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Adapting to climate-related health risks:

The economic case for climate services for health

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CONTENTS

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Executive Summary

Highlights

- This exploratory analysis estimates the economic value of climate services for health (CSfH), defined as producing and applying climate knowledge to enhance health decisions and services. It uses cost-benefit analysis (CBA) to model the effects of CSfH on reducing climate-related health impacts and costs.
- The estimated economic returns from investing in CSfH range from US$3.60 to $68.40 per dollar invested, reflecting modest funding requirements relative to the high value of lives saved. The wide range reflects different assumptions on risk, scale, and effectiveness. Returns remain strong even under worst-case assumptions.
- While priorities, capacities, and costs vary across countries, average CSfH investment needs for a median-sized developing country are estimated to be $12–$18 million per year.
- Only 23 percent of surveyed World Meteorological Organization (WMO) Member States integrate meteorological information into health surveillance systems, yet such integration helps decision-makers understand the type, location, and scale of health risks. Such information is important for addressing climate-related diseases, including malaria, dengue, cholera, diarrhea, and heatstroke—which disproportionately affect more vulnerable populations.
- Implementing CSfH activities is complex and interdisciplinary. They require improved capacities, leadership, and collaboration across hydrometeorological, health, planning, research, and other institutions.

Context

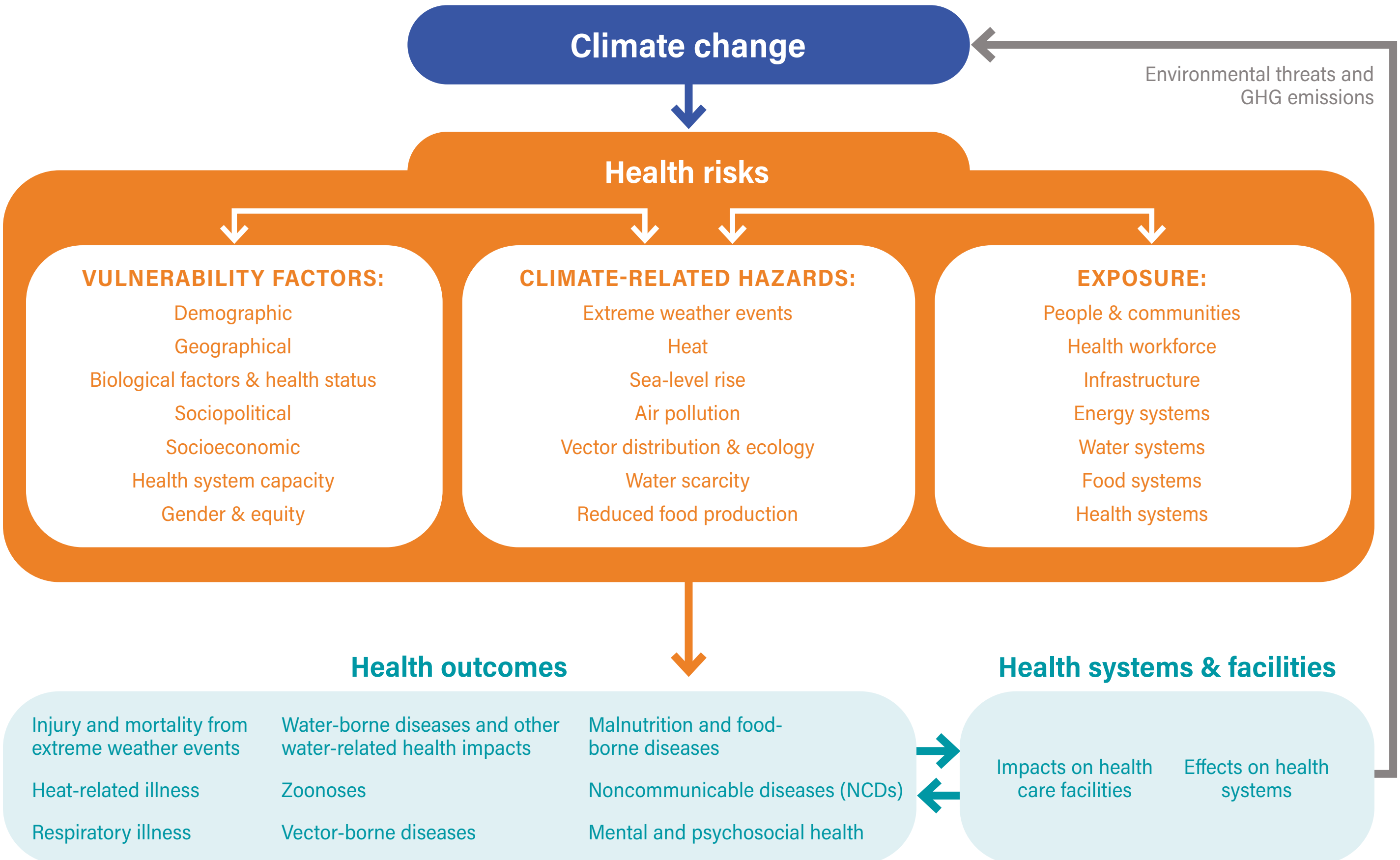
Countries increasingly recognize the negative impacts of climate change on health access and outcomes (WHO 2023b). Floods, droughts, extreme heat, and other climate-related impacts exacerbate existing disease burdens such as cholera, malaria, and heat-related illnesses and mortality (Figure ES-1) (Pörtner et al. 2022; WHO 2023a; Willetts and Campbell-Lendrum 2022), undermining the social determinants of good health by threatening nutrition, livelihoods, and access to health care (WHO 2023a). As climate-related health risks increase with global average temperatures, all 59 national adaptation plans (NAPs) submitted to the United Nations Framework Convention on Climate Change from 2021 to 2024 identify the health sector as vulnerable to climate change, and 90 percent include at least one health adaptation action (WHO 2025). Yet only 41 percent of NAPs and 48 percent of health national adaptation plans estimate the required financial resources to implement health adaptation measures (WHO 2025).

CSfH refer to the iterative, collaborative, and cross-disciplinary process to generate and build capacity to access, develop, deliver, and apply climate knowledge to enhance health decisions and services and ultimately health outcomes (Shumake-Guillemot and Fernandez-Montoya 2019; WMO 2023). They help public and private decision-makers understand how climate change will influence the seasonality, geography, and magnitude of climate-sensitive diseases; damage public health infrastructure; and undermine access to public health services. CSfH play an important role in building the resilience of health systems in a changing climate.

CSfH investments can enable decision-makers to understand and adapt to climate-related health risks, but their uptake is limited. While 81 percent of the national meteorological and hydrological agencies (NMHAs) of WMO Member States self-report providing climate services for the health sector (WMO 2023), only 23 percent of 101 ministries of health surveyed by the World Health Organization report having national health surveillance systems that include meteorological information (WHO 2021b).

This analysis supports global efforts to scale up CSfH development and application by strengthening their investment case. There is extensive literature on how climate change influences health outcomes (Pörtner et al. 2022; Romanello et al. 2024; WHO 2023b; World Bank 2024d), yet specific economic analysis of the costs and benefits of investing in CSfH remains underexplored. Insufficient financing for CSfH may be due to this gap in understanding—a gap that this study addresses.

Figure ES-1 | **Exposure pathways and vulnerability factors for climate-sensitive health risks**



Note: GHG = greenhouse gas.
Source: WHO 2023a.

About this paper

This study estimates the economic value of investing in CSfH in a developing country context. It focuses on developing countries—defined as low- and middle-income countries—given their comparatively higher vulnerability to climate change (World Bank 2024d). The study includes countries based on the public availability of information on climate-related health and adaptation investments. Its target audience includes health and finance ministries, NMHAs, and donors involved in CSfH funding decisions. More specifically, this paper seeks to inform practitioners of the high returns to investing in CSfH, thereby allowing more informed comparisons with other investment options.

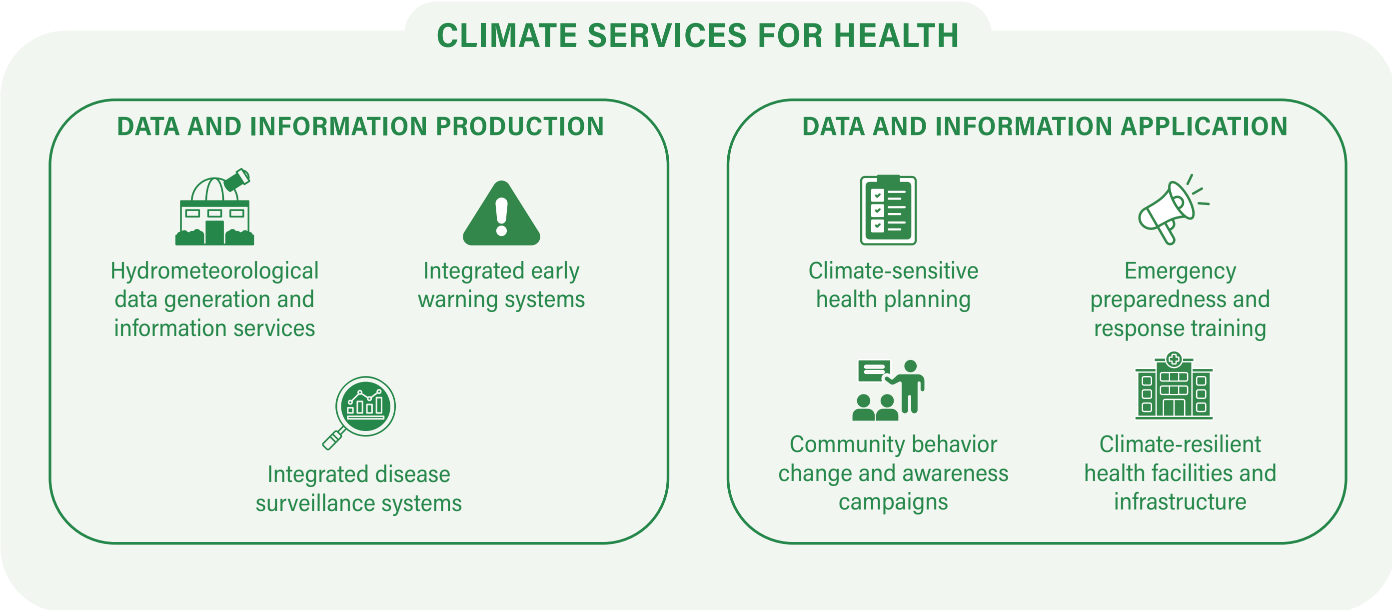
The findings are based on a CBA of CSfH investments drawing from an exploratory literature review of real-world investments and projections of climate-related health impacts. It creates a working definition of CSfH activities and estimates their costs by analyzing donor-funded investments in developing countries. The country sample includes 40 low- and middle-income countries representing 38 percent of 2025 global population and 8 percent of 2024 global gross domestic product (GDP). On the benefit side, it explores available case studies on the impact, measured or projected, of climate change on disease burdens. The climate health projections draw from 24 studies ranging from country-specific to regional and global analyses. We compare the estimated costs of CSfH investments with their marginal estimated benefits based on disability-adjusted life years (DALYs) and the value of statistical lives saved. The analysis aggregates projected climate-related health impacts across all developing countries for malaria, dengue, cholera, diarrhea, and heat-related diseases.

The findings are exploratory and approximate given the need for broad assumptions due to future uncertainty and data gaps. However, the results consistently indicate the potential for high economic returns based on improved understanding, analysis, planning, and health sector resilience needed to better address climate-related health risks.

Key findings

- **Based on an exploratory literature review, a working definition of CSfH includes seven activities supporting both the production and application of improved knowledge**. They are collaborative, multidisciplinary processes that include hydrometeorological services, climate-sensitive health planning, disease surveillance, emergency preparedness, early warning systems, public awareness campaigns, and climate-resilient health facilities (Figure ES-2). By helping identify climate-related health risks and vulnerabilities, CSfH support better health policies and regulations, disease monitoring and surveillance, pharmaceutical supply chains, and health infrastructure (Shumake-Guillemot and Fernandez-Montoya 2019).
- **Insufficient funding is a key barrier for CSfH, as funding is required for the staff, equipment, and capacity-building needed to foster collaboration across institutions and sectors.** Ministries of health, for example, report that CSfH activities are the most underfunded and difficult to implement (WMO and WHO 2023), with few having health surveillance systems that integrate meteorological information (WMO 2023). NMHAs also often report a lack of funding to collaborate with health agencies (WMO 2023). This gap could be due to limited understanding of the scope, costs, and benefits of CSfH activities, including a current lack of impact evaluations illustrating those benefits.
- **Strengthening CSfH within a developing country context may only require a relatively modest level of investment.** A review of 46 World Bank project appraisal documents shows that the estimated national-level cost of all seven identified CSfH activities are approximately $18 million per year, although countries were not found to have implemented all seven. The estimated costs for particular CSfH activities range from $1.4 to $5.9 million per year. CSfH activities that support planning, capacity-building, and community behavior and awareness campaigns require the least investment, whereas building resilient health facilities and infrastructure requires relatively more.
- **Investments in CSfH are bookended by complementary investments in upstream climate services that collect and share basic climate and weather data with all sectors, including agriculture, water, and cities, as well as downstream investments in on-the-ground health services.** Data show that these investments also have very high economic rates of return, supporting the hypothesis that investments in the entire climate services and health services value chain is highly economically viable, and CSfH is an integral part.

Figure ES-2 | **CSfH activities**



Source: WRI authors.

- **This exploratory analysis suggests that investing in CSfH could generate very high economic returns, with benefits ranging from 3.6 to almost 70.0 times the cost of investment.** This is because CSfH costs are modest compared to their modeled impact on the high value of lives saved and illnesses avoided. These benefit-cost ratios are presented as ranges since they vary in practice depending on a country's costs, capacity, implementation success, and climate trends.
- **The estimated high returns on CSfH investments could help countries attract the finance needed to implement the climate and health priorities identified in their NAPs and nationally determined contributions.** Our findings also provide strong economic evidence supporting key priorities in important recent climate-and-health strategies. For example, the Belém Health Action Plan orients its first two out of three priorities around "surveillance and monitoring" and "evidence-based policies, strategies, and capacity-building" (Government of Brazil 2025a). These key priorities support CSfH as defined in this paper. A recent strategy developed by the Alliance for Transformative Action on Climate and Health highlights eight high-value actions for health sector adaptation, and four fall under the CSfH umbrella (World Bank et al. 2025).
- **Further research could help countries apply these findings to their climate and health decision-making.** Deeper analysis of the costs, benefits, and impact pathways associated with each of the seven identified types of CSfH could improve country priority setting. Further analyses of the institutional, technical, and financial challenges in implementing CSfH are needed.
- **Implementing CSfH is complex.** CSfH are interdisciplinary and the work entailed spans across agencies. They require close collaboration between NMHAs and health agencies, which rarely work together. Without increased investment in CSfH and better evaluation frameworks and data to assess their impact, developing countries will miss high-return opportunities for improving their health system effectiveness and the health outcomes of vulnerable populations amid a changing climate.

Introduction

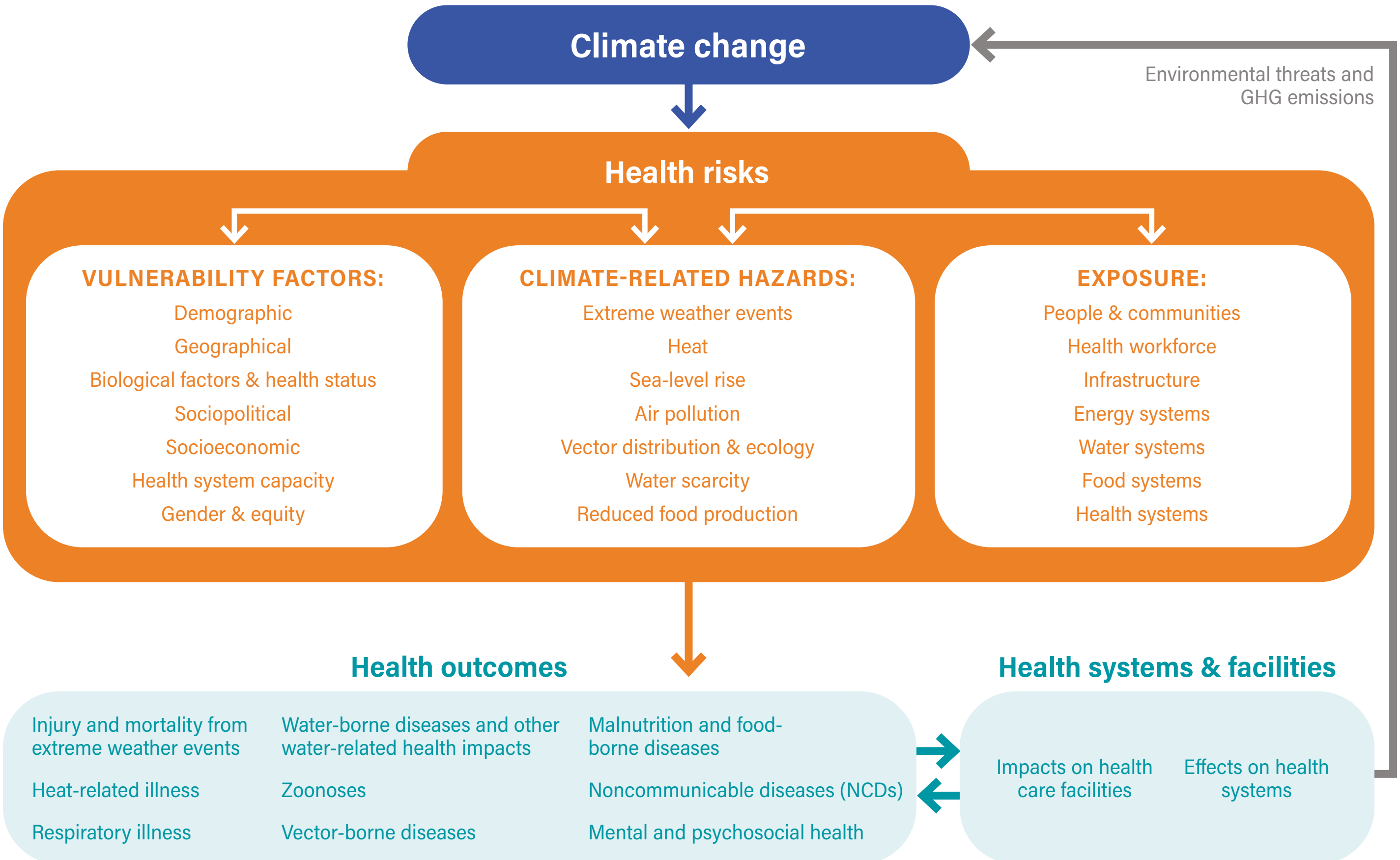
Climate change poses one of the largest global health threats this century (Romanello et al. 2024; von Hammerstein et al. 2024). Floods, droughts, and other climate-related impacts negatively affect health outcomes by exacerbating existing disease burdens such as heat-related illnesses, respiratory illnesses, dengue, malaria, cholera, mental stress, and malnutrition (Pörtner et al. 2022; WHO 2023a; Willetts and Campbell-Lendrum 2022). Climate change also undermines the social determinants of good health by threatening livelihoods and access to health care (WHO 2023a), including damaging health infrastructure. Climate change impacts, including those related to health, disproportionately affect people facing poverty, those with illnesses or disabilities, women, children, and the elderly (Tye and Waslander 2021). Figure 1 summarizes the exposure pathways and vulnerability factors for climate-sensitive health risks.

Projected climate-related health impacts are significant and uneven across countries and income levels. Between 2026 and 2050, climate change is projected to cause 4.1–5.2 billion morbidity cases and 14.5–15.6 million deaths in low- and middle-income countries under intermediate and high future warming scenarios, respectively (World Bank 2024d). The economic costs of climate-related health impacts are estimated to be US$20.8 trillion or 1.3 percent of gross domestic product (GDP) across low- and middle-income countries by 2050 (World Bank 2024b). Low- and middle-income countries are more vulnerable to climate-related health impacts due to higher poverty rates and weaker health care systems compared to higher-income countries (WHO 2023b).

Climate-related health impacts vary across regions. Sub-Saharan Africa is projected to experience approximately 71 percent of all morbidity cases and nearly one-half of all climate-related deaths between 2026 and 2050, and South Asia is expected to experience 18 percent of all cases and one-quarter of all deaths (World Bank 2024b). Latin America is particularly sensitive to dengue, chikungunya, and zika virus; reported cases have nearly doubled between 2022 and 2023, with the highest figure reported in Brazil (Caballero et al. 2025).

Health systems must account for both shifting disease burdens and the resilience of health facilities and infrastructure. Integrated risk monitoring, early warning systems (EWS), research and assessments that integrate climate change and health, health-informed workforces, and resilient health infrastructure are therefore among the building blocks of climate-resilient health systems (WHO 2015).

Figure 1 | **Exposure pathways and vulnerability factors for climate-sensitive health risks**



Note: GHG = greenhouse gas.
Source: WHO 2023a.

Climate services for health (CSfH) help agencies anticipate, manage, and adapt to climate-related health risks. CSfH refer to the iterative, collaborative, and cross-disciplinary process to generate and build capacity to access, develop, deliver, and apply climate knowledge to enhance health decisions and services (Shumake-Guillemot and Fernandez-Montoya 2019; WMO 2023). Improving the development, quality, and uptake of CSfH is essential to ensuring that the type, location, and magnitude of climate-related health risks are fully understood and considered in defining and funding adaptation priorities (Shumake-Guillemot and Fernandez-Montoya 2019).

CSfH involve collaboration across diverse actors, including NMHAs, health ministries, research institutions, and communities, among others (Figure 2). In Colombia, for example, the National Health Institute; the Institute of Hydrology, Meteorology and Environmental Studies; and the Ministry of Health and Social Protection jointly developed a climate and health bulletin that provides subnational health bureaus with recommendations based on climatic and epidemiological predictions (WMO 2023). Argentina's EWS for extreme temperatures relies on collaboration between the National Meteorological Service and Ministry of Health, which issue weather alerts and health care recommendations, respectively (WMO 2023).

Figure 2 | **Actors often involved in producing and applying CSfH**

- **Health sector**
- **Research institutions**
- **Funders/investors**
- **Private sector and industry**
- **Climate and meteorological organizations**
- **Regional and local organizations (NGOs, IGOs, nonprofits)**
- **Local communities and civil society**
- **Media and communication**

Notes: IGO = intergovernmental organization. NGO = nongovernmental organization.
Source: Diaz et al. 2024.

While the ultimate responsibility for health sector planning resides at the national level of each country, CSfH also benefit from a global network of collaborators spanning health, hydrometeorology, and climate. For example, with support from the Pan American Health Organization (PAHO) and the World Health Organization (WHO), the government of Belize identified five vulnerable health facilities using PAHO's Smart Hospitals Toolkit, which includes climate risk assessments. It improved their climate resilience by installing rainwater harvesting and storage tanks, more resilient windows and shutters to withstand hurricanes, and photovoltaic power systems (PAHO and WHO 2019; WHO 2022). When Hurricane Lisa damaged Belize's housing sector (by an estimated $10 million) in 2022, the five participating hospitals remained operational without disruption to critical services (WMO 2023).

CSfH are an essential middle step between generating climate data and information, typically led by NMHAs, and planning and delivering public health services by a country's health system. Ideally, the actors in this process would be well integrated; in reality, however, collaboration is institutionally difficult and not the norm (Martins 2024). NMHAs are not typically qualified to do health sector modeling, just as staff within health agencies lack capacity for weather and climate modeling. Coproducing CSfH by diverse actors expands available expertise and knowledge and can support decision-making under uncertainty (Shumake-Guillemot and Fernandez-Montoya 2019).

The demand for climate information, data, and knowledge will grow as countries grapple with adapting their health systems to increasingly severe and frequent climate impacts. While countries conduct valuable upstream analyses, such as health national adaptation plans and vulnerability assessments, there are few rigorous analyses of the economic value of national investments in CSfH (examples are given in Table 5 in the "Findings" section). Insufficient funding for CSfH may be attributable in part to this gap in understanding (WMO and WHO 2023). This study helps to fill this knowledge gap by estimating the costs and benefits of investing in CSfH in a developing country context.

The study focuses solely on upstream investments in CSfH. It does not examine the economic returns to, nor cost-effectiveness of, medical treatments for climate-related health impacts. It also excludes analysis of the benefits of addressing climate-related health impacts through pathways in other sectors, such as improving water management, agriculture resilience, or urban heat, even though these interventions are important entry points for reducing climate-related health impacts.

Methodology

This exploratory study assesses the economics of CSfH. It defines specific CSfH activities by applying existing definitions to a review of real-world investments and then applies a cost-benefit analysis (CBA) to estimate a range of economic values created by investing in those CSfH activities.

CSfH in practice

We derived a working definition of CSfH based on an exploratory literature review of CSfH in practice. Literature was first sourced from this study's steering committee, consisting of academics, policymakers, and practitioners spanning climate change, health, and hydrometeorology. The review included 42 academic and gray sources published between 2015 and 2024 and covering topics ranging from the impacts of climate change on health to the economic value of weather and climate information services. We also reviewed relevant references included in these recommended sources. Based on this review, we developed a working definition of CSfH.

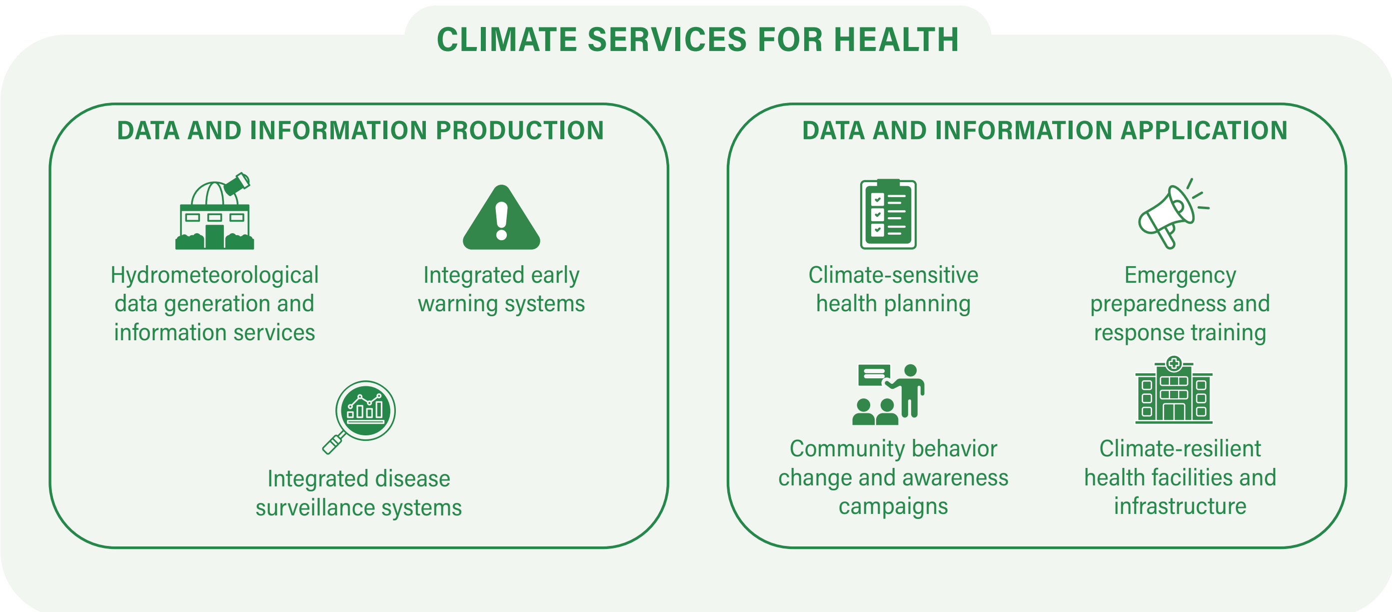
We then applied this working definition to a review of real-world health and hydrometeorology investments to identify more specific CSfH activities. We reviewed 79 health and hydrometeorological projects with adaptation cobenefits cofinanced by the World Bank since 2017. World Bank projects were reviewed due to their strong health sector involvement, regional breadth, project transparency, and local costing in appraisals. Project data were sourced from the publicly available operations database (World Bank n.d.c).

Activities supporting the production and/or application of CSfH were included in 46 of the 79 projects. Their activities were grouped into seven activity clusters (Figure 3 and Table 1). The resulting sample included 40 low- and middle-income countries representing 38 percent of the global population (World Population Review 2025) and 8 percent of global GDP (World Bank n.d.a), with a median population of 21.5 million people. Appendix A summarizes country investments in each CSfH activity type.

Estimating the costs of CSfH

The estimated costs of investing in CSfH are based on the budgets for those World Bank projects, representing project cost estimates developed by recipient country governments. Across the 46 projects, we averaged and annualized the budgeted costs of each activity across countries, assuming a five-year implementation timeline (which is typical of World

Figure 3 | **CSfH activities**



Source: WRI authors.

Bank–financed projects). To supplement and validate the project cost estimates, we also reviewed available national budgets of the same recipient countries (see Table 4 in "Findings").

Using available budget data, we did not find that CSfH investment costs increased on a linear basis with country populations. There is likely to be a large share of centralized costs supporting basic CSfH. Therefore, the projected CSfH costs are standardized on a country size of 25 million people, which is the median size of developing countries and close to the median size of the country sample for CSfH costs.

Estimating the benefits of CSfH

Estimating the benefits associated with investments in CSfH is less straightforward than estimating their costs. Impacts are highly approximate and location specific, and they involve nonmarket socioeconomic variables such as the value of a statistical life (VSL). Country-level data are lacking for both the level of CSfH implementation and projected climate-related health impacts. It is not currently possible to directly measure the aggregate benefits of improved CSfH in any one country, much less across all developing countries. To address these challenges, we used two complementary approaches to estimate the economic benefits of CSfH investments: an exploratory literature review and a global CBA based on varying cost-and-benefit scenarios.

In the first approach, we reviewed case studies evaluating the benefits of CSfH (see Table 5 for studies and Appendix D for search terms). The review revealed that very few published case studies exist that document the economic benefits of CSfH. While the literature is growing, evidence is limited to evaluating specific interventions, such as disease-specific surveillance or EWS. These studies cannot be directly compared given their different scopes, time frames, and methodologies. The literature review primarily served to justify the need for a more systematic and quantitative CBA across all CSfH benefits.

The second approach involved estimating the total economic cost associated with climate-related health impacts. We then imposed scenarios modeling the extent to which CSfH could reduce those costs. These were three steps taken to complete this analysis:

1. Approximate the total economic value of negative climate-related health impacts across developing countries. We extrapolated health costs from 21 studies that quantified the projected impact of climate change on malaria, dengue, diarrhea, cholera, and heat in developing countries (Appendix B). Appendix B also cites studies of the impact of climate change on malnutrition. Although extremely important, malnutrition is a complex and multisectoral problem for which DALYs are not available to the extent they are for other diseases.

   Although the studies cited in Appendix B are all disease specific, they cover different geographies and time frames. For example, some studies might be for one country and others for an entire region or all developing countries; likewise, some studies might project impacts to 2030, whereas others project impacts to 2050 or beyond. Aggregating the projections across all diseases and geographies for the year 2030 required assumptions described in Appendix C. This standardization process was necessary to compare the projected benefits of investing in improved CSfH with the estimated costs.

2. Estimate the global impacts that could be attributed to improved CSfH by assuming a small, nonnegative improvement in health service effectiveness. The measure used for improved effectiveness is the economic value of a projected reduction in DALYs. As explained in Box 1, we hypothesize a range of improved health outcomes due to CSfH at the very low level of 2 percent gains. It is highly unlikely that CSfH investments would lead to zero improvements in health outcomes and even less likely that there would be a negative impact. As part of sensitivity analysis, we also modeled a 5 percent reduction in DALYs due to CSfH.

3. Estimate the benefit-cost ratios (BCRs) for developing country investments in CSfH. Based on the above CSfH cost estimates, we assumed average investment levels of $12 million (lower bound) and $18 million (upper bound) for a median-sized developing country of 25 million people. The upper bound figure assumes a country invested in all seven CSfH activities. The lower bound figure assumes a country invested at only two-thirds of this level; this is based on countries investing, on average, only a few of the seven CSfH activities in the 46 reviewed projects. This approach shows that if even modest projected benefits of CSfH investments show high rates of return, then CSfH investments would be economically justified. Additional discussion is provided in the "Limitations" section below.

The CBA estimates the return on generic CSfH improvements only. Analysis did not project a rate of return for any specific CSfH activity because the CBA approach does not disaggregate between the seven CSfH activity types. It is not prescriptive; it does not recommend either specific CSfH priorities or the precise level of investment required for any given country. That determination depends on the local context, climate-related health risks, and institutional capacity needs—and need to be determined locally.

Box 1 | **Defining improved health service effectiveness due to climate services for health**

At the simplest level, health agencies can treat *X* number of people with a *Y* percent success rate at *Z* cost per person. If they do their job more effectively, for the same cost they can either treat more people (i.e., increase *X*), improve patient outcomes (increase *Y*), and/or reduce per-patient costs (lower *Z*). All three measures are quantifiable indicators of an increase in health service effectiveness.

In the case of investing in climate services for health (CSfH), where might positive changes in *X*, *Y*, and *Z* come from? Better climate data could allow health agencies to plan for, train, equip, build public awareness, and target their resources better. They will better understand how many people might be affected by a particular climate-related disease (e.g., malaria), when, and where. The upstream analytics that underlie climate-informed health services will improve vulnerability analysis; proactive risk reduction; disease control strategies; health policy and regulations; disease monitoring and surveillance; financial and human resource allocation; pharmaceutical, health, pesticide, and vaccine supply flow; and health infrastructure siting and maintenance.[a]

There is little empirical data directly linking the seven identified CSfH activities to impact on the ground. Between the CSfH themselves, and health outcomes, there is high uncertainty, such as questions about their uptake, the current geographic range and incidence of climate-related diseases, the magnitude or complexity of incremental projected climate impacts, the level of staff capacity in the various relevant agencies, and the quality of institutional leadership to foster collaboration across agencies.[b] While the conceptual pathway from each CSfH activity to impact is clear, the methodology for measurement in a given country is not.

This study assumes very modest levels of improved effectiveness. If countries start improving CSfH in 2025, the impact on the ground in terms of *X, Y,* or *Z* should be positive but still small by 2030. For scenario-building purposes, we assume a range, starting at the very low level of 2 percent efficiency gains. It is unlikely that CSfH investment will have either zero or negative impacts on health service effectiveness, so a 2 percent gain is almost as low as one can go. For sensitivity analysis, at the higher end, we assume 5 percent gains, which may still be conservative given the multiple identified pathways by which CSfH can improve health outcomes. Additional empirical analysis is needed to better understand the impact of CSfH as modeled in terms of reduced disability-adjusted life years.

Sources: a. WMO 2023. b. Martins et al. 2024.

Limitations

This study's methodology and subsequent findings face limitations. Publicly available evaluations of the costs and economic benefits of investing in CSfH are scarce. While there are many studies on the benefits of investing in meteorological, climate, and health services (Box 2), we found no study that analyzed the value of investing across the full spectrum of CSfH activities. Therefore, for this analysis we defined CSfH as a set of seven activities. Large data gaps—on the side of both costs and benefits—means that this analysis is exploratory and approximate.

On the cost side, this study only provides average upper-bound cost estimates for each CSfH activity due to the limited granularity of available data. Project-level cost data were most frequently provided for a bundle of activities that included—but was not limited to—one or more CSfH activities. The result is that we were largely unable to determine the project-level cost for a particular CSfH activity and instead documented the cost for the entire bundle of activities, regardless of the number of activities included. The benefit side had different data limitations. The literature review on specific CSfH activities for specific diseases in specific countries revealed that the literature is extremely thin. This paper makes no attempt to generalize from this literature and merely presents a few studies as examples of CSfH investments with different levels of economic analysis.

We draw from current research on future DALYs associated with climate change to estimate the cost of future climate-related health impacts. Yet the state of research for this is also preliminary. One meta-analysis found that only 10 out of 4,500 identified articles—mostly from Brazil and Mexico—met the study's inclusion criteria, and only four articles explicitly estimated economic costs (Caballero et al. 2025). Another study noted that available evidence is limited to a small set of countries or regional analyses and highlighted the need to analyze the cost-effectiveness of policies aimed at coping with and adapting to climate-related health impacts (Helo Sarmiento et al. 2023). Finally, as acknowledged above, this study excludes health costs associated with malnutrition and mental health, which may be significant sources of higher benefits from investing in CSfH.

The result is that the global CBA uses a high level of aggregated benefits, simplifying assumptions (Appendix C) and sensitivity analysis given the high uncertainty. The study also is conservative in modeling the projected benefits of CSfH investments. Nevertheless, the findings are intended to contribute to the current limited literature on CSfH.

Box 2 | **Investments in improved climate services and health services indicate high returns**

This box summarizes what is known about the rates of return of two types of investments that are complementary to, but distinct from, climate services for health (CSfH). They are investments in general climate services that support users across multiple sectors (i.e., agriculture, water, and infrastructure) and investments in actual health services that address climate adaptation activities as a secondary objective. These two types of investment bookend CSfH because they are upstream and downstream of CSfH. Data showing high rates of return for both support this study's hypothesis that investment in the entire climate-and-health services value chain is highly economically viable.

The benefits of investing in climate services, primarily by hydrometeorological agencies, are well-known. The Global Commission on Adaptation found that investing US$1 in strengthening early warning systems (EWS) returns over $9 on average over a 10-year period.[a] The World Meteorological Organization compiled economic analyses of meteorological and hydrological services across sectors and geographic regions, showing average BCRs for EWS ranging from 3.4 to 10.5.[b] Weather and Climate Information Services for Africa (WISER)—a program funded by the United Kingdom's Foreign, Commonwealth and Development Office and managed by the Met Office from 2015 to 2021—yielded diverse socioeconomic benefits, including reduced fatalities, increased incomes, and improved savings with estimated BCRs across eight WISER projects ranging from 7:1 to 26:1.[c]

Investments in health services addressing climate impacts also show high rates of return. The 74 World Bank health investments with adaptation cobenefits reviewed by this study have an average economic internal rate of return (EIRR) of 74 percent. This is exceedingly high, as the typical minimum threshold typically required by multilateral development banks is only 12 percent. (The median EIRR for all World Bank projects between 1980 and 2004 was 15 percent; the median EIRR for health and nutrition projects was 21 percent.[d]) In comparison, median EIRRs were 30 percent for private sector development projects, 19 percent for education projects, 14 percent for rural development projects, and 9 percent for water supply and sanitation projects.

A previous World Resources Institute analysis of 320 donor-financed climate adaptation investments across the health, agriculture, water, and infrastructure sectors also found that health sector adaptation investments were the highest across all four sectors. Health projects with climate adaptation components had average EIRRs of 79 percent, about three times the average economic returns of projects in the other sectors.[e] These high rates of return are attributed to the far higher value of the avoided loss of life compared to the relatively low cost of expanded health services.

Sources:
a. Global Commission on Adaptation 2019
b. WMO 2015
c. Watkiss and Cimato 2021
d. Herrera 2005
e. Brandon et al. 2025

Findings

Producing and applying CSfH

As defined in this study, CSfH can range from the exchange of health and climate data between ministries of health and NMHAs to developing and managing multihazard surveillance or EWS that integrate climate and health data and information (Shumake-Guillemot and Fernandez-Montoya 2019). In terms of benefits, CSfH can help to better identify climate-sensitive health risks and vulnerabilities, control strategies for climate-sensitive diseases, allocate human and financial resources, prepare for emergencies, and design and maintain health infrastructure (Shumake-Guillemot and Fernandez-Montoya 2019).

We applied this definition to a review of real-world health investments and determined that, for the purpose of this analysis, CSfH consist of seven activities. These activities can be grouped into activities that *produce* and disseminate climate and health data and activities that use or *apply* such information to support health-related decision-making. On the production side, CSfH activities include the upstream generation and analysis of hydrometeorological data and information, integrated EWS, and integrated surveillance systems. On the application side, CSfH activities include health sector planning, community behavior change and awareness campaigns, emergency preparedness and response training, and resilient health facilities and infrastructure (see Figure 3). Table 1 summarizes these seven CSfH activities and provides illustrative investments based on a review of real-world projects.

Table 1 | **CSfH activities and illustrative investments**

CSfH ACTIVITIES THAT PRODUCE CLIMATE AND HEALTH DATA		
Activities	**Illustrative investments**	**Pathway to increased effectiveness**
Hydrometeorological data generation and information services	• Strengthening meteorological information services[a] • Modernizing national meteorological observation systems and forecasting[b] • Improving hydrometeorological and EWS[c]	Hydromet data are required for modeling the epidemiological and ecological impacts of climate change.
Integrated early warning systems	• Establishing an EWS to monitor the impact of climate change on infectious diseases and enable their prediction[d] • Developing an integrated EWS using data from diverse sources for real-time outbreak detection and visualization, including meteorological data[e] • Training health ministry staff to deploy EWS[f]	EWS help avoid potential health impacts before they occur by initiating public health responses based on observed hazards.
Integrated disease surveillance systems	• Monitoring climate-sensitive diseases against meteorological data to better understand the relationship between climatic patterns and climate-sensitive diseases[g] • Developing standards to manage climate-sensitive disease outbreaks and specific mechanisms for collecting and testing climate-sensitive disease samples[h] • Strengthening national and regional capacities and promoting cross-border collaboration for surveillance[i]	Integrated disease surveillance supports iterative learning and analysis to improve understanding of the linkages between climate and health, to design appropriate facilities and staff training programs, and to monitor the effectiveness of targeting and treatments.
CSFH ACTIVITIES THAT APPLY CLIMATE AND HEALTH DATA		
Activities	**Illustrative investments**	**Pathway to improved effectiveness**
Climate-sensitive health planning	• Developing and costing a climate and health adaptation strategy[j] • Leveraging climate risk information to improve the resilience of pharmaceutical supply chains and stockpiles[k] • Developing action and contingency plans for health emergencies[j]	Integrating climate and health data into health sector planning helps to ensure that decisions related to services, infrastructure, and workforces are responsive to climate-related health risks.
Emergency preparedness and response training	• Training health facility staff to detect and respond to climate-related health emergencies[j] • Mapping health workforce needs based on current and projected climate vulnerability[j] • Developing health workforce training, regulatory, and management mechanisms to improve preparation for and response to climate-induced health emergencies[l]	Emergency preparedness and response training ensures that health workers are prepared to identify and respond to the health impacts of climate-related events, including droughts and floods.
Community behavior change and awareness campaigns	• Developing and disseminating climate and health promotion information to enhance the adaptive capacity of communities in the face of extreme climate-related events[m] • Developing social behavior change communication materials that increase awareness about the impacts of climate change on health and nutrition and adaptation measures[n] • Improving community awareness of the impacts of climate change on water- and vector-borne diseases[h]	Community awareness campaigns reduce behavioral vulnerabilities and support physical improvements in households and at the workplace.
Resilient health facilities and infrastructure	• Applying climate-resilient designs to construct health facilities[o] • Developing a national plan for climate-resilient health care infrastructure[j] • Rehabilitating health facilities selected based on their exposure to climate risks, including flooding and extreme heat[p]	Integrated analysis of climate and health risks enables the identification and adaptation of health infrastructure to ensure service continuity.

Notes: This is the authors' analysis of 41 health-related and 5 hydrometeorological projects cofinanced by the World Bank with adaptation cobenefits that support climate services using publicly available project appraisal documents and project information documents. EWS = early warning system.

Sources:

a. World Bank 2016b
b. World Bank 2016a
c. World Bank 2019
d. World Bank 2018
e. World Bank 2024c
f. World Bank 2020b
g. World Bank 2022
h. World Bank 2024d
i. World Bank 2020a
j. World Bank 2023a
k. World Bank 2024a
l. World Bank 2024e
m. World Bank 2020c
n. World Bank 2021
o. World Bank 2020b
p. World Bank 2023b

Table 1 illustrates the potential pathways from specific CSfH activities to potential increased effectiveness of health services. These pathways form the basis of projecting the economic benefits associated with investments in CSfH. For example, generating and integrating hydrometeorological data and information supports how integrated disease surveillance systems understand how climate risks might exacerbate or introduce climate-sensitive vector- and waterborne diseases. Forecasting systems that integrate climate, health, and socioeconomic data enhance health risk assessments (von Hammerstein et al. 2024). Emergency preparedness and response training that integrates climate risk information and adaptation strategies can improve the capacity of those delivering services to manage the health impacts of floods, droughts, and extreme heat. Building or retrofitting health facilities and infrastructure that are more climate-resilient can mitigate disruptions of health services, including by securing the supplies of vaccines and life-saving medicines as well as the structural integrity and operability of health facilities.

Countries are increasingly prioritizing investment in CSfH (WHO 2023b). Table 2 highlights four countries' national priorities related to CSfH, which span many of the seven CSfH components. Kenya, for example, aims to develop a public awareness campaign concerning climate-related health impacts and establish guidance to manage new climate-related diseases and risks (Ministry of Environment and Forestry 2020). In its updated nationally determined contribution (NDC), Belize prioritized investment in health infrastructure based on vulnerability assessments and implementing EWS (Government of Belize 2021). In general, one priority area for investment is in forecasting systems that include climate and health/social data to enhance climate-specific health-risk assessments (von Hammerstein et al. 2024).

However, many countries are at an early stage in developing CSfH, and the health sector currently underutilizes climate services. Although 81 percent of World Meteorological Organization (WMO) Member States provide climate services (WMO 2023), only 23 percent of health ministries report having a health surveillance system that includes meteorological information (WHO 2021b). The coverage of national health surveillance systems that include meteorological information varies by climate-sensitive risk. The highest coverage of such systems is for vector-borne diseases (14 percent), and the lowest is for mental and psychosocial health (3 percent) (WHO 2021b).

Several barriers can prevent the successful uptake of CSfH. First, there is a limited understanding of what CSfH even are, much less the economic benefits that they can bring (von Hammerstein et al. 2024). This paper aims to help fill this gap in awareness.

Table 2 | **Examples of NDC priority health actions related to CSfH**

COUNTRY	PRIORITY HEALTH ACTIONS RELATED TO CLIMATE SERVICES
Belize[a]	• Conduct a climate change vulnerability and capacity assessment for the health sector. • Implement EWS for health sector for specific diseases, vectors, and high temperatures. • Invest in health infrastructure based on findings of sector vulnerability assessment.
Cabo Verde[b]	• Create a national climate change and health profile and improve the national database for diseases related to climate change and climate-vulnerable groups to track, monitor, and evaluate the effects of climate change on health. • Identify the vulnerabilities and strengthen the climate resilience of health care facilities and infrastructure. • Develop a national action plan on health and climate change.
Cambodia[c]	• Generate information and improve surveillance or early warning systems (EWS) to enable effective decision-making for health interventions. • Strengthen institutional capacities to effectively integrate climate risks and adaptation options in health sector planning and implementation.
Kenya[d]	• Develop a public awareness and social mobilization strategy on climate change and health impacts as well as health programs and protocols. • Establish guidance to manage new climate-related diseases and risks.

Sources:

a. Government of Belize 2021

b. Ministry of Agriculture and Environment 2021

c. MoE 2020

d. Ministry of Environment and Forestry 2020

Second, data collection and management are difficult, whether related to climate, health, or even ecology (such as the impact of temperature and rainfall changes on mosquitoes). In many countries, limited capacity to generate disaggregated data at scale hinders efforts to build baselines, analyze trends, and identify inequities. Stronger data systems and inclusion of greater social and equity-related data are critical for effective and equitable CSfH implementation.

Third, collaboration across institutions and sectors is fundamental to the successful uptake of effective CSfH, but institutional barriers are common. Just as staff within health ministries are not sufficiently equipped to conduct weather and climate modeling of climate impacts on all epidemiological factors, NMHAs lack the required training to integrate health sector modeling. All actors involved in both the upstream and downstream components of CSfH require sufficient training, resources, and coordination mechanisms to leverage their respective expertise and engage in collaborative, cross-sectoral work. Overcoming such institutional barriers requires active and sustained collaboration, including both domestic and global partnerships.

Finally, a lack of finance contributes to the fragmented CSfH development across actors and, subsequently, their limited uptake within the health systems. Few NHMAs report having sufficient funding to support staff assigned to collaborate actively with other agencies, including health (WMO 2023). While health is increasingly mentioned in national climate plans, just 11 percent include unconditional finance targets for health-related actions (WMO 2023). Ministries of health also report that activities related to climate services are the most underfunded and difficult to implement (WMO and WHO 2023).

Estimating the cost of investing in CSfH

Each CSfH activity requires a relatively modest investment. The estimated average annual cost of investing in CSfH—assuming a five-year implementation timeline of the World Bank–financed investment projects—ranges from $1.4 to $5.9 million per CSfH activity per year, or a total of $17.9 million per year across all seven activities. See Table 2 for illustrative investments and Table 3 for cost estimates by CSfH activity. These cost estimates can be considered the upper bound because the costed CSfH-related activities were often grouped with other unrelated activities in project appraisal documents.

On average, activities supporting planning, capacity-building, and community engagement require the least amount of investment, whereas building resilient health facilities and infrastructure requires the most. The cost of developing integrated disease surveillance, implementing EWS, and generating hydrometeorological data and information services falls in between. This is likely because these three CSfH activities entail investments in both infrastructure—such as observatories for monitoring changes in weather and climate and laboratories for conducting epidemiological research—and capacity-building for the health workers responsible for managing information systems (Table 1).

While each of the CSfH activities contribute to a climate-resilient health system, countries are not likely to invest in all seven activities every year. For example, in the sample of 40 countries using World Bank resources, Malawi and Zambia invested in six of the seven CSfH activities identified by this study, and a few more (Bangladesh, Cape Verde, Rwanda, South Sudan) invested in five (see Appendix A). Countries most frequently invested in developing integrated disease surveillance systems (86 percent) and integrated EWS (43 percent).

Not included in these cost estimates are the bookends to CSfH: upstream climate services that collect and share basic climate and weather data with all sectors and downstream investments in on-the-ground health services (Box 2). These investments have been analyzed on their own terms in the economic literature. CSfH, although an integral part of the entire climate services and health services value chain, have not been analyzed separately, hence the focus of this paper.

Table 3 | **Upper-bound, annualized cost estimates of investing in CSfH**

CLIMATE SERVICES FOR HEALTH ACTIVITY	FREQUENCY OF APPEARANCE IN REVIEWED PROJECTS	AVERAGE ANNUAL UPPER-BOUND COST ESTIMATE (US$, MILLIONS)
Production		
Hydrometeorological data generation and information services	17	2.82
Integrated early warning system development	12	2.52
Integrated disease surveillance development	38	1.95
Application		
Climate-sensitive health planning	19	1.57
Emergency preparedness and response training	23	1.67
Community behavior change and awareness campaigns	16	1.39
Resilient health facilities and infrastructure	18	5.94
Indicative total		**17.86**

Notes: This is the authors' analysis of 41 health-related and 5 hydrometeorological projects cofinanced by the World Bank with adaptation cobenefits that integrate climate services using publicly available project appraisal documents and project information documents. These costs are based on the full cost of programs cofinanced by the World Bank and national governments. Annualized costs assume an average five-year implementation period, which is the World Bank average.

Source: WRI authors.

In addition to project-level costs, we reviewed publicly available national budgets to better understand current expenditure across the seven CSfH activities. Nine of the countries in the project sample had publicly available data that included line items for climate or health services. Across these countries, the most frequently recurring activity was hydrometeorological data generation and information services (90 percent of the sample). This is likely because most—though not all—countries surveyed have a meteorological agency that collects national-level weather and climate data. There is a wide range in the amounts budgeted in 2025. In Brazil, for example, the estimated cost of generating hydrometeorological data was US$11.6 million. For smaller and lower-income countries such as Kenya and Zambia, the costs were estimated to be US$2.24 million and US$1.14 million, respectively.

It was not possible, however, to directly map budget lines to specific CSfH activities given the limited information provided. Table 4 maps budget line items to relevant activities that could plausibly support CSfH activities. Budget data, for example, cannot indicate whether and how well meteorological and hydrometeorological information is shared across ministries, departments, and states/provinces to improve health services. In summary, the national budget data are not inconsistent with the CSfH cost estimates put forward above based on World Bank–financed projects. However, the national budget data are not as disaggregated, complete, or representative as the World Bank project data, so the latter are used for cost estimates in this paper's CBA.

Table 4 | **National budget allocations that potentially support CSfH activities**

AGENCY	ACTIVITY	AMOUNT ALLOCATED (US$, MILLION)	CSfH ACTIVITIES POTENTIALLY SUPPORTED
Bangladesh[a]			
Ministry of Environment, Forest and Climate Change	• Improving flood forecasting and early warning system (EWS)	13.0	Integrated EWS
Cross-agency collaboration	• Awareness raising and public education toward climate resilience	45.7	Community behavior change and awareness campaigns
Brazil[b]			
National Water and Basic Sanitation Agency	• Operating the hydrometeorological network	11.6	Hydrometeorological data generation and information services
Ministry of Health	• Health surveillance	71.0	Integrated disease surveillance system
	• Support to states, federal district, and municipalities for health surveillance	411.3	
	• Strengthening the national health and environmental surveillance system	80.4	
Ethiopia[c]			
Ethiopia Meteorology Institute	• Meteorological stations, information, and instruments	26.0	Hydrometeorological data generation and information services
	• Meteorological analysis and early warning	9.3	
The Gambia[d]			
Ministry of Health	• Epidemiology and disease surveillance unit (salaries and allowances)	0.06	Integrated disease surveillance system
Ministry of Fisheries and Water Resources	• Meteorology Division (salaries)	0.1	Hydrometeorological data generation and information services
India[e]			
Ministry of Earth Sciences	• Mission Mausam	158.8	Hydrometeorological data generation and information services
	• National Centre for Medium Range Weather Forecasting	1.9	
	• High-performance computing system	6.6	

Table 4 | **National budget allocations that potentially support CSfH activities (cont'd)**

AGENCY	ACTIVITY	AMOUNT ALLOCATED (US$, MILLION)	CSfH ACTIVITIES POTENTIALLY SUPPORTED
Indonesia[f]			
Meteorology, Climatology, and Geophysics Agency	▪ Meteorology, climatology, and geophysics program	0.09	Hydrometeorological data generation and information services
Kenya[g]			
State Department for Environment and Climate Change	▪ Weather radar surveillance network	1.9	Hydrometeorological data generation and information services
State Department for Water and Sanitation	▪ Installing hydrometeorological network under IGAD-HYCOS	0.2	Hydrometeorological data generation and information services
Nigeria[h]			
Nigerian Meteorological Agency	▪ General maintenance and retrofitting national weather forecasting and climate research center	0.2	Hydrometeorological data generation and information services
	▪ Procuring and installing smart weather board	0.1	
	▪ Expanding rainfall station network and increasing outreach of hydrometeorological information service and products	0.04	
Nigeria Hydrological Service Agency	▪ Establishing and maintaining automated weather observation and flood alert system	0.02	Hydrometeorological data generation and information services
	▪ Establishing automated weather station	0.01	
	▪ National hydrometric network project	0.03	
Zambia[i]			
Health Ministry	▪ Early warning and preparedness	0.3	Integrated EWS
	▪ Health infrastructure development	13.4	Resilient health facilities and infrastructure
Ministry of Green Economy and Environment	▪ Weather observation infrastructure	0.04	Hydrometeorological data generation and information services
	▪ Forecasting and research services	1.04	

Notes: National budgets were reviewed using keyword searches based on the climate services for health (CSfH) activity names. Relevant line items were documented and their associated expenditure was converted from local currency into US dollars based on average exchange rates in 2024 as reported by the International Monetary Fund. IGAD-HYCOS = Intergovernmental Authority on Development–Hydrological Cycle Observing System.

Sources:

a. Finance Division 2025

b. Government of Brazil 2025b, 2025c

c. Government of Ethiopia 2018

d. Government of The Gambia 2025

e. MoF Budget Division 2026

f. Government of Indonesia 2025

g. National Treasury and Economic Planning 2025

h. Government of Nigeria 2025

i. MoFNP 2025

The benefits of investing in CSfH

This report estimates the returns on investing in CSfH using two complementary approaches (described in the "Methodology" section). First, it explores the literature for case studies evaluating health initiatives supporting CSfH activities. Secondly, it applies global CBA to assess the potential BCRs of CSfH investments in a developing country context.

Case studies of specific CSfH investments

This study conducted an exploratory literature review on the benefits of CSfH investments. The case studies presented in Table 5 offer examples of documented investments in CSfH that have varying degrees of economic analysis showing returns on investment.

The cases demonstrate that CSfH have improved health services targeting heat, malaria, dengue, and waterborne diarrheal diseases through such activities as early warning, early disease prediction, and improved surveillance. In some cases, costs and benefits are quantified; in others, they only note that the actions are cost-effective in comparison with alternative interventions. As Table 5 shows, those with calculated BCRs include dengue EWS (modeled BCR = 4:1) and heat-health warning systems in both Europe and India (BCRs > 10:1). Other cases of community behavior change and awareness campaigns have returns of 3:1, and efforts to make health facilities in the Caribbean more climate resilient have extremely high returns of over $100 per $1 expended. These studies cannot be aggregated given their different scopes, time frames, and methodologies, yet they illustrate the range of CSfH initiatives beginning to be evaluated.

The limited number of available case studies evaluating the economic returns on CSfH activities reinforces the need for this study to adopt an exploratory approach and also the added value of doing so. This approach is presented in the following section.

Table 5 | **Selected examples of costs and benefits of CSfH interventions**

CSFH ACTIVITY TYPE	DESCRIPTION	BENEFITS	COSTS (US$)	BENEFIT-COST RATIO (BCR) OR OTHER METRIC (US$)	SOURCE
Ex ante studies					
Integrated early warning system	Heat-Health Warning System and physical cooling (greening, cool roofs), India	Reduced heat-related deaths and labor productivity losses	Variable costs for Chennai, Lucknow, and Surat under different climate scenarios	Average BCRs for Heat-Health Warning System > 50:1; average BCR for urban greening investments, 3:1.	Jones et al. 2024
Integrated early warning system	Urban heat wave warning systems in Europe (London, Madrid, and Prague)	Projected decrease in population vulnerability and avoided excess deaths	Variable costs for London, Madrid, and Prague under different climate scenarios	BCRs of 11:1 and higher even under low heat scenarios; benefits are increasing more rapidly than costs in hotter scenarios	Hunt et al. 2017; Rao et al. 2025
Community behavior change and awareness campaign	Raise awareness about climate-sensitive diseases (malaria, acute respiratory infections, diarrheal diseases)	Reducing climate-related health risks in Côte d'Ivoire, particularly for vulnerable populations	Not provided	Highest cost-effectiveness ratio across all alternatives considered	Francis 2025
Ex post studies					
Community behavior change and awareness campaign	Climate-Health Education for Communities in Karachi, Pakistan	Out-of-pocket savings from avoided hospitalizations	Incidental costs of home visits and community meetings	Every $1 invested yields > $3 in returns (ex post over three months)	World Bank et al. 2025
Resilient health facilities and infrastructure	Pan American Health Organization's Smart Hospitals initiative retrofitted health facilities in seven Caribbean countries	Improved health service delivery avoiding costly service disruptions during disasters (especially hurricanes)	Initial costs range $3.6 to $6.9 million, and ongoing annual costs are $10,000–$20,000 per facility (ex ante modeling)	Every $1 invested yields $168 (Jamaica) to $317 (St. Lucia) in returns (ex post assessment)	World Bank et al. 2025

Source: WRI authors.

Estimating the BCRs of investing in CSfH

This section takes a more aggregated estimate of the benefits of investing in CSfH based on global assumptions. It models the marginal economic value of CSfH impact on health outcomes due to improved analytics and planning along the pathways described in Table 1. These are the necessary steps:

1. Estimate the total economic costs of climate-related health impacts in developing countries by 2030.
2. Estimate a small reduction in those global impacts potentially attributable to improved CSfH, which are the estimated benefits.
3. Compare the projected estimated CSfH costs and benefits within a median-sized developing country and generate BCRs.

The value of benefits (Step 2) represents a hypothetical marginal gain in effectiveness due to reduced DALYs, and the BCR is the ratio of those discounted benefits to discounted costs. The details of Step 1 are in Appendix B and the details of Step 2 are in Appendix C.

In this analysis, the projected increase in health service effectiveness due to investments in CSfH is 2–5 percent. As explained in Box 2, it is unlikely that CSfH investments will have zero or negative impacts on health service effectiveness given the number of positive pathways for CSfH to improve health outcomes. In other words, it is not plausible that improved CSfH would reduce the effectiveness of health service delivery. But since there is no current empirical evidence of how much CSfH investment may improve health services delivery more generally, a minimal range of increased effectiveness is assumed here. This range of increased effectiveness is less than the range of positive impacts reported in the studies cited in Table 5; for example, an effective EWS could reduce health impacts by 33–66 percent (Hunt et al. 2017).

The variable that drives the economic valuation of health benefits is the estimated value of a statistical life per year (VSLY). This is based on the global average VSL of $1.625 million (Sweis 2022) and corrected for current prices. Critics may argue that using a global average VSL for a developing country population is high; that is an ethical debate over valuing human life in countries with different levels of per capita income. We used a global average for the VSLY economic valuation and believe a global average is appropriate.

The CBA sensitivity analysis is based on these differing assumptions:

- Low-to-high projected climate health impacts on the incidence of malaria, dengue, diarrhea/cholera, and heat-related diseases (Appendix B for supporting studies and Appendix C for results).
- Lower- and upper-bound investment levels made in CSfH (i.e., $12 million versus $18 million per year for a median-sized developing country).
- Lower and higher assumed levels of improved effectiveness that might be gained due to expanded CSfH investments (i.e., 2–5 percent increased effectiveness).
- The projected average cost of climate-related illness in a median-sized developing country during the 2026–30 period ranges from $3.3 billion to $16.4 billion per year. This translates to an estimated health impact of $130–$660 per capita. The high estimated health impact is five times the low estimate given the large variation and uncertainty in available disease projections.

The estimated BCRs under all modeled scenarios indicate the potential for high economic returns for investing in CSfH (Table 6). The most important estimate is the one with the lowest projected climate impact on health, the highest investment cost of CSfH, and the lowest project effectiveness since this would be the worst-case scenario for such investments. That estimated BCR is 3.6:1, which nonetheless indicates very strong economic viability even under these assumptions.

This worst-case BCR is more than double the minimum threshold typically used by multilateral development banks when evaluating the projected viability of development investments (Herrera 2005). It compares favorably with other high-return climate adaptation investments. For example, it is slightly below the average BCR of 5:1 for climate adaptation projects in the agriculture, water, and infrastructure sectors (Global Commission on Adaptation 2019). All other CSfH scenarios analyzed here have higher BCRs.

Each of the other CSfH scenarios model different combinations of higher projected climate impact on health, lower investment costs, and/or higher project effectiveness. These BCRs range from 5.5:1 (assuming lower project costs) and 9.1:1 (assuming high project costs but also higher project effectiveness). The highest estimated BCR, 68:1, is based on the most favorable assumptions in each of the modeled dimensions.

Table 6 | **BCRs of investing in CSfH**

ASSUMED INCREASE IN EFFECTIVENESS OF HEALTH SERVICES DELIVERY	RANGE OF MODELED BCRS FOR US$18 MILLION ANNUAL INVESTMENT IN CSFH	RANGE OF MODELED BCRS FOR US$12 MILLION ANNUAL INVESTMENT IN CSFH
2% gain in effectiveness	3.6–18.2	5.5–27.4
5% gain in effectiveness	9.1–45.6	13.7–68.4

Notes: The low and high range corresponds to low and high projected climate-related health impacts in developing countries for malaria, dengue, diarrhea/cholera, and heat-related diseases. In cost-benefit analysis, any investment with a benefit-cost ratio (BCR) above 1.5 is generally considered to be highly economically viable. CSfH = climate services for health (see Appendix C, columns h and i).

Source: WRI authors.

While approximate and subject to error margins of 25–50 percent or more, the overall results appear robust and suggest that CSfH offer substantial returns. The estimated CSfH BCRs are in the same range or higher than the high BCRs found in the studies cited in Table 5. However, given the exploratory nature of this analysis, the sources of uncertainty, and the potential oversimplification in the aggregations of costs and benefits, these results should be interpreted in the context of the limitations described in the "Methodology" section.

Building on this analysis, Box 3 provides several recommendations for future research. For example, the current analysis does not specify which CSfH activities may generate the highest returns because that will vary by country. However, as climate change impacts worsen, health ministries and donors will seek more concrete guidance on the most cost-effective solutions to reduce those impacts.

Box 3 | **Recommendations for future research**

These are some of the potential areas for future research based on this study's findings and limitations:

- **More nuanced characterizations of each of the seven climate services for health (CSfH) activities, including their scope and costs.** These improved characterizations could be used to create an internationally accepted framework that would support and help organize ongoing research across CSfH activities, countries, and time frames.
- **A stocktake of the current level of CSfH implementation in developing countries.** The stocktake could address several key questions: the level of climate and health data collection, management, and analysis currently underway; the level of technical and administrative capacity in relevant agencies, including cross-institutional collaboration; and CSfH outputs and effectiveness, including reference to the political economy of CSfH implementation. If time series data are collected, it would be helpful to analyze the drivers behind changes in the implementation gap.
- **Deeper empirical analysis of the economic benefits of improving CSfH, with specific reference to their pathways toward improved health outcomes.** This could be disaggregated by regions, countries, or diseases using experimental methodologies. Analysis could differentiate results according to variables such as income levels and country sizes. In-depth case studies on each of the seven CSfH activities could assess the disaggregated returns to each, showing their priorities.
- **Deeper empirical analysis of the health costs associated with climate change.** This study uses standard methodologies associated with disability-adjusted life years and the value of a statistical life. However, they are incomplete and inadequate for country-level analysis, where local social, economic, and environmental factors come into play.
- **Ex post impact evaluations in CSfH to better calibrate assumptions made in this and future cost-benefit analyses.** Evaluations could disaggregate data by social factors, including age and sex, to capture differentiated impacts of investments in CSfH activities.
- **An analysis of the roles of different actors—both public and private—in producing and applying CSfH.** While this study focuses on public efforts to support CSfH activities, private companies and universities may be active in analytics, and private health care providers also play a key role in delivering health services.

Conclusions

CSfH are collaborative, multidisciplinary processes that comprise multiple activities. These include hydrometeorological services, climate-sensitive health planning, disease surveillance, emergency preparedness, EWS, public awareness campaigns, and climate-resilient health facilities. Based on the results of this study, the total annual cost of investment in CSfH could range from $12 to $18 million for a median-sized developing country depending on local needs and priorities.

The returns on investing in CSfH are estimated to be very high. Even under the worst-case scenario—assuming the lowest intervention effectiveness, highest intervention cost, and lowest project climate impact on health—the estimated economic return is $3.60 within five years for every dollar spent. For all other scenarios, the returns are much higher, up to almost $70 in economic returns in cases of high climate health impacts, low CSfH costs, and high CSfH effectiveness.

The high returns on CSfH are due to the modest funding requirements compared to the high value of lives saved from improved effectiveness of health services. They include investments in data, modeling, collaboration, upstream planning, and building health system resilience, all of which are a small fraction of total health sector costs.

CSfH make important contributions to ensuring that the nature and magnitude of climate-related health impacts are fully understood and effectively reflected in the decisions made by public and private actors. These include improved vulnerability analysis; proactive risk reduction; disease control strategies; health policy and regulations; disease monitoring and surveillance; financial and human resource allocation; pharmaceutical, health, pesticide, and vaccine supply flow; and health infrastructure siting and maintenance. They can enable governments to better understand the science, epidemiology, and health service strategies required to manage the climate and health needs of target populations.

There is, however, limited awareness of these high benefits, and it is hoped that this study will help close this awareness gap. Other barriers, such as insufficient finance, insufficient institutional capacity, and poor cross-agency collaboration are also factors. However, improved awareness of their benefits is the first step in supporting countries to scale up their CSfH investments and towards encouraging agencies to work together. In addition, understanding the high returns to investments in CSfH may help scale up donor and philanthropy interest in providing finance and capacity-building activities.

There is momentum around the CSfH concept: CSfH activities are a prominent part of recent climate and health strategies. Climate-informed epidemiological surveillance is a commonly cited priority intervention in Health National Adaptation Plan and National Adaptation Plans (WHO 2025). For example, the Belém Health Action Plan, presented at the 2025 UN Climate Change Conference, supports three foundational "action lines" for countries to better scale up attention to climate health issues: surveillance and monitoring; evidence-based policies, strategies, and capacity-building; and innovation, production, and digital health (Government of Brazil 2025a). Of these three, the first two are CSfH, bringing improved climate and health analytics to the delivery of health services. This paper, therefore, helps provide economic evidence in support of key priorities in the Belém Health Action Plan.

In another example, the Alliance for Transformative Action on Climate and Health, in a report led by the World Bank, the Inter-American Development Bank, and KfW, offers countries a set of options for adaptable, cost-beneficial actions to strengthen health sector adaptation and resilience in the face of climate change (World Bank et al. 2025). Of the eight priority options, four are activities that fall under the umbrella of CSfH. These are implemented heat action plans; integrated surveillance and early warning and response systems; climate-resilient health infrastructure; and community health worker-led climate-health education for communities. Again, the economics of these strategic priorities are underpinned by the findings of this paper.

This paper's findings are compelling because they suggest that relatively modest investments for developing countries can make a big difference in how well a country is equipped to manage climate health risks. The benefits of CSfH would particularly help countries to support the most climate-vulnerable populations. Until gaps in CSfH are filled, developing countries will lose large opportunities to address climate-related health risks, with large negative economic, health, and social consequences.

Appendix A. Overview of reviewed investments in CSfH investments by country

COUNTRY	POPULATION (MILLIONS)	GDP (CURRENT US$, MILLIONS)	INCOME STATUS	ND-GAIN VULNERABILITY RANK	INVESTMENTS IN CLIMATE SERVICES FOR HEALTH						
					Hydrological data generation and information services	Climate-sensitive health planning	Integrated disease surveillance development	Integrated early warning systems	Emergency preparedness and response training	Community behavior change and awareness campaigns	Resilient health facilities and infrastructure
Angola	39.04	80,396.94	Lower middle	140			✓				
Bangladesh	175.687	450,119.42	Lower middle	170	✓		✓	✓		✓	✓
Benin	14.816	21,482.64	Lower middle	171			✓	✓			
Brazil	212.812	2,179,412.08	Upper middle	54			✓	✓			
Burundi	14.39	2,162.38	Low	164			✓		✓	✓	✓
Cabo Verde	0.527	2,767.60	Upper middle	92		✓	✓	✓	✓		✓
Chad	21.004	20,625.71	Low	187		✓	✓				✓
Central African Republic	5.513	2,751.54	Low	175			✓				
Colombia	52.426	418,542.04	Upper middle	83							✓
Democratic Republic of the Congo	112.832	70,749.36	Low	167		✓	✓		✓		
Djibouti	1.184	4,086.40	Lower middle	138				✓			
Dominica	0.066	688.88	Upper middle	107			✓				
Egypt	118.366	389,059.91	Lower middle	88			✓				
Ethiopia	135.472	126,772.71	Low	150		✓	✓	✓			
Gambia, The	2.822	2,507.52	Low	152	✓					✓	
Ghana	35.064	82,825.29	Lower middle	113	✓						
Grenada	0.117	1,391.44	Upper middle	71			✓				✓
Guinea	15.099	25,334.31	Lower middle	153		✓	✓	✓	✓		
Guinea-Bissau	2.25	2,119.87	Low	183	✓						
Haiti	11.906	25,224.15	Lower middle	141			✓				

					INVESTMENTS IN CLIMATE SERVICES FOR HEALTH						
COUNTRY	POPULATION (MILLIONS)	GDP (CURRENT US$, MILLIONS)	INCOME STATUS	ND-GAIN VULNERABILITY RANK	Hydrological data generation and information services	Climate-sensitive health planning	Integrated disease surveillance development	Integrated early warning systems	Emergency preparedness and response training	Community behavior change and awareness campaigns	Resilient health facilities and infrastructure
India	1,463.87	3,912,686.17	Lower middle	128			✓	✓			✓
Kenya	57.532	124,498.69	Lower middle	137		✓					✓
Liberia	5.731	4,750.00	Low	157		✓	✓	✓	✓		
Madagascar	32.74	17,420.81	Low	166			✓		✓		
Mali	25.199	26,588.07	Low	172	✓		✓	✓	✓	✓	
Malawi	22.216	11,008.93	Low	161		✓	✓	✓	✓	✓	✓
Mauritania	5.315	10,766.73	Lower middle	174			✓	✓			
Mozambique	35.632	22,416.65	Low	135		✓			✓	✓	✓
Niger	27.918	19,537.64	Low	186			✓	✓		✓	
Nigeria	237.528	187,759.70	Lower middle	126		✓				✓	
Philippines	116.787	461,617.51	Lower middle	109			✓		✓	✓	
Republic of the Congo	6.484	15,719.99	Lower middle	150			✓				
Rwanda	14.569	14,251.64	Low	169		✓	✓		✓	✓	✓
Senegal	18.932	32,267.25	Lower middle	155						✓	
South Sudan	12.189	11,997.80	Low	Not included		✓	✓		✓	✓	✓
St. Lucia	0.18	2,459.06	Upper middle	62			✓				✓
St. Vincent and the Grenadines	0.01	1,157.21	Upper middle	99			✓				✓
Uzbekistan	36.36	114,965.29	Lower middle	41	✓						
Yemen	41.774	21,606.16	Low	154				✓	✓	✓	
Zambia	21.914	26,325.78	Lower middle	128		✓		✓	✓	✓	✓

Appendix B. Literature review of projected climate impacts on health

MALARIA	
Scope	**Projected climate impacts on health**
Africa	Regional estimates indicate intensified transmission and up to an additional 30.1–58.5 million cases by 2030.[a]
Lower- and middle-income countries (LMICs)	Multiple climate models under Representative Concentration Pathway (RCP) scenarios project that by 2050 the population at risk of malaria in endemic regions will increase compared to a 1970–2000 baseline, particularly in East Africa and parts of South America, although projections varied significantly between models and RCPs.[b]
Global	The average global change from modeling Shared Socioeconomic Pathways (SSP) by 2040 in malaria infection cases is 3,655 million cases, representing a 1.5 percent increase to the 241 million infection cases reported in 2020.[c]
Nigeria	Nigeria reports an increase from 310 to 366 cases per 1,000 population by 2050.[d]

DENGUE	
Scope	**Projected climate impacts on health**
Latin America, Asia	Studies across the Americas and Asia indicate a midcentury increase of 40–57 percent.[e]
Latin America and the Caribbean (LAC)	Studies modeled climate change impacts on dengue risk in Latin America and the Caribbean. Under RCP 8.5, projected increases in dengue risk (a composite measure including incidence potential) are 11–20 percent by the 2050s compared to a 1950–2005 baseline for countries such as Brazil and Colombia.[f]
Mexico	In Mexico, dengue fever incidence is estimated to rise by 12–18 percent by 2030, 22–31 percent by 2050, and 33–42 percent by 2080.[g]
Vietnam	Vietnam shows projected potential increases in dengue cases by 10–25 percent by 2050 under moderate warming scenarios, linked to higher temperatures and altered rainfall patterns.[h]

WATERBORNE DISEASES	
Scope	**Projected climate impacts on health**
Global	Global estimates for diarrheal diseases suggest an extra 88.4–134.2 million cases by 2030.[a]
Tropical LMICs	Applying this to projected temperature increases suggests potential rises in diarrheal disease burdens of 5–10 percent by the 2030s in many tropical LMICs under moderate warming scenarios (RCP 4.5), potentially higher under RCP 8.5 by the 2050s, although this is a simplified extrapolation.[i]
Coastal Asia	Increased exposure to coastal flooding under RCP 4.5 and 8.5 is projected to affect millions more people in major Asian coastal cities by 2050, increasing diarrheal disease risk.[j]
Bangladesh and India	Models suggest that rising sea surface temperatures and increased extreme rainfall events could enhance cholera suitability in coastal areas of Bangladesh and India by 5–15 percent between the 2030s and 2050s under moderate to high emission scenarios.[k]
Ethiopia	A 1°C temperature rise could correlate with roughly a 5–10 percent increase in diarrheal disease incidence in vulnerable populations, based on historical data and general risk assessments applied to future warming contexts.[l]

HEAT-RELATED ILLNESS AND MORTALITY	
Scope	**Projected climate impacts on health**
Global	Heat-related mortality projections range from 38,000 additional deaths globally by 2030 to a doubling of child mortality in some African cities by 2050.[m]
China	The predicted age standardized rate of disability-adjusted life years (DALYs) attributed to high temperatures in 2030 is 15.05/100,000.[n]
Developing countries	Lives saved from heat-health warning systems in 57 countries, 2025–28: 98,314 lives/year. The total impact is conservatively assumed to be twice the number of estimated lives saved.[o]
Developing countries	Under a high emissions scenario (RCP 8.5), the global mortality risk from extreme heat could increase by roughly 73 deaths per 100,000 by 2100 compared to a historical baseline, with LMICs in hot regions (e.g., South Asia, sub-Saharan Africa, parts of Latin America) facing disproportionately higher risks.[p]
Tropical LMICs	Specific projections for LMICs suggest potential increases in heat-related mortality rates of 50–200 percent or more by the 2050s under high emissions scenarios compared to late 20th-century baselines, depending on the region and adaptation measures.[q] For example, studies focusing on India project substantial increases in heat wave days and associated mortality, potentially leading to thousands of additional heat-related deaths annually by midcentury under RCP 8.5.[r]
Africa	Heat-related mortality is projected to increase dramatically across tropical and subtropical regions of Africa by the end of the century under high emissions scenarios (e.g., SSP5-8.5) compared to lower emissions scenarios, based on projected percentage increases in mortality relative to baseline.[s]
Latin America	Across LAC cities, heat-related excess mortality is projected to increase substantially. Under RCP 8.5, increases could exceed 500 percent in many Central and South American cities by the 2080s compared to a 1991–2015 baseline, assuming no adaptation.[r]

MALNUTRITION	
Scope	**Projected Climate Impacts on Health**
Global	Projections for malnutrition risk (linked to crop yields) and diarrheal disease risk (linked to environmental suitability/flooding) exist, but specific future DALYs or precise case numbers under RCP/SSP scenarios remain less common compared to heat and dengue risk projections.[t]
Global	Climate change impacts malnutrition primarily through its effects on food security (reducing crop yields, disrupting fisheries, affecting livestock) and potentially increasing the burden of infectious diseases that impair nutrient absorption.[u]
Africa and South Asia	Projections of malnutrition indicate increases in child stunting of 1–29 percent for moderate cases and 31–62 percent for severe cases by midcentury in South Asia and sub-Saharan Africa.[v]

Notes and Sources:

a. Dickerson et al. 2022
b. Caminade et al. 2014
c. Li and Managi 2022
d. Adewoyin and Adeboyejo 2018
e. Childs et al. 2025
f. Colón-González et al. 2018
g. Colón-González et al. 2013
h. See Linh Tran et al. 2023
i. Carlton et al. 2016
j. IPCC 2022; Lane et al. 2013
k. Akanda et al. 2011; Jutla et al. 2013
l. Fatima et al. 2025
m. Honda et al. 2014; Chapman et al. 2022
n. Zheng et al. 2023
o. WMO 2025
p. Carleton et al. 2022
q. See Honda et al. 2014
r. Vicedo-Cabrera et al. 2021
s. Zhao et al. 2021
t. Watts et al. 2021
u. IPCC 2022; Springmann et al. 2016
v. Lloyd 2021; Lloyd et al. 2011

Appendix C. Estimated value of potential health impacts due to climate change in developing countries

DISEASE	HEALTH IMPACT PROJECTIONS	INCREMENTAL CLIMATE-HEALTH CASES PER YEAR (IN THOUSANDS)	REGION/ COUNTRY POPULATION (IN MILLIONS)	INCREMENTAL # CASES IN LMICS IN 2030 (PER THOUSAND PEOPLE)	DALYS IN LMICS FOR 2030 (PER THOUSAND PEOPLE)	VALUE OF DALYS IN LMICS FOR 2026-30 (US$, MILLIONS)	LOW RANGE, AVERAGE FOR 2026-30 (US$, MILLIONS)	HIGH RANGE, AVERAGE FOR 2026-30 (US$, MILLIONS)
a	b	c	d	e	f	g	h	i
Malaria							**$159**	**$521**
DALY weight = 0.092	Africa, 2030, low	30,100	1,550	19.42	1.79	311.1		
	Africa, 2030, high	58,500	1,550	37.74	3.47	604.5		
	Global, 2040	3,655	6,500	0.42	0.04	6.8		
	Nigeria, 2050	12,544	230	27.27	2.51	436.8		
Dengue							**$7**	**$36**
DALY weight = 0.092	Southeast Asia, low, 2050	3,124	700	2.23	0.21	35.7		
	Southeast Asia, 2050, high	4,452	700	3.18	0.29	50.9		
	Latin America, 2050, low	508	664	0.38	0.04	6.1		
	Latin America, 2050, high	924	664	0.70	0.06	11.1		
	Mexico, 2050, low	33	130	0.26	0.02	4.1		
	Mexico, 2030, high	55	130	0.42	0.04	6.8		
	Vietnam, 2050, low	200	101	0.99	0.09	15.9		
	Vietnam, 2030, high	500	101	2.48	0.23	39.6		
Cholera/ diarrhea							**$384**	**$ 1,817**
DALY weight = 0.1605	Global, 2030, low	88,400	8,100	10.91	1.75	305.0		
	Global, 2030, high	134,200	8,100	16.57	2.66	463.0		
	Africa, 2030, low	50,400	1,550	32.52	5.22	908.6		
	Africa, 2030, high	151,200	1,550	97.55	15.66	2,725.9		

DISEASE	HEALTH IMPACT PROJECTIONS	INCREMENTAL CLIMATE-HEALTH CASES PER YEAR (IN THOUSANDS)	REGION/ COUNTRY POPULATION (IN MILLIONS)	INCREMENTAL # CASES IN LMICS IN 2030 (PER THOUSAND PEOPLE)	DALYS IN LMICS FOR 2030 (PER THOUSAND PEOPLE)	VALUE OF DALYS IN LMICS FOR 2026-30 (US$, MILLIONS)	LOW RANGE, AVERAGE FOR 2026-30 (US$, MILLIONS)	HIGH RANGE, AVERAGE FOR 2026-30 (US$, MILLIONS)
a	b	c	d	e	f	g	h	i
Heat							**$106**	**$911**
DALY weight = 0.3	Global, 2030 /*	38	8,100	0.00	0.16	28.6		
	China, 2030	N/A	1,400	N/A	2.11	366.8		
	Developing countries, 2030 /*	196	6,500	0.03	1.06	183.8		
	Developing countries, 2100 /*	6,205	6,500	0.24	8.35	1,454.3		
Total value of estimated climate-related DALYs for 2026-30 (per million people)							**$656**	**$3,284**
Total value of estimated climate-related DALYs per year for a median-sized country (population 25 million)							**$3,280**	**$16,420**
Estimated per capital health costs, average per year over the 2026-30 period							**$131**	**$657**

Notes: The letters below correspond to each column in the above table. N/A = not applicable.

a. *For each of the four climate-related diseases, the value of a disability-adjusted life year (DALY) was taken from World Health Organization (WHO) "Global Health Estimates" (WHO 2021a). Each DALY weight is based on "WHO Methods and Data Sources for Global Burden of Disease Estimates 2000–2021," which is an input to the Global Burden of Disease studies (WHO 2024).*

b. *The studies referenced in this paper were combined to form a broad synthesis of expected climate-related health impacts by 2030. Some studies were regional in scope (e.g., Africa, or lower- and middle-income countries [LMICs]), some were country specific, and some were global. Also, some studies themselves offered low and high estimates, both of which are included here.*

   The / indicates that the projected health impacts in these studies were given in the form of mortality, not morbidity. In these cases, the DALYs are equivalent to the years of life lost, which are assumed to be 35 years on average (see the note for column g).*

c. *The health impact projections given in each study, whether given in terms of total cases, additional cases, or percentage impacts, were all converted into the number of projected cases per thousand people in the target year using baseline population and disease incidence data.*

d. *All studies were weighted by population (World Bank n.d.b).*

e. *The incremental impact per thousand people in LMICs is calculated, first, by scaling the number of cases in column c to the total population of LMICs in 2025 (6.5 billion) (World Bank n.d.b), and second, by adjusting for the target year of the projection to 2030. The following adjustment factors were used:* for studies with projections to 2040, projected impacts were reduced by 25 percent; for studies with projections to 2050, projected impacts were reduced by 50 percent; and for studies with projections to 2100, projected impacts were reduced by 75 percent.

f. *The projected number of DALYs in LMICs is the product of columns a (the DALY weight) and e (cases per thousand people).*

g. *The value of the DALYs in column f for the five-year period 2026–30 is the product of the DALYs and an average value of a statistical life per year (VSLY) for LMICs. This column requires two calculations. First is the total DALYs for the full five-year period 2026–30. This is not simply column f times 5 because the projected health impact will be scaling up each year from 2026 to 2030. Assuming a stepwise increase, where current (2025) health impacts are only half of 2030, the five-year total DALYs are estimated to be 3.75 times column f. Second, the economic value of the total DALYs requires an estimated VSLY. This is based on the global average value of a statistical life (VSL), which was assumed to be $1.625 million (based on Sweis [2022] and corrected for current prices). Then, assuming the average remaining life expectancy of the average-aged LMIC adult population is 35 years, this puts the VSLY at $46,428. Column g, therefore, is column f times the VSLY and divided by 1,000 to convert to millions of dollars.*

h. *The low range shown for each disease is the average of the lowest two or four (for dengue) impact projections. At the bottom of column h are two more rows. The first is a simple sum across the four diseases showing the low range of the total health impact for 2026–30 per million people. The second is the annualized value of those health impacts for a country of 25 million, where 25 million is the median size of countries in the project cost database. This last row is needed to compare estimated benefits and costs and thereby calculate the estimated benefit-cost ratios of investing in CSfH.*

i. *The same as column h but for the high range of the estimates.*

Appendix D. Additional methodological details for exploratory literature reviews

The following search terms were used to conduct the two different literature reviews that formed part of this study. First was a search for examples of at least one component of "climate services for health" being implemented and analyzed for impact (see Table 5). Second, epidemiological studies that projected climate impacts on one or more of the main types of health impacts (heat-related illnesses, respiratory illness, dengue, malaria, cholera, and malnutrition; see Appendix B).

Search 1: Examples of the costs and benefits of selected CSfH interventions

In the first search, the objective was simply to find examples of existing case studies that combined the implementation of at least one CSfH component with some commentary (ideally quantitative) about its costs and benefits or cost-effectiveness. This search excluded studies of the costs and benefits of disease treatment because such treatments are not CSfH.

The search terms used were ("climate change" OR "extreme weather" OR "heat" OR "drought" OR "flood" OR "storm" OR "cyclone" OR "biodiversity loss") AND ("finance" OR "adaptation finance" OR "climate finance" OR "investment" OR "economic instrument" OR "policy instrument" OR "financial mechanism" OR "blended finance" OR "bond" OR "debt swap" OR "guarantee" OR "insurance" OR "resilience fund" OR "grant" OR "loan" OR "payment for ecosystem services") AND ("cost-effectiveness" OR "cost-benefit" OR "evaluation" OR "impact assessment" OR "return on investment") AND ("public finance" OR "private sector" OR "developing countries" OR "India" OR "South Asia").

Search 2: Studies of projected future climate impacts

The second literature search conducted was for epidemiological studies that projected climate impacts on one or more of the main types of health impacts (heat-related illnesses, respiratory illness, dengue, malaria, cholera, and malnutrition). This search focused on studies that could help quantify the projected health impacts of climate change in developing countries by 2030. The search methodology used to identify the studies retained in Appendix B is below.

Databases and sources searched

- Academic databases: PubMed, Scopus, Web of Science, Google Scholar
- Specialized journals: *Malaria Journal, PLOS Neglected Tropical Diseases, Lancet Global Health, BMJ Global Health, International Journal of Hygiene and Environmental Health, BMC Public Health*
- Major health agencies: WHO, United Nations Children's Fund (UNICEF), Centers for Disease Control and Prevention, World Bank, and relevant government/nongovernmental organization reports (for published program evaluations)
- Time frame: January 2019–May 2024 (the most recent comprehensive period)
- Languages: English

Search terms used

- General:
  - ("cost-effectiveness" OR "cost-benefit" OR "economic evaluation" OR "DALY" OR "cost per DALY" OR "cost per case" OR "impact evaluation") AND
  - ("intervention" OR "program" OR "policy" OR "strategy") AND
  - ("developing country" OR "low-income" OR "LMIC" OR specific country/region name)
- By disease:
  - Heat: ("heatwave" OR "heat stress" OR "extreme heat" OR "heat action plan" OR "early warning" OR "cooling center")
  - Malaria: ("malaria" OR "LLIN" [long-lasting insecticidal net] OR "bed net" OR "IRS" [indoor residual spraying] OR "indoor residual spraying" OR "community health worker" OR "case management" OR "RDT" [malaria rapid diagnostic test] OR "vector control")
  - Dengue: ("dengue" OR "Aedes" OR "vector management" OR "larvicide" OR "community mobilization" OR "fogging" OR "school-based education")
  - Diarrheal disease: ("diarrhea" OR "diarrhoeal" OR "WASH" [water, sanitation, and hygiene] OR "water treatment" OR "chlorination" OR "latrine" OR "hygiene promotion" OR "point-of-use water" OR "filters" OR "cholera")
- By outcome:
  - ("DALY" OR "disability-adjusted life year" OR "cases averted" OR "deaths averted" OR "benefit-cost ratio" OR "impact")

Criteria for and selection of studies

Inclusion criteria:

- Studies were global or focused on developing countries or LMICs (World Bank or UN designation).
- They reported outcomes in DALYs averted, cases averted, cost per DALY/case/death, or similar quantitative public health impact.
- Study findings appeared in peer-reviewed journal articles, published evaluation reports, or major agency technical reports.

Exclusion criteria:

- Studies or reports did not provide quantitative cost/outcome data.
- They did not specify disease focus or intervention type.
- Published study findings were not available in English.

Selection process:

- Titles and abstracts were screened manually for relevance and inclusion criteria.
- For overlapping studies in the same setting, the most recent or comprehensive study was included.

Abbreviations

CBA	cost-benefit analysis
CSfH	climate services for health
DALY	disability-adjusted life year
EIRR	economic internal rate of return
EWS	early warning system
GDP	gross domestic product
GHG	greenhouse gas
IGAD-HYCOS	Intergovernmental Authority on Development–Hydrological Cycle Observing System
LAC	Latin America and the Caribbean
LMIC	lower- and middle-income country
N/A	not applicable
NAP	national adaptation plan
NDC	nationally determined contribution
ND-GAIN	Notre Dame Global Adaptation Initiative
NMHA	national meteorological and hydrological agency
PAHO	Pan American Health Organization
RCP	Representative Concentration Pathway
SSP	Shared Socioeconomic Pathway
UNICEF	United Nations Children's Fund
VSL	value of a statistical life
VSLY	value of a statistical life per year
WHO	World Health Organization
WISER	Weather and Climate Information Services for Africa
WMO	World Meteorological Organization

Glossary

benefit-cost ratio (BCR): The ratio of discounted benefits of an investment to its discounted costs. A BCR greater than 1 represents an economically beneficial investment with a positive net present value, and a BCR less than 1 represents a negative net present value and an investment that may not be considered economically sensible—although there may be other reasons for investment. BCRs greater than 1.5:1 are typically considered to indicate highly profitable or economically viable investments (Herrera 2005).

climate services: The provision and use of climate data, information, and knowledge to improve decision-making (WMO n.d.). Although defined differently in practice depending on their intended application and users (Bessembinder et al. 2019), typical users include practitioners in the health, agriculture, water, oceanic, transport, and urban sectors (IPCC 2022). Climate services range from forecasting extreme events and seasonal impacts (e.g., droughts or floods) to making long-term projections (e.g., sea level rise or temperature changes).

climate services for health (CSfH): The iterative, collaborative, and cross-disciplinary process to generate and build capacity to access, develop, deliver, and apply climate knowledge to enhance health decisions and services and, ultimately, health outcomes (Shumake-Guillemot and Fernandez-Montoya 2019; WMO 2023). CSfH can include analysis of weather forecasts and climate trends on disease vectors and public vulnerability; improved epidemiology of climate-related disease trends, vectors, and treatments; integrated surveillance; early warning systems; and policy analysis to increase preparedness for climate health impacts.

cost-benefit analysis (CBA): A common analytical approach used to compare the estimated costs and benefits of a particular investment or decision to determine its economic and/or financial viability. The CBA in this paper is based on economic (not financial) valuation.

disability-adjusted life year (DALY): A metric that represents the loss of years of full health due to premature mortality or years lived with disability or illness. A WHO metric that combines mortality and morbidity, DALYs are frequently used to quantify disease burdens and evaluate the cost effectiveness of different interventions.

health services: The people, facilities, and financing required to provide public health services. Health systems are large and complex, representing several percentage points of a country's GDP. The basic components include the workforce, workforce capacities, available medical treatments and technologies, facilities, financial systems, and management (Shumake-Guillemot and Fernandez-Montoya 2019).

value of a statistical life (VSL): An economic metric that refers to the cost that a society is willing to pay to reduce the risk of mortality. While a key input into CBA, the use and variance in the VSL across countries with different incomes per capita is an ethical debate over the valuing of human lives. This study therefore uses the global average VSL.

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Brandon conceived this study and designed the analytical framework. Brandon, Kratzer, and Aggarwal collected the data. Brandon and Kratzer conducted the analysis and wrote the manuscript.

About WRI

World Resources Institute works to improve people's lives, protect and restore nature, and stabilize the climate. As an independent research organization, we leverage our data, expertise, and global reach to influence policy and catalyze change across systems like food, land and water, energy, and cities. Our 2,000+ staff work on the ground in more than a dozen focus countries and with partners in over 50 nations.

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