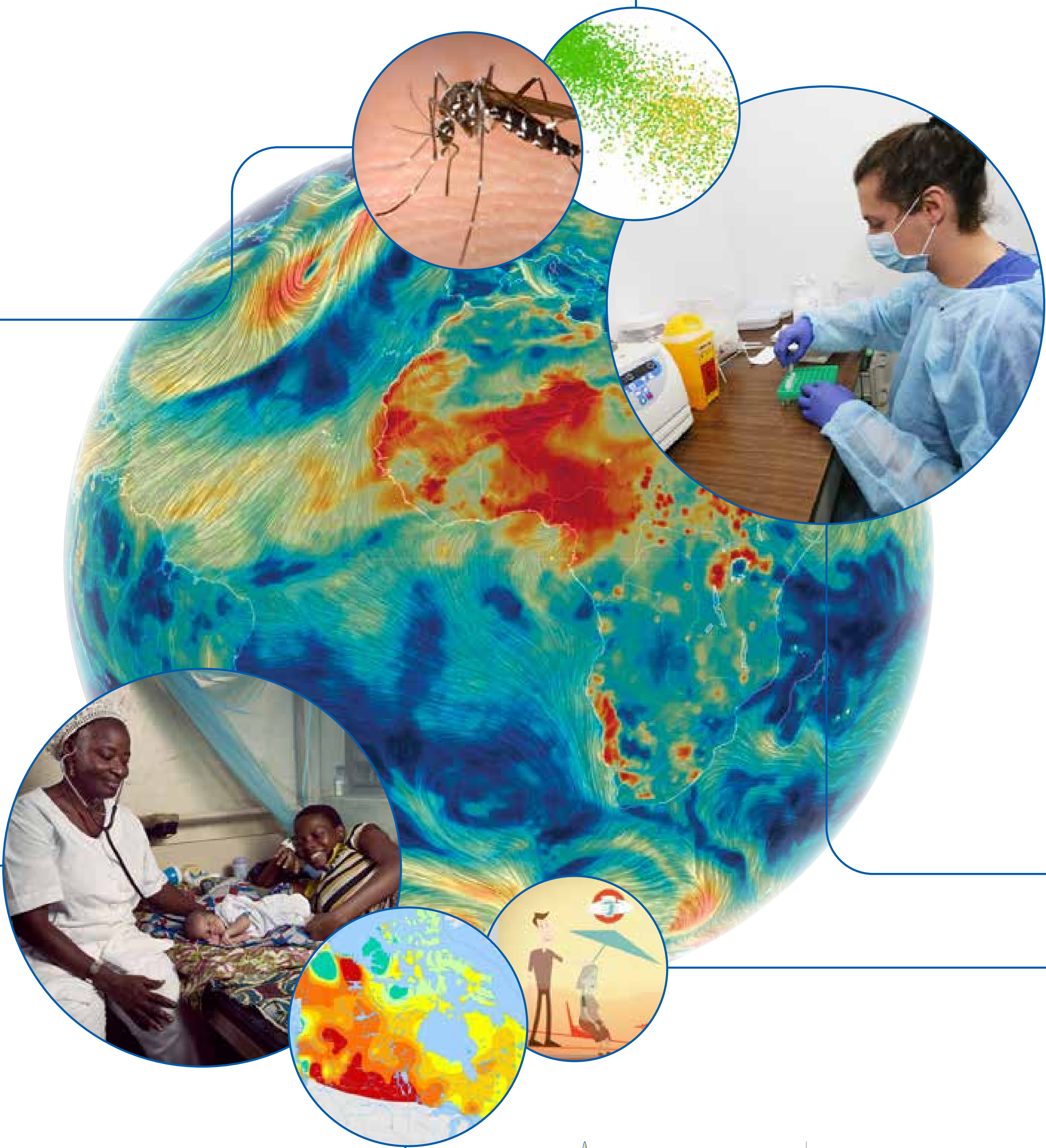
Fundamentals

CLIMATE SERVICES FOR HEALTH

Improving public health decision-making in a new climate



WORLD METEOROLOGICAL ORGANIZATION

World Health Organization

JOINT OFFICE FOR CLIMATE AND HEALTH

WHO Library Cataloguing-in-Publication Data

WHO/WMO. (2016) Climate Services for Health: Improving public health decision-making in a new climate. Eds. J.Shumake-Guillemot and L.Fernandez-Montoya. Geneva.

Photo credits | Front cover © Stephan Gladieu / World Bank

ISBN pending

Subject headings are available from WHO institutional repository.

Graphic design and layout
ACW, London, UK
www.acw.uk.com

ABOUT

CLIMATE SERVICES FOR HEALTH – FUNDAMENTALS

Today, health practitioners, researchers, policy-makers and individual citizens have greateraccess than ever to relevant and real-time information about hazardous weather and climate conditions. Learning to harness this knowledge will be a fundamental part of adapting to climate change and can help anticipate problems and produce more targeted public health interventions. The integrated use of climate knowledge in health is proving time and time again to result in more lives saved, more patients treated, reduced burdens of disease, and cost savings in health service delivery. Climate services can therefore help health professionals to become smarter, faster and more agile in response to the consequences of increasingly extreme climates.

Climate Services for Health – Fundamentals is an easy to read guide to support the development of more effective solution-focused services for health. It helps users to understand:

- how climate information can help health decision-making
- what climate products and services for health are
- the types of information products which are commonly developed
- Six fundamental components that should be addressed during climate services development
- How to trouble shoot common problems encountered

The six fundamental components contained in this guide have been derived from the critical analysis of a wealth of global experiences. They are:

1. to build an adequate enabling environment
2. to guarantee sufficient capacity
3. to compile and conduct necessary research
4. to conduct purpose-driven product and service development
5. to achieve context-suited service application
6. the establishment of strong evaluation mechanisms which measure impact to improve any given climate service

To learn more about how these components were identified, what their goals are, and to consult case studies illustrating approaches used to address each of them, please refer to the publication *Climate Services for Health – Improving public health decision-making in a new climate*. A full map of the case studies included in these publication is provided in the next two pages.

CLIMATE SERVICES FOR HEALTH CASE STUDIES

Enabling environment

Case study 2A Ecuador–Peru cooperation for climate-informed dengue surveillance: creating an interdisciplinary multinational team.

Case study 2B Addressing impacts of poor air quality on health in India: integrating air quality, health and meteorological expertise.

Case study 2C Long-term climate and health collaboration to forecast malaria outbreaks in Ethiopia.

Case study 2D Madagascar Climate and Health Working Group.

Capacity-building

Case study 3A Training a new generation of professionals to use climate information in public health decision-making.

Case study 3B Protecting the elderly from heat and cold stress in Hong Kong: using climate information and client-friendly communication technology.

Case study 3C Working with communities in East Africa to manage diarrhoeal disease and dengue risk in a changing climate.

Research

Case study 4A Vulnerability and adaptation assessment: Identifying climate information and decision needs in Bhutan.

Case study 4B Understanding the sensitivity of dengue to climate and urban risk factors in Minas Gerais State, Brazil.

Case study 4C Analysis of the health impacts of climate variability in four major South American cities.

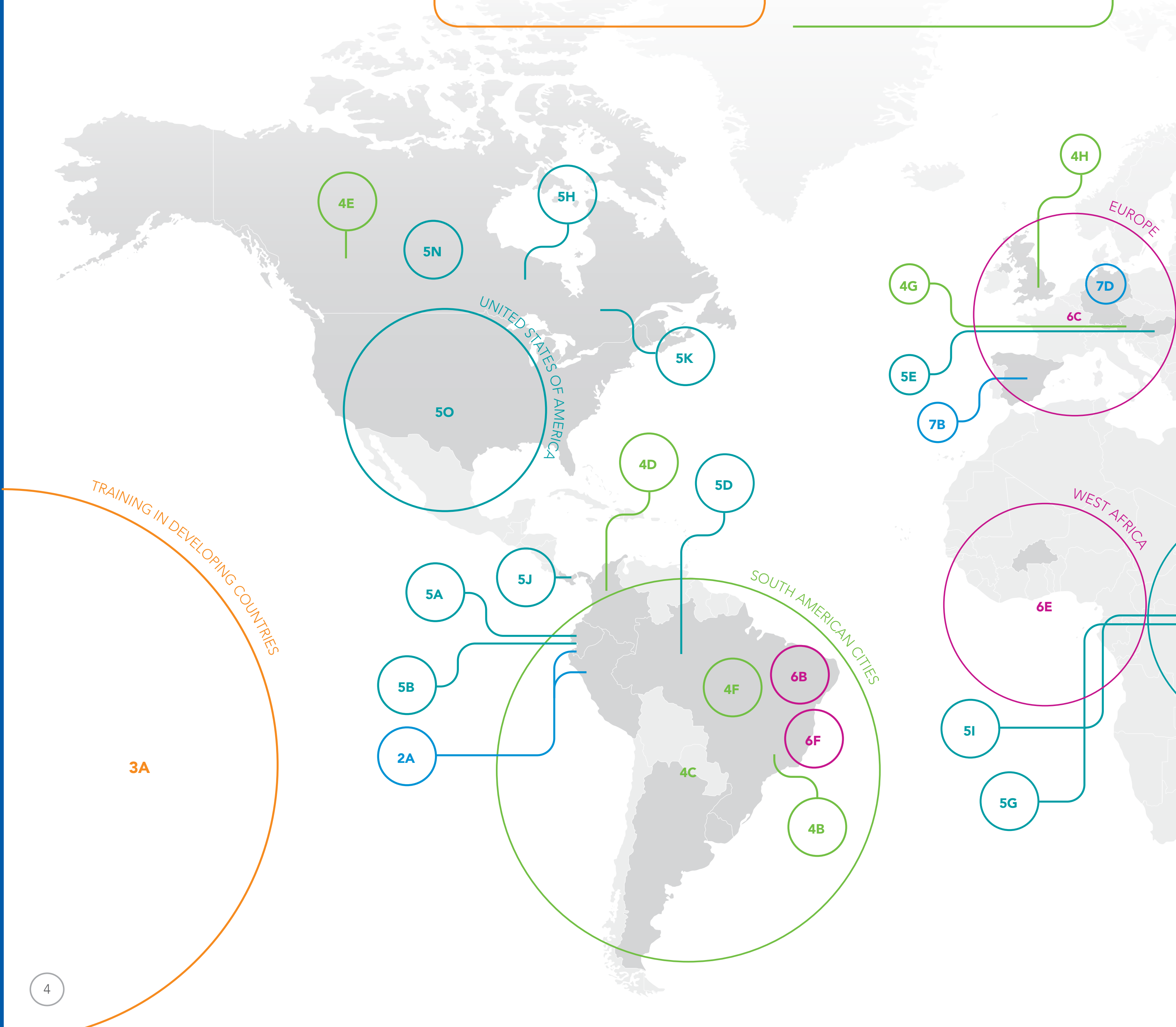
Case study 4D Malaria sensitivity to climate in Colombia: The importance of data availability, quality and format.

Case study 4E Iterative development and testing of a heat warning and information system in Alberta, Canada.

Case study 4F Predicting the impacts of climate on dengue in Brazil: Integrated risk modelling and mapping.

Case study 4G CcTalk! Communicating effectively with high-risk populations in Austria: A five-step methodology.

Case study 4H Knowing when cold winters and warm summers can reduce ambulatory care performance in London.



Produce and service development

Case study 5A Innovative community-based data collection to understand and find solutions to rainfall-related diarrhoeal diseases in Ecuador.

Case study 5B Vector-virus microclimate surveillance system for dengue control in Machala, Ecuador.

Case study 5C EPIDEMIA: integrating climate information and disease surveillance for malaria epidemic forecasting in Ethiopia.

Case study 5D The Brazilian Observatory of Climate and Health: Experience of organizing and disseminating climate and health information in Manaus, Amazon region.

Case study 5E Climate-specific pollen indicators and population exposure monitoring tools to better manage the allergy season in Hungary.

Case study 5F MalaClim: climate-based suitability mapping to inform vector control programmes in the Solomon Islands.

Case study 5G Mapping and modelling plague in Uganda to improve health outcomes.

Case study 5H Forecasting wildland fire smoke hazards in urban and rural areas in Manitoba, Canada.

Case study 5I Forecasting malaria transmission: finding the basis for making district-scale predictions in Uganda.

Case study 5J Bio-climatic bulletins to forecast dengue vectors in Panama.

Case study 5K SUPREME: an integrated heat health warning system for Quebec.

Case study 5L Heat wave and health risk early warning systems in China.

Case study 5M HEALTHY FUTURES Atlas: A publicly available resource for evaluating climate change risks on water-related and vector-borne disease in eastern Africa.

Case study 5N Comprehensive climate risk modelling framework to help protect future food and water safety in Canada.

Case study 5O How hot will it be? Translating climate model outputs for public health practice in the United States.

Application

Case study 6A Innovative heat wave early warning system and action plan in Ahmedabad, India.

Case study 6B Managing the health impacts of drought in Brazil: a comprehensive risk reduction framework.

Case study 6C Early warning systems to guide infectious disease control in Europe.

Case study 6D Improving malaria evaluation and planning with enhanced climate services in East Africa.

Case study 6E Using climate information to predict and control meningitis epidemics in West Africa.

Case study 6F Using climate knowledge to guide dengue prevention and risk communication ahead of Brazil's 2014 FIFA World Cup.

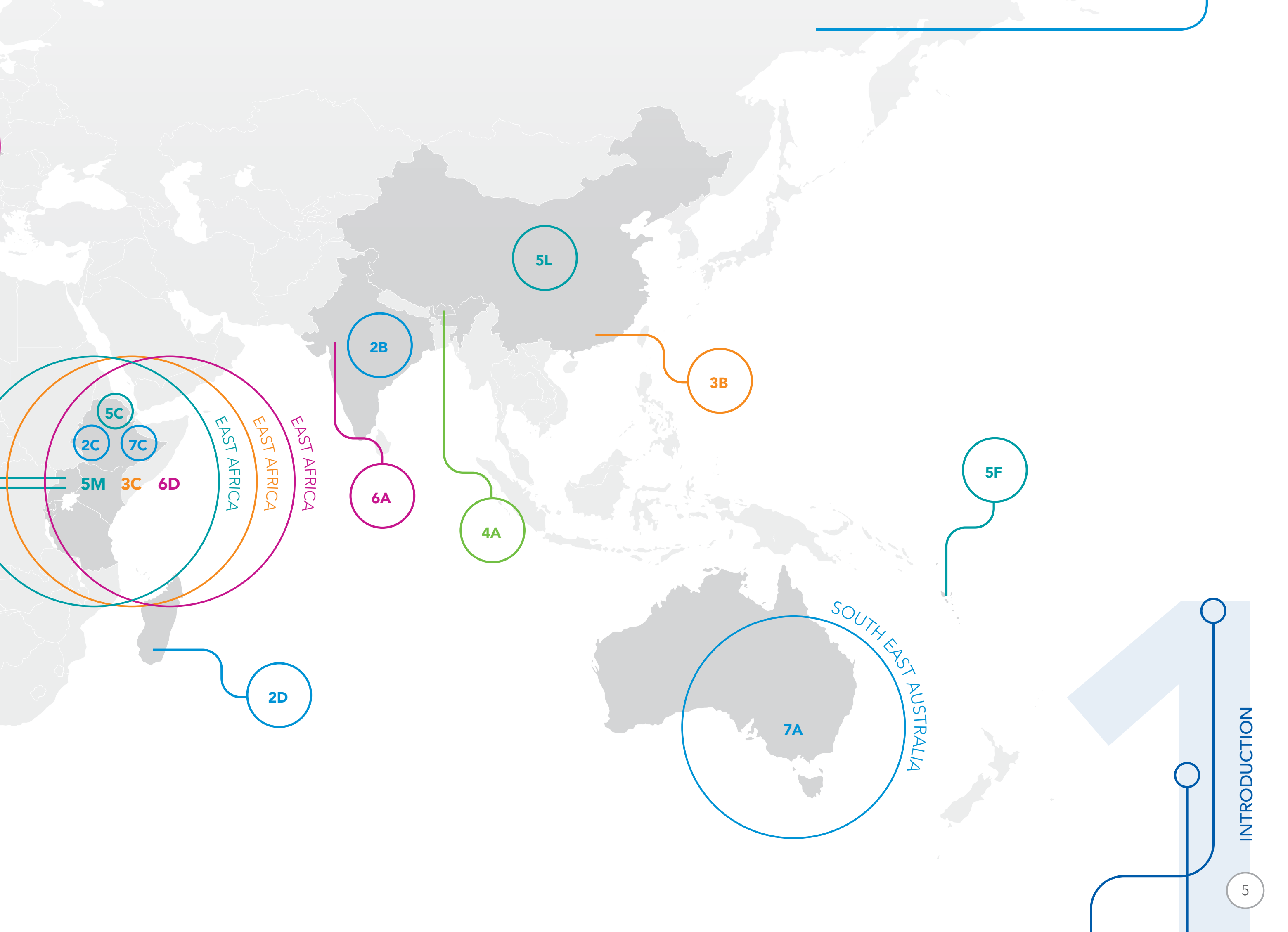
Evaluation

Case study 7A Building evidence that effective heat alert systems save lives in southeast Australia.

Case study 7B Finding the right thresholds to trigger action in heat wave early warning systems in Spain.

Case study 7C Looking back: documenting lessons learned from the implementation of a climate and health project in Ethiopia.

Case study 7D How to reach vulnerable populations? Evaluation of UV index, heat warning system, air-borne pollen and ozone forecasts in Germany.



CHAPTER 1

INTRODUCTION: HEALTH-TAILORED CLIMATE SERVICES

1.1 WHY DOES THE HEALTH COMMUNITY NEED CLIMATE SERVICES?

Health professionals are increasingly concerned about how changing patterns of climate variability and long-term climate change are mediating health risks and affecting their ability to protect the health of citizens. The direct and indirect influences of meteorological and climatic conditions are complex but can result in acute health impacts, as well as slow onset changes in health risk determinants. At one end of a spectrum, extreme weather events can seriously affect people's mental and physical health and can compromise their access to health care, food, clean water and physical safety, resulting in vulnerability, illness, injury or death. And at the opposite end, even small or gradual changes in weather and climatic conditions – such as local temperature, humidity or wind direction – can result in significant shifts in people's exposure to harmful or beneficial conditions, from disease transmission to changing water quality. The growing understanding that changing climate conditions can influence many global health priorities has recently unlocked a strong demand for improved evidence and decision tools that can harness this knowledge for action.

Public health policy and practice is founded upon evidence-based decision-making. Professional and ethical standards call upon the field to use rigorous approaches to collect and use the best available information. In the context of climate change, information from the health domain alone is insufficient. It has thus become imperative for public health professionals to take a transdisciplinary approach to problem solving, which includes building partnerships that generate appropriate, integrated and actionable scientific knowledge about the health impacts of climate and weather exposure.

Strengthening the climate resilience of the health sector will increasingly call for reliable and robust climate services. Robust and tailored climate products and services can become a powerful part of the public health toolkit that enhance the evidence and information available to detect, monitor, predict, and manage climate related health risks.

1.2 HOW CAN CLIMATE INFORMATION AND SERVICES HELP THE HEALTH COMMUNITY?

Climate services for health can facilitate access to multidisciplinary risk knowledge and increase capacity. Customized tools can be developed to identify and target the most vulnerable areas or populations. Analytical diagnostics can improve available evidence about how, when and where climate can affect human exposure to hazardous or beneficial conditions, who is likely to be affected, and what the magnitude, pattern and duration of the exposure and vulnerability are likely to be. Future climate scenarios can be explored to hypothesize how service delivery may perform under diverse climatic conditions and evaluate which health interventions are most likely to be effective at different times of the year.

At a broad level, health decisions that can benefit from being informed by weather and climate information include:

- risk and vulnerability identification;
- disease control strategies;
- health policy and regulations;
- disease monitoring and surveillance;
- financial and human resource allocation;
- pharmaceutical, health, pesticide and vaccine supply flow;
- health infrastructure siting and maintenance;
- emergency preparedness;
- community education and public health information dissemination, such as through public service announcements and alerts to raise awareness of risks;
- targeted public advisories, medicines or supplies for vulnerable populations;
- training of the health workforce for potential outbreaks or signs of illness;
- impact assessment of climate sensitive interventions.

Climate services for health have been developed to monitor how and where smoke plumes move during forest fires to anticipate when and where populations may be in harm’s way; to map disease transmission risks at high spatial resolution to better target vector control interventions and train traditional healers; to provide real-time and customized information for high-risk populations during heat waves; or to understand changing drought risks and reduce vulnerabilities to rapid and slow-onset impacts of droughts.

There are many measurable benefits of climate-informed decisions resulting from applied climate services. Lives can be saved and case burdens reduced. Health systems and communities can become better prepared for extreme weather events. Health intervention can become more cost-effective.

1.3 WHAT KIND OF CLIMATE AND WEATHER INFORMATION IS USEFUL TO HEALTH PARTNERS?

The type of weather and climate information that can be useful to health decisions varies greatly according to four factors: the health problem being addressed, the timescale of climate-related risk decision needs, the geographic scope of the problem, and availability and quality of data.

The principle determining factor of what climate information may be decision relevant depends on the health problem, decision, or policy-relevant research question to be addressed – starting with what is known about the environmental and climate sensitivity of the health outcome of interest. To determine sensitivity and identify if a reliable climate signal or measurable influence on health exists, quantitative and qualitative approaches to integrate historical climate data observations and epidemiological information are used based on our understanding of the particular disease transmission mechanisms and/or exposure-response relationships. If appropriate diagnostics reveal statistically significant associations between key variables and a climate signal is understood, then climate information may be helpful to estimate population risk, monitor the effectiveness of health planning and interventions, and detect, monitor and anticipate climate-sensitive health hazards (e.g. flooding, pathogen transmission, extreme temperatures), up to days, months, years or even decades in advance.

The second determining factor of what climate information may be decision relevant is the time frame of when identified risks may occur (today, next year, or 20 years from now) and when decisions need to be made. For example, information to trigger emergency response actions will turn to daily or weekly forecasts of extreme weather risks. However, for planning a vaccination campaign, disease transmission and outbreak risks need to be evaluated months in advance to allow enough time for vaccine procurement and mobilization of local immunization campaigns, and planners may turn to seasonal scale climate information. Table 1.2 shows weather and climate information products and services according to timescale (e.g. the historic record of climate observations, current weather information, short- to long-term future climate information).

Table 1.2 General status of climate and weather information relevant for health decision-making.

Timescale	Forecast & records' period and lead times	Example of climate information products available	Example of health-decision applications
HISTORIC RECORD OF CLIMATE OBSERVATIONS (Observational, gridded data sets and reanalysis). OPERATIONAL	Hourly, daily, monthly or annual records of past climate conditions.	Historical data on rainfall, temperature, humidity, wind, dust, pollution, etc. Model-driven reconstruction of historical climate records. Summary statistics of past climate (e.g. rainfall seasonality, 30- average temperature and rainfall monthly means, geographical rainfall distributions, etc.). Drought monitoring (intensity, duration). Summary statistics of extreme events (e.g. number of days of heavy rainfall, per week, month, year; number of cyclones per season).	Epidemiological trend and regression analysis to understand associations of climate and health, set risks thresholds and inform disease control plans. Analysis of extreme events impacts to identify high-risk areas and populations and define priority high impact extreme events for design of response plans. Production of baselines to monitor future evolution of climate risks.
WEATHER MONITORING AND NOWCASTING PRODUCTS OPERATIONAL	Current weather conditions provided in real-time of with some delay, and very short-term predictions.	Tracks and intensities of cyclones and storms. Temperature, wind speeds, humidity, rainfall intensities for the current day and next few minutes or hours. Accumulated rainfall, average/ maximum/ minimum temperatures for the current day and next few minutes or hours.	Trigger emergency response plans when pre-fixed risk thresholds are exceeded. Guide emergency interventions (e.g. identify flooded areas, potentially damaged health infrastructure, isolated communities; decide on staff deployment, delivery of supplies, and public protection needs). Trigger preparedness plans when conditions indicate that certain slow-onset hazards are evolving (e.g. local strong storms).
WEATHER FORECASTS OPERATIONAL	Hourly or daily weather conditions forecasted multiple times a day from hours to around 12 days ahead.	Real-time monitoring of daily weather: temperature, precipitation, humidity, wind speed and direction, etc. Hourly and daily rainfall probability and temperature ranges. Daily risks levels of extreme events (heat wave, strong winds, storms, snow, frosts, haze) and probabilities for different intensities. Maps of extreme event risks.	Trigger preparedness plans when hazards are forecasted (e.g. heavy rainfall, cyclone, strong winds). Example decisions: Identify at risk populations and disseminate public health advisories; initiate evacuations; activate emergency committees and response teams; pre-position emergency supplies; estimate needs of and strengthen emergency services; activate health impacts monitoring mechanism.
SUB SEASONAL CLIMATE FORECASTS UNDER DEVELOPMENT	Average climate conditions over a week (approx.) forecasted from 2 weeks to 60 days ahead.	Research is being undertaken to identify the probability of high-impact extreme events, such as heavy rainfall, heat waves, cyclones, dust or landfalls 2-3 weeks ahead of occurrence.	
SEASONAL CLIMATE FORECASTS OPERATIONAL	Seasonal climate conditions forecasted up to 6 months ahead.	Seasonal probability of temperature and rainfall exceeding normal conditions (upper tercile, lower tercile or user defined thresholds). Probability of occurrence of La Nina and El Nino phases of El Niño Southern Oscillation (ENSO). Probability of extreme events occurring during the season (e.g. droughts outlooks).	Trigger operational decisions months ahead of time when increase risk is forecasted. Example decisions: supplies procurement and pre-positioning; health workforce deployment; initiate communications campaigns with communities; strengthening disease surveillance and outbreak prevention and control mechanism in at risk areas and drought response when needed; initiate communication with relevant partners to prepare response actions. It is recommended to integrate seasonal forecast with monitoring system to forecast in context.
INTER-ANNUAL CLIMATE FORECASTS UNDER DEVELOPMENT	Seasonal climate conditions forecast around 1 year ahead.		

Timescale	Forecast & records' period and lead times	Example of climate information products available	Example of health-decision applications
DECADAL CLIMATE FORECASTS UNDER DEVELOPMENT (Mainly focused on temperature and temperature related extreme events, first operational products available).	Multi-annual climate conditions forecasted annually.	5 year mean temperature conditions compared to previous periods. 5-year probability of temperature conditions exceeding certain lower or upper normal thresholds. Multi-year predictions of hurricane frequency.	Inform 1-5 year policy decisions for heat related health outcomes in areas with strong temperature change trends. Example decisions: create or strengthen early warning and risk monitoring mechanism; initiate community awareness campaigns; revise health supply needs and distribution; establish cool centers; strengthen disease surveillance systems; retrofit health infrastructure; train workforce in disease diagnosis and identification of vulnerable populations.
DECADE TO CENTURY CLIMATE INFORMATION (Climate projections). OPERATIONAL	Conditions expected at different points in time the next 30 to 100 years and run every 5 years or upon specific needs.	Average patterns of temperature and rainfall in 30-40-50-80-100 years-time at different spatial scales (continental, regional or downscaled to country level). Prospects of frequency and intensity of extreme weather events and sea level rise.	Inform long-term policy decisions and investments for research a development and infrastructure. Example decisions: investment in drought resistance crops, vaccine development, heat resilient cold chains, water systems for health facilities, uninterrupted power supplies, workforce development.

Summary of weather and climate information, including historical records, current conditions and forecasts, at different time scales for health applications. It is importance to notice that 1) the ability to produce reliable products is different at different time scales and 2) the reliability of each of the products listed vary across regions and seasons. The status of development of the products at different time scales has been classified in this table as Operational (products being release on a regular basis for operational purposes by different producing centers) or Under Development (products that are in an experimental phase and not yet released regularly). For example, currently weather forecast techniques are much more developed and, hence, yield more reliable results than decadal forecasting does. To better understand the reliability of individual products for an specific region or season expert advice should be seek. It is recommendable to contact the national and local met service or the Regional Climate Centers for further information.

The third factor to determine which climate information may be decision relevant is the spatial scale of problem and information. Health data is presented at a specific spatial resolution (e.g. at the facility level, the district level, the provincial level etc.). Climate information must be available at the appropriate spatial scale to match the health data. Many climate products are simply too crude to match with point- or district-based health information, and techniques for aggregating comparative scales such as district, province, or national level are often needed.

Understanding and selecting the appropriate spatial scale of information, along with considerations of the quality of this information to inform the health decision, is important. For example, global scale dynamical climate models will not provide the needed level of detail to create future projections of climate change impacts at the national and/or sub-national levels.

Fourthly, the availability, accessibility, and timeliness of information will determine its adequacy and relevance for use in the public health context. The professional and ethical standards of public health practice demand that the information used for making decisions about people's lives and well-being are held to robust standards and methods. Health professionals must scrutinize available information with the recognition that data quality may be poor, measurement biases may exist, the skill of forecasts are regionally and seasonally specific, and that conditions of uncertainty must be clearly documented for users and decision makers. Health professionals may deem climate information unusable if products are not validated, unreliable, or other conditions cannot be met. Furthermore, if information cannot be provided in a timely manner, it may not be usable. For example, if observed or forecasted climate information is available, but not updated routinely in a timely manner, it cannot be used for early warning systems.

The availability, reliability and quality of these products can vary greatly from country to country and operational products may not exist at the national level in many cases. Techniques to use alternative downscaled regional or global information products, such as remotely sensed data, can in these situations be used with certain trade-offs.

Critically, climate is only one of many factors that influence health outcomes and health service delivery. However, climate and weather conditions can have complex direct and indirect effects on health risk management. For climate-smart public health, (such as climate-appropriate investments in and deployment of health care's policy and services), information on the degree of direct influence that climate and weather bear on health risks and outcomes should complement well-founded understandings of short- and long-term climate influences on proximal determinants of health, such as drinking water, food security, disaster management, and urban planning.

For national or subnational health decision-making, a first step to identifying the relevant, available, and accessible weather and climate information is a discussion with the National Meterological and Hydrological Services, which is most often responsible for collecting and producing climate and weather information, and understanding local data-sharing policies.

1.4 WHY IS CO-PRODUCTION IMPORTANT?

Climate services represent a process of activities that cannot be accomplished by one sector alone. In the case of climate and health, health professionals depend on strong partnerships with the national meteorological services and other partners to access relevant data and capacity to solve health challenges and questions related to weather and climate.

Different levels of collaboration may be called for depending on the activity. Where good quality data, capacity, and knowledge sharing capabilities exist, the health community may rapidly expand their use of climate information without additional cumbersome administrative burdens often associated with multi-sectoral arrangements. For example, the analyses of climate and health relationships that strictly use historic observations of quality controlled meteorological data may call for less joint collaboration, but require data services and data sharing policies that will allow health partners to build the evidence base for identifying further potential climate service needs.

However, when the public health problem requires probabilistic weather or climate forecasts, projections or scenario information, close collaboration and co-production of products becomes particularly important.

Co-production not only expands the available expertise and knowledge that can be harnessed for problem solving, it also helps to make informed judgments about the uncertainty and the probabilistic nature of future weather and climate conditions, which are inherently uncertain. Joint accountability for the generation and use of probabilistic information is fundamental.

Developing tailored climate products and services that can be fully mainstreamed into public health decision-making, policy and operations is a multifaceted collaborative process. It calls for first clearly identifying the problem and information needs; having the capacity to interpret the information provided by climate products; having mechanisms to incorporate this information into decision-making; building communication channels with partners and communities involved in risk management or response; and monitoring mechanisms to evaluate the performance of the products.

The development process for creating usable climate products and services for robust public health decision-making may take months to years, and commonly requires iterative rounds of trial and error, capacity-building, and refinements through active partner engagement and collaboration. Furthermore, the development process should focus not only on the technical specifications of the climate product, but also on the soft processes that are necessary for building capacity for uptake and use.

1.5 DEVELOPING CLIMATE SERVICES FOR HEALTH: A HOLISTIC PROCESS

By definition, climate services are an end-to-end multifaceted process through which a partnership creates a fit-for-purpose information solution. The process of developing a climate service starts with an active discussion between climate information producers and users about specific problems, such as the context, ultimate application, and user specifications. It starts with the question, "What is the climate-sensitive health problem, decision, or policy relevant research question that needs to be addressed, and what is its spatial and temporal dimension?"

Following careful problem definition, six common components frequently comprise the approaches taken to develop and deliver climate products and services for health. These include activities to create an enabling environment, build capacity, conduct research, develop and deliver products and services, apply the knowledge, and evaluate the products and user experience. Each component serves a specific goal in the overall process, as shown in Figure 1.1.

It is highly recommended that an assessment of readiness is conducted to identify available building blocks, resources, and the level of readiness for each phase of development. Although this is not a strictly sequential process, the components of enabling, the components of enabling environment, capacity, and research set the foundations and readiness levels to adequately advance to product and service development and delivery, application and evaluation. Additionally, maintaining the enabling environment and strengthening capacities should occur in parallel to activities focused on the design, development, and application of weather and climate services.

Table 1.3 presents the goals of each component. Global experiences have shown that although the product development process can be difficult, ensuring that the resulting tools and information are effectively applied and maintained are even greater challenges.

Figure 1.1 Process of tailoring climate services for health.

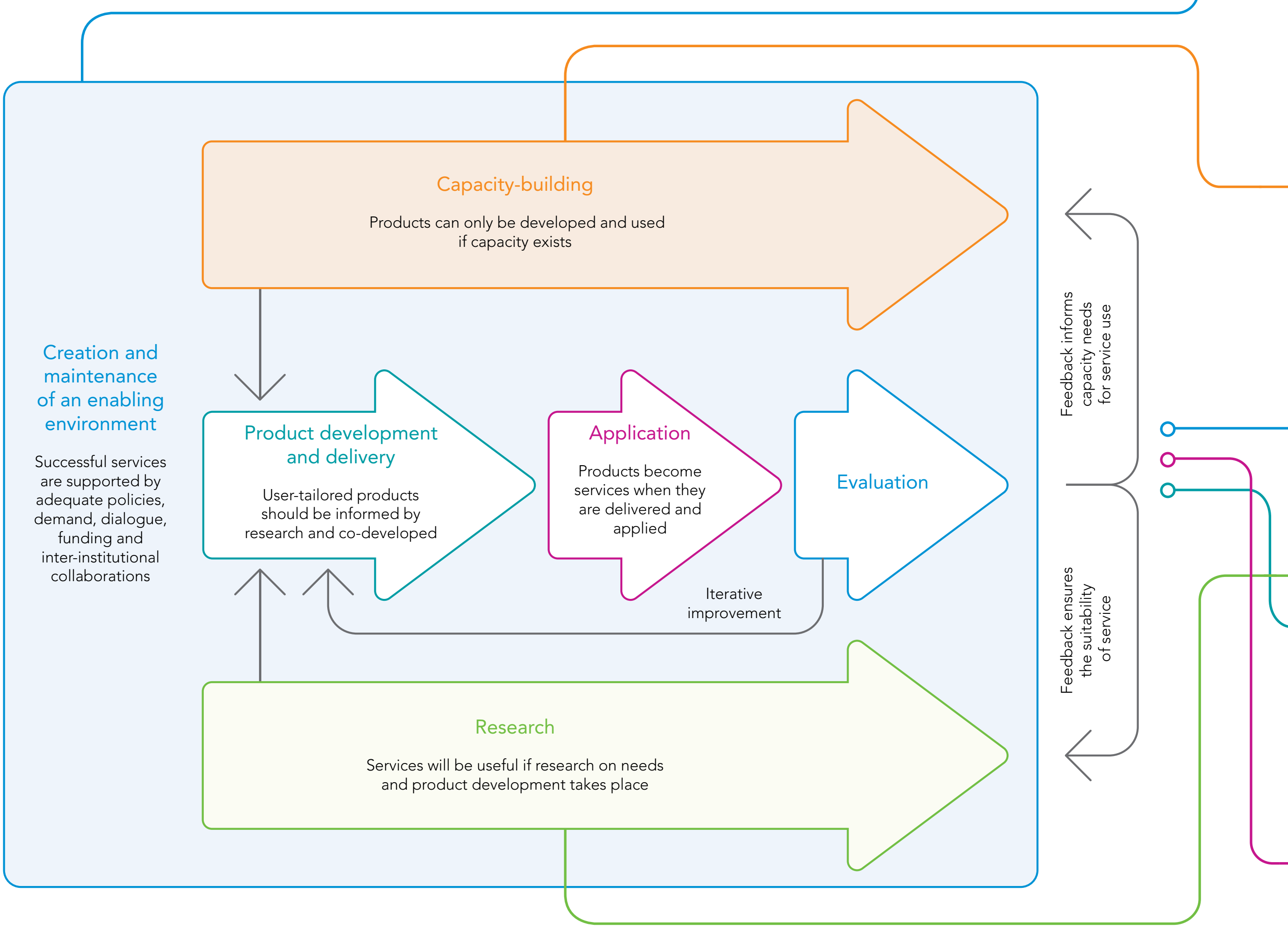
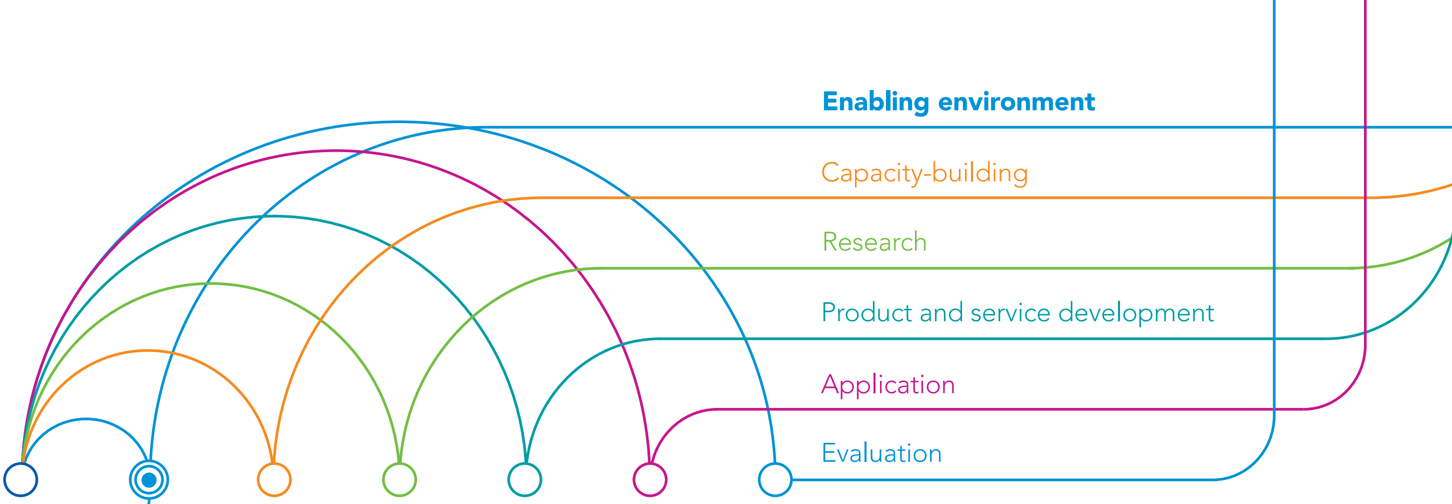


Table 1.3 Goals of individual process components.

ENABLING ENVIRONMENT	Promote the close, coordinated and sustained collaboration and exchange of information between relevant stakeholders, thereby building the technical, institutional, legal and normative foundations that allow smooth, timely and successful collaboration for activities within each of the process components.
CAPACITY-BUILDING	Ensure that adequate human and other resources, institutional and community skills and know-how are available to allow for appropriate development, optimal use and sustainability of climate services.
RESEARCH	Generate evidence on the needs for climate services for health, and to produce the necessary know-how for the development and application of such services.
PRODUCT AND SERVICE DEVELOPMENT	Collaboratively design and create tailored information products that are integrated and interoperable to user specifications, which provide decision-makers and communities with timely and relevant information to manage health risks specific to climate and weather.
APPLICATION	Apply climate knowledge to bring benefits to individuals and communities.
EVALUATION	Provide evidence on the performance, effectiveness and cost-effectiveness of climate services to save lives and reduce climate-related health risks.



CHAPTER 2

CREATING AN ENABLING ENVIRONMENT

GOAL: Promote the close, coordinated and sustained collaboration and exchange of information between the climate and health sectors and other relevant stakeholders, thereby building the technical, institutional, legal and normative foundations that allow for smooth, timely and successful collaboration for activities within each of the process components.

An enabling environment is the structured context that brings together the principal actors whose technical and practical expertise and decision-making are needed to inform, develop, and apply the climate service knowledge to solve problems within a health system on a sustainable basis. An enabling environment is formed by the:

- national policy and financial landscape
- problem awareness and scientific and programmatic demand
- institutional mandates, procedures, and capacities
- multi-sectoral partnerships and communication mechanisms

Recognizing and understanding the enabling environment is critical for climate services to generate relevant knowledge, become integrated with the health system, and improve decision-making on a sustainable basis where needed. Simple organizational and institutional steps can markedly improve the enabling environment, such as increasing risk communications and local evidence which enhance problem understanding, as well as forging structured partnerships. Certain actions can help to delineate clear and joint expectations, procedures, and processes that can assist partnerships to mature and be successful throughout their intended duration. For example, the frequent and structured exchange of information, such as through regular meetings, or communications, provides the opportunity to actively participate in discussion and decision-making at each step.

Participation and ownership is key for the creation of trust and mutual understanding between partners, which will help climate and weather knowledge products be confidently endorsed and applied by users to improve health decision-making. Communication of evidence of local climate and health linkages, and evaluating and demonstrating the added value of understanding climate influences on health and using this knowledge to improve programmatic decision-making, is also a fundamental part of enabling, sustaining, and justifying the value of investments in tailored climate service developments.

IMPORTANCE OF AN ENABLING ENVIRONMENT TO EFFECTIVE CLIMATE SERVICES

An enabling environment should be fostered and maintained throughout the whole climate service production process. In the initial stages of new activities, the following intentional actions should be undertaken:

- Clearly define the health problem being solved and its space and time dimensions.
- Envision together with relevant actors the scope of the type of climate products and services to be developed. Create mechanisms and norms for dialogue between partners to set appropriate expectations, and understand each other's needs, interests and limitations, including data sharing and resource exchange policies.
- Evaluate the readiness for the specific products/service development, including capacity, research, political support, application requirements, financial and technical resources.
- Explore feasibility and sustainability of different implementation models. Define a service development progress monitoring system to identify and manage setbacks and breakthroughs.
- Establish rules and procedures for engagement (such as meeting schedules, memorandums of understanding, timetables, data sharing arrangements).
- Create a plan for evaluating, providing feedback, and making needed adjustments.
- Ensure the right policies and mandates are established to develop and apply the service. Generate a strategic plan for long-term financial sustainability.

In the later stages of product development and application, the following activities may be needed:

- Maintain and boost communication channels for partners to exchange data and information.
- Identify and solve problems related to testing and application.
- Evaluate and provide constant mutual feedback.
- Monitor usage, value, and sustainability of services.
- Identify new needs and/or expand the applications and partnerships in relation to real-time challenges. Inform the education sector and partners of the skills and education needed to enable the workforce.

COMMON APPROACHES

Enabling environments are fostered in different ways, depending on the context, national institutional environment, and familiarity of partners with the subject and with each other. Activities that help create and structure an enabling environment include:

- Assessing readiness and defining demand for climate services;
- Mapping national partners' interests and strengths;
- Collaborating with international stakeholders or partner countries to fill gaps in available knowledge or resources;
- Clearly defining roles and responsibilities of partners;
- Formalizing a memorandum of understanding or clear terms of reference outlining how the collaboration will work and enabling key activities such as data exchange;
- Adopting common standards and schedules;
- Revising institutional mandates and policies, including formulating effective data-sharing policies;
- Creating a multidisciplinary team;
- Scheduling regular meetings, trainings, and workshops with all stakeholders;
- Involving high-level decision-makers to increase their understanding, appreciation and trust to use the information and services in order to make critical and often life-saving decisions;
- Partnering with academia and civil society organizations as neutral actors working between national health and climate authorities;
- Engaging and communicating actively with donors to ensure future sustainability.

WHO IS OFTEN INVOLVED?

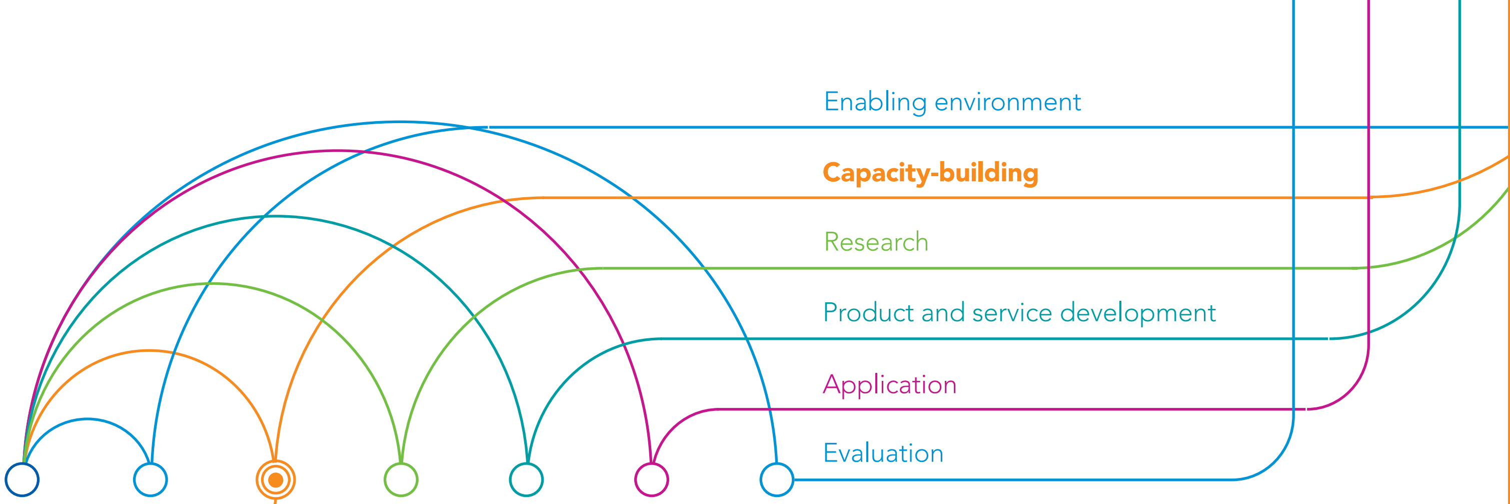
Health professionals: Health authorities and programmatic decision-makers, planners, researchers, statisticians, epidemiologists, public health practitioners, clinical staff and community health workers, who may be working for the private sector, government or non-governmental health system.

Climate professionals: Meteorologists, climatologists, and researchers from the National Meteorological Services, academia, or applied institutes.

Professionals from health-determining sectors: Water management, agriculture and food security, urban planning, and disaster risk management are also key actors in developing tailored information products related to or adapted from knowledge and decision tools used in these domains.

Knowledge brokers and professionals from complementary disciplines: Information and communication technologists, project managers, policy-makers, legal experts, statisticians and community representatives.

Community members: Individuals expected to use the climate information, and the media who may be transmitting information to the public, are also important stakeholders.



CHAPTER 3

BUILDING CAPACITY FOR CLIMATE SERVICES

GOAL: Ensure that adequate human and other resources, institutional and community skills and know-how are available to allow for appropriate development, optimal use and sustainability of climate services.

Capacity-building refers to the broad range of activities and resources needed to enhance human resource knowledge and technical skills, institutional abilities, and infrastructural capacities to generate and apply climate knowledge to decision-making.

Fundamentally, the underlying state of the science and functional capacities of national hydrological and meteorological services to provide end-to-end climate services will determine the starting point for many collaborations toward health-tailored climate services. The infrastructural and institutional capacity includes: observation of the local climate, along with data collection and exchange procedures; the practices for climate data management and quality control, including data rescue and digitization; the status of product development such as operational climate monitoring, assessment and prediction, climate change projections and downscaling; and finally the ability to engage with various sectors in order to appropriately package and communicate tailored products. Health partners or authorities can parallel these services with health surveillance, data management procedures, epidemiological analysis, and the familiarity and confidence to use probabilistic risk information for intervention monitoring and planning.

Figure 3.1 Students of the Computer Sciences at Khowaja Institute of Information Technology (KIIT) in Hyderabad, learn computing skills. The KIIT provides training and skill development programmes to help graduates rise to the challenges. Photo credit: Visual News Associates / World Bank

Different kinds of stakeholders will require diverse types of capacity-building, based on the roles they play to produce and use climate information. Focusing on the human and institutional resources needed to co-produce and apply climate information, the principle actors can be grouped into four broad categories: meteorological and climate professionals, health professionals, health-relevant partners, and citizens. (See Table 3.1)

The meteorological community needs technical and infrastructural capacities to produce and deliver usable and reliable climate products, and human resource skills to understand the health problems being addressed, to clearly communicate climate science, and to listen and understand user needs to be able to engage in meaningful dialogue.

Activities targeting health professionals often focus on enhancing managerial capacities to lead the development and implementation process; engage in multidisciplinary dialogue; understand and generate evidence on the linkages between climate and health; and to value and use the climate services developed to protect the health of the population.

Multi-disciplinary health-relevant partners are critical to develop effective climate services for health risks that originate and are managed outside the health sector. Capacity-building should help build bridges that share information and diagnostics, strengthen collaboration, and improve multi-sectoral risk management.

Community-targeted capacity-building often includes efforts to raise awareness of the health risks of extreme weather and climate; identify which populations are most vulnerable; interpret public service messages; and and take actions at the community and individual levels to protect health.

Table 3.1 Example of capacity-building needs of diverse partners.

	Meteorological professionals need capacity to:	**Health professionals need capacity to:**	**Multi-disciplinary health relevant partners need capacity to:**	**Citizens need capacity to:**
ENGAGEMENT	Listen and understand user and community needs. Communicate climate science.	Define, inform, and prioritize information and knowledge needs.	Identify and translate risk or impact-relevant information and stakeholders.	Access information and value the benefits of climate services.
RESEARCH	Conduct product research and development. Access and understand global and regional products.	Conduct research using climate information.	Participate in climate and health research.	Collect and provide community-sourced information.
PRODUCTION AND DELIVERY	Ensure quality observational data is available and related products and services are quality controlled and transparently produced. Develop and test products. Deliver services .	Identify and provide data and analytical inputs. Develop and test products.	Identify and support linkages. Contribute relevant data and analytical inputs.	Inform preferences for climate service outputs, i.e. language, format, frequency.
APPLICATION	Communicate uncertainties and strengths/limitations of the services developed.	Understand and internalize new information. Institutionalize climate services as decision tools.	Share information and build bridges to integrate knowledge into multi-sectoral risk management.	Understand messaging Know how to respond appropriately to information and warnings.
EVALUATION	Use resources and methods that measure reliability and validity of products, as well as user-uptake and satisfaction.	Use resources and methods that measure and evaluate impacts.	Use resources and methods that measure and evaluate cross-sectoral impacts.	Provide feedback on user-experience and impact.

Box 3.1 Types of capacity development for climate services.

Human resource capacity – equipping individuals with the knowledge, skills and training to enable them to generate, communicate and use decision-relevant climate information.

Infrastructural capacity – enabling access to resources that help generate, archive, ensure quality control, communicate, exchange and use climate data and decision-relevant information and products, including both supply and demand side instruments for observing networks, data management systems, computer hardware and software, internet access, communication tools, manuals and scientific literature, with similar things on the health sector side but potentially much more diverse.

Institutional capacity – on the climate side includes elaborating management structures such as defining the position and terms of reference of the National Meteorological and Hydrological Services for climate services, processes, policies and procedures that enable effective climate services, not only within organizations but also in managing relationships between the different organizations and sectors (such as public, private and community, including international collaboration).

On the health side this includes mandates of government agencies to prioritize and address climate change as a health risk, as well as the organizational arrangements for disease control, nutrition, environmental management, and emergency preparedness and response; policies and procedures that facilitate intra- and inter-sectoral environmental, disaster, and climate risk management; data management and exchange policies; working relationships with other health sector partners (such as nongovernmental organizations, research institutions and universities) and the availability of personnel.

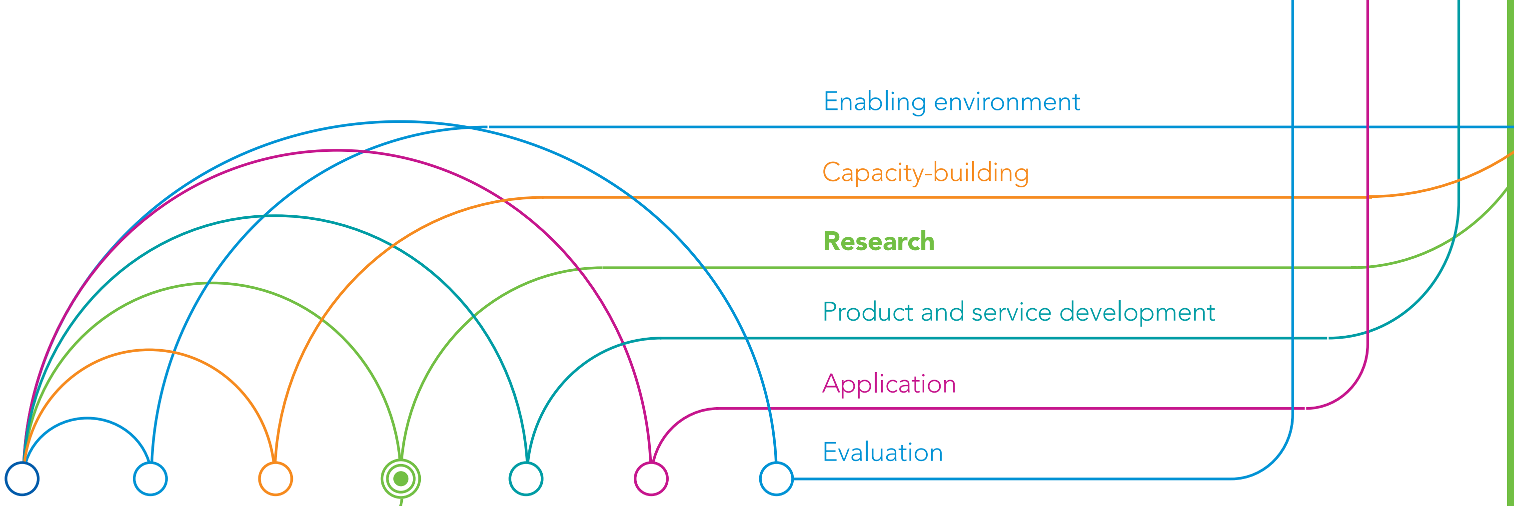
IMPORTANCE OF CAPACITY-BUILDING IN EFFECTIVE CLIMATE SERVICES

Capacity should be built simultaneously at individual, institutional, and community levels. Even with adequate levels of technical expertise for climate services development, they will not become useful tools for health decision-making unless health decision-makers are able to effectively understand, value, trust and use these services. This requires decision-makers to have the capacity to institutionalize climate services as decision tools; interpret climate service outputs; integrate and use these outputs in the global context of health risk evaluation; and include information provided by climate services in identifying and selecting the most cost-effective solutions. This capacity can be improved by communication and dialogue with other experts and partners. Likewise, if the technical expertise and capacity among health decision-makers is present but communities are not capable of understanding or taking action based upon public advisories, the advantage derived from those services will be severely limited. Communicating research findings to communities in a clear and understandable language will help them understand the need for climate services. The engagement of communities in climate service development, application and evaluation will help to build their capacity to benefit from the climate services developed. This implies that climate knowledge and information need to be integrated into public health training at all levels – including schools of public health and professional courses such as those for field epidemiologists.

COMMON APPROACHES

Capacity-building needs will vary depending on the goals of the climate service being developed. However, some useful common approaches include:

- Mapping and assessing existing institutional, infrastructural, human resource, and community capacities through surveys or other instruments.
- Strengthening the enabling environment to reinforce institutional capacities.
- Investing in, and upgrading information technology and communication equipment and systems.
- Training community leaders, volunteers and health workers on the health risks exacerbated by climate and weather conditions and appropriate responses that can be taken.
- Involving communities in health and climate data collection and interpretation.
- Training health professionals from local and regional health bureaus on health and climate linkages, disaster management, and analytical methods, such as environmental epidemiology and spatial biostatistics.
- Conducting workshops to build capacity at appropriate levels (local, regional and national) to use the climate products and services developed.
- Embedding climate and health courses in the course curricula of higher education institutions and engaging them in technology and knowledge transfers to the public health community.
- Developing tailored training and outreach materials especially targeted to high-risk groups.
- Organizing multidisciplinary discussion groups to increase communication capacities across professionals from different fields.
- Organizing regular knowledge refresher courses on climate–sensitive disease detection and diagnosis.
- Fostering expert and staff exchanges between national and regional partners, such as the WMO Regional Climate Centers.



CHAPTER 4

4 RESEARCH TO INFORM CLIMATE SERVICES

GOAL: Generate evidence on the needs for climate services for health, and produce the necessary know-how for the development and application of such services.

Climate services for health begin with research, or are based on research that establishes the associations of climate and weather conditions with health outcomes, risk factors, or health service delivery performance. Understanding the "climate signals" which may play a role in disease outcomes are required for any application of climate information to decision-making.

Figure 4.1 Statisticians entering data into the database for further processing and analysis. Turkmenistan. Photo credit: World Bank.

Research for climate services may come in many forms, since a broad range of technical and context-specific information is needed to develop products and design effective services. Research activities often fall into three categories:

1. **Applied research** includes investigations undertaken to acquire knowledge about a specific practical aim or objective, such as understanding the linkages between climate conditions and health outcomes; the relative need for and value of climate information; data validation and development; and specific analytical methodologies to assess model validity and uncertainty.
2. **Product research and development** can include purpose-based activities for the generation of sufficient know-how to develop tailored climate information products and services. Some examples include: exploration of context-appropriate data collection, data digitalization and data transferring systems, analysis and refinement of the sensibility of the service to detect certain levels of climate-related risks, comparative evaluation of different risk indicators or exploration of information visualization and communication tools.
3. **Operations research** draws upon management and organizational sciences, using qualitative or quantitative techniques to explore and generate practical knowledge and know-how on climate services application. Operations research is applicable to the entire climate services development process, and can include analyses on: the demand for and readiness of communities or organizations to use a climate service; the optimal internal administrative and human resources structures needed for the successful application and sustainability of the service; the legal institutionalization of the service; the best stakeholder coordination and information-sharing mechanisms; as well as cost-efficiency assessments.

IMPORTANCE OF RESEARCH FOR EFFECTIVE CLIMATE SERVICES

Applied research helps define priorities for health care delivery using an evidence-based approach, and provides new information on the potential uses and limitations of climate services. This type of research is also important for exploring the potential benefits from developing decision tools relative to other public health interventions; and can help identify needs and justify investments in climate services for health, as well as identify data related shortcomings or issues.

Product research and development is crucial to the development of functional and reliable climate services that meet user-needs. User-centered approaches in which users are involved in the product development should be prioritized. These approaches allow for timely feedback on progress and user-specifications, and testing of prototypes before the service is rolled out on a larger scale. They help ensure that climate services are valid, quality controlled, and reliable; use appropriate technology for target users; and provide relevant information which is accessible, interpretable and usable.

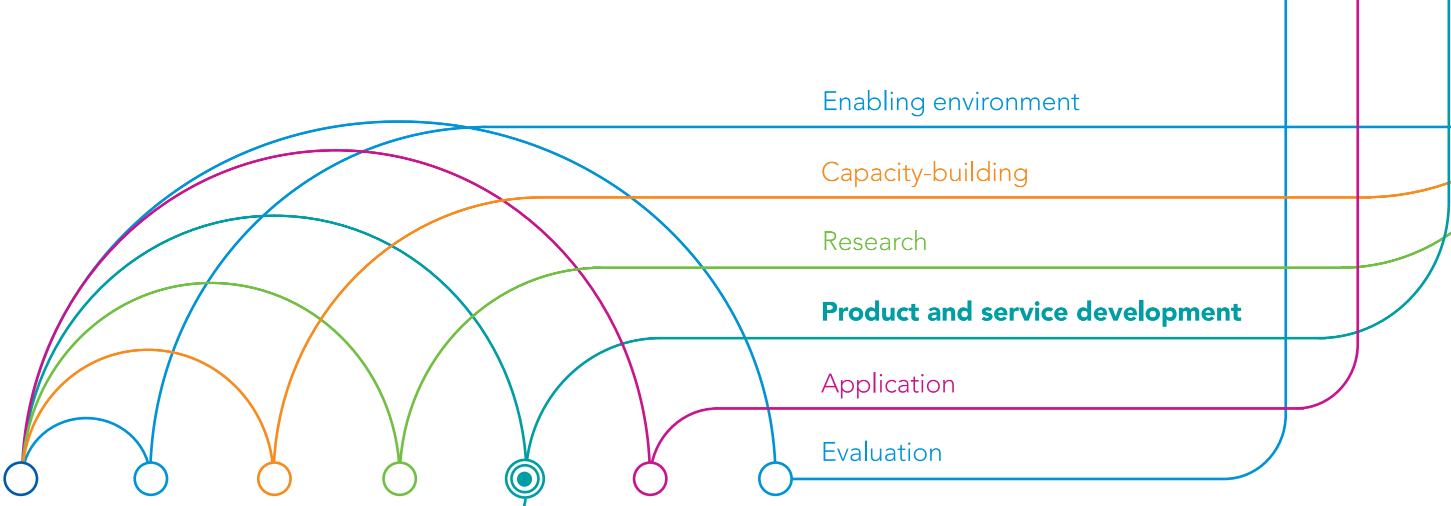
Operations research generates evidence on how to best support climate services with suitable administrative, organizational and legal structures that enhance application and sustainability. It helps optimize the use of resources during climate service implementation, such as by building on existing climate products. Operations research is crucial for ensuring that implemented climate services achieve the greatest benefits, with the lowest resource burden possible.

COMMON RESEARCH TOPICS AND TOOLS

Iterative research and information collection for feedback is essential prior to development of climate products or services. It informs product specifications, user needs and requirements, and identifies optimal communication and application. Research methodologies range from quantitative analyses, to focus groups and surveys for exploring community perceptions and human resource capacities.

The following types of research are commonly used:

- Statistical analysis of health sensitivity to climatic conditions.
- Mathematical or statistical modelling of climate risk indicators and thresholds.
- Spatial or temporal risk modelling and mapping.
- Feasibility and readiness assessments of data or information systems.
- Qualitative study of population risk perceptions, behaviours, priorities, and practices.
- Operational or process research on health service delivery.
- Institutional and human resource capacity assessments.
- Assessment of adaptation options, including identification of climate information needs.
- Identification and development of appropriate communication strategies.



CHAPTER 5

CO-DEVELOPMENT AND DELIVERY OF HEALTH-TAILORED CLIMATE PRODUCTS AND SERVICES

GOAL: Collaboratively design and create tailored information products that are integrated and interoperable to user specifications, which provide decision-makers and communities with timely and relevant information to manage health risks specific to climate and weather.

Tailored climate products are most frequently the result of partnerships that process and present climate data or information, either alone or in combination with other types of data or information, in such a way that makes the information usable for a specific purpose. Climate services, on the other hand, refer to the needs-driven processes that bring about the production and delivery of climate information relevant for managing climate-sensitive health risks.

The transformation and translation of climate information products to useful tailored climate-informed health decision tools often involves the development of a combination of separate but interlinked products, which are needed to forecast health risks or produce early warnings. Each product must have a sufficient degree of quality, reliability, usability, suitability and responsiveness to changing needs. The degree to which these criteria are met determines how, and if, the information can be further applied, and whether health decision-makers will trust the information enough to use it confidently for decision-making. Health decision tools which use climate information to understand and predict health risks commonly fall into the following categories (figure 5.1) and present characteristic advantages and challenges (figure 5.2):

Figure 5.1
Common health tailored climate products

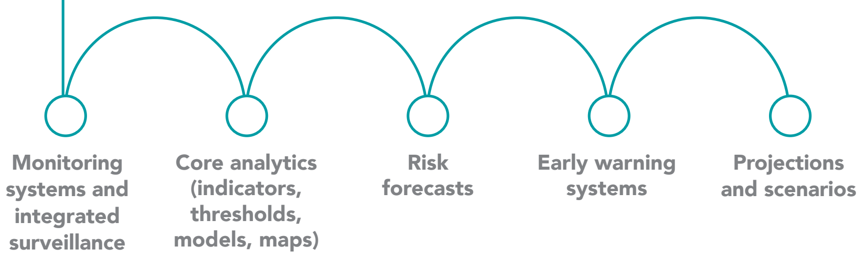


Figure 5.2 Advantages and challenges of the common health-tailored climate products.

Categories of tailored products	Example advantages	Example challenges
MONITORING SYSTEMS AND INTEGRATED SURVEILLANCE	Provide comprehensive and real time detection of health risks. Serve to trigger response plans. Facilitate data sharing and access for relevant stakeholders. Provide the basis for development of all other product categories.	Poor data quality, availability and interoperability across systems. Establishment of data sharing agreements between stakeholders. Effective links between monitoring activities and response plans.
CORE ANALYTICS	Enable dynamic characterization of health risks across space and time. Facilitate identification of vulnerable populations.	Lack of analytical capacity to calculate thresholds and develop risk models. Lack of fundamental research to inform the development of key analytics. Absence of standard indicator definitions. Limited availability of geo-coded information.
RISK FORECASTS	Anticipate the likelihood of when and where health impacts may occur. Provide extended lead time for preparedness.	Varied level of skill in weather and climate predictions across regions and seasons. Lack of sufficiently reliable and long data sets. Poor mechanistic understanding of health risk dynamics.
EARLY WARNING SYSTEMS (EWS)	Create awareness of prevention and preparedness needs and opportunities. Provide authoritative and continuous source of information to guide risk management.	Dependencies on quality of all the above product categories. Limited availability of robust thresholds to trigger warnings. Reliance on weather and climate forecasts with limited predictive ability. High levels of institutional commitment and capacity to sustain the EWS and respond to warnings.
PROJECTIONS AND SCENARIOS	Enable foresight of future risks and alternative futures to inform mid- and long-term decision making.	High levels of uncertainty in climate projections.

IMPORTANCE OF PRODUCT DEVELOPMENT AND DELIVERY FOR EFFECTIVE CLIMATE SERVICES

The technical development of tailored climate products and services is crucial. For product development and delivery to be effective, however, the activities conducted within the other five components must lead up to and support this stage.

Critically, almost all activities to develop health-tailored climate products and services must first begin with looking backwards and working with historical climate data to conduct a combined longitudinal analysis of epidemiological data (or a sensitivity analysis) to identify if climate signals exist, and can be further used to forecast or predict disease outbreaks or other health risks. Therefore, the data sharing policies for the access and use of national climate data should be immediately established as part of an enabling environment and in order to advance to developing applied services.

Both an enabling environment and sufficient capacity play a crucial role in ensuring the access, applicability and suitability of the climate products and service developed. Research findings are key to informing the necessary requirements and optimal conditions for further deployment. Evaluation will ensure that services meet the expected quality criteria, serve the functions they were designed for, and provide feedback from users to iteratively improve the product or service.

COMMON HEALTH-TAILORED PRODUCTS AND SERVICES

A range of decision tools can be developed to inform and bring insight to a vast range of health problems. Common types of health-tailored climate products are briefly explained below:

Monitoring systems and integrated surveillance are foundational elements for most climate products and services, necessary to collect, compare, and manage data. Technical data and software requirements vary according to the respective goals of each initiative. Data quality, availability and compatibility are common challenges, and innovative data collection or data preparation techniques are frequently needed to enhance, transform or blend data to be usable.

For example, to compensate for the lack of, poor quality, or poor coverage of climate and environmental observation and monitoring systems, techniques that blend local meteorological or environmental observations with remotely-sensed data are often used. Similarly, national health surveillance systems can be strengthened by integrating data sourced from sentinel sites, early disease detection or community-based disease surveillance systems in order to generate comprehensive datasets. Furthermore, in addition to climate and environmental variables, socioeconomic data or other data representing population vulnerability may also be needed for a more comprehensive understanding of the health problem.

Monitoring and integrated surveillance systems combine relevant health, climate and other socioeconomic data and are commonly presented through user-friendly interfaces that allow for data to be queried, visualized and downloaded according to desirable criteria (e.g. disease type, risk factors, time interval, future climate scenarios, etc.). To ensure these systems can support health decision inputs from the public health community, spatial and temporal data compatibility are essential. Health decisions are often made at a district/county level, requiring climate or weather forecasts, outlooks or projections to be downscaled to spatial units that are meaningful to health professionals. Climate and health data comparability can be increased when data is collected from meteorological and health stations located in close proximity.

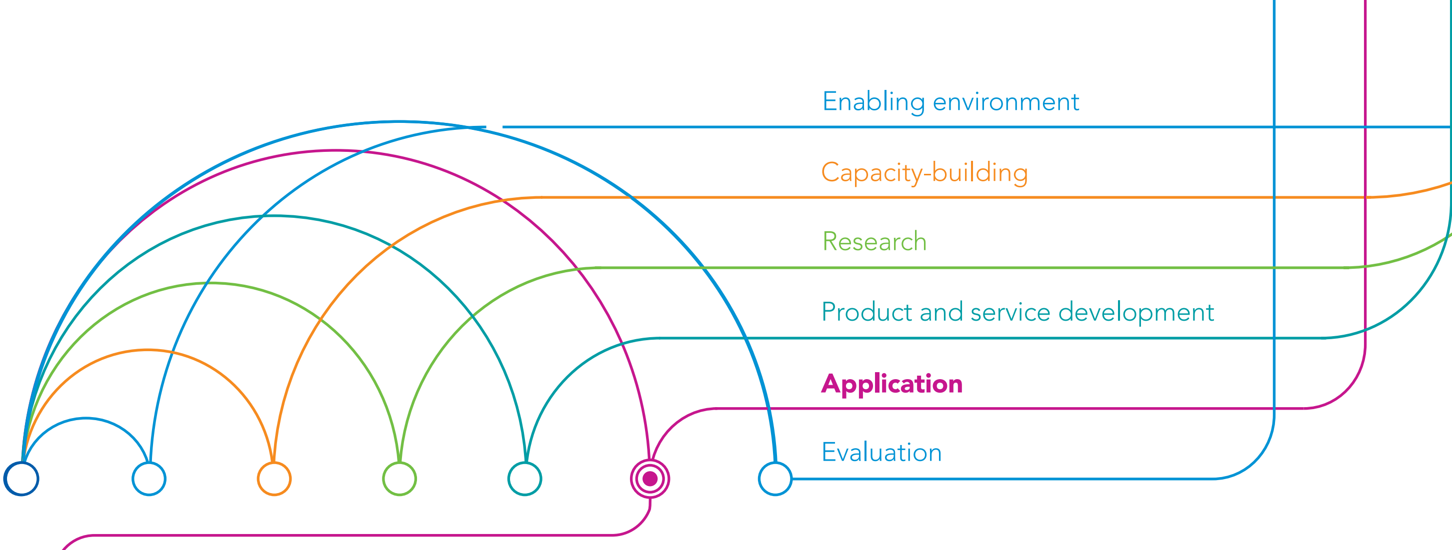
Core analytics including indicators, thresholds, models and maps are generated from descriptive and statistical analyses. Indicators and thresholds are typically numerical indices against which health risks or impacts can be measured. Choosing appropriate indicators and thresholds is vital for triggering health alerts, such as air pollution indicators or UV indices. While there are a wide variety of possible risk indicators that can be used, the main types of information used to construct such indicators are: climate or environmental hazard characteristics (such as severity, starting time, duration, etc.); climate and environment conditions (humidity, temperature, rainfall, etc.); population vulnerability and exposure factors (such as immunity, remoteness, malnutrition or poverty); and the socioeconomic context of a given population (such as conflict, agricultural practices or education level).

Risk models and maps help describe and illustrate the spatial and temporal dimensions of climate-related health risks to population health. Three main types of maps can support climate-smart health decision-making: 1) maps presenting the expected frequency of the climate hazards (e.g. expected number of extreme hot days); 2) maps presenting the environmental suitability for (infectious) disease transmission, based on climatic, environmental or ecosystem conditions (e.g. number of days exceeding a certain precipitation rate, altitude, land use, salinity, bird flight patterns, etc.); 3) maps illustrating the probabilistic likelihood of a subsequence (e.g. epidemic outbreaks), based on empirical or deterministic models of a specific disease's transmission.

Risk forecasts can be used to anticipate when and where climate conditions may increase the likelihood for health impacts to occur. These risks can be estimated by integrating forecasts of weather, climate and other relevant conditions at different timescales into mathematical or statistical disease transmission or incidence models. The risk management of diverse health hazards may require weather and climate forecasts with different lead times. For example, initiatives addressing community heat-related health risks may use local weather forecasts with lead times of several days to anticipate heat stress risks for specific populations. Long-term climate projections can help anticipate the number of extreme hot days populations may be exposed to in the future.

Early warning systems use risk forecasting and thresholds to alert health professionals as well as the public of rapid-onset emergencies such as extreme weather or disease outbreaks. They are important to provide communities and professionals additional lead time for preparing and responding to the event. Hazard and exposure thresholds are set at different levels of estimated risks to trigger appropriate actions. Communication strategies within these systems ensure the proper dissemination of warnings to health decision-makers, emergency response teams, communities and especially to vulnerable populations. Strategies to disseminate warnings include formal partnerships and communication exchange protocols with key stakeholders and the assessment of the most popular and effective communication channels (such as social media and instant messaging platforms, television, radio or websites) to reach out to the greatest possible number of community members.

Projections and scenarios are risk models that generate projections of health risks up to several decades into the future, and are commonly based upon IPCC climate change scenarios and regional climate change projections. Risk models can go beyond generating estimations of future health risks of diseases, to incorporate evaluations of the effectiveness of different adaptation strategies in accordance with different climate scenarios.



CHAPTER 6

APPLYING CLIMATE KNOWLEDGE TO PRACTICE

GOAL: Apply climate knowledge to bring benefits to individuals and communities.

The ultimate goal of developing tailored climate services is to apply the climate knowledge to answer a specific health question or provide a solution to a health risk management problem. Applying climate products and services bridges the gap between the largely theoretical research or development process and applying the outputs to real-world problems. The successful application of knowledge entails activities that help to appropriately communicate information, and work to integrate climate knowledge, decision-tools and information effectively within health decision-making and protection measures.

The scope of application is extensive. Relevant and tailored climate information is commonly used to enhance health decision tools, through the use of risk assessments, risk monitoring and disease surveillance; emergency response planning; health services planning and delivery; resource allocation; facilities siting and maintenance; evaluation of health interventions; health policy, standards and norms formulation; public safety advisories and community health education.

Steps to ensure resulting climate information and decision-tools are effectively applied and maintained must be intentionally incorporated into the process, starting at the very beginning of the project or partnership. In addition to products and services producing quality, reliable, usable, suitable and responsive information, the climate knowledge generated must be relevant, accessible, credible and sustainable over time. Projects that do not meet these criteria often result in unused or unsustainable products and wasted resources.

IMPORTANCE OF PRODUCT DEVELOPMENT AND DELIVERY FOR EFFECTIVE CLIMATE SERVICES

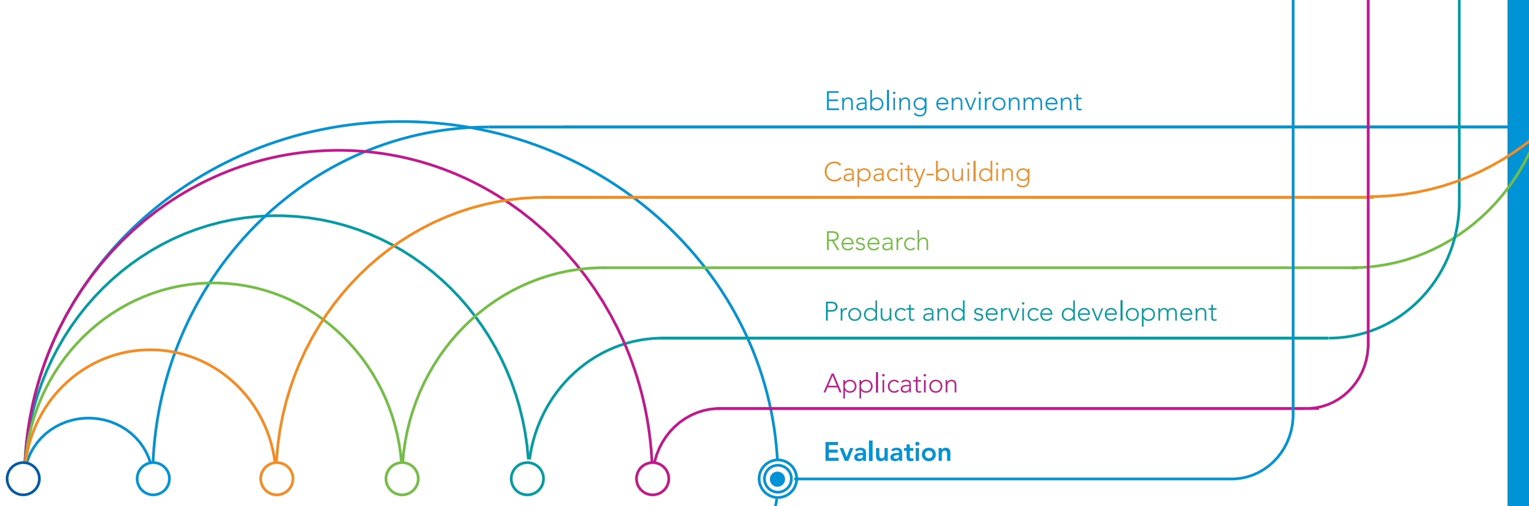
The application of a climate service will test whether other process components have been adequately met, such as if the user needs were clearly defined and whether adequate capacity was developed to ensure information is of high quality and is relevant to the last mile. Trialing the product in real time is also crucial for generating feedback on its performance and impact in order to make future investments or improvements.

Figure 6.1 Officer from the national meteorological and hydrological service introducing health officers to the Maprooms, a newly installed climate service in Malawi. Photo credit: Lucía Fernández Montoya.

COMMON APPROACHES

Several strategies can help operationalize and maintain climate services, as well as increase user appreciation and willingness among decision-makers to support and integrate such products and services. These strategies include:

- Mainstreaming partnerships and information products into health policies and programmes, by justifying the dependencies on climate information to improve health system performance and health outcomes.
- Jointly engaging ministries of health and national meteorological services to endorse, launch, and sponsor projects that establish the value of the climate service and increase its acceptance.
- Holding workshops to co-develop research and climate service features with national health authorities, to ensure that they are driven by national strategic health priorities.
- Providing open access to processed information and promoting available resources.
- Encouraging open discussion and feedback opportunities on climate products and services to increase understanding, ownership, and facilitating agreement on the essential climate service features, ensuring optimal fit-for-purpose and added value to health decision needs.
- Communicating local evidence of climate and weather impacts on community health, and highlighting climate-informed risk management opportunities.
- Pilot testing the service prior to extensive implementation.
- Providing decision-makers with hands-on exposure to prototypes or preliminary versions of the services.
- Increasing capacity among medical professionals and health decision-makers to value and use the information generated by the climate service.
- Supporting national agencies in technical implementation to address capacity gaps and maximize quality and reliability of information.
- Encouraging regional knowledge exchange to ensure local lessons are shared.
- Ensuring appropriate and adequate investment in communications and capacity-building of end-users and ultimate beneficiaries.
- Partnering with the media and use of social media and other communication technologies to conduct extensive communication campaigns.
- Holding evaluation meetings or using survey instruments to collectively evaluate and improve sub-optimal performing aspects of a service.
- Measuring and communicating the value and impact of using the climate information on health outcomes and health system performance.



CHAPTER 7

EVALUATION AND FEEDBACK TO IMPROVE HEALTH DECISION SUPPORT

GOAL: Provide evidence on the performance, effectiveness and cost-effectiveness of climate services to save lives and reduce climate health risks.

Measuring how well a climate service meets its intended goal and providing feedback on benefits, impacts, and user-satisfaction is extremely important to maintain and improve future services. Early in the development processes all stakeholders should be involved in discussing and agreeing on how to measure success and the methodologies that will be used for monitoring progress and collecting key information. Open discussion can help to ensure that all stakeholders participate in and become aware of the expected achievements.

An evaluation commonly assesses three aspects of a given climate service:

- performance of the products and services (such as its credibility, availability, reliability, usability, usefulness, suitability, responsiveness, sustainability and accessibility);
- effectiveness to have positive health impacts (such as its value to save lives and improve health outcomes);
- cost-effectiveness of the service in comparison to other alternative tools.

Other factors related to process undertaken and the adequacy of the enabling environment or capacity are also frequently measured, including community perceptions, institutional capacity and partnership efficacy, ethical dilemmas encountered, etc.

IMPORTANCE OF EVALUATION FOR EFFECTIVE CLIMATE SERVICES

Evaluation allows for the iterative feedback and improvement of the climate services, notably to generate evidence that can increase the level of trust of health decision-makers in the service, and identify good practices as well as limitations, barriers, and threats. Evaluation is a fundamental exercise that requires planning and coordination. When done properly, evaluation can reveal whether activities were sufficient and balanced to meet the service's goals. Active and transparent participation of all stakeholders is important to identify service strengths and weaknesses, detect potential risks to service provision or application, and to define strategies to improve the service. The results of an evaluation will, in turn, define the needs for specific activities that can reinforce and improve the application and effective functioning of the service.

COMMON APPROACHES

Evaluation approaches of climate products and services are often adapted from those used in public health to measure health system performance or health intervention efficacy. Important outcomes and impacts to evaluate include:

- increase in community protective behaviours;
- increase in human and institutional capacity;
- improvement in health service delivery;
- lives-saved;
- cost-effectiveness;
- improvements in timeliness, accuracy and credibility of decision-making;
- climate and health data availability at adequate spatial and temporal scale;
- climate service usability (user-friendliness);
- climate service sustainability.

CHAPTER 8

8

SOLUTIONS TO COMMON CLIMATE SERVICE CHALLENGES

Learning from the insights, tools and experiences of the global community of practice is extremely valuable to scaling up climate services for health, in the current absence of sufficient formal evaluations of climate service performance, process development and impacts. Review of the current case studies identified project teams frequently had to overcome five common challenges:

1. Working with available data to develop fit-for-purpose products and services;
2. Drawing upon and developing sufficient foundational capacities to support climate services;
3. Generating adequate demand and endorsement to mainstream climate service application;
4. Securing and sustaining sufficient financial and human resources;
5. Communicating climate information and risks effectively.

By learning from the solutions employed to address these challenges, other projects may be able to reduce or eliminate them in future initiatives.

CHALLENGE 1:

WORKING WITH AVAILABLE DATA TO DEVELOP FIT-FOR-PURPOSE PRODUCTS AND SERVICES

- Unaligned data collection spatial scales (climate data is collected at localized weather stations, health data is collected aggregated at different administrative levels).
- Gaps and inaccuracies in climate data due to poor coverage and quality of observation networks.
- Global climate products unable to provide quality data for all locations and climate variables.
- Unaligned data collection frequency (health data typically collected at weekly or monthly frequencies; climate data at hourly, daily frequency).
- User unfriendly data formats.
- Inconsistencies across data from different sources.

Fit-for-purpose products and services start with matching information to the spatial and temporal scales of decision-making. A range of challenges commonly arise while identifying, collecting, cleaning and preparing climate and health data to be interoperable and appropriate to the spatial and temporal time scales of decisions that need to be made. Spatial alignment is a challenge. Health decisions are most often made at the local level, such as the district or county level, down to specific point locations of health facilities and villages. However, climate observations are collected at specific stations which may and may not correspond to those locations and reflect the actual climate and weather conditions in the health catchment area; or data may be aggregated at broader spatial scales which can mask specific microclimates or conditions that are important to understand disease transmission. Spatial gaps and inaccuracies are often found in national climate data reflecting the status of the observational network. Global climate products can provide useful information at the national scale but, depending on the complexity of the local climate, they may not provide the quality of information needed for district-based health decision-making. Climate data should have both national coverage and local relevance to be useful for health research or planning.

Temporal alignment can also be a challenge. Environmental and climate global products are often disseminated at 10 day (dekadal) or monthly timescales. While the monthly time scale is a common time unit used in health decision-making, weekly data is preferred for epidemiological surveillance. Monthly averages for example may be of little use to understanding diseases that can be triggered in a matter of days. Hence, adjustments and transformations of climate observations often need to be made for it to be compatible to understanding the specific disease transmission or health risk conditions. The lack of customized data collection and formatting methods to meet the specific service needs was a key constraint for some projects. The mismatch of data collected from various sources, and the complexity of some data formats and archiving methods can often render existing data unusable and incompatible which block further advances to developing decision tools.

- Poor and discontinued access to climate observations.

Furthermore, access to the daily or hourly observational climate data which is most often required for establishing associations between climate conditions and health outcomes, remains limited by data dissemination policies of the national meteorological agencies in many countries. This occurs when authorities view observational data either as highly sensitive, an economic asset, or fail to understand the importance of daily values to developing climate services. As a consequence, data owners are often reluctant to provide raw observational data unless a clear value is shown for doing so and the conditions of data use are clearly documented. Where clear data exchange protocols have not been established, the regular and continuous access to observational climate data for risk monitoring and climate services can be interrupted or discontinued by personnel turn over, administrative changes that lead to changes in employees' responsibilities and roles, or policy changes.

SOLUTIONS

- Produce consistent and integrated datasets containing health and climate data in the shame time and spatial scales.

Some projects created new integrated datasets and systems that transform health and climate data to common time and spatial scales, thereby resolving data mismatches and gap problems. For example, the Enhanced National Climate Services Initiative is creating national climate products that are a blend of the best available global products and the national meteorological monitoring and archived data. Daily products under development in certain locations can be aggregated to weekly time scales that match surveillance data. Tools, such as the E3 geoportal and the International Research Institute for Climate and Society (IRI) Data Library, can be used to resample climate and health data to common time and space scales.

CHALLENGE 2:

DRAWING UPON AND DEVELOPING SUFFICIENT FOUNDATIONAL CAPACITIES TO SUPPORT CLIMATE SERVICES

- Limited capacity of both Meteorological Services and Health partners.
- Inability of core observation and surveillance systems to produce quality data at adequate scales.
- Lack of appropriate ICT infrastructure.
- Scientific limitations to the reliability of core climate products and services.
- Lack of human understanding of the limitation of climate products and services and health surveillance systems.

A range of core infrastructure, institutional, and human capacities are needed pre-requisites to co-produce and support tailored climate products and services. In many countries, limited capacity of both the National Meterological and Hydrological Service and health partners hinders the technical feasibility of developing fit-for-purpose products, and readiness to apply climate-informed decision tools and products. Experience has shown that availability and access to specific resources and capacities strongly influences the potential to develop viable and relevant climate-informed decision products and service.

Teams often reported being unable to meet project goals or develop a skilful product. Authors cited insufficient readiness and foundational prerequisites to develop climate services such as: inability of core information systems to produce adequate data (such as poor availability, quality, homogeneity and good spatial and temporal resolution, as well as coverage of data at local and regional level); lack of information communication technology infrastructure, such as internet access or sufficiently robust data management systems and analysis tools; scientific limitations of core products and services (such as inadequate forecast skill to be used for local decision-making); lack of understanding about the limitations across institutions; and lack of human capacity and experience to propose solutions to overcome these shortfalls.

Weak underlying capacity of core observational and data management systems (in both the health and climate fields) is a particular limitation in developing countries. The limited number, location and functioning of weather stations, non-digitized historical climate and health information records, inadequate data management systems, are commonly cited challenges to identifying and developing technically feasible and reliable analytical and forecast products. Data quality issues can also arise due to data collection, handling and storage methodologies. Understanding how data collection errors occur is critical to understanding how they might be removed. Within the health and climate communities, standard protocols exist that can help clean the data, which usually requires expert knowledge and awareness of appropriate methodologies.

CHALLENGE 3:

GENERATING ADEQUATE DEMAND AND ENDORSEMENT TO MAINSTREAM CLIMATE SERVICE APPLICATION

- Lack of experience using climate services and information as decision-making tools.
- Limited number of evaluations demonstrating the value and cost-benefit.
- Poor involvement of either health or climate authorities and lack of sufficient in-country coordination.
- Products and services developed that inadequately respond to operational health decision needs.

The difficulty of mainstreaming climate services as a consistent resource for health decision-making tools was a commonly cited challenge. This is often due to health decision-makers being unfamiliar with using climate information for health planning, tending to mistrust and undervalue non-health related information, or not understanding the uncertainty associated with climate-based disease forecasts. The limited number of evaluations demonstrating the value and cost-benefit of climate-informed health programming and policies remains a key hindrance to building strong business cases for mainstreaming climate services in the health sector.

Another barrier is the poor involvement of either health or climate authorities in the service development process. When academia led, it was sometimes difficult to engage and identify key decision-makers or professionals in the health and climate sectors. Without their engagement, misunderstandings can occur, leading to underestimating the value of climate knowledge, a diminished willingness to share data and information, and a poor sense of ownership. This ultimately results in products that do not meet the operational needs and in an inadequate response.

The lack of sufficient in-country coordination at the national, sub-national and local levels sometimes threatened the application of the climate services.

SOLUTIONS

- Establish multi-sectorial and multidisciplinary groups.
- Use academia and nongovernmental institutions as mediators, translators and knowledge brokers when needed.
- Communicate and establish dialogue with local expert climate science experts.
- Establish bilateral agreements and memoranda of understanding.
- Comply with data access and use policies.

In many case studies, multi-sectoral and multidisciplinary groups were created at the beginning of the process. These groups have often included researchers, public officers from the health and climate sectors, public officers from other sectors, and community leaders. The creation of these groups and their continuation along the entire service development and application process has shown many benefits. These groups allow for the identification of decision needs and the selection of the most appropriate service features to meet these needs; increases the sense of ownership; improves perceptions towards the value of climate services; builds capacity; and aligns stakeholders' objectives and expectations. The collaborative and communicative environment that the groups generate reinforces trust among stakeholders and facilitates the exchange of feedback at every step of the development process. Furthermore, diverse partners from academia or nongovernmental institutions can often be very constructive as mediators, knowledge brokers, and translators.

Communication and dialogue with local expert climate scientists about the products are essential to understand the reliability and uncertainty of probabilistic information products and how they should be used. Bilateral agreements and memoranda of understanding have been instrumental in facilitating access to data and defining respective roles and responsibilities in a mainstream service. Some case studies led to the improvement of national data exchange policies between partners and government agencies. The responsibility of researchers and project managers to fully comply with data access and use policies has been highlighted as a useful means to increase the level of trust and credibility.

CHALLENGE 4:

SECURING AND SUSTAINING SUFFICIENT FINANCIAL AND HUMAN RESOURCES

- Lack of sustained funding.
- Lack of human capacity.
- Lack of training opportunities.

Lack of sustained funding was a reported reason for the interruption of service provision, cancelled products or services, the inability to advance from product R&D to application, or the further tailoring or upgrading of products and services to maximize uptake. This particularly occurred in cases where the service was developed as part of an externally funded project. The lack of funding made it impossible to maintain the salaries of the trained personnel, train new human resources, support the continuous engagement of national or international experts and fund other running costs required to sustain the service. Similarly, insufficient access to training, and too few experienced and engaged staff to develop and use the product, slowed or hampered local progress.

SOLUTION

- Conduct cost-effectiveness and cost-benefit evaluations.
- Demonstrate benefits for health service provision and saving lives.
- Document public appreciation and value.

Research and evaluations are extremely important to generate adequate evidence, and to increase awareness about the value of tailored decision tools and climate services. In order to transition from project-based funding to leverage core budget resources (such as from ministries of health or vertical health programmes), some groups conducted cost-effectiveness or cost-benefit evaluations to strengthen the business case for the climate service. Strong arguments for mainstreaming climate-based information and services could be supported by showing how climate-informed decisions can improve health service provision, save lives through anticipated planning, and save costs to the health system. Furthermore, studies that document public appreciation and value for services – for example, that early warning and action systems make them feel safer and more aware of the action they should take to avoid harm – can be helpful in obtaining political and financial support to maintain and mainstream services, and to invest in core capacities such as improving data quality and availability.

- Build partnerships.
- Gain hands-on experience.
- Establish students and staff exchanges.
- Attend international training courses and seek placements and funding for masters and doctoral level studies.

The lack of local human resources is often tackled through building partnerships, either locally or internationally to supplement and diversify the available skills and experience needed. Many case studies involved multiple institutions, which often include international experts from a range of disciplines who provide access to required technical expertise. Hands-on experience working with experts is often the best way to build capacity; climate and health seminars and workshops, and specific analytical skill-based trainings were shown to be beneficial. Other approaches to capacity-building include longer student and staff exchanges, attending international training courses, and seeking placements and funding for masters and doctoral level studies.

CHALLENGE 5:

COMMUNICATING CLIMATE INFORMATION AND RISKS EFFECTIVELY

- Poor understanding of uncertainty.
- Lack of awareness on climate driven health risks.

Communicating uncertainty to decision-makers, clearly presenting interpretations of statistical or technical analyses, and explaining climate-driven health risks to non-technical audiences were frequently reported challenges. Some public warning systems were reportedly not used when local communities did not understand the risk warnings, value or trust the information, or have adequate information about the actions they should take when a warning was issued. The development of specific materials tailored to communicate with particular populations, such as vulnerable groups, was reported as essential for climate service messages to effectively reach communities.

- Better understand the local risk perceptions.
- Use modern communication technologies.
- Partner with local and global media.
- Include community representatives in service development processes.
- Engage communities in more effective health prevention and promotion.
- Present information in a visual and clear manner.

SOLUTION

To address this challenge, many case studies drew upon community-based surveys in order to better understand the local risk perceptions of target audiences, and to improve the effectiveness of public outreach strategies and messaging. The use of modern communication technologies (such as social media, text messages and web portals), the identification of community agents with the potential of acting as knowledge disseminators, and the design of population-specific communication strategies, can all help reach more individuals. Partnerships with local and global media (global TV channels and newspapers) have also been efficient in communicating messages on the presence or absence of disease risks, such as ahead of international mass gatherings that may affect international travel. The inclusion of community representatives in the development of communication materials is extremely important. Some projects consulted or included indigenous leaders or the elderly in the project development process, to ensure translation into local languages was appropriate and that messages were tailored appropriately. To engage communities in more effective health prevention and promotion, the use of narrative 'life stories' was shown to be helpful in translating relatively technical health data in ways that help communities better understand and contextualize risks. Furthermore, the effective use of data visualization in the form of well-designed maps, graphs, infographics and other figures can help information users and communities navigate and interpret complex information more easily.

CHAPTER 9

9

BENEFITS OF CLIMATE SERVICES TO HEALTH POLICY AND PROGRAMMING

KEY BENEFITS

Provide a more comprehensive understanding of immediate, short- and long-term health risks

Enhance integrated disease surveillance and monitoring systems

Provide tactical information to improve health service design and delivery

Provide health early warning systems

Help to increase community risk awareness

Inform mid- and long-term health sector adaptation planning

Support the evaluation of climate-sensitive health services and interventions

The case study experiences from around the world demonstrate the many advantages and benefits of enhancing traditional health information and decision tools with climate knowledge. Greater consideration of climate and meteorological information in health science, practice and policy-making can help the health sector better understand and document the influence of climate on health; anticipate who is at greatest risk of harm, when and where; and become better prepared to manage the impacts of increasing climate variability and longer-term climate change. The value of climate services are best measured in social and economic terms. Thus, users of climate services share the responsibility of evaluating and providing feedback to service providers on the measured value, effectiveness and utility of tailored climate products and services.

As a result of developing or using tailored climate services, most case studies reported stronger contacts and collaboration between the National Meteorological and Hydrological Service (NMHS) and health agencies, often bringing these partners together for the first time. Furthermore, to understand the complex interactions between health and climate, the relations and collaborations with other health-determining sectors also improved. For example in Hungary, collaboration was forged not only with the NMHS but with the agricultural sector to reduce pollen exposure, and in Brazil, partnership with the national water agency was needed to integrate river level information with national health surveillance data to comprehensively monitor risks for water-borne diseases.

Additionally, since neither epidemics nor climate zones are constrained within national borders, climate services are shown to help open doors to regional collaboration. In Peru and Ecuador, where intense commercial and touristic activity leads to high cross-border human mobility, the creation of a bi-national dengue surveillance network has promoted technical cooperation and is helping health authorities in both countries better understand and align control strategies on each side of the border in order to better manage disease risks.

Experience is showing that the use and application of tailored climate knowledge can:

PROVIDE A MORE COMPREHENSIVE UNDERSTANDING OF IMMEDIATE, SHORT- AND LONG-TERM HEALTH RISKS

Research and risk assessments can assist health professionals take more timely and appropriate preparedness and response actions to save lives. For example, in Uganda the climate-informed spatial risk model helped authorities better identify communities at high risk for plague, and scale up efforts to enhance early detection and referral. As a result, hundreds of additional patients received medical care at the closest clinic. In Brazil prior to the World Cup, dengue research models and forecasts using climate information informed a multilingual risk communication campaign for local communities and international visitors, and helped health authorities raise financial resources to scale up vector control in high-risk areas.

ENHANCE INTEGRATED DISEASE SURVEILLANCE AND MONITORING SYSTEMS

Climate-enhanced surveillance can improve the monitoring of climate conditions and climate-affected risk factors, and allow public health teams to take advantage of environmental signals to better detect and anticipate health risks. For example, the customized on-line integrated health surveillance databases developed in Europe, Brazil and Ethiopia allow health researchers and experts to monitor and analyse real-time environmental and climatic conditions for early disease detection and triggering health prevention. The European Environment and Epidemiology (E3) portal used in Europe tracks the environmental suitability of multiple diseases such as Vibrio cholera risk in the Baltic Sea, areas suitable for malaria transmission in Greece; and drivers of West Nile Virus in southeastern Europe. Similarly, the Brazilian Climate and Health Observatory helps to monitor, model and rapidly detect climate-related disease risks, such as increasing river levels and the risk of leptospirosis. In Ethiopia, the web-based processing and modelling system EPIDEMIA accelerates the rapid detection and forecasting of malaria epidemics.

PROVIDE TACTICAL INFORMATION TO IMPROVE HEALTH SERVICE DESIGN AND DELIVERY

Climate information can help hone in on high risk conditions and populations, as well as when health service delivery itself is hampered by climate conditions. Multiple projects demonstrate the strategic advantages, such as in London where analysis of the demand for emergency services in relation to heat and cold episodes demonstrates important fluctuations that inform management changes to improve emergency response services. In Hong Kong, climate information is used to design and provide highly tailored and personalized health care to the elderly during extreme heat episodes. In the Solomon Islands, customized rainfall outlooks used by the National Vector Control Programme improve planning of community awareness and vector control activities as well as more efficient allocation of diagnosis and treatment resources. In Burkina Faso, the national disease surveillance teams depend on a climate service to help predict meningitis incidence and plan responses for the upcoming epidemic season. Risk maps and advisories inform estimated needs for resource mobilization, the location and timing of awareness and vaccination campaigns, and the allocation of staff and health equipment. In Panama, a monthly bulletin predicting the *Aedes aegypti* infestation rates during the following three months is shared with the ministry of health, city mayors, researchers and national environmental authorities to raise awareness of climate risks for dengue, and is used by the vector control department to plan their activities.

PROVIDE HEALTH EARLY WARNING SYSTEMS

Timely advanced notice of dangerous weather and climate conditions can improve health emergency preparedness and response, save lives and reduce negative health impacts. In Ahmedabad, India, the creation of an early warning system and heat preparedness plan is increasing the resilience of the most at-risk residents to extreme temperatures. It has improved the capacity of health professionals to care for patients with heat-related illnesses, and has been demonstrated to reduce deaths during recent heat waves. A Heat Health Warning System in Quebec uses urban meteorological monitoring systems to design targeted intervention strategies to mitigate risks of heat stress on vulnerable populations in various urban sub-regions. Finally, also in Canada, ground-level monitoring of wildfire smoke and plume modelling provide forecasts of rural and urban areas that may be affected by poor air quality, and allow the Office of Disaster Management to protect communities in harm's way from the adverse health effects of wildfire smoke.

HELP TO INCREASE COMMUNITY RISK AWARENESS

Awareness is the trigger to encouraging protective behaviours and increasing autonomous adaptation and community capacity to respond to health risks. The case studies show risk communication is often part of more comprehensive risk management approaches, and is sometimes the central goal, particularly in reaching targeted vulnerable populations. This is the case of CcTalk in Austria, which developed communication materials on the impacts of excessive heat on health for the elderly and identified the most effective modes of communication to motivate protective behaviours. A project in eastern Africa used climate information to design community health-related contingency plans, educational materials and to inform community interventions on water and sanitation, hand-washing practices, kitchen utensil handling and pit latrine constructions, which were proven to reduce the level of community risk behaviours.

In Ecuador, diarrhoeal disease incidence data were transformed into 'life stories' (a compilation of the story behind a sentinel event) to help communities better understand and analyse the relation of diarrhoea in the community to rainfall and propose feasible solutions. In China, a heat wave warning system provides timely and tailored risk information to community health centres and triggers advisories and awareness to residents, especially vulnerable populations, via multiple means of communication (such as TV, mobile text, instant messaging groups and electronic display, newspapers and painting contests) to encourage and facilitate locally appropriate preventive actions.

INFORM MID- AND LONG-TERM HEALTH SECTOR ADAPTATION PLANNING

Climate projections can support health planners to imagine and understand future conditions. The national disaster risk reduction framework to drought management in Brazil is a good example. This was motivated by the observed severe health effects of past drought events, and concern about future projections in the different climate zones in the country. In Canada, the risk modelling framework for food and water safety provided projections of potential climate impacts on food and water safety up to 2100 and incorporated diverse scenarios of adaptation options. This approach helps decision-makers compare and select the most realistic mitigation and adaptation strategies across multiple diseases and commodities. In eastern Africa, a web-based mapping tool helps visualize current and future risks of malaria, schistosomiasis and Rift Valley fever at different time scales, along with a detailed analysis of long-term future disease risk. By providing the opportunity to disaggregate composite risk indicators, decision-makers can better understand the significance of individual risk factors, and decide where risk reduction investments may have the greatest protective value.

SUPPORT THE EVALUATION OF CLIMATE-SENSITIVE HEALTH SERVICES AND INTERVENTIONS

Climate services can be a critical asset to health professionals when evaluating the performance of health services and interventions that may be influenced by extreme weather, seasonal or inter-annual climate conditions. This benefit can be seen in Ethiopia where the influence of seasonal and long-term climate changes was included in the evaluation of the malaria control programme performance, and helped account for the potential confounding effects of climatic conditions on the observed efficacy of vector control interventions.

WORLD
METEOROLOGICAL
ORGANIZATION

World Health
Organization

JOINT OFFICE FOR CLIMATE AND HEALTH