps regarding the health impacts of climate-related extremes are very significant. These gaps are related to some extent to a lack of capacity for basic information generation. For example, of all countries, territories and areas assessed by the United Nations Statistical Division, only 57 percent had appropriate (90 percent or more) death registration coverage in 2014 (WHO, 2018a). Detailed information on progress and the health adaptation gap in climate-related extremes is presented in chapter 6.

Regarding climate-sensitive infectious diseases, there is also a clear link between global progress in addressing the adaptation gap and sustainable development efforts. For example, global progress against water- and food-borne diseases is closely linked to the status of effective action on water, sanitation and hygiene. As of 2015, 71 percent of the global population used a safely managed drinking water service, and only 39 percent had access to a safely managed sanitation service (WHO and UNICEF, 2017), and progress in this area is expected to be hindered by climate change (UNESCO, 2012). Regarding vector-borne diseases, the situation and progress varies across diseases. For example, to reach a global reduction of at least 40 percent in the incidence of malaria cases and mortality rates by 2030,[23] annual funding would need to increase from around US$2.7 billion in 2016 to US$6.5 billion per year by 2020 (WHO, 2017a). Detailed information on progress and the health adaptation gap in climate-related infectious diseases is presented in chapter 7.

Similarly, key indicators of progress with food insecurity and nutrition show slow progress. For instance, the World Health Assembly's main target for 2025, a reduction of stunting in children under five by 40 percent compared with 2012, is not yet on track, and projections based on the current trajectory are heading towards a prevalence of 19 percent, instead of the target of 14.6 percent (UNICEF *et al.,* 2018). Detailed information on progress and the health adaptation gap in food and nutritional security is presented in chapter 8.

While these estimates clearly suggest that much more needs to be done to deal even with today's climate impacts, progress has been made to protect people from current climate hazards. However, it cannot be assumed that a moderate expansion of existing measures and the implementation of new public health initiatives based on current hazards will be sufficient to deal with projected climate risks (Watts *et al.,* 2018). In fact, any increase in global warming, even under the most optimistic scenarios (for example, 1.5°C warming), will pose significant risks to health that will disproportionately affect disadvantaged and vulnerable populations (Ebi *et al.,* 2018). For instance, at +1.5°C, over 350 million additional people would be exposed to deadly heat stress by 2050, significant increases in various vector-borne diseases would be expected, and food security would be affected. Most of these impacts would be greatly exacerbated under +2°C warming (Ebi *et al.,* 2018). Limiting global warming to 1.5°C or less is simply the most important action to reduce the health impacts of climate change.

23 Compared to 2015 levels.

5.4 OPPORTUNITIES TO ADDRESS THE GLOBAL ADAPTATION GAP IN HEALTH

Health authorities with support from other sectors can take measures to avoid many of the possible health impacts of climate change over the next twenty to thirty years (Ebi and Burton, 2008; WHO, 2015a). Many actions designed to adapt to the health impacts of climate change may be considered low or no-regret measures – those that lessen future trends in exposure, vulnerability and climate extremes while addressing current impacts (IPCC, 2012). Low- and middle-income countries in particular can benefit from such actions because they provide immediate benefits to population health, may help reduce the risks from future climate change and will support progress towards the SDGs (Hoegh-Guldberg *et al.,* 2018). Such measures can help address current challenges in preparing for health emergencies, controlling disease burdens, protecting individuals with basic health-care and public health services, ensuring equitable health outcomes, and employing resources effectively and efficiently (WHO, 2015a). Central to these efforts are actions to increase the climate resilience of individuals, communities and, particularly, health systems. Resilient health systems should be able to deal effectively with climate-related shocks and stresses, thus creating sustained improvements in population health, even in a changing climate (WHO, 2015a). Key opportunities to increase the resilience of health systems and reduce climatic risks on health are discussed below.

SYSTEM-WIDE POLICIES AND PLANNING TO STRENGTHEN HEALTH SYSTEMS

Despite the gap in many areas, it is important to recognize that progress is being made globally in many areas to protect health from projected impacts. Expanding system-wide policy and planning action would further bridge the gap, specifically: 1) climate change, health vulnerability and adaptation assessments; 2) climate change and health action plans; 3) the climate resilience of health systems; and 4) health workforce preparedness.

Climate change and health vulnerability and adaptation assessments identify and interpret the information needed to prepare health systems for the impacts of climate change and are conducted by health authorities from the local to international levels. They provide the data required to develop robust adaptation strategies or action plans and processes such as Health National Adaptation Processes.[24] In 2018, 92 countries had conducted national assessments covering high- and low-income countries in all regions of the world (Berry *et al.*, 2018).

Climate change and health action plans, strategies and profiles[25] identify a country's key climate-change risks to health, the priority adaptations, partners and resources that are needed for action, and the timeframe over which the objectives will be achieved. A survey by the WHO in 2015 revealed that thirty out of forty respondent countries reported having a climate change and health strategy or plan in place (Watts *et al.,* 2018). Many of these strategies have been developed in countries that are highly vulnerable to the health impacts of climate change, especially in Africa, Southeast Asia and South America. Many more countries have developed cross-sectoral National Adaptation Plans (NAPs), where health (both as a topic and sectorally) is frequently represented. However, like other sectors, NAP supported health adaptation is still rare because of the low overall level of implementation.

Efforts to prepare for climate change require that more countries develop actions plans to protect health. Action plans should mainstream climate change information into a broad range of health policies, programs and services. Future warming of the globe and continued changes in key demographic and socioeconomic trends that underlie vulnerability to health impacts necessitates the regular review and updating of action plans based upon monitoring of outcomes to ensure they are fully protective of health, including that of the most vulnerable in society.

Building the Climate Resilience of Health Systems is a key priority, given how many climate-related risks, and specifically extreme weather events, are expected to worsen under likely climate scenarios. Health-care providers and administrators in developed and developing countries recognize the need for health facilities to build the capacity to cope with and adapt to current and projected impacts (WHO, 2015a; Bowen and Ebi, 2017). A range of new tools have been developed to assist health-sector officials in assessing the resilience of health facilities to climate change impacts (see Balbus *et al.,* 2016). However, only sixteen out of a sample of forty countries in a recent survey have implemented activities to increase the climate resilience of their health infrastructure. This suggests that significant vulnerabilities exist to climate change impacts and that there is a high level of risk to populations served by these institutions (Watts *et al.,* 2018).

24 Health National Adaptation Processes outline the national strategic goals for enhancing the resilience of health systems to climate change (WHO, 2014). The NAP a country draws up under the United Nations Framework Convention on Climate Change (UNFCCC) should ideally be supplemented with a Health National Adaptation Process.

25 The WHO-UNFCCC climate change and health country profiles are available at: http://www.who.int/globalchange/resources/countries/en/.

Photo: *© Climate Centre (Flickr)*

The climate resilience of health systems not only depends on the facilities, but also on health workforce preparedness for climate-related threats relevant to their patients and pratice. While there are no reliable global data on climate change and health content in the curricula for health sector workforces, national-level research suggests that very limited training and educational opportunities are being provided for health sector workers, thereby limiting their ability to reduce the vulnerability of populations to climate-related hazards (Cruz *et al.,* 2018; Shaman and Knowlton, 2018; Wellbery *et al.,* 2018). In addition, health system resilience and the ability of health authorities to reduce climate impacts can be greatly strengthened through integrated risk monitoring and early warning systems. However, as illustrated by current tracking under the Sendai Framework of Disaster Risk Reduction 2015-2030, most countries (particularly low-income countries and lower-middle income countries) still lack robust systems of integrated risk monitoring and early warning.

To plan for greater climate-related hazards health authorities will need to follow an iterative risk management approach based upon wide stakeholder engagement and development of flexible and adjustable policies that can respond to uncertain health risks that change across time and across locations. Evidence from regular national assessments should be used to routinely monitor the success of adaptation actions, and make course corrections.

ENHANCING CROSS-SECTORAL COLLABORATION FOR HEALTH ADAPTATION

Climate change is inherently a multi-sectoral issue, and opportunities exist for collaboration between health decision-makers and officials in other sectors. Health adaptation is most effective when it is fully integrated into broader policies and programmes, notably development activities. Adaptation to climate change impacts in several areas (for example, agriculture, water and sanitation, infrastructure, transport, energy and urban design) is crucial in reducing the impacts on health and well-being. Climate-resilient health systems are most effectively developed when achieving synergies with actions in complementary initiatives such as the Sendai Framework for Disaster Risk Reduction, the United Nations' SDGs, the Paris Agreement on Climate Change and the International Health Regulations, among others. Thus, the health impact of climate-relevant policies and programs should be systematically assessed. In addition, national and subnational authorities should enable the effective engagement of health professionals in advocacy against climate change. Internationally, health-sector advocacy to promote climate change action by groups such as the WHO, the Climate and Clean Air Coalition,[26] the Global Alliance for Clean Cookstoves,[27] the World Medical Association, Health Care Without Harm[28] and the Global Climate and Health Alliance[29] has increased. At the Global Climate and Health Forum in 2018 a call to action outlining ten priority actions[30] to protect people's health from climate change was signed by fifty health organizations, representing millions of health professionals and thousands of hospitals (Global Climate and Health Forum, 2018). However, more efforts are needed to raise awareness of the threats to health from climate change and to build the scientific evidence base for action, particularly in developing countries.

HARNESSING THE HEALTH CO-BENEFITS OF MITIGATION AND ADAPTATION MEASURES

Climate change action presents an unprecedented opportunity to improve global health (Watts *et al.,* 2015). Proactive and well-designed efforts to address the drivers of climate change through greenhouse gas mitigation could provide substantial health benefits through reductions in air pollution and increased physical activity along other pathways (Haines *et al.,* 2009, Smith *et al.,* 2014). Fundamental to achieving these gains will be robust greenhouse gas mitigation measures and adaptation actions in a range of health-relevant sectors (Chang *et al.,* 2017). Moreover, frequently being major greenhouse gas emitters themselves (Chung and Meltzer, 2009; Roschnik *et al.,* 2017), health systems should, where possible, lead by example in efforts to reduce greenhouse gases. Mindful of the health effects of pollution and climate change, the World Medical Association recommended that all health organizations divest where and when feasible from fossil fuels (WMA, 2016). Existing evidence suggests that carbon-cutting strategies in health care may represent significant savings that can be reinvested in health systems' core functions (WHO, 2017a). In addition, early transitions towards low-carbon energy systems can ease the health sector's adjustment towards climate-smart and resilient health systems.

FUNDING HEALTH ADAPTATION

In principle, most of the financing mechanisms for adaptation are prepared to consider projects geared towards health adaptation. Multilateral examples include the Special Climate Change Fund, the Least Developed Countries Fund, the Pilot Program for Climate Resilience, the Adaptation Fund and the Green Climate Fund, among others. In addition, many multilateral development institutions have bilateral instruments and programmes that provide such funding. However, thus far participation by the health sector in accessing these adaptation funds has been very low. For instance, health is the only sector for which there is no correlation between countries highlighting the sector as a priority in their NDCs and Green Climate Fund financed projects (GCF, 2018). With some variations, the overall presence of health-sector projects in most of the funds compared to other large sectors of the global economy is negligible. Between 2003 and 2017 less than one percent of international finance for climate change adaptation was allocated to health adaptation despite the high levels of engagement by health officials in adaptation planning processes such as NAP, suggesting that faster implementation of agreed NAP priorities should help (Watts *et al.,* 2018). The engagement of health officials in other processes geared towards supporting adaptation implementation (for example, Technology Needs Assessments, Climate Technology Centre Network proposals, Multilateral Development Banks-supported portfolios) should be expanded. Low-regret health adaptation actions with substantial benefits, such as increasing the climate resilience of health facilities, should be prioritized. In addition, resources should be dedicated to building the capacities of health administrators and institutions to apply for or access national and international adaptation funding, whether private or public. Most importantly, the notion that the health sector can or should undertake adaptation without additional support, specifically from international and multilateral adaptation funds in the case of developing countries, should be dispelled.

26 Available at: http://ccacoalition.org/en.

27 Available at: http://cleancookstoves.org/.

28 Available at: https://noharm.org/.

29 Available at: http://www.climateandhealthalliance.org/.

30 Available at: https://www.globalclimateandhealthforum.org/call-to-action/.

06

CHAPTER 6

HEAT AND EXTREME EVENTS

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6.1 INTRODUCTION

Recent hydrometeorological and climatic extremes (climate-related extremes for short), such as heat waves, droughts, floods, cyclones and wildfires, reveal significant vulnerabilities and the exposure of many human systems to current climate variability (IPCC, 2014). Impacts of such climate-related extremes include increased mortality and morbidity, including mental health disorders, disruption of food production and water supplies, and damage to infrastructure and settlements, among others (IPCC, 2014). At all levels of development, these impacts indicate a significant lack of preparedness, response capacity and adaptation to current climate variability (IPCC, 2014). Moreover, in the absence of significant and accelerated actions, climate change is expected to aggravate several health-impacting exposures and hazards, including climate-related extremes (see box 6.1).

The 2015 Paris Agreement aims to limit the global average temperature increase to significantly below 2°C and as close to 1.5°C as possible above the pre-industrial period by the end of the century (UNFCCC, 2015). Assuming no changes in population and vulnerability, this limitation in the increase in temperature would prevent large increases in temperature-related mortality in most regions of the world (Vicedo-Cabrera *et al.,* 2018a). However, without decisive mitigation action, projected temperature changes will be far above that goal: in 2050 the increase could range from about 1.7 to 2°C. An increase of 2°C would severely increase heat-related morbidity and mortality, heat stress, (ground-level ozone) and undernutrition (Ebi *et al.,* 2018). Acknowledging the uncertainty in the existing projections, health risks from flooding and windstorms are also generally expected to worsen, albeit unequally in different world regions due to a multitude of factors, notably different current and projected exposures and underlying vulnerabilities.

The remainder of the chapter is structured in two sections and various sub sections. Section 6.2 summarizes current and, where possible, projected impacts of heat and weather extremes and presents a characterization of the current and future health adaptation gap from climate-related extremes. Section 6.3 outlines key priorities to reduce the gap.

Box 6.1: Statements related to climate change and weather extremes in the Summary for Policy Makers of the Working Group II Contribution to the IPCC Fifth Assessment Report

'Until mid-century, projected climate change will impact human health mainly by exacerbating health problems that already exist (*very high confidence*)'. Throughout the 21st century, climate change is expected to lead to increases in ill-health in many regions and especially in developing countries with low income, as compared to a baseline without climate change (*high confidence*). Examples include greater likelihood of injury, disease, and death due to more intense heatwaves and fires (*very high confidence*); increased likelihood of under-nutrition resulting from diminished food production in poor regions (*high confidence*); risks from lost work capacity and reduced labour productivity in vulnerable populations; and increased risks from food- and water-borne diseases (*very high confidence*) and vector-borne diseases (*medium confidence*).

Source: IPCC, 2014.

6.2 THE CURRENT AND FUTURE GLOBAL ADAPTATION GAP IN HEALTH FOR HEAT AND EXTREME EVENTS

Ascertaining how far we are globally from a situation in which most of the current and projected health impacts of climate-related extremes could be averted constitutes a formidable challenge, both conceptually and practically.

To begin with, no simple or universal definition of an extreme event exists. The Intergovernmental Panel on Climate Change (IPCC) defines extreme events as "the occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable" (IPCC, 2012). However, this definition may not be readily operational for those concerned with the impacts of heat and extreme events. In 2011, the World Health Organization (WHO), together with partners in health and meteorological agencies, published a fact sheet on useful definitions and early warning information for natural hazards (WHO *et al.,* 2011), but more progress is urgently needed in this area, as explored in section 6.3.

In addition, measuring the health impacts of current and past climate-related extremes also presents several challenges, which vary according to both the type of exposure (for example, heat, storms, flooding) and the type of health outcome (whether, immediate, like injuries or drowning, or delayed, like long-term mental illnesses). These challenges apply even with good availability of data and information systems, a situation far from the global average status quo, particularly in developing countries. While these challenges preclude obtaining reliable figures on global health impacts, partial estimates can provide an overview and a basis for action. Tracking global progress in the prevention of climate-related extremes that affect human health also poses great challenges, although the core set of indicators devised to monitor progress towards the global targets under the Sendai Framework will crucially support efforts in this direction, as will the monitoring of progress towards the Sustainable Development Goals (SDGs).

Moving beyond the current situation to projected scenarios also entails difficulties: rigorous projections need to incorporate baseline uncertainties, along with those of alternative scenarios in social, economic, environmental and climate trends. However, despite these challenges and shortcomings, existing data and evidence are robust enough to inform action in several important areas in order to reduce the current and forthcoming health impacts of climate-related extremes.

CURRENT AND PROJECTED HEALTH IMPACTS FROM HEAT

CURRENT IMPACTS

There is extensive evidence of the impacts of heatwaves on health in the form of changes in mortality and morbidity (Kovats and Hajat, 2008). For example, the 2003 heatwave in western Europe resulted in over 70,000 excess deaths (Robine *et al.,* 2008). In 2010, many eastern European cities recorded extremely high temperatures, particularly in Russia, where the deaths attributable to these high temperatures were estimated at around 55,000 (Barriopedro *et al.,* 2011). The greatest share of heat-associated health impacts is respiratory and cardiovascular-related mortality (WMO and WHO, 2015), and health impacts affect vulnerable groups disproportionately (see box 6.2). Mortality comparisons across times and locations should be made with caution, as high temperatures can have different impacts depending on the duration and severity of the event, as well as the acclimatization and health status of the population. The geographical coverage of studies linking heat to mortality is unequal, developing countries hardly being represented at all (Campbell *et al.,* 2018). This patchy coverage, along with the difficulties in extrapolation, largely explain the absence of comprehensive global estimates for current impacts. In addition to heat-related mortality, many studies find an overall increase in several types of hospital admissions during or just after heatwaves (Kovats *et al.,* 2004; Linares and Díaz, 2008). For example, there is clear evidence that renal and respiratory admissions are linked to heatwaves in different parts of the world (Davis and Novicoff, 2018). Occupational health studies have demonstrated an increase in accidents during heatwaves (Martinez-Solanas *et al.,* 2018). In addition, a recent systematic global review found evidence of an increased suicide risk during hot weather, as well as an increase in heat-related morbidity and mortality among people with known mental health problems (Thompson *et al.,* 2018). Moreover, cold waves also cause very significant impacts in terms of mortality and morbidity. In fact, some studies have estimated that most of the temperature-related mortality burden was attributable to the contribution of cold (Gasparrini *et al.,* 2015), pointing to an urgent need for planned public health interventions of proven effectiveness (Mayrhuber *et al.,* 2018). This urgency is further reinforced by persistent problems of fuel poverty around the world (Bouzarovski and Petrova, 2015).

PROJECTIONS

The health-related impacts of climate change would be especially severe in warmer and poorer regions; a recent study of 23 countries across nine regions of the world projects that warmer regions, such as the central and southern parts of America or Europe, and especially Southeast Asia, would experience a sharp surge in heat-related impacts and extremely large net increases in temperature-related excess mortality from around 3 percent in Central America to around 13 percent in Southeast Asia by the end of the century (Gasparrini *et al.,* 2017). Adaptation is expected to be a substantial modifying factor in how warming from climate change affects health. For instance, in the absence of any adaptation of the population, heat-related deaths in the United Kingdom can be expected to rise by around 257 percent by the 2050s from a current baseline of around 2,000 deaths annually, while cold-related mortality would decline by 2 percent from a baseline of around 41,000 deaths annually (Hajat *et al.,* 2014). In 2014, the WHO assessed the potential for adaptation to reduce climate change-attributable heat-related excess deaths for people aged over 65 years based on a single medium to high emissions scenario (WHO, 2014). Adaptation was incorporated into the assessment by changing the optimum temperature for future time periods. Assuming no adaptation, additional annual deaths attributable to heat in this age group were estimated to be over 92,000 in 2030 and around 255,000 in 2050. Relative increases from 2030 to 2050 are largest in sub-Saharan Africa, Latin America and South and South-east Asia. Estimates are reduced considerably when adaptation is assumed, with attributable mortality dropping to zero with 100 percent adaptation. With 50 percent adaptation, additional mortality was estimated at close to 38,000 in 2030 and close to 95,000 in 2050 (WHO, 2014).

It is important to note that, although reduced in number, cold waves will continue to occur under climate change (Zhang *et al.,* 2017), and that potential decreases in cold-related mortality are unlikely to offset the potential increases in heat-related deaths without adequate adaptation to heat (Martinez *et al.,* 2018).

CURRENT AND PROJECTED HEALTH IMPACTS OF FLOODING

CURRENT IMPACTS

Floods are the most common type of disaster globally, and by far the most frequent climate-related disaster, having affected about two billion people in the last two decades (UNISDR, 2018). They also have significant health impacts: they were responsible for almost 53,000 deaths between 2002 and 2012, with a ratio 23:1 in low- versus high-income countries (Alderman *et al.,* 2012). In Europe alone, in the ten years to 2017, over a thousand people were killed by floods and five to six million more were affected (CRED, 2018a). The health impacts of flooding are both short and longterm. Short-term health effects are typically attributed to injuries, infections, chemical hazards and disruption to health services. The long-term health effects of flooding are becoming better understood through recent research and are estimated to be substantial (Fernandez *et al.,* 2015). For example, twelve months after the 2014 floods in England, the prevalence of probable psychological morbidity was found to have increased among both people who were flooded (depression 20.1 percent, anxiety 28.3 percent, PTSD[31] 36.2 percent) and those who experienced disruption without floodwater entering their homes (depression 9.6 percent, anxiety 10.7 percent, PTSD 15.2 percent) (Waite *et al.,* 2017). Flooded households who reported disruption to domestic utilities (such as electricity, gas or water) or to health care had higher odds of contracting all probable psychological disorders compared with other households, as did those displaced from their homes. The health burden declined somewhat after two years but remained high among all groups affected (Jermacane *et al.,* 2018). Commissioners and providers of health care and social care should be aware that an increased need for support exists in flooded populations, which may be prolonged. Efforts to resolve persistent damage to homes may reduce the risk of psychological morbidity. Overall, psychological morbidity is estimated to be responsible for 80 percent of the longer term health burden attributable to flooding in developed countries (Hajat *et al.*, 2005).

Box 6.2: Vulnerable Groups to Heat and Extreme Events

Population vulnerability to heat and extreme events is strongly influenced by socioeconomic and demographic factors (WMO and WHO, 2015). Effective risk reduction depends crucially on targeting interventions for populations at particular risk and in modifying amenable risk factors. Although the main determinants of vulnerability may vary geographically depending on the social, economic and political circumstances, there are some commonalities across populations in terms of risk factors. Populations at particular risk include:

- The elderly (Benmarhnia *et al.,* 2016; Díaz *et al.,* 2015) are at high risk of health impacts of heat due to dysfunctional thermoregulatory mechanisms, chronic dehydration, medication and pre-existing diseases, especially cardiovascular or pulmonary illnesses (Mayrhuber *et al.,* 2018).
- Pregnant women and fetuses; extreme heat is a risk factor for adverse birth outcomes such as low birth weight and premature birth (Arroyo *et al.,* 2016; Ngo and Horton, 2016). One study projected that the average birthweight in New York will drop by 4.6 grams between 2070 and 2099 because of the warming associated with climate change (Zhang *et al.,* 2017).
- Patients with chronic diseases; for example, people with diabetes are more vulnerable to heat (Yardley *et al.,* 2013), as are those who are obese and those with cognitive impairments (Bouchama *et al.,* 2007; Linares *et al.,* 2016).
- Outdoor seasonal workers; their extensive physical exposure, sometimes coupled with low salaries, unfavourable living conditions (Al-Sayyad and Hamadeh, 2014; Martínez-Solanas *et al.,* 2018) and intense physical activities (e.g., rickshaw drivers), puts them at particular risk (Knowlton et al., 2014).
- Travellers are especially susceptible to impaired acclimatization during heatwaves (Tobías *et al.,* 2012; Gómez-Martín *et al.,* 2014).
- Socially disadvantaged or isolated groups; effects are particularly pronounced among those who are socially deprived, substance abusers or homeless (Nicolay *et al.,* 2011; Martin, 2016). Also women living in single households (Wong *et al.,* 2011, Sorensen *et al.,* 2018), and certain specific ethnic communities like Native Australians (White-Newsome *et al.,* 2014; Kovats and Ebi, 2006) are more vulnerable.
- Migrants, refugees and internally displaced people may have pre-existing and post-displacement vulnerabilities such as malnutrition, untreated chronic medical conditions from limited access to health care and a lack of shelter to provide adequate protection, predisposing them to decompensation from heat and other extreme events (McMichael *et al.,* 2012).

31 Post traumatic stress disorder.

Box 6.3: Health impacts of droughts

The most recent data available from the international disasters database estimate that more than 50 million people around the world were affected by drought in 2011 (Stanke *et al.,* 2013). Despite their dangerous global impacts, the health effects of droughts are poorly researched and understood, partly due to the complexities involved in ascertaining the beginning and end of the events, individual and population exposures and their accumulated effects over time. In addition, many of its effects are indirect (Vins *et al.,* 2015; Ebi and Bowen, 2016; Berman *et al.,* 2017) and thus inherently difficult to attribute.

PROJECTIONS

Research indicates that there is a clear relationship between atmospheric warming and future risks of river flooding in most world regions (Alfieri *et al.,* 2017). However, whether the increased flood risk will translate into increased mortality and illness depends heavily on the level of effort devoted to implementing protective measures and adaptation. Health impacts associated with coastal flooding attributable to climate change are also highly sensitive to adaptation. Construction and maintenance of coastal defences in appropriate areas might eliminate some of the anticipated future burden of coastal flooding (WHO, 2014). Models estimate that, without climate change adaptation, mortality attributable to coastal flooding will rise rapidly by 2030 and remain high in 2080 in East Asia, North America, Oceania, and parts of sub-Saharan Africa. However, assuming climate change and sea-based adaption, in the same regions mortality would increase slightly between 2030 and 2050 and would be further reduced roughly to baseline levels by 2080, suggesting that affordable sea-based adaptation would bring significant benefits. In contrast, in South Asia, even in a future with climate change and sea-based adaption, projected storm-surge mortality is high, and climate change remains a major threat.

CURRENT AND PROJECTED HEALTH IMPACTS OF WINDSTORMS

Windstorms, including cyclones (also known as typhoons and hurricanes), have affected over 700 million people in the last two decades (about 16 percent of those affected by a disaster) (UNISDR, 2018). They also cause substantial associated health impacts globally (Goldman *et al.,* 2014). In this period windstorms have caused at least 230,000 direct deaths (UNISDR, 2018), a figure that is probably a severe underestimate. Many windstorms cause secondary hazards, including flooding, landslides and storm surges, adding health risks and impacts (Malilay, 1997). The 2017 Atlantic hurricane season in particular underscored the significance of these storms for human health (O'Shultz *et al.,* 2018), as well as the challenges related to disaster epidemiology. For instance, the official death toll associated with Hurricane Maria in Puerto Rico until 31 December 2017 was 64, but a separate estimate conducted using household surveys and the official Centers for Disease Control and Prevention definition of hurricane-related deaths yielded an estimate of over 4,600, one third of which were related to delayed or interrupted health care (Kishore *et al.,* 2018). Risks are expected to worsen going forward as a result of hazard amplification and increasing vulnerability (Forzieri *et al.,* 2017). Hazard amplification relates fundamentally to a demonstrable increase in the kinetic energy contained in storms, driving increases in peak storm intensities, precipitation rates, storm frequencies and the geographical extent of associated flooding (Emanuel, 2008; Kossin *et al.,* 2017). Several sociodemographic trends, including population growth, migration to cities and associated increases in population density, the location of critical infrastructure in coastal cities, damaged ecosystems, increasing inequalities and infrastructural fragility, all contribute to worsening impacts (O'Shultz *et al.,* 2018). Sea level rises are also increasingly amplifying risks (Hinkel *et al.,* 2014). However, there are currently no reliable projections of windstorm mortality attributable to climate change, so direct comparisons with extreme heat and flooding events are not possible.

CHARACTERIZING THE GLOBAL ADAPTATION GAP IN HEALTH FOR HEAT AND EXTREME EVENTS

A substantial proportion of the mortality and illnesses attributable to climate-related extremes is preventable, even acknowledging the diversity of baselines and national circumstances. The burden of mortality attributable to heat, floods, windstorms and other extreme weather events such as droughts (see box 6.3) constitutes in itself a metric against which to evaluate efforts to reduce the current health gap of climate-related extremes. Without sustained and strengthened efforts, these impacts may increase significantly. Even under a 1.5°C warming scenario, globally we are far from adequately addressing the projected health adaptation gap for climate-related extremes.

Adaptation interventions to heat and extreme events can happen at several levels, including the individual, interpersonal, community, institutional, environmental and public policy levels (Wight *et al.,* 2016). Moreover, adaptation can be both passive and active, and the two are not mutually exclusive. For example, equatorial countries generally exhibit higher heat thresholds consistent with passive adaptation (Hajat and Kosatky, 2010). However, passive adaptation cannot address the increasingly severe climate-related extremes, something clearly illustrated by current trends and recent occurrences. In 2014, several countries in Southeast Asia (Malaysia, Indonesia and Thailand) were hit by serious floods that caused major displacements as well as damage to property and infrastructure. Extreme heatwaves were observed in Southeast Asia following several months of the 2015/2016 El Niño event, which researchers attributed fully to anthropogenic warming (Imada *et al.,* 2018). This extreme warmth during the south-western monsoon exacerbated forest fires caused by clearing land and increased air pollution throughout the region. These trends demonstrate that active adaptation is key.

INTERNATIONAL PROGRESS WITH POLICY AND NATIONAL-LEVEL IMPLICATIONS

Recent international developments have created an opportunity for national governments to pursue active adaptation with substantial international support. Taken together, the synchronous adoption of the Paris Climate Agreement (UNFCCC, 2015), the Sendai Framework for Disaster Risk Reduction (UNISDR, 2015) and the SDGs within the 2030 Agenda for Sustainable Development represent a significant opportunity to build coherence across disaster risk reduction platforms, representing a major turning point in global efforts (Aitsi-Selmi *et al.,* 2015) and a shift to a proactive, preventive stance.

The Sendai Framework's global targets directly address the reduction of mortality and the exposure of populations to disasters, including climate-related extremes: (1) Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020–2030 compared to the decade 2005–2015; and (2) Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020–2030 compared to the decade 2005–2015.

These agreements set the stage for national health authorities to take measures to avoid many of the possible health impacts of climate change over the short term (20-30 years) (WHO, 2015) – see box 6.4. The first cycle of monitoring progress in implementing the Sendai Framework, covering 2015-2016 and 2017-2018, will be completed in 2019, providing an overview of both status indicators and the capacity of countries to undertake assessments. A recent review found that data was available for most countries for Targets A (83 percent of 87 reporting countries) and B (66 percent) with between 50 percent and 60 percent being able to establish baselines (UNISDR, 2017).

EARLY WARNING AND PLANNING FOR THE HEALTH IMPACTS OF HEAT AND EXTREME EVENTS

Prevention of the health impacts of climate-related extremes requires a portfolio of actions at different levels: from health-system preparedness coordinated with meteorological early warning systems to timely public and medical advice and improvements to housing and urban planning. For heat, these actions can be integrated into a defined heat–health action plan (WHO, 2008; Matthies et al., 2008; WHO, 2014). As at August 2017, stocktaking efforts by the Global Heat Health Information Network identified 47 countries which have national or sub-national heat–health action plans in place (GHHIN, 2018), the majority being sub-national. Over two thirds (75 percent) of heat–health action plans were identified in Europe, as many countries invested in such planning efforts following the extreme 2003 European heatwaves. To date, current records indicate that fewer than a quarter (23 percent) of countries have some form of national or sub-national change to heat–health action plan in place (see table 6.1).

Box 6.4: Two recent examples of national-level action on climate-related extremes

- In Malaysia, a National Disaster Management Agency was established in 2015 as the focal point for disaster management in order to coordinate disaster risk reduction initiatives among multi-agencies and to adopt national plans such as Integrated Flood Management, a National Haze Action Plan, and an Extreme Weather Warning System. The Ministry of Health has also adopted adaptation measures by enhancing and sustaining health services, preparedness and response plans, monitoring and disease surveillance, and capacity-building.
- In the United Kingdom, the national government published a National Risk Register in 2017, which links extreme weather events to changes in the UK's climate in order to address health and other impacts (UK Cabinet Office, 2017). The UK government has also launched its second National Adaptation Programme and its Third Strategy for Climate Adaptation Reporting (UK Department of Environment, Food and Rural Affairs), which emphasize the need for continued developments in monitoring and prediction systems because of the increase in the frequency and severity of extreme events. For example, Public Health England and its partners are responsible for publishing the Heatwave Plan for England (Public Health England, Department of Health and Social Care, and NHS England) and for its implementation and monitoring. Recently the United Kingdom House of Commons Environmental Audit Committee (2018) suggested that there is a need for a public information campaign on the developing threat of heatwaves and their significant impacts on human health and activities.

Table 6.1: Regional distribution of heat–health action plans

WHO Region	No. of countries identified as having heat–health action plans	Total heat–health action plans by Region	Countries with heat–health action plans	No. of countries in region
Eastern Mediterranean	1	2%	5%	22
Europe	35	74%	66%	53
Americas	2	4%	6%	35
South East Asia	5	11%	45%	11
Africa	0	0%	0%	47
Western Pacific	4	9%	11%	37
Total	47	-	23%	204

Source: Data in this table were obtained from the Global Heat Health Information Network Database. Information displayed was obtained through a systematic review of online heat–health action plans undertaken by the WHO and World Meteorological Organization Climate and Health Office in August 2017 (GHHIN, 2018).

While many of the adverse health effects of hot weather and heatwaves are largely preventable, there are physiological limits to the degree of compensation beyond which thermoregulation simply cannot cope with heat exposure. Further work is needed to determine these levels and the actions needed. Improvements to housing and the outdoor built environment, such as increasing green spaces and shading solutions (Silva *et al.,* 2010), may prevent some mortality from high temperatures.

For other climate-related extremes as well, early warning systems are a common intervention, being particularly effective when linked with adequate intersectoral responses and targeted activities that reduce risks for particularly vulnerable groups (Vicedo-Cabrera *et al.,* 2018a; Benmarhnia *et al.,* 2016). The Sendai Framework promotes "risk assessment and EWS [as] essential investments that protect and save lives, property, and livelihoods…." There are no reliable comprehensive estimates of the global state of preparedness and response, though this knowledge gap is expected to decrease with the reporting under the Sendai Framework and the SDGs.

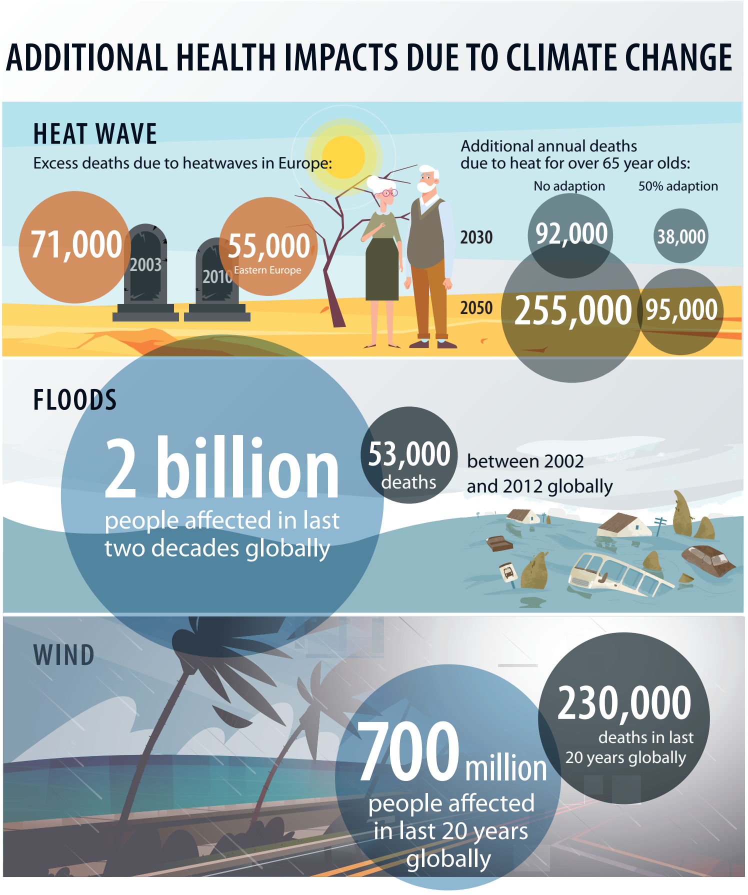
MEASURING CLIMATE-RELATED EXTREMES' IMPACTS ON HEALTH

By their nature, heat and extreme events are difficult to predict and tend to disrupt data collection systems. Monitoring after extreme events is more complicated, as the data collected may be less reliable (Dominici *et al.,* 2005). In settings where monitoring capacity is already low, there may be no reliable data at all. Countries with robust civil registration and vital statistics systems typically monitor mortality through the continual registration of deaths (Rampatige *et al.,* 2014). More than a hundred countries, primarily low- and middle-income countries, lack functioning civil registration and vital statistics systems. Among the countries, territories and areas assessed by the United Nations Statistical Division, only 57 percent had 90 percent or more death registration coverage in 2014 (Byass, 2007; WHO, 2018). These factors further magnify the data deficit (Osuteye *et al.,* 2017). A plan scaling up investment in civil registration and vital statistics capacities has set a goal of achieving universal civil registration of deaths, including causes of death, for all individuals by 2030 (IEAGDRSD, 2014).

While there are significant challenges in assessing the impacts of climate-related extremes on health, there is sufficient data to generate partial global estimates of such impacts. Some organizations have analyzed the links between exposure and outcomes. Global exposure data are curated by the United Nations Office for Disaster Risk Reduction and the Center for Research on the Epidemiology of Disasters. The latter also provides data on and analyses of the health impacts of extreme events (CRED, 2018b) through the Emergency Events Database. Other epidemiological analyses are being conducted by the WHO and the Institute for Health Metrics and Evaluation, which produces the Global Burden of Disease (Naghavi *et al.,* 2017). In 2018, the two organizations signed a memorandum of understanding governing their co-production of estimates of global health burdens, though it is unclear whether health impacts associated with heat and extreme events and projections associated with climate change will be among the estimates thus produced.

Accounting for the health burden associated with heat and extreme events depends on clear definitions of both exposures and outcomes (Noji, 2000; Dominici *et al.,* 2005). Often this includes a "case definition", for example, a statement of who has been affected by the exposure and in what ways (Kishore *et al.,* 2018). Differences in case definitions are often a source of significant variability in burden estimates. Robust global accounting of disaster impacts depends on generally accepted definitions of both the exposures of concern and the case definitions of who is affected, but a consensus on this points remains elusive (Combs *et al.,* 1999). Figure 6.1 highlights the magnitude of weather extremes on mortality and morbidity as explained in detail below.

Figure 6.1: Excess mortality and morbidity due to heat, floods and wind



Sources: Robine *et al.*, 2008; Barriopedro *et al.*, 2011; Alderman *et al.*, 2012; WHO, 2014; UNISDR, 2018.

6.3 OPPORTUNITIES TO ADDRESS THE GLOBAL HEALTH ADAPTATION GAP FOR HEAT AND EXTREME EVENTS

While recognizing that some countries are addressing climate-related extremes and climate change and trying to minimize their causes and impacts in a proactive manner, there are still significant adaptation gaps that need to be bridged. These are summarized in the following paragraphs.

IMPLEMENTATION GAPS

Implementation gaps regarding the health impacts of heat and extreme events remain significant and need to be addressed urgently. Chapter 5 lists crucial systemic and cross-sectoral activities to increase resilience, both in general and in health systems in particular. In addition, and pertaining to climate-related extremes, important areas of action include:

Promoting the systematic integration of disaster risk reduction into all health policies, and the integration of health into disaster risk reduction national plans and strategies, from their inception.

Strengthening the capacity of the health workforce to deal with disaster risk reductions through specific education and training.

Investing in **making health systems resilient to climate-related extremes**, keeping hospitals, health facilities and the health workforce safe from disasters, and ensuring access before, during and after the events.

Raising awareness among national and sub-national governments on the health impacts of heat and extreme weather events and of how the different frameworks are aligned. This alignment and its potential efficiency gains should enhance collaboration and coherence in addressing gaps in adaptation. All the elements needed to bridge the health adaptation gap in respect of climate-related extremes should be evidence-based, coherent and grounded in the coordinated planning and implementation of disaster risk reduction strategies across all sectors and diverse contexts.

Ensuring national ownership and leadership of all of the above frameworks will also be fundamental to success. Instituting clear governance arrangements contributes to ensuring successful collective action and accountability, such as collaboration between public health and health-care sectors and national and local partners, including town planning and city parks, as well as the facilitation of sustainable transport mechanisms.

Promoting the involvement of health science and technology by funding national and regional research projects. The Sendai Framework calls specifically for enhanced scientific work on disaster risk reduction and the better coordination of existing networks and scientific research institutions in order to understand disaster risks, as well as creating national and local risk registers.

Early warning is a key to reducing the impacts of heat and extreme events along with effective planning and responses. The adaptation gap identified for the health impacts of heat and extreme events includes the development of early warning and effective planning, risk assessment and management to improve community resilience and to engage various stakeholders. The implementation of heat–health action plans coupled with adequate heat-warning systems is a clear example. As one of its global targets, the Sendai Framework identifies the need to increase substantially "*the availability of and access to multi-hazard EWS and disaster risk information, and assessments to people by 2030*" (UNISDR, 2015).

Expanding the evidence base is crucial to our understanding of disaster risks. Monitoring capacity varies greatly across countries and regions, hindering both local preparedness and response capacities, as well as the global understanding of health-related disaster risks and losses. It is crucial to promote the development, dissemination, adoption and use of evidence-based methods and tools to minimize health impacts from climate-related disasters.

KNOWLEDGE GAPS

Addressing knowledge deficits, including those relating to causal pathways, exposure, population-level acclimatization capacity and the effectiveness of prevention across different settings, is critical. Robust estimates of the future projected burden of diseases from heat and extreme events and the paucity of data, especially in developing countries, need to be addressed.

DEFINITIONS OF HEAT AND EXTREME EVENTS

More and urgent work is needed in furthering globally accepted and operationally viable definitions of climate-related extremes. Although the United Nations General Assembly has agreed the Sendai Framework terminology (UNGA, 2016), definitions of heat and extreme events were not included. As a result, developing consistent definitions, particularly of heat and extreme events mortality, morbidity, including mental health, and resilience, are common themes across all three 2015 United Nation Landmark Agreements (ODI, 2016).

OUTCOME METRICS FOR THE HEALTH IMPACTS OF HEAT AND EXTREME EVENTS

Recognizing that there is a lack of consensus over appropriate outcome metrics, how to estimate the burden of mortality and morbidity from heat and extreme events is critical. Adequate global monitoring processes which track progress with implementation of the Sendai Framework to determine the subsequent reductions in the health impacts of heat and extreme events are essential. Strengthening monitoring capacities for disasters globally, for example, by increasing the collection, integration and dissemination of monitoring data on heat, climate and biological hazards, will lead to improved estimates of health burdens and mortality impacts. These will also help minimize the reporting burden on countries, making data collection more efficient and goals achievable.

RISK ASSESSMENT AND MANAGEMENT OF THE HEALTH IMPACTS OF HEAT AND EXTREME EVENTS

Improved risk assessments are critical to understanding the hazards of and relevant plans to reduce the health impacts of heat and extreme events in all countries. The Sendai Framework includes a global target for risk assessments and states that action is required to "substantially increase the number of countries with national and local disaster risk reduction strategies by 2020" (UNISDR, 2015). Action on this target should be urgently strengthened, as well as in respect of the other Sendai Framework Priorities for Action, by all the United Nations member states (UNISDR, 2015). Besides risk assessments, improved risk management is critical. Adopting a resilience-strengthening, people-centered approach to heat and extreme event risk management is likely to improve effectiveness in implementation. This may include engaging the community in risk communications about avoiding outdoor exposure and ensuring adequate hydration; developing preparedness, including contingency plans and training health-care workers to respond effectively to heat-related illnesses; and using the post-extreme event-recovery phase as an opportunity to build climate-resistant health-care telecommunication infrastructures, thereby enhancing future capacity. Measures to improve the resilience of vulnerable populations should also be included.

07

CHAPTER 7

CLIMATE-SENSITIVE INFECTIOUS DISEASES

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7.1 INTRODUCTION

Infectious diseases still represent a large share of the global burden of disease, and global climate change is very likely to increase this burden (Smith *et al.,* 2014; Vos *et al.,* 2015; IPCC, 2018). Recent Intergovernmental Panel on Climate Change (IPCC) reports (IPCC, 2013; 2014; 2018) have acknowledged that many infectious diseases are highly sensitive to climate variability and change (Dilling *et al.,* 2017; Liang and Gong, 2017; Short *et al.,* 2017). Box 7.1 highlights the statements of the IPCC "Special Report on the impacts of global warming of 1.5°C" related to climate change and infectious diseases.

There are three important categories of infectious diseases sensitive to climate change: (1) water-borne diseases (WBDs), (2) food-borne diseases (FBDs), and (3) vector-borne diseases (VBDs). While water- and food-borne diseases (WFDs) are linked to the ingestion of pathogens via contaminated water or food, VBDs are linked to the infections transmitted by arthropods such as mosquitoes. The epidemiological cycle of both WFD and of VBDs depends on factors pertaining the host (for example susceptible humans), the pathogen/s, the vector/s and the environment (particularly water and food).

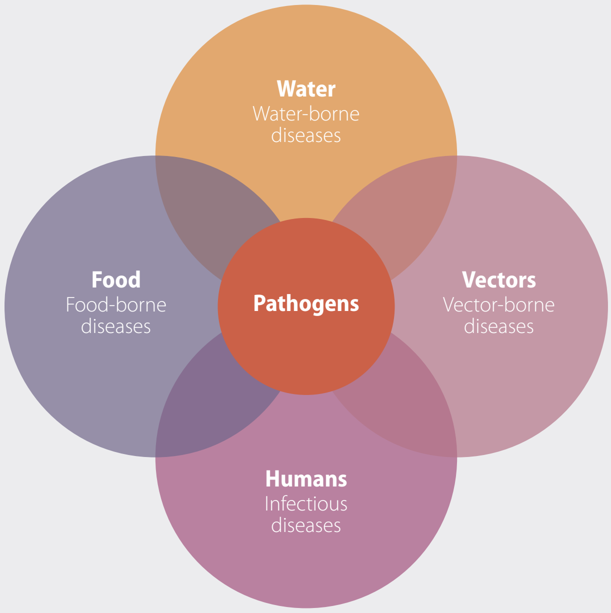
Figure 7.1 provides a host-pathogen-vector-water-food framework to highlight the risks of infectious diseases for humans under climate change and the challenging adaptation areas.

Box 7.1: Statements related to climate change infectious diseases in Summary for Policy Makers of the IPCC Special Report on the Impacts of Global Warming of 1.5°C

Climate-related risks to health, livelihoods, food security, water supply, human security and economic growth are projected to increase with global warming of 1.5°C and to increase further at 2°C. Any increase in global warming is projected to affect human health, with primarily negative consequences (*high confidence*). Risks from some vector-borne diseases, such as malaria and dengue fever, are projected to increase with warming from 1.5°C to 2°C, including potential shifts in their geographical range (*high confidence*).

Source: IPCC, 2018.

Figure 7.1: Key climate-sensitive factors for the global burden of infectious diseases, particularly vector-, food- and water- borne diseases



Source: Drawn up by the authors.

There are inherent uncertainties in projections of the future health impacts of climate change under different climate scenarios (Ebi *et al.,* 2013). Moreover, projections of the effects of climate-related infectious diseases are crucially dependent on assumptions about declines in poverty levels, progress on water, sanitation and hygiene (WASH), and universal health coverage (WHO, 2014; Sellers and Ebi, 2017).

The evidence base for the effects of climate change on health is more developed for VBDs (Liang and Gong, 2017) than for WFDs, the paucity of literature on the latter resulting in a significant knowledge gap (Ebi *et al.,* 2018). This chapter analyzes the adaptation gap associated with infectious diseases with a focus on WFDs and VBDs. Section 7.2 highlights the range of specific actions and progress needed, while section 7.3 lists priority activities to bridge the gap.

7.2 THE CURRENT AND FUTURE GLOBAL ADAPTATION GAP IN HEALTH FOR CLIMATE-SENSITIVE INFECTIOUS DISEASES

CURRENT AND PROJECTED BURDEN OF FOOD AND WATER-BORNE DISEASES

CURRENT BURDEN

Due to the complexity of the pathways and factors involved in their transmission, the effective burden of WBDs and FBDs (diarrheal diseases, gastro intestinal, bacterial, viral and protozoan infections) is difficult to establish, and the precise attribution to one or another is not easy in many cases, particularly in developing countries. In 2016, diarrheal diseases (4.48 billion cases) were among the ten causes of the global burden of diseases with the highest incidence (Vos *et al.,* 2015). Diarrheal diseases were also among the top thirty causes of both Years of Life Lost and Years Lived with Disability. The World Health Organization (WHO) estimates that there were 600 million food-borne illnesses and 420,000 associated deaths in 2010 (WHO, 2015a).

Globally, developed countries have fewer problems with water-related diseases, concerns being primarily directed at FBDs instead (Gibney *et al.,* 2017). A number of important FBD agents (for example, salmonella and campylobacter) have received increased attention in developed countries (for example, the USA, United Kingdom, Australia and Switzerland), with some recent studies looking at the possible impacts of climate change on food-borne pathogens (Lake, 2017; Lake and Barker, 2018). Temperature has a pronounced influence on salmonellosis and food-poisoning notifications, as well as campylobacteriosis. In Europe, a review of studies spanning the period 2000 to 2009 found that the most prevalent WFD is campylobacteriosis (ECDC, 2012), a disease that exhibits strong seasonality and has been associated with a number of meteorological variables and specific weather events. In Oceania, a study in Adelaide, Australia, showed that the daily number of salmonella cases increased by 1.3 percent per 1°C rise in temperature (Milazzo *et al.,* 2016). In New Zealand, high temperatures were also found to be positively correlated with infection risk by salmonellosis in Auckland and Christchurch (Lal *et al.,* 2016); a 1°C increase in monthly average ambient temperature was observed to be associated with a 15 percent increase in salmonellosis notifications within the same month (Britton *et al.,* 2010). So far there have been limited efforts to undertake detection and attribution analyses of climate change in developing countries (Ebi *et al.,* 2017a).

Water and sanitation systems are very sensitive to flooding and run-offs, causing increases in the risk of WFDs (Sherpa *et al.,* 2014). Risks are also increased with water scarcity because the of unprotected water sources and reduced hygiene practices when water is scarce increases the risk of cases of diarrhea as a result of flooding (Lloyd *et al.,* 2007). There is a correlation between higher temperatures and diarrhea for all causes of diarrhea, but in particular diarrhea caused by bacteria and protozoa (Levy *et al.,* 2016). In developed countries (for example, USA, Canada, UK) a significant association has been found between rainfall and outbreaks of WBDs or hospital admissions for diarrhea. In the US heavy rainfall was found to be associated with an 11 percent increase in acute gastrointestinal illness visits four days later (Levy *et al.,* 2016). In general, there is clear evidence of the links between flooding or surface run-off and both diarrhea and other types of WBD outbreaks (Ding *et al.,* 2013; Miettinen *et al.,* 2001).

In Asia, the monthly average incidence (that is, new cases) of diarrhea in Bhutan was found to be highly seasonal.

Incidence increased by 0.6 percent for every degree increase in maximum temperatures and 5 percent for a 1 mm increase in rainfall (Wangdi and Clements, 2017). In Taiwan, the average temperature and the maximum daily rainfall influenced the incidence of outbreaks of *Vibrio parahaemolyticus* disease (Hsiao *et al.,* 2016). Significant associations between weather variables, including flooding, and diarrhea have also been observed in Cambodia (McIver *et al.,* 2016) and parts of China (Liu *et al.,* 2018).

In Africa, there is some evidence of a correlation between temperature variability and cholera outbreaks, but the quality of evidence is low for similar studies on diarrhea (Amegah *et al.,* 2016). In Senegal, Thiam *et al.* (2017) observed an association between diarrheal incidence and both high temperatures (36°C average and above) and high rainfall (57 mm monthly cumulative and above). In South Africa, and specifically in Cape Town, an increase of 5°C in minimum and maximum temperatures was observed to increase new cases of diarrhea by 40 percent and 32 percent, respectively (Musengimana *et al.,* 2016). In Mozambique, a strong association was found between diarrheal diseases and precipitation (Horn *et al.,* 2018), while in Ethiopia, increased monthly average temperatures and monthly rainfall were found to be associated with an increase in cases of childhood diarrhea (Azage *et al.,* 2017).

PROJECTIONS

Water-borne enteric diseases are among the primary expected health impacts of climate change (Levy *et al.,* 2016), and FBD are projected to become a climate-aggravated public health issue (Lake and Barker, 2018). Different long-term warming trends across regions may induce outbreaks of clustered infectious diseases, particularly at non-traditional places and atypical times (Wu *et al.,* 2016). The IPCC (Smith *et al.,* 2014) has reported studies projecting an increase of 8 percent to 11 percent in the risk of diarrhea in the tropics and subtropics in 2039 due to climate change (Kolstad and Johansson, 2010).

It is expected that climate change will significantly affect important water-related diseases globally. For instance, an additional 48,000 deaths in children aged under 15 are projected due to diarrheal disease for 2030 and 33,000 deaths for 2050 (WHO, 2014). The impact of climate change on diarrheal disease is projected to be higher in Asia and Africa (see table 7.1). In 2030, sub-Saharan Africa is projected to have the greatest burden of mortality impacts attributable to climate change, while in the 2050 horizon it will be Southeast Asia.

The decline shown in values for the 2050 horizon stems from the assumption that recent trends in socioeconomic

Table 7.1: Estimated number of additional deaths due to diarrheal disease in children aged under 15 by region for 2008, 2030 and 2050, due to climate change (under A1b emissions and the base case socioeconomic scenario)

ADDITIONAL DEATHS DUE TO DIARRHEAL DISEASE
in children aged less than 15 years by region

Region	2008	2030 Without Climate change	2030 With Climate change	2050 Without Climate change	2050 With Climate change
ASIA	554,453	+170,870 +30%	+186,833 +33%	+59,227 +10%	+67,426 +12%
AUSTRALASIA AND OCEANIA	747	+368	+390	+175	+190
EUROPE	454	+56	+62	+18	+20
LATIN AMERICA (incl. Caribbean's)	20,065	+3,612 +18%	+3,862 +19%	+581	+642
NORTH AMERICA	38	+17	+18	+10	+11
AFRICA	774,299	+435,715 +56%	+467,587 +60%	+223,532 +29%	+248,209 +32%
World	**1,350,056**	**+610,638**	**+658,752**	**+283,543**	**+316,498**
	Difference:		**+ 48,114**		**+ 32,955**

Source: Adapted from WHO, 2014; IHME, 2018.

development, education and technology will continue for the next fifteen years, resulting in a decline in mortality from infectious diseases and under nutrition. However, a recent World Bank report warns that climate change could force more than 100 million additional people into extreme poverty by 2030, thereby reversing previous development progress (Hallegatte *et al.,* 2016). There are no similarly comprehensive projections for several climate-sensitive water-borne and food-borne outcomes. In Europe, climate change is expected to impact upon the campylobacter risk (Semenza *et al.,* 2012), and in the 2080s, climate change could induce an additional 40,000 cases of salmonella (Watkiss *et al.,* 2009). For Hubli-Dharwad in India, the prevalence of all causes of diarrhea was predicted to increase by 4.9 percent by 2011-2030 and 11.9 percent by 2046-2065, with cryptosporidium and *E. coli* prevalence increasing by 9.9 percent and 6.3 percent respectively by 2080-2099 (Mellor *et al.,* 2016). In the Middle East, a study for Bayrout predicted a substantial increase in food- and water-borne related morbidity of 16 percent to 28 percent by 2050 (El-Fadel *et al.,* 2012).

CURRENT AND PROJECTED BURDEN OF VECTOR-BORNE DISEASES

CURRENT BURDEN

The most studied type of infectious disease with regard to climatic influences is VBD. Recent studies focus on mosquito-borne infections such as dengue fever, zika virus, chikungunya and malaria (Caminade *et al.,* 2012; Altizer *et al.,* 2013; Roiz *et al.,* 2015; Murdock *et al.,* 2016; Mordecai et al., 2017). Other VBDs with a high global burden of disease include lymphatic filariasis (also transmitted by mosquitoes), onchocerciasis (blackflies), leishmaniasis (sandflies), chagas disease (triatomine bugs), schistosomiasis (freshwater snails) and lyme disease (ticks). Table 7.2 summarizes the global burden of these major VBDs.

The influence of climate variability, and particularly temperature, is well studied for several vectors, particularly with regard to biological processes, such as replication rate, development and transmission of pathogens (Altizer *et al.,* 2013). Even small changes in seasonal temperature can lead to considerable seasonal changes in abundance and mosquito phenology in some species (Ewing *et al.,* 2016). Mosquitoes of the genus *Aedes* show high sensitivity to temperature and have gained importance in the context of VBD–climate interactions, as they are implicated in the cycles of several diseases (Caminade *et al.,* 2012; Chaves *et al.,* 2014).

Zika is a good example of a disease that presented an explosion of cases in the world from the 2000s: 2007 in Micronesia, 2010 in Cambodia, 2012-2014 in Thailand, 2013 in French Polynesia and 2016 in Brazil (Sikka *et al.,* 2016). In Brazil, the outbreak of 2016 was related to the hot and dry winter of 2015, influenced by the natural phenomenon of El Niño, which contributed to the zika epidemic in South America (Caminade *et al.,* 2017). Annual numbers of cases of dengue fever have also experienced a notable increase, doubling every decade since 1990, with over 58 million apparent cases (that is diagnosed, but not confirmed in a laboratory) in 2013 (Stanaway *et al.,* 2016).

The last malaria report shows declines in estimated cases worldwide in 2016 (216 million) compared to 2010 (237

Table 7.2: Global burden of major VBD, as of March 2017

Vector*	Disease	Estimated** or reported annual number of cases	Estimated annual number of deaths
Mosquitos	Malaria	212,000,000	429,000
	Dengue	96,000,000	9,110
	Lymphatic filariasis	38,464,000	NA
	Chikungunya	693,000 (suspected, 2015)	NA
	Zika virus disease	500,000 (suspected, 2016)	NA
Blackflies	Onchocerciasis	15,531,500	NA
Sandflies	Muco/cutaneous	3,895,000	NA
	Visceral	60,800	62,500
Triatomine bugs	Chagas disease	6,653,000	10,600
Ticks	Borreliosis (Lyme disease)	532,125	NA
Snails	Schistosomiasis	207,000,000	200,000

*Only the VBDs with the largest burdens are included. **Central estimate. Source : (WHO, 2017a).

million cases), while between 2014 and 2016 substantial increases were detected in the Americas, and marginally the Southeast Asian, western Pacific and African regions. For mortality between 2015 and 2016, the rates fell in the latter regions but increased in the eastern Mediterranean and Americas (WHO, 2017c). Nkumama *et al.* (2017) argued that malaria control presents new and evolving challenges mainly due to changes in disease epidemiology (for example, emerging populations at risk and resistance in mosquitoes).

PROJECTIONS

The most widely expected scenario regarding climate change is an increased area of occurrence for many vector species. Diverse approaches have been used to assess the future distribution and incidence of VBD associated with environmental changes. Most models tend to project an increased risk for VBD transmission at high latitudes during the next century (Tjaden *et al*., 2017). For example, heavy increases in rainfall are expected for some regions, which could increase the risk of diseases like chikungunya (Roiz *et al.,* 2015; Tjaden *et al.,* 2017). Nevertheless, future warming could in some cases reduce the potential risk in existing high-transmission settings due to a reduction in vectorial capacity (Chaves *et al.,* 2014; Murdock *et al.,* 2016). It is possible that changes in temperature and precipitation in future decades may turn environments that are currently suitable for VBD transmission into less favorable locations for the occurrence of vectors. Escobar *et al.* (2016) estimated a reduction of 53 percent in the distribution area of *A. aegypti* and 52 percent in the number of potentially exposed individuals in Ecuador. Similar numbers were found for *Aedes albopictus*.

The further development of both pathogens and vectors caused by warming temperatures increases the VBD transmission potential of diseases such as malaria and dengue fever, although other non-biological processes (for example, population vector control and health care) may blur the identification of this relationship (Gething *et al.,* 2010; Altizer *et al.,* 2013). In addition, the great complexity of the cycles of VBD transmission makes estimating future incidence difficult because several drivers of VBD infection other than climate play important roles in transmission, such as socioeconomic factors, human modifications to ecosystems and biological adaptation of vectors to the new warmer conditions (Chadee and Martinez, 2016).

Photo: *© Franc60 (Shutterstock)*

Under both moderate and pessimistic temperature scenarios, an expansion of chikungunya transmission-suitable areas is expected in China, sub-Saharan Africa, South America, the United States and continental Europe, while in South America transmission should decline by the end of the century (Tjaden *et al.,* 2017). Models of the impact of temperature on zika, dengue and chikungunya transmission in the Americas reveal that the transmission peak of *A. aegypti* is at 29.1°C, falling to zero below 17.8°C or above 34.6°C (Mordecai *et al.,* 2017). Using ecological niche modelling, in different scenarios of greenhouse gas emissions (A2, B1 and A1B), the expected changes in temperature and precipitation can lead to a change in the establishment of *A. aegypti* and *A. albopictus*. While *A. aegypti* may increase its distribution in South America, rearrange its occurrence in Europe and lose ground in Australia, *A. albopictus* may be more successful in expanding across North America and East Asia (Campbell *et al.,* 2015).

Mosquitos of the genus *Aedes* can transmit the viruses that cause dengue, zika and chikungunya, among other VBDs. Both an intensification in endemic areas and a spreading of the dengue virus to new areas in Asia, Europe and North America are expected, mainly due to projected trends related to rising temperatures and increased urbanization (Murray *et al.,* 2013; Messina *et al.,* 2015). Dengue epidemics are driven by climate to some extent, especially temperature and humidity; studies report medium and minimum temperature and precipitation as factors related to dengue transmission (Descloux *et al.,* 2012; Naish *et al.,* 2014; Akter *et al.,* 2017). An association also exists between El-Niño-Southern Oscillation and a higher incidence of dengue (Naish *et al.,* 2014).

Malaria is associated with temperature in a non-linear fashion, so projections of changes of risk under climate change result in complex patterns (Ebi *et al.,* 2018). On the one hand, projections under the 1.5°C and 2°C global average warming scenarios indicate a possible global increase in the burden of malaria with climate change, while some regions are projected to become too hot and/or dry for the *Anopheles* mosquito (Ebi *et al.,* 2018). While some studies found that an increase in monthly precipitation resulted in an increase in episodes of clinical malaria, others observed a pattern of reduced burdens with a rise in temperatures in West Africa (Yamana *et al.,* 2016; M'Bra *et al.,* 2018). A warming climate does not directly translate into greater malaria transmission in Africa (Tompkins and Caporaso, 2016; Murdock *et al.,* 2016).

For areas of unstable transmission, such as the highlands of Africa and South America, where the disease intensifies and shifts to higher altitudes during exceptionally warm years, climate change may already have played an important role in cases of malaria (Bouma *et al.,* 2016). A highly nonlinear response to warming from malaria cases was observed in the East African highlands (Alonso *et al.,* 2010), whereas a strong association between malaria and El-Niño was found in Ethiopia, indicating a 70 percent increase in malaria risk (Bouma *et al.,* 2016). Similar results (increase in the altitude of malaria distribution in warmer years) were found for highland parts of Ethiopia and Colombia (Siraj *et al.,* 2014).

Table 7.3 estimates that, compared to a future without climate change, a significant number of additional deaths are projected for 2030 and 2050 (WHO, 2014). For comparison, currently estimated deaths for both diseases are also presented for 2016.

CHARACTERIZING THE GLOBAL ADAPTATION GAP FOR CLIMATE-SENSITIVE INFECTIOUS DISEASES

Despite an overall decreasing trend, infectious diseases still account for around 20 percent of the global burden of disease (Murray *et al.,* 2012). As already noted, a significant proportion of these infectious diseases is influenced by weather, climate variability and climate change in complex multi-causal

Table 7.3: Estimated number of additional deaths due to malaria and dengue by region, for 2030 and 2050* and number of deaths estimated for 2016

Region	Estimated deaths in 2016		2030		2050	
	Malaria	Dengue	Malaria	Dengue	Malaria	Dengue
Asia	75,615	35,014	+2,425	+236	+9,630	+240
Australasia and Oceania	912	7	44	0	32	0
Europe	0	0	0	0	0	0
Latin America (incl. Caribbean)	259	2'463	+163	+16	+107	+33
North America	0	0	0	0	0	0
Africa	643,582	287	+57,459	+7	+22,927	+7
World	**720,368**	**37,774**	**60,091**	**259**	**32,696**	**280**

*Under A1b emissions and a base case socioeconomic scenario. Source: adapted from: (WHO, 2014; IHME, 2018).

networks involving interactions with social, economic, ecological and other factors. Along with uneven data availability and quality, uncertainty and significant knowledge gaps, these make the characterization of the global adaptation gap for climate-sensitive infectious diseases challenging. What follows is a partial characterization of the state of activities in various relevant areas.

WATER- AND FOOD-BORNE DISEASES

Given the wide variability in data availability and evidence on WFDs, global progress against them is best tracked by using the status of effective action on WASH as a proxy. Estimates by the Joint Monitoring Programme for Water Supply and Sanitation (WHO/UNICEF, 2017) show that in 2015:

- About 71 percent of the global population used a safely managed drinking water service, though deep regional inequalities persist, as well as urban/rural differences and patchy data coverage. Those having to collect water from unimproved sources and surface water face an additional burden of time use, as well as gender inequalities (women and girls are responsible for water collection in eight out of ten households with water off premises)

- Only 39 percent of the global population used a safely managed sanitation service. Although the use of basic sanitation is increasing more rapidly than the use of basic drinking water services, no SDG region is on track to achieve universal basic sanitation by 2030. Use of basic sanitation is actually decreasing in one out of seven countries, and open defecation gas increased in sub-Saharan Africa and Oceania.

- Data on hygiene, which is crucial for WFD prevention, are insufficient to produce global estimates, though they cover some regions. Coverage of basic handwashing facilities with soap and water ranged from 15 percent in sub-Saharan Africa to 76 percent in western Asia and North Africa, while many high-income countries lacked sufficient data to estimate the population without basic handwashing facilities.

Climate change is expected to make progress on these targets more difficult through various influences, notably by increasing water scarcity (UNESCO, 2012) and knock-on effects like population displacement.

VECTOR-BORNE DISEASES

Most VBDs can be prevented through well-implemented vector control. The WHO global vector control response for 2017–2030 set targets of reducing VBD mortality by at least 75 percent and new VBD cases by at least 60 percent in 2030 compared to 2016 (WHO, 2017a). However, several interconnected challenges are impeding progress against VBDs. With few exceptions, national and subnational VBD prevention programmes have limited public health entomology capacity and poor infrastructure. Other challenges include scarce local evidence, environmental changes, increased movements of people and goods, and political/financial imbalances, among others (WHO, 2017a).

Among all VBDs, data on progress and implementation are probably the most complete for malaria. According to the 2017 World Malaria Report (WHO, 2017c), as of 2016 around US$ 2.7 billion had been invested in malaria control and elimination efforts globally, with 74 percent spent in the African Region, followed by the regions of Southeast Asia (7 percent), the Eastern Mediterranean and the Americas (each 6 percent), and the Western Pacific (4 percent). Governments of malaria endemic countries contributed around 31 percent of the total funding. The current level of investment is far from what is required to reach the first milestone of the Global Technical Strategy for Malaria 2016-2030, namely a global reduction of at least 40 percent in the incidence of malaria cases and mortality rates globally when compared to 2015 levels. To reach this milestone, annual funding would need to increase to US$6.5 billion per year by 2020 (WHO, 2017b). Further, increased funding alone may not be enough, depending on various trends, including climate change, and resistance to antimalarial medications and insecticides.

Similarly, the global strategy for dengue prevention and control for 2012-2020 set out to reduce mortality and morbidity from dengue by 2020 by at least 50 percent and 25 percent respectively, using 2010 as the baseline of the global burden of the disease (WHO, 2012). However, this baseline is uncertain, making estimating progress challenging. As of 2015, the number of cases reported increased from 2.2 million in 2010 to 3.2 million in 2015, though this sharp increase is explained in part by the initiation of activities to record all dengue cases. Broadly, only when dengue diagnosis and notification worldwide have become sufficiently established will reliable data on progress or lack thereof be available.

For several other VBDs, including zika and chikungunya, estimates are less reliable regarding status and response, let alone of how much progress is being made in closing the gap. Since the WHO declared the clusters of likely zika-related microcephaly and neurological disorders in Brazil a Public Health Emergency of International Concern in 2016, several countries in Latin America and the Caribbean have since taken various measures and strengthened their zika virus detection capabilities. In its Zika Strategic Response Framework & Joint Operations Plan, the WHO anticipates that the zika virus will continue to spread to all territories in the Americas where *Aedes aegypti* mosquitoes are found, notwithstanding a much farther geographical reach, including temperate climates, through other *Aedes* species which are believed to be competent vectors for zika (WHO, 2016).

CLIMATE-SENSITIVE INFECTIOUS DISEASES IN ADAPTATION PLANNING AND IMPLEMENTATION

In general, current policies and programs to control climate-sensitive infections fall within basic public-health functions, progress therefore being linked to general progress in the area. However, these policies and programmes do not consistently and systematically incorporate projections of climate change or other relevant global trends. A critical challenge in many low- and middle-income countries is the limited data availability on the number of cases of non-reportable infectious diseases such as dengue fever or diarrheal disease. Where data are available, limited analytical capacity may hinder responses and policy (Ebi and Prats, 2015). Nonetheless, a large number of activities are already being implemented on the ground, ranging from policies planned and implemented by national and subnational governments to various actions being undertaken by intergovernmental organizations, non-governmental organizations and communities (UNFCCC, 2017). Infectious diseases are being incorporated into several national adaptation plans. For example, a review of National-Level Adaptation Planning in fourteen middle- and high-income countries revealed a variety of proposed adaptation activities with very different levels of detail (Panic and Ford, 2013). Even there, planned adaptation is primarily designed using a sectoral rather than integrated approach. The links between climate change and health, including infectious diseases, are being addressed under the United Nations Framework Convention on Climate Change (UNFCCC) through the Nairobi Work Programme, the activities of the Least Developed Countries Expert Group and the Warsaw International Mechanism for Loss and Damage, among others. Sectors crucial to the minimization of WFDs and VBDs, such as water and sanitation, as well as disaster resilience, are consistently prioritized in operational adaptation planning processes, such as the Technology Needs Assessments (UDP, 2018).

7.3 OPPORTUNITIES TO ADDRESS THE GLOBAL ADAPTATION GAP IN CLIMATE-SENSITIVE INFECTIOUS DISEASES

In order to respond effectively to uncertain future scenarios for WBDs, FBDs and VBDs under a changing climate, we need to build resilient and equitable systems in the present. Climate change is set to impede or reverse efforts further in areas where progress is already slow or insufficient. With an average warming of 1.5°C likely to be reached in the 2030s and a warming of 2°C likely to be reached in the 2050s under most scenarios (Ebi *et al.,* 2018), systemic responses on the part of the health sector will be needed to bridge the adaptation gap in climate-sensitive infectious diseases (examples of these can be found in Chapter 5). Social responses, human factors and efforts in respect of the Sustainable Developments Goals (SDGs) will play an important role in the capacities needed to face the risks of infectious diseases under circumstances of climate change and climate variability. There is a need to combine proper adaptation measures that must include actions for a strong public-health sector, good communications and education programs towards society and a stable infrastructure that contributes to fulfilling adaptation awareness and implementation gaps (Gislason, 2015; WHO, 2015b). Below, selected priorities are listed with respect to implementation and knowledge development to curb climate-related increases of WFDs and VBDs.

WATER- AND FOOD-BORNE DISEASES

In respect of reductions in the incidence (that is, new cases) and prevalence (that is, number of cases found in the population at a given time) of climate-sensitive WFDs, two specific action areas will be of particular importance: (1) increasing actions to protect water and food from contamination at all levels (from farm to household); and (2) increasing research and knowledge generation on WFDs in different contexts, as well as on the vulnerability of WASH and food systems to climate extreme events (for example, floods and droughts).

IMPLEMENTATION GAPS

Making progress towards the SDGs

Global progress against water- and food-borne diseases is closely linked to progress against various SDGs, specifically the achievement of global targets 1.4 (ensuring access to basic services, including drinking WASH), 6.1 (safe and affordable drinking water) and 6.2 (ending open defecation and access to adequate sanitation and hygiene) (WHO, 2017d). In both developing and developed countries, some major efforts are needed to improve WASH systems. This entails preventing the contamination of water systems, building flood-control systems, reducing the presence of pathogens in the environment through the proper disposal of excreta and wastewater, improvements to hygiene, promotion of the treatment of household drinking water and increasing understanding of the vulnerability of water systems to climate extreme events.

Access to safe water and sanitation

A significant improvement in access to safe water and sanitation is necessary to reduce the increase in the burden of diarrheal diseases due to climate change (Ebi *et al.*, 2017b). Moreover, as similar extreme events may lead to different health effects due to several factors, particular importance must be placed on improving understanding not only of climate change trends but also of the dynamics of human patterns of activities and capacities, taking into account different shared socio-economic pathways (Sellers and Ebi, 2017).

Specifically addressing the impacts of climate change on WASH, the Vision 2030 study (WHO, 2009) proposes a number of considerations with regard to implementation, including: (1) applying an adaptation to climate change lens on water, sanitation and hygiene places the emphasis on water source sustainability; (2) technologies applied to WASH need to be prioritized so that they can cope with multiple threats, including climate change; and (3) resilience needs to be integrated into drinking water and sanitation management to cope with present climate variability.

KNOWLEDGE GAPS

Data availability and regional coverage

Regarding data availability and the coverage of evidence, the most highly studied countries with regard to climate and WFDs are generally developed countries and/or BRICS (Brazil, Russia, India, China and South Africa), with most studies focusing on China and the USA (Liang and Gong, 2017). However, many regions facing increasing temperature variation are yet not receiving sufficient attention in terms of research. The geographical pattern of research concerning climate and WBD or FBD does not match the areas most affected by climate extreme events. The imbalance and disproportionate coverage of knowledge regionally needs to be tackled as a major contribution to reducing the global adaptation gaps. It will be important to invest more in health research in areas that are most affected by WBD and FBD and also more likely to be impacted by weather change. Furthermore, in many regions the lack of reliable data and its limited availability must be overcome. The insufficiency of knowledge is linked to the multiple factors at play and the multiple possible and uncontrollable changes that could happen to these factors at the same time. Scientific evidence is needed that goes beyond simply empirical observations of correlations to more explanatory efforts. We need more regional specific projections of climate change and their likely implications for WFDs.

Knowledge generation

At the level of knowledge, projecting correlations of WFD distribution and incidence with climate change is difficult due to the complexity of the drivers and causal pathways of different diseases. Existing models used to estimate future burdens have high levels of uncertainty. Better models and more research are necessary to bridge the knowledge gap and inform the design of adaptation strategies properly in respect of their future trends in occurrence, at different spatial scales. This includes a better understanding of the sensitivities of WBD, FBD, VBD and zoonotic diseases to climate variability and extremes, including heat waves (see Chapter 6), and the nutritional status of children (see Chapter 8). WBD outbreaks are most commonly a result of excessive precipitation (55 percent of outbreaks) and floods (53 percent) and the subsequent contamination of the drinking water supply (FAO, 2018). Women and young children can be particularly vulnerable to climate variability and change, as can the elderly and socially isolated, categories that are at greater risk of incurring infectious diseases. Here there is also an important knowledge gap, with a paucity of information about adaptation efforts on the ground on the part of individuals, institutional and community-level actors in low-resource settings.

VECTOR-BORNE DISEASES

IMPLEMENTATION GAPS

Reduction of the population of parasites, microbes and vectors

Populations of urban vectors can be controlled in large areas or even eliminated, as happened with *A. aegypti* in South America in the twentieth century. However, wild species of vectors cannot be adequately controlled in their natural environments and are usually reduced only locally (that is, around small rural communities) through standard measures of control. The dynamics of VBD are strongly correlated with several social factors, and these should be addressed as part of the adaptation process (Confalonieri *et al.,* 2017). For example, urbanization and sanitation are critical for the growth of populations of *A. aegypti* and are also drivers of changing patterns of visceral leishmaniasis in urban areas. These factors should be widely evaluated regionally to assist in reducing both the knowledge and implementation gaps.

Improving integrated vector management

Most VBDs can be prevented through vector control, especially when based on a strong political and financial commitment. Newer approaches already exist for vector control that may provide integrated vector management and can be implemented on a large scale. Integrated vector management has been proposed as a way of achieving an optimal use of resources for vector control during the decision-making process by, for example, evidence-based decision-making, multi-sector collaboration and social mobilization, which has been recommended by WHO since 2004 (Beier *et al.,* 2008). In European countries, there is a good level of consistency between what is recommended in guidance and what is happening in reality regarding implementation and the success of integrated vector management strategies, although some gaps have been identified (ECDC, 2017).

Reduction of human exposure

This has to be implemented in both urban and rural contexts. The approach to the control of VBD will be different when urban vectors (for example, *A. aegypti*) are compared to vector species that essentially breed only in natural habitats in forests and other natural ecosystems (for example, *Anopheles darling*). Public policies aimed at improving or controlling VBD's non-climatic drivers should be an important and ever-present part of any set of adaptation measures to current and future threats posed by a changing global climate.

Reduction of the burden of infection

The core adaptation strategy must be increased monitoring, both epidemiological and entomological. By monitoring shifts in the distribution and population densities of vector species, investigators could address rapidly changing transmission patterns and clarify the role of climate in these contexts. There is a need to enhance the control of VBDs in currently endemic areas, especially in the tropics, as part of a global adaptation strategy (Confalonieri *et al.,* 2015; 2017). Programs like "malERA" (for malaria) should be implemented for other VBDs of global and regional importance like dengue, zika and chikungunya, which are currently emerging or re-emerging.

KNOWLEDGE GAPS

It is imperative to have better coverage of data and research from areas and regions with the largest burden of VBDs. In addition, several areas of knowledge within VBD epidemiology, prevention and treatment are strongly in need of further research. For instance, in urban settings these may include, among others (Degroote *et al.,* 2018): (1) development and implementation of low-cost simple and/or rapid diagnostic technologies for VBDs; (2) development of effective monitoring systems for VBDs and the translation of data into action; (3) evaluations of the impact, cost-effectiveness and sustainability of integrated vector management; (4) transmission dynamics, vectoral capacity and coinfections; (5) evaluations of the effectiveness of containment measures for emerging and re-emerging VBDs; and (6) housing, hygiene, sanitation and water, waste and infrastructure management in VBD prevention.

Moreover, projections of the correlations of VBD distribution and incidence with climate change are also difficult due to the extreme complexity of the disease cycles and their drivers. Models for the projection of the future burden of VBDs also have high levels of uncertainty, so better models and more scientific knowledge will be necessary if the knowledge gap is to be bridged.

08

CHAPTER 8

FOOD AND NUTRITIONAL SECURITY

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8.1 INTRODUCTION

Climate change threatens global food and nutritional security through its direct and indirect impacts on agriculture, food, health, and socio-demographic and economic systems (see box 8.1). Other environmental changes may amplify the adverse effects of climate change, including biodiversity loss (including pollinators), fisheries depletion, carbon dioxide fertilization (which affects nutritional quality), soil degradation, and freshwater depletion (Whitmee *et al.,* 2015). The impacts of climate change on agricultural yields, pests, price and food supplies are projected to have major implications for sustainable development, inequality, poverty eradication and the achievement of the Sustainable Development Goals (SDGs) (IPCC, 2018).

The Food and Agriculture Organization of the United Nations defines food security as "a situation when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for a healthy and active life" (FAO, 2012). Food security is a complex issue with important causal links beyond food production. For example, it was found that between 1970 and 2012, 67 percent of the reduction in stunting was due to improvements in women's education, gender equality and access to adequate water and sanitation services (Smith and Haddad, 2015). Food security is at the core of Sustainable Development Goal 2, which aims to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture"; three of the targets within this goal are focused on the nutrition of children under five. Climate change threatens progress towards SDG2 and could in fact reverse the progress already made (IPCC, 2018; Lloyd *et al.*, 2018).

While production and yield growth have greatly improved food security in the majority of countries over the past few decades, over half of the world's undernourished people live in rural areas as smallholder food producers (IFAD, 2011; Lloyd *et al.*, 2018). Although over 70 percent of the countries included in the Global Food Security Index for 2018 have shown improvements in their scores, with the highest gains in lower-middle and low-income countries (EIU, 2018), the 2017 World Hunger Index estimates that 52 of the 119 countries assessed have levels of hunger that are serious, alarming or extremely alarming (IFPRI, 2017). State and non-state conflicts, natural disasters including extreme weather events and global food price volatility, all of which are climate sensitive, remain major drivers of the current lack of global food and nutritional security (Gregory and Coleman-Jensen, 2013; Cornia *et al.,* 2016; Haile *et al.,* 2017; Lewis, 2017). Current progress on ending all forms of malnutrition is limited and largely insufficient (Hawkes *et al.,* 2017).

Given that hunger and undernutrition are the leading risk factors for death and morbidity in children under five, (IHME, 2015), this chapter focuses on undernutrition as a component of climate-driven food security risks in children under five years of age. Stunting (that is, low height for age) is presented as the main measurement for undernutrition, as it best reflects long-term average conditions such as average access to nutritious food (Black *et al.,* 2013). However, this chapter will also highlight other priority areas in the strengthening of global food security and nutrition, acknowledging that multiple forms of malnutrition co-exist. An integrative perspective is adopted to explore potential policy and programmatic approaches to bridge the adaptation gap in this extremely complex societal and health challenge. The systemic links between nutritional status and other related health issues identified in earlier chapters of this report are highlighted, and the fundamental challenge of food security as a multiple burden in the face of a changing climate is discussed.

Box 8.1: Statements related to climate change and food security in the Summary for Policy Makers of the Working Group II Contribution to the IPCC Fifth Assessment Report

Climate change is projected to undermine food security. […] For wheat, rice and maize in tropical and temperate regions, climate change without adaptation is projected to negatively impact production for local temperature increases of 2°C or more above late 20th century levels, although individual locations may benefit (medium confidence). Global temperature increases of ~4°C or more above late 20th century levels, combined with increasing food demand, would pose large risks to food security globally (high confidence). Climate change is projected to reduce renewable surface water and groundwater resources in most dry subtropical regions (robust evidence, high agreement), intensifying competition for water among sectors (limited evidence, medium agreement).

Source: IPCC, 2014.

8.2 THE CURRENT AND FUTURE ADAPTATION GAP IN HEALTH FOR NUTRITION AND FOOD SECURITY

CURRENT GLOBAL NUTRITION ESTIMATES

Estimates for the 1990-2017 period indicate that the global prevalence (that is frequency in the population) of stunting in children under five has fallen from 39.3 percent to 22.2 percent. In the same period, the percentage of children under five who are overweight showed a small increase, from 5 percent to 5.6 percent (UNICEF *et al.,* 2018). However, the Food and Agriculture Organization estimates that after a prolonged period of decline, world hunger is on the rise. Globally, the number of undernourished people increased from 804 million in 2016 to 821 million in 2017 (one out of every nine people). About 151 million children under five (22 percent) were stunted, 50 million were wasted, and 38 million were overweight in 2017 (FAO *et al.,* 2018). The current estimates (2017) for children under five wasted and severely wasted (that is low weight for height) are 7.5 percent and 2.4 percent, respectively (UNICEF *et al.,* 2018). High rates of multiple forms of malnutrition coexist in many countries (FAO *et al.,* 2018).

The World Health Assembly has endorsed global nutrition targets that have been widely adopted by global initiatives (WHO, 2014). Its main target on stunting, to reduce the number of children stunted by 40 percent by 2025 compared with 2012, is not yet on track. Projections based on the current trajectory are heading towards a prevalence of 19 percent instead of the target of 14.6 percent by 2025 (UNICEF *et al.,* 2018). Together, Africa and Asia account for nearly all the global burden of stunting and although prevalence rates are decreasing in all regions worldwide, Africa faces a rising number of new cases of stunting in children (UNICEF *et al.,* 2018). In relation to wasting in children under five, those living in South Asia represent more than half of all those who are wasted. In parallel, the prevalence of childhood obesity has rapidly increased, and in 2016 almost half of all overweight children under five lived in Asia and one quarter lived in Africa (UNICEF *et al.,* 2018).

While the World Health Organization (WHO) did not estimate the current burden of stunting and wasting due to observed climate change, there is a clear adaptation deficit, as can be seen from the food security impacts arising from weather and current climate variability, and their pathways to undernutrition as described above (WHO, 2014).

FOOD AND NUTRITIONAL SECURITY AND CLIMATE CHANGE

Nutrition is a crosscutting determinant for many health and development challenges (Hawkes *et al.,* 2017), and climate variability and change will likely increase them (Figure 8.1). All aspects of food security are potentially affected by climate change, including food availability (quantity and quality), access (physical and economic), stability and utilization (IPCC, 2014). Several regions of the world show evidence of climate change negatively affecting crop and terrestrial food production (IPCC, 2014), which will potentially increase the risk of undernutrition. Recent evidence suggests an average reduction in the global yields of wheat by 6 percent, rice by 3.2 percent, maize by 7.4 percent, and soybean by 3.1 percent for each degree Celsius rise in global mean temperature in the absence of effective adaptation (Zhao *et al.,* 2017). In addition, projected increases in infectious disease morbidity, particularly for diarrheal diseases, would increase the climate change impacts on child nutrition (WHO, 2014), as described in chapter 7. Thus, the improvements we might start to see in reducing rates of undernutrition may be negatively affected by climate change impacts and potentially reversed.

PROJECTIONS OF THE ADDITIONAL BURDEN OF STUNTING ATTRIBUTABLE TO CLIMATE CHANGE FOR 2030 AND 2050

WHO (2014) recently assessed future nutrition and food security risks related to climate change, focusing on stunting as the indicator for undernutrition, since stunting best reflects long-term average conditions such as average crop productivity (Black *et al.,*2013; WHO, 2014). The assessment is based on a single climate scenario[32] and various socio-economic scenarios, and analysed the effect of climate change on the two main causes of stunting: food causes, that is a lack of food, represented as a proportion of the population undernourished; and non-food causes, focusing on socioeconomic factors. It is important to acknowledge the major uncertainties surrounding these impact projections, given their long temporal dimension.

In all current socioeconomic scenarios, climate change is expected to cause a significant increase in the number of children with severe stunting. A snapshot of the main

32 The Special Report on Emission Scenarios (SRES) A1b (Nakicenovic and Swart, 2000).

Figure 8.1: Nexus between climate change, food systems and nutrition and health

Note: The figure is based on information from Phalky *et al.* (2015). Different size terms are for illustration purposes only and do not reflect importance.

findings of the report, including climate change projections, is presented here (WHO, 2014). Under the base case socioeconomic scenario[33], it is estimated that there will be an additional 7.5 million moderately and severely stunted children by 2030. By 2050, this is estimated to increase to a total of 10.1 million additional moderately and severely stunted children. Under the low growth socio-economic scenario, it is estimated that by 2030 there will be 8.5 million children with climate-change attributable stunting, and by 2050 this would be reduced to 3.3 million. In the final high growth scenario, climate change is expected to increase moderate and severe stunting by 6.5 million in 2030 and 5.2 million in 2050. Moving beyond stunting as a measure of nutritional status, the report projects a global estimate of an additional 95,176 deaths of children under five due to undernutrition by 2030 globally, with the largest share in sub-Saharan Africa, and further, that by 2050 this figure will only fall slightly to an additional 84,697 deaths.

There have been other efforts to project the additional burden of nutritional issues that is attributable to climate change. Various recent studies support the conclusions of the Intergovernmental Panel on Climate Change (IPCC) (Smith *et al.,* 2014) that climate change will negatively affect childhood undernutrition and stunting through reduced food availability, and will negatively affect undernutrition-related childhood mortality and increase disability-adjusted life years lost, with the largest risks in Asia and Africa (Ishida *et al.,* 2014, WHO, 2014, Hasegawa et al., 2015). Researchers have compared health risks associated with food insecurity with both the 1.5°C and 2°C scenarios, concluding that the risks are higher at 2°C (Ishida *et al.,* 2014, WHO, 2014, Hasegawa *et al.,* 2015). Warming is associated with an increase in the global undernourished population to 530–550 million and to 540–590 million at 2°C (Hasegawa *et al.,* 2015). A recent study in 44 low- and middle-income countries estimates the mean climate-change attributable

33 Base case: economic growth according to projections by World Bank, OECD, International Monetary Fund, and International Futures; Low growth scenario: country-level growth in Gross Domestic Product per capita remains at zero from 2015 to 2100; High growth scenario: very rapid economic growth in accordance with the SRES A1 scenario (3.6 percent global average 1990-2050, 2.3 percent global average 1990-2100).

Table 8.1: Current and projected global food and nutritional security

Outcome/ exposure	Current burden	Projected additional burden relative to the current burden				
		Mortality		Morbidity		
		2030	2050	2030	2050	
Undernourished (global population)	821 million in 2017 (FAO, 2018)					1.5 °C 530-550 million 2 °C 540-590 million (Hasegawa *et al.*, 2015)
Undernutrition in children under five	150 million (IFPRI, 2017)	95,176 (WHO, 2014)	84,697 (WHO, 2014)		4.8 million (climate attributable) in 2050 NCAR climate model A2 Scenario (IFPRI, 2017)	
Stunting (children under five)	155 million (23% of total children under five) (UNICEF *et al.*, 2018			(WHO, 2014) 7.5 million	10.1 million under base-case socioeconomic scenario (WHO, 2014)	
				8.5 million	3.3 million (Low growth socio-economic scenario) (WHO, 2014)	
				6.5 million	5.2 million (High growth socio-economic scenario) (WHO, 2014)	
				570,000 (under the prosperity/low climate change scenario) >1 million (under the poverty/high climate change scenario) (Lloyd *et al.*, 2018)		
Micronutrients Zinc **Protein** **Iron** (Smith and Myers, 2018)* **CO_2 induced Zinc and Iron deficiencies and associated DALYS over 2015-2050** (Weyant *et al.*, 2018)	1.5 billion 622 million 2 billion 364.3 million DALYs in SE Asia 299.5 million DALYS in Africa				175 million additional 122 million additional 1.4 billion additional children under 5 and women of reproductive age live in areas at highest risk Additional 125.8 million DALYs (95 percent credible interval: 113.6-138.9) globally over 2015-2050 in the presence of increasing CO2. 44 million additional DALYS in SE Asia and 28.5 million DALYS in Africa.	

*Studies used varying assumptions which are important to consider when interpreting the results.

stunting in 2030 to be between 570,000 (under a global prosperity and low climate scenario) and one million (under a global poverty and high climate scenario). The impact of climate change on stunting will be greater in rural areas under both scenarios, and severe stunting will account for a greater proportion of climate change–attributable stunting under the poverty/high climate change scenario (Lloyd *et al.*, 2018).

Climate change impacts on dietary and weight related risk factors are projected to increase premature mortality (especially through non-communicable diseases) by 2050 due to global per-person reductions in food availability and access, among other factors (Springmann *et al.*, 2016). Yields of (non-staple) vegetables and legumes are projected to fall based on predicted changes in environmental exposure (including ambient temperature, carbon dioxide and ozone concentrations, water availability and salinization) in a business-as-usual scenario (Scheelbeek *et al.,* 2018). Further, higher CO_2 concentrations reduce the protein, iron, and zinc content of major cereal crops, which is expected to drive the *hidden-hunger* crisis further and affect nutritional security (Myers *et al*., 2017)[34]. Under population and emissions projections for 2050 it is estimated that by that date increased levels of CO_2 will cause an additional 175 million and 122 million people to be zinc- and protein-deficient respectively (see table 8.1). Over 1.4 billion women of reproductive age and children under five would lose over 4 percent of their dietary iron (Smith and Myers, 2018). A recent study investigating 18 genetically diverse rice lines from ten countries with rice as the main staple, reports consistent declines in vitamin B1, B2, B5 and B9 and an increase in vitamin E in addition to reductions in proteins, zinc and iron. This will potentially affect 600 million people in high rice-consuming countries globally (Zhu *et al.,* 2018).

As these examples show, climate change is a risk multiplier for food security and nutritional status. Given that the global health goals for nutrition do not currently consider the potential negative impacts of climate change, there is an even greater task ahead to improve food security and nutritional status worldwide, one which has not yet been adequately understood or resourced. The various determinants of nutritional outcomes are complex and intertwined, among others including women's educational levels, national-level policies and programmes, availability of clean water and sanitation, culture and access to health services, among others (FAO, 2017). Some suggestions on approaches to bridge the gap to address food security and nutritional challenges in light of a changing climate are presented below.

8.3 BRIDGING THE ADAPTATION GAP DUE TO FOOD AND NUTRITIONAL INSECURITY

ENABLING ENVIRONMENTS: GOVERNING RESOURCES, SECTORS AND ACTORS EFFECTIVELY

Addressing nutrition in a changing climate will require the regulation and fostering of coherent supportive action from all actors that produce, retail and consume food (Kuhl, 2018). It will also require investments across the full range of nutrition-relevant sectors, including environment, agriculture, health, education, economics, social protection, infrastructure, urban design, water and sanitation, trade, and industry (Tirado *et al.*, 2013; FAO, 2017; WHO, 2017a). Consistently, there is an urgent need to scale up integrated evidence-based solutions that tackle multiple forms of malnutrition (especially stunting and micronutrient deficiencies) with a clear focus on prevention (WHO, 2017b). Achieving the Sendai Framework global target[35] of reducing damage to critical infrastructure, including building back better and building better at the start, is the key to sustainable global food systems (FAO, 2017). This will require fostering coordination mechanisms between development aid and humanitarian assistance for nutritional security in the wake of natural disasters and complex emergencies (WHO, 2017b; IASC, 2018).

In order to sustain progress, countries may explore the use of non-trade-distorting policy measures to incentivize and improve the supply and competitiveness of local nutritious plant-based food (for example, vegetables, fruits, pulses, nuts), especially for vulnerable communities and groups and in sub-national climate hotspots (Godfray *et al.*, 2010). At the individual level, among other strategies, this may involve: 1) well-designed policies to encourage healthy food purchasing and consumption behaviours (for example, reduction in the overconsumption of red meat) (Colchero *et al.*, 2016); and 2) developing, updating and communicating dietary and physical activity guidelines alongside facilitating the necessary infrastructural changes to achieve this (McFadden and Schmitz, 2017, Mozaffarian *et al.*, 2018).

SUSTAINABLE NUTRITION DRIVEN FOOD SYSTEMS: FROM FARM TO FORK

Combating climate change using both mitigation and adaptation technologies is crucial for global food production and nutritional security (Lobell *et al.*, 2008; Ebi, 2011; Hess *et al.*, 2012; Haile *et al.*, 2017). Building food systems that are resilient to climate change, environmental

34 Studies used varying assumptions which are important to consider when interpreting the results.

35 For more on global targets within the Sendai Framework, see Chapter 6.

degradation, natural hazards, and economic volatility is an urgent priority. Most disasters are climate sensitive (see chapter 7) and have the capacity to destroy agricultural, livestock and fishing infrastructure, assets, inputs and affect production capacity. They interrupt market access, trade and food supplies, reduce incomes, deplete savings and destroy livelihoods. Supporting the sustainable intensification of produce that supports high-quality and sustainable diets while also improving carbon efficiency is an important adaptation and mitigation response. An increasingly important issue to be addressed is the declining populations of pollinators due to climate change, agricultural production and intensification and habitat loss (IBPES, 2017). Individuals also play an important role in food choice and consumption behaviour in light of perceptions of health risks. Studies that identify drivers for sustainable choices can guide adaptation.

CLIMATE SENSITIVE AND RESPONSIVE HEALTH AND NUTRITION SERVICE PROVISION

Strengthening health information systems to *detect* changes in nutritional burdens and improve institutional and human capacities within the health sector to *prevent*, *diagnose* and *treat* multiple forms of malnutrition at scale is key to climate-smart nutrition service provision (Delisle *et al.,* 2017). Strengthening health systems core functions to *respond* to the nutritional impacts of climate change is a 'no-regret' option with multiple co-benefits (WHO, 2015).

The foundations of optimum health, growth and neurodevelopment across the lifespan are established in the first thousand days of life (that is, from conception to 24 months) (Biesalski and Black, 2016). This is a critical window of opportunity to scale viable maternal and child nutrition interventions simultaneously so as to reduce the global burden of undernutrition in terms of both impacts and returns on investment (Bhutta *et al.,* 2013). Findings from The Lancet Series on Maternal and Child Nutrition 2013 suggest that scaling up a package of 10 evidence-based interventions (see table 8.2) from their current population coverage to 90 percent in the 34 countries bearing 90 percent of the global undernutrition burden, could: reduce mortality in children younger than five years by 15 percent, saving 900 000 lives over five years; reduce stunting overall by 20 percent (33 million children); and reduce severe wasting overall by 61 percent. The annual costs for scaling up these *nutrition-specific* interventions globally is US$9.6 billion (Bhutta *et al.,* 2013). The Universal Health Coverage (Action Contre la Faim, 2015) and WHO Integrated Management of Childhood Illness

Table 8.2: Evidence based nutritional interventions for maternal and child undernutrition

Sufficient evidence for implementation in all 34 countries	Evidence for implementation in specific, situational contexts
Maternal and birth outcomes	
Iron folate supplementation **Maternal supplements of micronutrients** Maternal iodine through universal iodisation of salt **Maternal calcium supplementation** Interventions to reduce tobacco consumption or indoor air pollution	**Maternal supplements of balanced energy and protein** Maternal iodine supplements Maternal deworming in pregnancy Intermittent preventive treatment for malaria Insecticide-treated bed nets
Newborn babies	
Promotion of early exclusive breastfeeding for 6 months, continued until 24 months (individual and group counselling)	Neonatal vitamin A supplementation Delayed cord clamping
Infants and children	
Promotion of early exclusive breastfeeding for 6 months, continued until 24 months (individual and group counselling) **Appropriate complementary feeding education** in food secure populations and **additional complementary food supplements in food insecure populations** Preventative zinc supplementation **between 12 and 59 months of age** Zinc in management of diarrhea Vitamin A fortification or supplementation **between 6 and 59 months age** **Universal salt iodisation** Hand washing or hygiene interventions **Treatment of severe acute malnutrition** **Supplementary feeding for moderate acute malnutrition**	Conditional cash transfer programmes (with nutritional education) Deworming Iron fortification and supplementation programmes Insecticide-treated bed nets

Note: Components of the package of ten proven interventions highlighted in bold.

Source: Bhutta *et al.*, 2013.

strategy represent important opportunities for countries to identify synergies for scaling up these evidence-based nutritional actions (Gera *et al.,* 2016). Scaling up evidence-informed interventions is an effective adaptation strategy and may reduce the current implementation gap in addressing the nutritional impacts of climate change.

ADDRESSING THE LIMITATIONS AND BARRIERS TO ADAPTATION

Nutrition is a massive unfinished global public health and equality agenda. Food and health systems will both require substantial adjustments to attain the desired transformations and eliminate malnutrition in all its forms, so in-depth analyses of the underlying drivers of national barriers and limits to adaptation are critical (Barnett *et al.,* 2015). For example, one of the many economic barriers to adaptation is the scarcity of resource investments in view of the uncertainties around the current (rather incomplete) nutrition risk estimates alongside the severely uneven evidence regarding how these burdens will evolve at the sub-national levels in the short and long term. Another major foreseeable limit is the maximum productivity threshold for food systems with physiological limitations for thermal and water stress (WHO, 2014; Smith *et al.,* 2014).

From a health systems perspective, a major barrier is gaps in human, equipment and technological resources, the design and implementation of climate-smart nutritional early warning systems at the sub-national level, community and individual participation, and cultural acceptance of dietary advice (Nielsen and Reenberg, 2010). Individuals will have an important role to play in the prevention and management of the residual nutritional impacts, despite optimal adaptation (FAO, 2017). Furthermore, climate mitigation strategies may help avert a greater proportion of some of the nutritional impacts (for example, micronutrients zinc and iron) as compared to traditional public health interventions and should therefore be prioritized (Weyant *et al.,* 2018).

ASSESSING SYSTEM-WIDE RISKS APPROPRIATELY: STRENGTHENING THE KNOWLEDGE BASE, INFORMATION SHARING AND ITS USE

The inability of existing climate risk assessments to inform public health decision-making on the ground in the short term is a key barrier to its uptake at subnational levels. A "mismatch between what is available versus what is required for on-the-ground decision making" remains a key challenge (Singh *et al.,* 2018). Given the uncertainties and difficulties involved in allocating funds where there are prospective risks, even long-term national public-health planners struggle to use decadal and multi-decadal climate projections sufficiently (Shaw *et al.*, 2009; Singh *et al.*, 2018).

In addition to improving the human resource capabilities to analyse and interpret nation-wide cross-sectoral data sets, greater investments are needed in strengthening the weather/climate and nutrition data architecture nationally and subnationally, with a clear focus on data quality. Mechanisms for inter-sectoral and inter-organizational data-sharing across the climate, agriculture, livestock and health sectors at the sub-national levels may prove useful (Costello *et al.,* 2018). The best case scenario includes linking existing weather, agriculture (yield stability, quality and quantity), health and nutritional information systems and augmenting them with data on socioeconomic and demographic trends alongside access to nutritional and health preventive and curative services (Phalkey *et al.,* 2015). This would address some of the current causality and attribution challenges in accessing the nutritional impacts of climate change and allow better projections of the burden, timing and sub-national distribution of multiple forms of malnutrition in the future (Ebi *et al.,* 2017). Furthermore, integrated real time surveillance systems improve early warning and timely response functions (Madoff and Li, 2014; Rippin *et al.,* 2018). Examples of successful global nutrition-relevant surveillance systems include the Food and Agriculture Organizations Global Information and Early Warning System (FAO, 2018), the Famine Early Warning Systems Network (FEWS NET, 2018) and the INFORM risk index for humanitarian crises and disasters (INFORM, 2018). Similar inter-sectoral robust early warning systems that monitor climate sensitive diseases in crops, livestock and humans at the sub-national level are needed.

Much of the current focus on climate risk assessments is on stunting (chronic undernutrition). However, the accumulated impacts from multiple episodes of acute undernutrition have been inadequately addressed. There are critical gaps in our understanding of the physiological relationship between the different forms of malnutrition, and how interventions for one may affect the other. Comprehensive risk assessments that cover multiple forms of undernutrition with relation to climate variability and change at the subnational levels should be a research priority (Angood *et al.,* 2016). Investigations that target the 'food intake - nutritional outcome - infectious disease susceptibility' nexus in relation to seasonality and weather variability are needed to improve understanding of the utilization aspects of food security alongside nutrition-disease interactions (Prentice *et al.,* 2008). Similarly, comparative studies that investigate the impacts of synergistic- simultaneous and/or sequential implementation of *nutrition-specific* and *nutrition-sensitive* interventions targeted at reducing malnutrition are needed (James *et al.,* 2016). These can help to identify optimal combinations and to prioritize resource allocations in the future.

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CHAPTER 6

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