Impact of Climate Change in Health in Colombia and Recommendations for Mitigation and Adaptation

Executive Summary

THE WORLD BANK
Impact of Climate Change in Health in Colombia and Recommendations for Mitigation and Adaptation

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Task Team Leaders
Jeremy Veillard and Gabriel Aguirre Martens

Component 1
Samuel Osorio, Rodrigo Sarmiento, Nelson Alvis Zakzuk, Jean Carlo Pineda, and María de los Ángeles Carrasquilla

Component 2
Mersedeh Tariverdi, Miguel Nuñez del Prado, and Daniel Clark Thompson

Component 3
Mikhael Iglesias, Marcela Portocarrero, and Luisa Castellano

Component 4
Eduardo Alfonso-Sierra

Editing: Katherine Ward

Graphic design and illustration: Danielle Willis
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1 Agence Française de Développement (AFD) implements France’s policy on international development and solidarity. Through its financing of NGOs and the public sector, as well as its research and publications, AFD supports and accelerates transitions towards a fairer, more resilient world. It also provides training in sustainable development (at AFD Campus) and other awareness-raising activities in France.

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INTRODUCTION

Climate change has been called the most important threat to human health in the 21st century. It is estimated that if the temperature rises and its impact on the other climatic variables continues unchanged, it will kill more than 83 million people (1 percent of the world’s population) in the next 80 years (Watts et al. 2020)—13 times the toll of the COVID-19 pandemic (World Health Organization 2023). Historically, only pandemics or world wars have posed such threats to human health. As a result, the issue has aroused unprecedented attention. In 2021, the World Health Organization (WHO) declared climate change the greatest health threat facing humanity (WHO 2021). Now, more than 195 governments have included climate change mitigation and adaptation as pillars in their multi-year plans, and government health sectors have been developing plans to measure and respond to the impact of climate change on health. However, recognition of the links between climate change and health remains nascent, so these efforts have not yet been accompanied by strategic and actionable approaches to measure the impacts and ground the responses. This report contributes to

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3 In 2015, 195 countries signed the Paris Agreement. The agreement aims to limit global warming to well below 2o Celsius (C), preferably 1.5oC, compared to pre-industrial levels. To achieve this goal, countries have committed to reducing their greenhouse gas emissions.
addressing that gap by providing a framework for understanding the impact of climate change on human health in Colombia and by outlining the most effective actions to mitigate the threat.

In Colombia, a health sector response to climate change is especially urgent due to geographic vulnerabilities which impact the health risk to its people. Most people in Colombia live in the Andes region, which is prone to landslides and floods. Floods account for 45 percent of all natural hazards in the country and landslides account for 19 percent. Melting glaciers and rising temperatures have increased the frequency of these dangers. Droughts are also increasing—now occurring 2.2 times more often than in previous years and generating direct health consequences, as well as indirect ones through impacts such as lower agricultural production. In addition, the El Niño Southern Oscillation phenomenon causes abnormal weather conditions, such as more intense droughts or extreme rainfall patterns. For example, the 2010–2011 La Niña floods caused 470 deaths due to the proliferation of waterborne diseases such as diarrhea, as well as economic losses of COP 3.4 billion. In total, between 1998 and 2011, weather-related disasters constituted around 90 percent of reported emergencies in Colombia. Significant risks also exist due to many hazards that have not yet materialized but are likely in the future. For example, communities along the Caribbean and Pacific coasts are at risk from sea level rise, storm surge, and temperature extremes. In addition, rising temperatures and changes in rainfall patterns may further spread vector-borne diseases such as dengue fever and malaria to higher elevations in the country and cities such as Bogotá, which is home to more than 7 million people. For all these reasons, there is an urgent need for a schematic analysis and a comprehensive response to the threats of climate change to health in Colombia.

Although there are global and regional level efforts to address this threat, its complexity has made analysis and development of comprehensive strategies difficult. While the direct impacts of climatic variables are limited to increases in temperature, humidity, and precipitation, these variables also have numerous indirect impacts on health. Reporting by groups such as the Intergovernmental Panel on Climate Change (IPCC) has
highlighted not only direct risks to health, but also impacts on infrastructure, productive activities, biodiversity, and ecosystems, which in turn affect health. For example, these variables can precipitate geological disasters that can damage health or affect the infrastructure necessary to ensure continuity of care. In turn, these impacts increase pressure on budget management, effective implementation of policies and programs, and identification of critical actors essential for timely responses to climate change hazards.

When evaluating the impact of climate change on health, it must be taken into account that we are dealing with a highly complex phenomenon. Simply put, the relationship between climate and health is very complicated. First, climate projections have a high degree of uncertainty, which then carries over to adaptation and mitigation plans that rely on those projections. Second, climate components are networked and interdependent, so a variation in one component affects the entire system. Third, the relationship between causes and effects is not linear, so small changes can have big impacts. For example, an increase of 1°C (Celsius) in global temperature can intensify the water cycle, which increases the probability of droughts and floods that threaten food security and displace people. On top of this, there is uncertainty about the long-term effects of climate change on health (Sarmiento-Suárez 2016). Further complicating the picture is the fact that climate change is only one of the global environmental changes and challenges associated with the Anthropocene (our current era in which human activity is the dominant force in changes to how Earth systems operates). Other examples include the loss of biodiversity and desertification, both of which trigger a cascade of direct, indirect, and ecosystem-mediated effects on health (McMichael et al. 1998). Finally, the picture is even more complex because these changes are all inter-related, so there are both additive and multiplicative impacts on health. Table 1 attempts to summarize this complicated picture by presenting these impacts, the global environmental changes associated with them, and the driving forces linked to the causal mechanism.
Table 1. Health Impacts Due to Climate Change

<table>
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<tr>
<th>Direct health impacts</th>
<th>Indirect health impacts</th>
<th>Health impacts caused by ecosystem changes</th>
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<tr>
<td>Flooding</td>
<td>Population displacements/ climate refugees</td>
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<td>Exposure to pollutants (forest fires, urban air quality)</td>
<td>Damage to health infrastructure</td>
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<td>Increased burden of chronic diseases</td>
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<td>Malnutrition</td>
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<td>Increase in skin and respiratory allergies</td>
<td>Inequities</td>
<td>Loss of natural medicines</td>
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<td></td>
<td>Poverty</td>
<td>Urban blight</td>
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**Driving forces and human pressures on the environment:**
economic growth, use of fossil fuels, greenhouse effect, population growth, and deforestation

**Global environmental changes:**
climate change, depletion of the stratospheric ozone layer, loss of biodiversity, depletion of freshwater reserves, desertification, and land degradation

**Direct health impacts**
- Floods
- Heat waves
- Increased exposure to ultraviolet radiation
- Landslides
- Exposure to pollutants (forest fires, urban air quality)
- Increased burden of chronic diseases
- Increase in skin and respiratory allergies

**Indirect health impacts**
- Population displacements/climate refugees
- Loss of livestock
- Conflict
- Damage to health infrastructure
- Inadequate mitigation and adaptation strategies
- Inequities
- Poverty

**Health impacts caused by ecosystem changes**
- Changes in the dynamics of vector-borne diseases
- Higher exposure to animal contact because of changes to the species’ ecological niche
- Emergence of new infectious diseases
- Droughts and crop decline
- Malnutrition
- Loss of natural medicines
- Urban blight
Due to the inherent complexity of the relationship between environment and health, environmental epidemiology has developed different models to address it. The most widely used models are (i) the model of socio-environmental determinants of health developed by the WHO; (ii) critical epidemiology; and (iii) the Ecosocial theory of disease distribution. Different strategies have emerged from these models, such as the ecosystem approach to health, with variations, including Ecohealth, the One Health approach, and the Planetary Health movement (Lebel 2005; WHO 2017; Planetary Health Alliance n.d.). These initiatives are all based on shared paradigm shift in the approach to public health: moving from an anthropocentric (human-centered) approach to a biocentric one that treats human, animal, and environmental health as inextricably linked. For example, the Ecohealth approach is centered on analysis of the determinants of health in socio-ecosystems, multidisciplinary approaches to develop a deeper understanding of environmental health problems, and the participation of civil society in the process. These principles focus on sustainability, social and gender equity, and translating knowledge into action. In recent years, academia and scientific societies in Latin America have made advances in environmental health understanding on the conceptual and methodological levels, but research funding is very low compared to scale of the needs and problems. Within this rubric, the relationship between climate change and health is one of the priority research topics (Rodríguez-Villamizar 2015).

Conceptual frameworks such as Planetary Health and One Health are useful to understand the interactions amongst human health, climate change, and biodiversity. These frameworks highlight three key challenges for climate change and health: (i) protecting health from the full range of climate impacts; (ii) building resilient and sustainable health systems for the 21st century; and (iii) promoting the health co-benefits of climate action. This report responds to these three challenges by providing data and tools useful for mapping vulnerability and sensitivity to temperature across Colombia, and for developing adaptation strategies focused on vulnerable populations and subnational areas. It also considers alternative pathways such as ecosystems and biodiversity, and the economic implications of those impacts.

This flagship report is focused on providing a holistic, actionable analysis of this complex but urgent issue—analysis rooted in methodologies specifically designed to assess the impact of climate change on health in Colombia, considering the complexity the factors involved and the particularities of the Colombian context. It is particularly designed to support policymakers in Colombia. Specifically, it lays the groundwork for policy action in Colombia and provides a starting point for World Bank collaboration with the government in understanding the phenomenon and taking concrete actions to tackle it, thereby improving health outcomes for all Colombians, and contributing to improvements in healthcare all around the world in the face of a
global threat. It also offers insights for policymakers and academics around the world seeking ideas and toolkits to confront this daunting challenge.

Using an actionable approach for policymakers that considers the complexity of the Colombian context, this report divides the interaction of climate change and health into four components. Component 1 looks at the direct impact of climate change on human health by analyzing the effect of temperature increases on mortality at the subnational level. Component 2 expands upon Component 1 and analyzes climate change-induced natural disasters, such as landslides and floods, and their potential impact on human population, health infrastructure, and access to health services. Component 3 addresses indirect interactions between climate change and health, with a focus on the One Health approach and particularly the biodiversity implications for human health given their importance in Colombia. Finally, Component 4 brings the first three lines of impact analysis together in a common monetary analysis to illustrate health economic benefits and to facilitate investment and policy decisions. Each of these four components is described in more detail below.
Component 1 addresses one of the major challenges Colombia faces in designing and implementing a policy to protect human health against climate change: namely, quantifying the impact. To build effective adaptation strategies, it is crucial that the government can quantify the health impacts of specific climate hazards and their distribution in each region of the country. This is a top priority for the government as a vulnerability mapping tool to build adaptation strategies. To address this need, Component 1 analyzes daily temperature-related mortality and its costs at the subnational level, by sex, age group, and cause of death, for the 2010–2019 period and 2050 Shared Socioeconomic Pathways (SSP) scenarios. The analysis uses the Global Burden of Disease (GBD) methodology, one of the most comprehensive and widely used approaches; this methodology also allows us to make comparisons with other countries.

Component 2 assesses climate change-induced natural disasters and how they affect health systems and vulnerable populations. It prioritizes resilience investments using developed compound and integrated risk indices at both national and departmental levels. Health facilities are further ranked based on criteria such as staff, supplies, infrastructure, climate vulnerabilities, and the communities they serve, both nationally and at the departmental level. For Bogotá, it identifies communities most affected by disruptions in health services during extreme events. To ensure uninterrupted supply chains and service access, critical road segments requiring cross-sectoral coordination and investment are also identified. The primary goal of these efforts is to offer guidance to policymakers, considering the diverse realities across regions of the country and the specific climate-induced challenges. The impacts and recommendations presented in this analysis align with existing legal frameworks, ensured through employing Frontline Rapid Scorecard to evaluate climate-related laws, regulations, and procedures across sectors. Finally, this data-informed deep dive employs cutting-edge approaches, including Artificial Intelligence and mathematical modeling, for prioritizations.
Component 3 focuses on biodiversity—a particularly important area of indirect climate impacts on health in Colombia. It assesses the drivers of biodiversity loss, emphasizing the interactions between biodiversity and air quality, and outlines the governance mechanisms being used to address environmental and climate-related health risks. Component 3 focuses on the crucial role that climate and biodiversity play as determining factors that shape not only the environment but also the ecological and social processes that take place within them. For example, changes in vegetation can increase global greenhouse gas emissions and impact capacity for absorbing carbon dioxide. Biodiversity can also contribute to adaptation efforts and reduce the risks of climate-related hazards to human health. In Colombia, water and air pollution constitute key environmental risks for biodiversity and health, increasing the burden of disease in the country. Drivers of biodiversity loss such as habitat loss and land use changes due to deforestation (which is the primary source of greenhouse gas (GHG) emissions in the country) threaten biodiversity, increasing channels of exposure for zoonotic diseases. In the context of a megadiverse country such as Colombia, paying attention to the interactions amongst health, biodiversity and climate change is essential. Lastly, Component 3 identifies and analyzes national and subnational governance structures and capacities—a key step for operationalizing effective policies and interventions addressing the interactions between biodiversity and human health.

Component 4 supports decision-making by integrating the findings from Components 1–3 into a comparative analysis the costs of intervention versus the costs of inaction. To this end, Component 4 integrates the findings of the economic burden associated with non-optimal temperature (Component 1), the implications for the cost of reconstruction of infrastructure affected by extreme events (Component 2), and indirect effects of climate change on health (Component 3) and complements it with an estimate of the costs associated with mortality and morbidity of six selected outcomes, using the World Bank's Climate and Health Economic Valuation Tool (CHEVT). In addition, the component identifies climate change adaptation interventions that have been proposed in the health sector and documents their implementation costs. Assessing the cost of inaction contributes to raising awareness and stimulating policy development about current and future health-related challenges that deserve attention. Highlighting the policy interventions from the health sector and their costs, contributes to cementing a roadmap of interventions to tackle the challenges of climate change.
COMPONENT 1
Burden of Disease Attributable to Non-optimal Temperature in Colombia and Its Costs: 2010–2019 and Future Projections

Key points

1. To our knowledge, this is the first study that has reported non-optimal temperature effects disaggregated by mortality cause, sex, age group, and department in Colombia.

2. We calculated that between 2010–2019, 0.43 percent of total mortality (1.05 percent of 17 mortality causes analyzed) was attributable to non-optimal temperatures: 24.3 percent attributable to heat and 75.7 percent to cold.

3. Most of the attributable burden occurred in men in the 70+ age group—a group expected to increase due to population transition.

4. Colombia’s heat-attributable mortality rate will surpass its cold-attributable mortality rate in 2040 for the climate change projection scenario SSP5 (8.5°C), or in 2049 for SSP3 (7.0°C).
5. The economic burden due to cold and heat variations varied from COP 0.26–1.5 and COP 0.38–1.2 trillion, respectively, and it was concentrated in people between 15 and 44 years old.

6. The cumulative economic losses due to non-optimal temperature related with premature mortality ranged from 0.1 to 0.4 percent of Colombia gross domestic product (GDP) in 2019.

**Background**

Colombia has made significant efforts to comply with its commitments under the Paris Agreement. For example, it has issued laws for climate management and action, energy transition, and the development of a national plan for adaptation to climate change, among others. Nonetheless, there are still related challenges concerning efforts to quantify health impacts of specific climate hazards and the distributions by regions of the country—all of which are a top priority for the government. Two factors are of particular note. First, Colombia has higher mean temperatures and more extreme weather events than other countries in the region and does not have a strong adaptation capacity to tackle these threats (National Planning Department (DNP) 2011). Secondly, there is evidence that global warming is increasing mean and extreme temperatures, which will trigger serious effects on health (Sarmiento-Suárez 2016).
To produce new knowledge to map vulnerability and design climate change adaptation strategies, the study used the temperature burden of disease methodology developed by the Global Burden of Disease (GBD) project (Lee et al. 2017). The GBD methodology included data from Colombia, but for this report, the analysis went further in order to provide analysis at the subnational level and disaggregated by sex and age group. The analysis is framed using the non-optimal temperature approach, which is different from extreme temperatures; it is comparable to the GBD attributable burden of disease analysis available for Colombia and other countries.

**Methods**

A spatial-temporal analysis of temperatures and mortality was conducted to determine the burden of disease of non-optimal temperatures and their costs for each department in Colombia from 2010 to 2019, and for five different forward-looking climate change scenarios: two low greenhouse gases emissions scenario (SSP4 1-1.9 and SSP1 1.9-2.6); one medium emissions scenario (SSP 2-4.5); and two high emissions scenarios (SSP 3-7.0 and SSP 5-8.5).

The analysis includes a systematic search of literature looking for methods quantifying the burden of disease in Latin American countries. This guided the selection of the methodology to be used for the present study.

ERA-5\(^5\) daily temperatures for 2010–2019 were used, with 0.25°x 0.25° spatial resolution, and gridded population data from Worldpop for the same years. Each temperature pixel was weighted by population. Mortality data were obtained from the Colombian National Department of Statistics (DANE, in Spanish) with the International Classification of Diseases, Tenth Revision (ICD-10) codes for 17 mortality causes used by the GBD: lower respiratory infections; noncommunicable diseases (NCDs): ischemic heart disease (IHD), stroke, hypertensive heart disease, cardiomyopathy, chronic obstructive pulmonary disease (COPD), diabetes mellitus, chronic kidney disease (CKD), road injuries, other transport injuries, drowning, exposure to mechanical forces, animal contact, exposure to forces of nature, self-harm, interpersonal violence, and other unintentional injuries. Missing data were imputed with random forest models, using the missForest package of R software.

A descriptive time series analysis of temperature and deaths was carried out. Daily relative risks (RR) and the population

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4. SSP stands for Shared Socioeconomic Pathway. SSPs are scenarios use to make projections about the socioeconomic impacts of climate change through 2100 depending on different courses of action. They predict how climate change will change in response to indicators such as population, economy, land use, and energy change.

5. ERA5 is the fifth generation European Center for Medium-Range Weather Forecasts (ECMWF) atmospheric reanalysis of the global climate covering January 1940 to the present.
Attributable fraction (PAF) were calculated by cause using the exposure response curves for each pixel, and then aggregated by department, based on the comparative risk assessment framework (Burkart et al. 2021). Additionally, the summary exposure values (SEV) were obtained to estimate the prevalence of exposure weighted by risk for each department, year and cause. Then, using temperatures for climate change scenarios from the Climate Change Knowledge Portal (CCKP) and population projections from DANE, the attributable mortality and years of life lost (YLL) were projected.

Attributable economic burden due to non-optimal temperatures for the 17 analyzed mortality causes was estimated using the modified human capital approach to the productive YLL (PYPLL). Two scenarios were simulated:

- **Best scenario (lower bond):** valuing the PYPLL with the annual minimum wage

- **Worst scenario (upper bond):** using the GDP per capita for each year

Both scenarios were discounted with a 5 percent rate.

### Results

The mean temperature in Colombia between 2010 and 2019 was 23.1ºC (± 3.92), with the highest mean in Sucre (28.18ºC, standard deviation (SD): ±1.26) and the lowest registered in Bogotá, D.C. (13.08 ºC, SD: ±2.52). There was higher variability in temperature in the departments of the Andean region. For instance, Boyaca had the lowest (7.08ºC) and the highest (38.62ºC) values. The departments with highest temperature increases on average from 2010 to 2019 were Magdalena (+1.12 ºC), Bolivar (+1.05 ºC), and Tolima (+1.02 ºC). The spatial representation of mean temperature zones is shown in Figure 1.

The number of deaths attributable to non-optimal temperature in the 2010–2019 period were 9,472 people (men n=5,510, women n=3,962). The attributable rate was 20.41 per 1,000,000; the rate was higher for men (24.27 per 1,000,000) than for women (16.72 per 1,000,000). Cold-related deaths (15.41 per 1,000,000) outpaced heat-related deaths (5.00 per 1,000,000). Non-optimal temperature accounted for 172,870 YLL (YLL rate=37.28 per 100,000). During 2010–2019, the YLL attributed to low temperature (n=109,313, YLL rate=23.62 per 100,000) was also higher than the YLL due to high temperature (n=63,556, rate=13.66 per 100,000).
Non optimal temperatures accounted for 0.43 percent of total mortality (1.05 percent of 17 mortality causes analyzed) between 2010-2019. Also, 75.7 percent of attributable deaths were associated with cold and 24.3 percent to heat.

The events with the highest PAF due to high temperature were homicides (0.7 percent), road traffic accidents (0.6 percent), and diabetes mellitus (0.5 percent). The departments with the highest mortality rate due to heat exposure were Sucre (21.17 per 1,000,000), Córdoba (16.69 per 1,000,000), and Arauca (16.47 per 1,000,000). The causes associated with the highest burden of mortality due to heat were homicides, road traffic accidents, and IHD. As a matter of fact, the YLL related to heat for homicides was 30,045 nationally, with higher departmental YLLs in Atlántico (4,850), Bolívar (3,891), and Córdoba (3,720). Road traffic accidents were responsible for 10,937 YLL nationally, with higher numbers in Córdoba (1,226), Cesar (1,109), and Atlántico (1,095). IHD YLL accounted for 48,907 YLL nationally, with higher YLL values in Bogotá (9,039), Antioquia (8,531), and Valle (6099). YLL related to cold for COPD were 18,723 nationally, with higher YLL values in Bogotá (4,394), Antioquia (3,675), and Cundinamarca (1,997). Stroke was responsible for 10,372 YLL nationally, with higher numbers in Bogotá (2,719), Antioquia (1,593), and Valle (1,081).
The regions with the highest burden due to heat were the Caribbean region with 64 percent of the total YLL, followed by the Eastern Andean region with 9.2 percent, and Antioquia and the Coffee Belt region with 8.9 percent. Regarding the cold-related burden, the highest YLL was in the Central Andean region with 38 percent of YLL, followed by Antioquia and the Coffee Belt region with 28 percent and the Western Andean region with 20 percent. A graphical representation of mortality rates attributable to heat and cold by departments is presented in Figure 2.

When analyzed by sex, the burden is higher for men, especially in heat (Figure 3). We can see that most of the mortality occurs in the 70-years and above age group. This is of high importance as it is a growing age group in Colombia.

The total economic burden attributable to non-optimal temperatures for 2010–2019 varied between COP 0.6 and COP 3.3 trillion for the period; and the amount related to cold and heat range from COP 0.26–1.5 to COP 0.38–2 trillion, respectively. Homicides, drowning, transportation-related injuries, and IHD showed the greatest economic burden due to non-optimal temperatures (Figure 4). Also, economic burden was greater between 15 and 44 years of age, mainly due to heat-related burden. Concerning subregional economic burden, consistent with YLL findings, heat-related burden was greater in Caribbean region—specifically Atlántico (COP 54–249 billion), Bolívar (COP 46–204 billion), and Cesar (COP 25–126 billion)—and cold-related burden was higher in Antioquia (COP 59–324 billion), Valle del Cauca (COP 51–251 billion), and Bogotá, D.C. (COP 31–212 billion). The cumulative economic losses due to non-optimal related premature mortality amount from 0.1–0.4 percent of the GDP of 2019 in Colombia.

Figure 2. Mortality Rates Attributable to Heat and Cold, by Departments in Colombia
Figure 3. Cold and Heat Attributable Deaths, by Sex and Age Group, Colombia 2010–2019

Figure 4. Economic Burden Due to Non-Optimal Temperatures, Colombia 2010–2019
Regarding temperature projections, particularly in scenarios with high greenhouse gases emissions (SSP3.70 and SSP5.85) the highest average temperature would be in the departments of the Caribbean region, but the highest gradient of change would be in the Orinoco region. Country heat attributable mortality rates might decrease 14 percent from 2020 to 2050 for very low greenhouse gases emissions scenario (SSP1-1.9) and increase for the other scenarios, ranging from 28 percent for SSP 12.6 to 63 percent for SSP5.85. By 2050 the YLL would nearly double in SSP5.85 (44,703 YLL) in comparison to SSP1.19 (25,493 YLL).

**Conclusions**

1. Heat was particularly linked to higher attributable deaths from homicide, ischemic heart disease, and road traffic accidents; while cold was particularly linked to higher attributable deaths from chronic obstructive pulmonary disease, ischemic heart disease, and stroke.

2. The departments with the highest mortality rates associated with heat exposure were Sucre, Cordoba, and Atlantico; while Quindío, Caldas, and Risaralda had the highest mortality rates due to cold exposure.

3. Most of the attributable mortality occurs in men aged 70 and older, but most of the costs occur in young men, especially for homicide. Due to the current epidemiological transition in Colombia, it is expected that NCD attributable burden will increase in the coming years.

4. The cumulative economic losses due to non-optimal related premature mortality are equal to between 0.1 and 0.4 percent of the GDP of Colombia in 2019.
5. The greatest share of the economic burden due to heat temperatures occurred in young adults due to external causes as homicides, transportation related injuries, and drowning.

6. The effects of cold are important for lower respiratory tract infection and are expected to be outweighed by the effects of heat in SSP5.85 by 2040, and in SSP3.70 in 2049.

7. Nationally, heat attributable mortality rates would decrease 14 percent between 2020 and 2050 for SSP1-1.9 or could increase 63 percent for SSP5-8.5.

**Recommendations**

1. This study can be used as a baseline to carry out health impact assessments of different adaptation and mitigation measures in the different climate change scenarios.

2. The current subnational analysis can serve to map vulnerability at regional and local levels to identify strategies to offset climate change impact and to build early warning systems.

3. The approach used here to estimate deaths associated with temperature exposure should also be used to assess the burden of disease related to morbidity; that will be necessary step in any potential health system reform in Colombia.

4. A further analysis using municipality and provinces as administrative units could help to reduce the uncertainty, especially in the departments of the Andean region.

5. An approach focused on NCD preventive programs for elderly people is needed to improve the ability of the elderly to adapt to future heat increases.

6. Developing strategies aimed at reducing the economic burden of heat on external causes of mortality such as homicides and traffic accidents in young adults is highly recommended.
COMPONENT 2

People at the Heart of Resilience-Informed Health System Investments: Colombia Hazard Risk Assessment using Artificial Intelligence

Scope

- This set of analyses quantifies the adverse effects of climate change and extreme events on the vulnerable populations and on the health system. It prioritizes departments for resilience-sensitive investments based on a compound (multi-hazard) and integrated (multi-factorial) risk index. 

  Priority health facilities for investment are further identified, nationally and in each department, and ranked based on medical staff, supplies and equipment, infrastructure condition, and climate vulnerabilities, as well as health system design and people who they serve. For a high-resolution analysis of the city of Bogotá, it identifies communities most affected by disruptions, directly and indirectly, in accessing health services due to extreme events. To minimize disruptions in health supply chains and service access, the analyses also identify critical road segments for cross-sectoral coordination and investment needs.
The principal goal of the study aims to prioritize resilience measures that can strengthen overlapping areas of vulnerability in the population and health system to climate-induced hazard impacts, including slow-onset and extreme events. This analysis focuses on flooding and landslide events. An analysis of existing legal frameworks and policies helped to translate these priorities into actionable recommendations.

Methods

We used the *Frontline Rapid Scorecard* (Thompson et al. 2023) to assess climate related laws, regulations, and procedures for the health sector and others (i.e. transport, energy) that support health system functionality in routine care and emergencies. The high-level assessment informed the design and depth of the country data informed deep dive.

Data-informed deep dive: Prioritizations are conducted by employing Artificial Intelligence and Mathematical modeling approaches. Data includes poverty, households’ characteristics, maternal and child health, population climate related health risks, access to basic utilities, health system capacity, and health infrastructure. Methods identify risks to climate change and extreme events for: (i) populations with direct exposure to hazards; and (ii) primary health care (PHC) centers and higher tier hospitals (levels II and III) which are directly and indirectly affected by extreme climatic events.
Figure 5. Climate and Disaster Risk Management For Health Systems Prioritization

Health System
1. Health Foundations
2. Resilient Health Care Facilities
3. Resilient Network of Health Facilities

At-risk populations, essential workers, and critical personnel
Population, facilities, and infrastructures exposure to hazards
Health system accessibility disruptions
Inter-agency coordination, preparedness, and response mechanisms
Infrastructure critical components

Figure 6. People and Health Systems

Proximity to facilities
Income
Gender
Age
Proximity to hazards

Services offered
# of beds
# of staff

Vulnerable People
Vulnerable Systems

HAZARDS

Health Systems: staff, space, system, social support, sustainability
Emergency Response: fire department, emergency management, military
Lifeline Infrastructure: transport, electricity, water/wastewater, ITC

Multilevel Approach
National / Sub-National

Prioritization

Tools and Interventions

Analyze

Enabling Key Sectors
1. Integrated
2. Resilient
3. Emergency Response
4. Health Systems
5. Infrastructure

Components
Poverty
Gender
Disabilities
Elderly
Care deserts
Female head of household

Table: Scorecard

Component 2

# of beds
# of staff
Findings

- The Government of Colombia has worked intensively on policy and legislative instruments for climate change. It has put in place data mandates and collection efforts for various determinants of climate and health risks, and conducted quantitative risk assessments on which this work is built.

- Risk exposure of PHC facilities potentially affect primary care services to 17 million and 25 million people facing flood and landslide risks, respectively, and exposure of hospitals to flood and landslide risks affects services for 16 million and 23 million people, respectively.

- The departments of Vaupes, Cundinamarca, Boyacá, and Arauca should be prioritized for all of the risks assessed. Cauca and Norte de Santander should primarily be monitored for flood risks, and Tolima and Cordoba for landslide risks.

- Approximately a quarter of Colombia’s population (15.7 million people) is directly exposed to low flood level risks (5 cm depth). This means they face higher risks of skin, acute respiratory infections, and diarrhea, in addition to wider socioeconomic impacts of floods on well-being and livelihoods. Valle del Cauca has the highest number of vulnerable people facing direct risks: 2.4 million (42.71 percent of its population).

- About 2.3 million inhabitants are directly exposed to landslides, which can cause high mortality due to trauma or suffocation by entrapment and injuries. In addition to service disruptions, landslide damage to lifeline infrastructure also leads to loss of access to essential services, water-borne diseases, electrocution, and lacerations from debris (World Health Organization 2023).

- About 1 out of 5 health facilities are directly exposed to disruptive floods. This includes 4,416 primary care facilities and 143 hospitals. Indirect impacts of floods are also substantial due to disruption to water, power, and communication networks, as well as impaired access to facilities.

- 549 primary care facilities and 20 hospitals are directly exposed to higher landslide risks, including the possibility of partial or full collapse. Adequate preparedness measures must be prioritized in these facilities to ensure patient and health workforce safety and to minimize service disruptions.

- We provide healthcare facility prioritization to highlight the top facilities at a national level and in each department for subnational health service delivery planning. Most
climate-vulnerable facilities, serving the most vulnerable populations, in areas with lower health system presence are prioritized. Regarding PHC centers, the departments in the north have more at risk of floods, while most affected hospitals are in the west and north. Notably, Bolivar has five of the 10 nationally prioritized PHC centers; Bolivar and Valle del Cauca have PHC centers prioritized for all risks; and Valle del Cauca and Antioquia have prioritized hospitals for all risks.

- **Impacts of extreme climatic events on transport networks slow access** to health services and the effects vary, as shown in the analysis. Northwestern areas of Bogotá are severely affected by floods, with average access time to all health services increasing from 15 to 80 minutes. Delayed access to care is associated with significant costs for patients due to higher risks of morbidity and mortality. Underserved populations further from health systems are less likely to seek care putting them at even higher risks. Disruptions in accessibility also affect supply chain and service availability.
In addition to the increased climate-related morbidity and mortalities discussed in Component 1, the last few years have seen increased impacts from climatic extreme events in Colombia, such as coastal and river floods and landslides, which affect people’s well-being and essential services, such as healthcare and transport. Extreme climatic hazards are expected to worsen severely due to climate change (World Bank 2021). Floods affect peoples’ health, livelihood, and well-being (Walker-Springett, Butler, and Adger 2017). They also have a significant impact on health services and patient care delivery (McGlown and Fottler 1996) through structural damage to buildings (McGlown and Fottler 1996); interruption of care (Yusoff, Shafii, and Omar 2017); loss of lighting, heating, and cooling (Martin 2019); extensive contamination of building structures, equipment, and supplies with microorganisms (CDC 2013); exposure to toxic chemicals and infectious waste (Martin 2019); and fire hazards due to erosion of electrical systems or equipment (Martin 2019). Furthermore, damage to health facilities and the utility services they rely upon (e.g., water, electricity, communication lines), directly and indirectly impacts access to essential services and quality of care (World Health Organization (WHO 2023); International Federation of Red Cross and Red Crescent Societies 2023; Centers for Disease Control and Prevention (CDC) 2018). Injury or illness in the affected population (WHO 2023; CDC 2018) and well-being losses also include and lead to adverse mental health impacts (Akpinar-Elci et al. 2018; Kennedy et al. 2015). Climate change impacts will also likely be exacerbated by human development through land use changes and the built environment, particularly in areas with laxer regulations and enforcement (Campos Garcia 2011).

Northwestern areas of Bogotá are the most affected by floods, with average travel times increasing five-fold (from 15 minutes to 80 minutes), indicating a severe delay in access to potentially life-saving services.

Colombia has taken significant steps to address climate change in national policies, but further research is necessary to enhance the understanding of its impacts on vulnerable populations and on the health system to strengthen evidence-based decision-making. The government has introduced legislation (Ministry of Environment and Sustainable Development 2017; Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) 2016; IDEAM et al. 2016; Ministry of the Environment 2014; Congress of Colombia 2018; Ministry of Environment and Sustainable Development 2023) and developed...
technical documents on risk assessment for floods (Pérez et al. 2018; Güiza 2013; Sedano Cruz 2017; Vargas et al. 2018; Villegas González 2020), ground mass movements (Cerquera Gómez and Novoa García 2021; Aristizábal 2019; Ruiz Peña 2017; Moreno et al. 2006; Gáfaro Duarte 2015; Cobos Romero and Salamanca Pira 2021), climate change (Mendoza 2011; Cuartas and Méndez 2016; Cardona et al. 2020), and the impacts on health (Rodríguez-Pacheco, Jiménez-Villamizar, and Pedraza-Álvarez 2019; World Bank 2012a), which have been reviewed and taken into consideration for study design and recommendations.

A high-level assessment of health system adoptive capacity to climate hazards was conducted using the Climate and Disaster Risk Management Frontline Rapid Scorecard (Frontline Rapid Scorecard) (Thompson et al. 2023). The results highlighted how Colombia's health system has benefited from investment in preparedness measures at the departmental and municipal levels and from policy and legislative strengthening. Notable investments in the health system include additional planning measures at the healthcare facility and system levels, such as mandating risk assessments for hospitals under the Disaster Risk Management Plan for Public and Private Entities (PGRDEPP), along with enhanced medical supply and distribution networks. These investments have been bolstered by improvements in the country's wider emergency response sector, which has strengthened its financing and funding measures for disaster mitigation, response, and recovery over the last two decades, including for extreme climatic events and health emergencies. Over the last decade, the government has focused more on its response to health emergencies, complimented by the 2012–2021 Public Health Plan, which identified infectious disease control as a critical mission—an important factor in responding to climate-induced incidents. Through the National Institute of Health (INS), surveillance and medical supply measures were prioritized and later accelerated through response measures during and in the aftermath of COVID-19. From a legislative and administrative perspective, departments and municipalities spearheaded much of the planning and work on response capabilities.

The scorecard assessment complemented the development of a data-informed, climate-sensitive risk index that combines wider health system characteristics with population-level health and sociodemographic information. To this end, the study acquired and processed related determinants, in consultation with stakeholders, and developed an Artificial Intelligence algorithm for the compound and integrated risk index. Compound refers to multiple hazards and integrated refers to consideration of population and health system climate vulnerabilities simultaneously.
The risk-informed prioritizations empower policymakers to:

1. Identify, locate, and target more vulnerable populations directly exposed to climate risks and indirectly impacted by climatic hazards;
2. Identify and locate PHC centers and hospitals that are at higher risk of climate-induced hazards and essential for continuity of care; and
3. Prioritize mitigation, preparedness, and response interventions in departments based on the most significant climate risks.

The climate risks and climatic hazards included in the analysis are recurring floods and landslides, as well as the population health risks estimated in Component 1 described in greater detail in the full report. These hazards were selected based on considerations on Colombia’s natural hazard exposure risk profile and data availability and quality for systematic analysis. An economic analysis of the impacts of extreme events on populations and health systems is being developed and will be provided as a follow-up note to this report based on the findings herein (Thompson et al. 2023).

Conclusions and Recommendations

The impact of climate change and hazards on population health is exacerbated by social inequalities, poverty, overwhelmed healthcare facilities, and a lack of evidence-based public policies (Palmeiro 2023). To better understand the situation in Colombia (including variations in different regions), this analysis identified vulnerable populations and overlayed that data with health system vulnerabilities. The results indicate a significant and direct impact of floods and landslides on both Colombia’s population and its health system, particularly where health resources are more limited and where they serve more vulnerable populations.

In this regard, the Climate-Sensitive Risk Index can be a starting point for prioritization, as it systematically classifies risk based on a normalized and representative set of information. It considers climate-sensitive risk determinants for populations and the health system simultaneously to identify departments, communities, and facilities at the forefront of climate change-related health risks. It directly supports decision making by providing timely key performance indicators and data analysis to prioritize departments, as shown in the results, while also generating detailed lists of vulnerable communities and priority health facilities (PHCs, hospital category II, and hospital category III) for targeted interventions.
The risk assessment results highlight several potential actions. Mitigation strategies are strongly recommended, preparedness interventions, and policies to reduce risks from floods and landslides, starting in the departments with the highest risks, as identified in the results and detailed in the annex. **Mitigation and preparedness measures are critical** for the identified departments due to the extensive exposures detailed in the findings. **Prioritization is key**, given the limited resources and vast potential impacts; it impossible to immediately equip every facility to the highest standard to minimize disruption of health services to the most vulnerable parts of the population.

Enhanced communication channels, data-driven approaches for coordinated service delivery, resource allocation, and targeted deployment of mobile clinics can help to meet surge demand through a system-level and regionally coordinated response. Table 10 lists the recommendations; they are aligned with previous government of Colombia policy measures to reduce the impact of climatic and non-climatic hazards, including seismic and some volcanic activity. While government ministries in Colombia agree about the vulnerability of the healthcare system due to climate change, to date, more work is needed. To address this, it is recommended that the emergency preparedness of the country’s health systems regarding extreme climatic events should be closely coordinated with the overall emergency management and disaster response systems, to increase efficiency and leverag existing structures. This includes further integrating the health system’s disaster risk management efforts with actors such as the military, civil protection, and community groups, with clearly defined roles and mandates for crisis response, including more frequent hazards such as floods.

Concerning preparedness for floods and impact mitigation, the Climate-Sensitive Risk Index can support local agencies to determine flood risk locations in each area and develop a detailed preparedness and response plan accordingly (Wood 2018). Department-level exposure maps can be used directly. Additionally, the index can be used to prioritize the creation of the evacuation protocols and multi-purpose shelter locations needed for critical hospitals this analysis has identified as priority facilities. Tailored response plans also need to be developed for each area.

We suggest adding information on long-term care facilities and strengthening service delivery for areas with a higher proportion of seniors and for people with jobs directly exposed to weather, such as construction and agriculture. Further assessments should be conducted to identify and prioritize the concrete needs and to tailor policy interventions according to community needs and routine health service delivery specific to the region’s need and disease profiles.
Lastly, multi-sectoral investment involving the health, transport, power, water, and communication sectors is recommended to strengthen the health system and enhance its climate resilience. As part of flood and landslide mitigation measures, transport upgrades should prioritize identified critical corridors for health service delivery. Measures could include maintaining critical routes and prepositioning response equipment. In addition, modes of alternative service delivery, such as telehealth, should be considered for highly impacted communities. However, doing so depends on the availability and strengthen of internet and cellular coverage in some areas of the country. It may also be useful to revisit land-use zoning to reduce risks to health services and populations in high-risk departments (Habitat for Humanity 2023).

In order to strengthen data-driven policy interventions and to enable more granular analyses at the municipality level (administrative level 2), increased access to sampling and coverage for the Large Integrated Household Surveys and Measuring Monetary Poverty and Inequality survey would be useful. Such granularity could enable efficient microtargeting. In addition, collecting data on how internally displaced population facing these hazards seek health, would greatly enhance any future analysis.

Recommendations—based on the results of this analysis and supporting research—include specific actions for planning, disaster preparedness, staff training, capacity building, and the structural quality of buildings and infrastructure (highlights in Table 10). Building capacity, particularly in under-resourced areas, will become increasingly important to minimize the losses to the health system and to population health due to climate change, which is contributing to increased risk from hazards. It is important to note that many recommendations require multi-level governance and multi-sectoral collaborations involving the health sector and other sectors, particularly emergency response and lifeline infrastructure. This reflects the importance of a unified approach in governance to strengthening health and other key systems from hazard impacts (Rentschler et al. 2021).
Table 2. Recommended Actions to Improve Health System Climate Resiliency in Colombia

<table>
<thead>
<tr>
<th>Observation</th>
<th>Potential Action</th>
<th>Action Type</th>
<th>Reference(s)</th>
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<tbody>
<tr>
<td>According to the Climate-Sensitive Risk Index, flooding impacts approximately 20% of healthcare facilities, and landslide risks affect approximately 3.5% of healthcare facilities. Many of the most exposed facilities are in areas with high percentages of vulnerable populations.</td>
<td>Prioritize in-depth risk assessments of facilities focused on hazards and health services being provided through various modalities (i.e. remote consultations, telehealth) in areas with vulnerable populations (e.g., Valle del Cauca) in line with national laws and guidance, such as Decree 2157 of 2017 (2.3.1.5.2.1).</td>
<td>Health infrastructure; Health system planning</td>
<td>Campos Garcia et al. (2011); Bennett and Iossa (2006); Government of Colombia (2021); California Hospital Association. 2023</td>
</tr>
<tr>
<td>Floods and landslides disrupt lifeline infrastructure, like electricity and water supplies; this reduces or cripples health facilities’ ability to function.</td>
<td>Invest and maintain redundancies as outlined in mandated risk assessments (e.g., Decree 2157 of 2017) or equivalent assessments (e.g., hospital safety index). Consider green solutions like solar panels that address climate and hazard mitigations together.</td>
<td>Health infrastructure</td>
<td>Rentschler et al. (2021)</td>
</tr>
<tr>
<td>The size and scope of flooding and landslide threats highlight the importance of data-driven prioritizing of healthcare investment in new building, retrofitting, and maintenance.</td>
<td>Conduct assessments of building, retrofitting, and maintaining health infrastructure based on the risk index to determine how to prioritize investments in these areas. To this end, Installing or improving built environment flood mitigation measures can be prioritized through a cost-benefit analysis.</td>
<td>Health infrastructure</td>
<td>Campos Garcia et al. (2011); Habitat for Humanity (2023); Edmonds et al. (2020); Thompson et al. forthcoming</td>
</tr>
<tr>
<td>Mitigating flooding and landslide threats to health facilities and other health infrastructure should be prioritized in alignment with available resources.</td>
<td>Use the Climate-Sensitive Risk Index and climate exposure and disruption analysis to help prioritize investment in flood and landslide mitigation measures for health facilities and other related infrastructure. That includes preparedness and evacuation planning for both hazards, which includes securing multi-sectoral support (e.g., enough evacuation vehicles, cross-agency training) to execute these plans. Additionally, implementing monitoring systems in hazard-prone and high-impact areas would improve preparedness.</td>
<td>Health system planning; Contingency planning</td>
<td>Rentschler et al. (2021); Thompson et al. forthcoming</td>
</tr>
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</table>
### Observation

| Climate change, coupled with changes in the built environment, may make flood and landslide zones exceedingly dangerous to inhabitants and responders. These areas may be too expensive to rehabilitate after the hazard. | Continue to be proactive in terms of health system planning. Align plans with interventions that incentivize or mandate that people in highest risk landslides and flood zones relocate/mitigate, based on precedents adopted for volcano zones. | Health system planning; Development and built environment | World Bank (2008) |

| Urban and rural development can change and exacerbate flood inundation areas and landslide flows, potentially impacting people, health service delivery, and lifeline infrastructure. | Include this consideration in health system planning and health system modality optimizations. High risk areas identified here can inform such decisions as starting point. Areas at high climatic risk, with currently lower accessibility to services, can benefit from mobile clinics and alternative solutions. | Health system planning; Development and built environment | Campos Garcia et al. (2011); World Bank (2012b) |

| Flood and landslides disrupt transportation networks, particularly in some regions (e.g., the western part of Bogotá), limiting or delaying accessibility to health services. | Promote multisectoral investment between health and transport to leverage potential synergies in investment goals. Consider increasing the health services in areas with very high baseline access times. | Multisectoral | Hallegate, Rentschler, and Rozenberg (2019); Edmonds et al. (2020) |

| Information from the analysis concerning the exposure of vulnerable populations, lifeline infrastructure, and health infrastructure highlights the importance of coordination across the national, departmental, and municipal levels. | Continue to increase coordination in planning and preparedness between the health and emergency response sectors, including civil protection, the military, and other designated response groups. Strengthen multi-level governance. | Multisectoral | Rentschler et al. (2021); Díaz-Tamayo (2022) |

<p>| More data on vulnerable populations can help refine prioritization related to health sector and multisectoral investment, planning, drills and simulation, response, and recovery, including mitigating some of the risks outlined by the Climate-Sensitive Risk Index. | Increase or mandate geospatial data collection for (i) vulnerable populations, particularly internally displaced populations, and (ii) other vulnerability indicators at the departmental and municipal levels, in alignment with previous efforts by the Instituto Geográfico Agustín Codazzi (IGAC). | Data capabilities and planning | Wood (2018); Habitat for Humanity (2023); World Bank (2021); Sipe and Dale (2003); Díaz-Tamayo (2022) |</p>
<table>
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<th>Potential Action</th>
<th>Action Type</th>
<th>Reference(s)</th>
</tr>
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<tr>
<td>One of the barriers in using data or data-driven tools, like the Climate-Sensitive Risk Index, in decision-making is an absence of integration of these data or tools in planning.</td>
<td>Incentivize or mandate the inclusion of geospatial and other data-driven tools in planning for health system planning and delivery—including service modality plans, shelter-in-place directives, and alternative patient care-paths through health system.</td>
<td>Health service delivery; Data capabilities and planning</td>
<td>Sipe and Dale (2003)</td>
</tr>
<tr>
<td>Climate change likely will change hydrometeorological hazards in Colombia and will impact other hazards, increasing the importance of using the most current hazard data to understand and plan for future impacts.</td>
<td>Update the assessments based on the latest climate modeling (e.g., rainfall predictions, wind speed) when possible. Collect data and monitor risk mitigation and preparedness interventions to adjust the risks accordingly. As shown in priority facility section above, vulnerabilities must be considered side-by-side with exposures.</td>
<td>Data capabilities and planning</td>
<td>Füssel (2007)</td>
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COMPONENT 3
Biodiversity and Climate Change: Implications for Human Health in Colombia

Context, Rationale, and Objectives

Biodiversity loss and climate change are both drivers and consequences of change and closely linked to human activities, resulting in impacts on human health and well-being. Climate change modifies the natural environment and its functions that affect human health (Bonebrake et al. 2018), to the extent that it affects the dynamics of ecosystems, including the quantity and quality of their functions. In addition, climate change is itself a modifier of ecosystems and has been identified as one of the drivers of biodiversity loss and environmental degradation.

The loss of biodiversity and climate change are interconnected. Both are increasingly influenced by anthropogenic activity (IPCC 2014) and generate different effects on social systems. These effects can be biophysical (such as the degradation of air and water quality) and/or socioeconomic and cultural.
In the context of megadiverse countries such as Colombia, it is essential to analyze biodiversity and its interaction with climate change and health. Due to its high species richness and the high number of species native only to the country, Colombia is classified as one of the 17 megadiverse countries on the planet, ranked as the country with the third greatest diversity (after Brazil and Indonesia). One of ten of all species that exist on the planet are found in Colombia (SIB Colombia 2022; Like Minded Megadiverse Countries 2002).

There is limited research and analytical work on the interaction between biodiversity, human health, and climate change. In this regard, this component contributes to better understanding the relationships between human health and environmental health. It also identifies evidence of these relationships and analyzes these relationships in the light of climate-related hazards. This analysis draws upon the One Health conceptual framework, which is based on an understanding that human, animal, and environmental health are inextricably linked. It also allows for a comprehensive and multisectoral approach to shape more robust animal and human health systems, while preserving ecosystem health.

The objectives of Component 3 are:

- Analyze the relationship between biodiversity as a regulator of temperature and air quality, highlighting the interactions amongst biodiversity, health, and climate change.
- Identify and outline the drivers of biodiversity loss, its mechanisms, and the risks for human health in Colombia.
- Assess the country’s governance capacities and opportunities for operationalizing a One Health approach to biodiversity as a critical element for human health.
Methodology

Incorporating biodiversity as a key dimension in the interaction between health and climate change is a novel approach, concerning which research and analysis have lagged. Because biodiversity plays a key role as a mediator and regulator for climate change and for critical variables that affect human health, it is pivotal to account for biodiversity and ecosystem functions as a means to understand and effectively address health and climate-related health risks.

For this component, the study team conducted a desk-based analytical review of relevant literature and consultations with key stakeholders. The qualitative systematic literature review extracted the information from three different sources: (i) peer-reviewed articles; (ii) grey literature from organizations that specialize in climate change, biodiversity, and/or associated health risks; and (iii) public datasets on environmental-related variables or health risks. The consultations with key stakeholders included both governmental and nongovernmental organizations at the forefront of implementing biodiversity or environmental health projects and programs.

Key Findings

Biodiversity loss in Colombia is affected by five main drivers, which, in turn, impact human health: (i) changes in land use and changes in coastlines and seas; (ii) direct overexploitation of organisms; (iii) the introduction of invasive species; (iv) climate change; and (v) pollution. All of these drivers acting together are exacerbating negative impacts on nature and humans and are driving biodiversity and its associated ecosystem services to a point of no return (Jaureguiberry et al. 2022; IPBES 2019).

Land Use Change

Construction and the expanding use of land for agriculture are the primary causes of land use changes in Colombia that are impairing ecosystem services. This is causing loss of crop biodiversity and species that control disease vectors, while also expanding channels of interaction between humans and wild animals— which increases risks of zoonotic diseases being transmitted to humans, expands exposure to herbicides and pesticides with health risks, and reduces ecosystem services overall. Between 2001 and 2021, Colombia lost more than 3.2 million hectares of forest. Also of note:

- In several large and compact Colombian cities such as Bogotá, 80 percent of the city’s population lives with a deficit of green areas.
• Forests play a fundamental role as natural air purifiers and temperature regulators.

• In the Colombian Amazon, the average annual rate of forest loss (AALR) was 142,204 hectares per year between 2020–2022. During that period, habitat loss in the Amazon region of Colombia due to increases in the amount of land used for raising livestock occurred at an average rate of 207,054 hectares per year.

**Overexploitation of Species**

Overexploitation of fishing resources and other wildlife species through legal or illegal hunting or logging are the main drivers of overexploitation of species. This creates risks for food security and food diversity, decreases sources for producing medicines (more than half of which are derived from species of plants, fungi, and animals), and increases channels for zoonoses linked to illegal wildlife trafficking.

• **Overfishing** in the Amazon has led to a decline in the abundance of species, particularly large catfish; about 62 percent of the fish marketed are below the minimum regulatory size (Agudelo-Córdoba et al. 2012).

**Climate Change**

Climate change and climate-related hazards affect the temperature and precipitation patterns, which, in turn, result in changes in vegetation and habitats for disease vector species and cause air quality degradation and desertification of natural and agricultural lands. These changes increase risks for vector-borne diseases, water-borne diseases, cardiovascular and respiratory diseases, and food security and food systems.
• **Deforestation** is the main source of greenhouse gas emissions (36 percent).

• **Climate change** is both a driver and a consequence of biodiversity loss.

• At the departmental level, the five departments with the highest climatic risk are San Andrés, Vaupés, Amazonas, Guainía, and Atlántico.

**Pollution**

Air and water pollution are critical sources of health risks. In Colombia, air pollution due to fossil fuel combustion, particulate matter from fires, or cooking food with solid fuels are among the main drivers of biodiversity loss and related health risks.

• **Air and water quality degradation** are the main environmental risk factors to human health in Colombia.

  » In Colombia, environmental risk factors account for 17,549 deaths per year, which is 8 percent of total annual mortality (INS 2018). Of that total, 15,681 deaths are associated with poor air quality and 1,209 with poor water quality.

  » The respiratory diseases with the highest incidence of mortality due to poor air quality are ischemic heart disease (IHD) and chronic obstructive pulmonary disease (COPD), with 7,230 and 3,873 attributable deaths respectively.

  » An estimated 1,209 deaths in Colombia are attributable to environmental risk factors associated with poor water quality, of which 593 are due to acute diarrheal disease, and 616 are due to acute respiratory infection (INS (National Institute of Health of Colombia) 2018).

• **Mercury contamination** of bodies of water and fish species is worrying in Colombia and represents a public health problem that urgently needs to be addressed.
Studies in indigenous communities of the Colombian Amazon reveal that of 1,875 hair samples taken, 1,525 had mercury levels above the World Health Organization (WHO) limit (2015), corresponding to 1 part per million (ppm) for hair (Foundation for Conservation and Sustainable Development 2022).

Likewise, in the indigenous community of Bocas de Taraira (Yaigojé Apaporis National Natural Park), mercury values were found in hair between 2.3 and 34.9 ppm—the highest value reported for an indigenous community in Latin America, according to published research (Valdemar-Villegas and Olivero-Verbel 2019).

Invasive species also drive biodiversity loss, to the extent that they drive out native species and degrade ecosystems.

- Colombia harbors a total of 508 recognized exotic species of fauna and flora. However, data are accessible for only 74 percent of these species (378); and among them, 22 have been identified as invasive (SIB 2022; World Wildlife Foundation 2022; Ministry of Environment, Housing, and Territorial Development Colombia 2008).

  There is limited information on the environmental or economic costs related to the species being introduced in Colombia.

  The invasive giant African snail and lionfish species are particularly harmful vectors for zoonoses in Colombia.

The health sector should consider and integrate the benefits that nature brings both to health and to climate change mitigation and air quality improvement. Different “biodiver-cities” initiatives are being developed in Colombia, to counteract the effects of air pollution and other factors and to improve the quality of life and health of its inhabitants. Examples include the city of Barranquilla (Atlántico department) and Leticia (Amazonas) as well as the RAMSAR-designated Urban Wetlands Complex of the Capital District of Bogotá. In addition, the Parques Nacionales

6 RAMSAR refers to the Convention on Wetlands which was signed in Ramsar, India.

Photo: © Adam Cohn ‘Bucaramanga Colombia Traffic’ (CC BY-NC-ND 2.0)
Naturales de Colombia is developing the Salud Naturalmente en los Parques (Healthy Naturally in Parks) program, with the objective of consolidating the country’s National Natural Parks as environments that promote healthy lifestyles.

**Forests have the potential to serve as robust thermal buffers, as well as to help filter air pollutants, effectively minimizing the occurrence of strong and extreme heat stress days and respiratory illness.** Global research identified that tree canopies provide a buffering effect to the forest floors, effectively regulating both high and low temperatures for the macroclimate (the overall climate in a large geographical area). However, large cities in Colombia such as Bogotá have poorer ratios of trees per person than WHO-recommended rate of half a tree per inhabitant. Addressing biodiversity challenges and furthering climate mitigation goals would result in 896,000 morbidity episodes averted by 2030—a 10 percent reduction relative to the business-as-usual scenario, without additional climate mitigation effort beyond current legislation (Ministry of Health and Social Protection (MSPS) 2022a).

**Addressing the interaction of biodiversity, health, and climate change poses a challenge that goes beyond technical and scientific analysis, and that translates into a need for effective for multisectoral and multilevel governance mechanisms in Colombia.** We identify three key areas for addressing climate, biodiversity and health challenges: (i) multisectoral and multilevel coordination;
(ii) capacity strengthening for local governments to implement public policy and execute resources; and (iii) integration of surveillance systems. These are key areas in developing strategies and interventions that address the interactions of environment, climate change, and health.

- **Multi-sectoral and multilevel coordination:** The National Climate Change System (SISCLIMA) and the National Intersectoral Technical Commission on Environmental Health (CONASA) are key governance structures engaged in collaborative arrangements for climate change and environmental health policies and programs at the national and territorial levels respectively. However, there is no information on the actual interaction between the two government levels. It is also not clear what roles each actor assumes and what plans or strategies are being implemented under these collaborative arrangements at the territory level.

- **Local governments play a critical role in implementing programs at the intersection of climate change, health, and biodiversity.** However, as of 2021, their budgets were insufficient for this work. About 19 percent of departments had poor budget execution, using less than 50 percent of their generated revenues. This limited their ability to effectively implement interventions. Some departments heavily relied on transfers from the central government. Additionally, in 2021, most departments achieved only a 50 percent average performance in disaster risk management. Implementation of environmental and sustainable development plans faced challenges, with several departments showing low implementation rates in 2022, such as La Guajira, Amazonas, Arauca, and Magdalena.

- **Integrated Surveillance Systems:** The databases addressing various social determinants of health in Colombia are fragmented, which limits the development of predictive analytical models and real-time results. Moreover, there is a lack of models that estimate compound risks associated with environmental, climatic, health, and health system variables. Originally focused on the natural environment, SUISA (the unified environmental health information system that has been under development since 2010) has now adopted a broader perspective encompassing natural, physical, economic, and social aspects. However, the existence of approximately 35 fragmented information systems managed by different ministries presents a barrier. These systems address diverse social, economic, and environmental determinants. The fragmented nature of information impedes disease surveillance related to social determinants and restricts the ability of national and local governments to design programs and interventions to reduce health risks.
Conclusions and Recommendations

1. **In the context of Colombia’s abundant biodiversity, understanding the drivers of biodiversity loss becomes a pressing concern for assessing associated health risks.** Ranking as the third most biodiverse country globally, Colombia faces significant risks with 88 percent of its ecosystems being threatened. It is essential to acknowledge that climate change acts as both a driver and a consequence of biodiversity loss, as outlined in this component. To address the challenges at hand, it is crucial to delve deeper into understanding the drivers of biodiversity loss and their implications for health. This includes acknowledging the dual role of climate change as both a driver and consequence of biodiversity loss, particularly in relation to deforestation. Further scientific investigation is necessary to examine the intricate interaction between biodiversity loss and health, guiding the formulation of effective public policies, decision-making processes, and resource allocation at the subnational level.

2. **In the light of the interaction of health, climate change, and biodiversity, Colombia can benefit from strengthening collaborative arrangements in order to harness policies and programs that would bring health co-benefits.** Important steps could include the following:
   - **Develop models** that estimate the benefits and economic costs of inaction and action on biodiversity to tackle health problems caused by interaction of climate change and air pollution
   - **Deepen efforts to address those interactions;** this will increase demand on governance mechanisms and require strengthened multisectoral and multilevel arrangements
   - **Integrate health risks as key determinants in urban planning and land use decision-making processes,** ensuring that health considerations are central to land use planning and development
   - **Strengthen the role of the health sector in Colombia** as central actor in the development of policies and programs to prevent and respond to health risks associated with biodiversity loss and climate change
   - **Scale up nature-based solutions** within the initiative of the Ministry of Health to capitalize on their potential for delivering significant co-benefits for both health and climate
COMPONENT 4
Towards a Roadmap of Interventions to Address Climate Change in Colombia's Health Sector

Background
In recent decades, climate change has gained increasing attention due to mounting evidence of its negative impacts on ecosystems and society. This has resulted in a series of calls for action on climate change, reflecting a growing understanding of the threat it poses to our planet and the urgent need to address it. These calls from scientists, social movements and international organizations already have a long history, with some significant milestones. From the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988 and the creation of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 to the adoption by many countries of the Paris Agreement in 2015, the world has gained greater understanding of climate change and its implications as well as an increased awareness of the urgent need for action. This process has led to recognizing health as a central issue in the debate, considering that climate change has significant direct and indirect consequences on people’s health,
exacerbating health inequalities and disproportionately affecting the most vulnerable populations, such as children, the elderly, the poor, and those living in remote regions (IPCC 2014a). This recognition has also led to calls for action from the health sector, both to mitigate and to adapt to the consequences of climate change. And while those calls are gaining traction, the pace at which these actions are being taken may not be fast enough. In the healthcare sector in particular, it has been noted that while progress has been made and “several NDCs have included healthcare in their new iterations, action is too slow, if any” (Hartinger et al. 2023). This component seeks to integrate the results of the first three components of this study into an analysis that can inform and facilitate decision making in the face of the challenges of climate change in the health sector.

Methods

The methodological approach is guided by the elements developed in the framework of analysis of costs and consequences of climate change in the health sector (WHO 2013; WHO 2023), which proposes a comparative analysis between the costs of inaction in the face of climate change and the potential costs and benefits of intervening to mitigate or adapt to the (partially unavoidable) consequences of climate change. To do this, on the one hand, this analysis identifies and estimates the impact of climate change on health. On the other hand, it identifies actions to face these challenges, and for each of these elements, it defines the indicators to be quantified. In this sense, the conceptual framework emphasizes the need to integrate knowledge from different disciplines into the analysis and highlights that it is essential to spotlight the role of assessing the cost of inaction in raising awareness of current and future health-related challenges that deserve attention from public policy. This becomes a critical element of the process, since it is expected to stimulate political intervention (WHO 2023).

Thus, this component integrates the findings of other components of this study that point to the costs of inaction and incorporates them in a comparative analysis alongside the costs of interventions. For this reason, the dimensions of the analysis start with the components of the study—in particular, the economic burden associated with non-optimal temperature and complements them with an estimate of the associated costs to mortality and morbidity of six selected, using a tool to assess the effects of climate on health (the Climate Change and Health Economic Valuation Tool discussed below).

In terms of the conceptual framework, the disease burden and economic component due to non-optimal temperature evidences the costs of inaction and assesses the economic cost of premature mortality associated with non-optimal temperature (Figure 7; see also methodological details in Component 1).
Additionally, as noted above, the effects of climate change on health are not limited to temperature. There are also important effects through changes in ecosystems that have, for example, substantial implications for diseases transmitted by vectors or in diseases related to the quality and availability of water. Therefore, to complement the analysis with a vision of the costs of inaction in other dimensions, the tool developed by Metroeconomica and the World Bank for the economic valuation of the effects of climate change on health is used (Metroeconomica–World Bank 2022). The methodology of the tool is described below.

**Figure 7. Quantifying the Costs of Inaction: Sub-Optimal Temperature**

The Climate Change and Health Economic Valuation Tool (CHEVT) tool helps to quantify the economic cost of inaction and is articulated with the framework described above, applying the steps of quantifying the impact of climate change on health and subsequently valuing that impact in economic terms.

To estimate the impact, the tool uses models proposed in the literature (Aström et al. 2012; WHO 2014) that describe the climate-health relationship for the following outcomes: dengue, malaria, malnutrition, diarrheal disease, health outcomes associated with temperature extreme, and health outcomes associated with extreme weather events. The models associate climate information, along with other demographic, economic, and health indicators, to quantify the number of cases and the number of deaths associated with each of the selected events, thus producing a quantitative measure of the impact of climate change on morbidity and mortality. Subsequently, it combines this information with cost data and uses the cost of Illness method to value morbidity and the value of a statistical life method to value mortality in order to estimate the economic value of that effect (Figure 8). For the climate data (temperature and precipitation) the tool uses the SSP3–RCP7.0 scenario from Coupled Model Intercomparison Project Phase 6 (CMIP6). The tool quantifies and
values deaths and cases attributable to climate change under two different scenarios—with and without climate change.\(^7\)

**Figure 8. CHEVT: The Tool in Brief**

<table>
<thead>
<tr>
<th><strong>Step 1: Quantify</strong></th>
<th><strong>Step 2: Value</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cover sheet</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Quantify climate-related number</strong></td>
<td><strong>Put a monetary value on the number</strong></td>
</tr>
<tr>
<td>of cases and deaths</td>
<td>of cases and/or</td>
</tr>
<tr>
<td>using peer-review-dose-response function (e.g., proposed in WHO 2014)</td>
<td>deaths using the cost of illness (includes productivity loss) and/or the VSL</td>
</tr>
<tr>
<td>1. DR function sheet</td>
<td>1. Analytical model sheet</td>
</tr>
<tr>
<td>2. Climate data sheet</td>
<td>2. Mortality values sheet</td>
</tr>
<tr>
<td>4. Demographic data sheet</td>
<td></td>
</tr>
<tr>
<td>5. Health data sheet</td>
<td></td>
</tr>
<tr>
<td>6. No. of cases and/or deaths (Step 1 output sheet)</td>
<td>4. Cost of cases and/or deaths (Step 2 output sheet)</td>
</tr>
</tbody>
</table>

Source: adapted from Metroeconomica-World Bank (2022).
Note: CHEVT = Climate and Health Economic Valuation Tool.

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\(^7\) RCPs are scenarios developed by the research community “to provide information on possible development trajectories for the main forcing agents of climate change”. See van Vuuren et al. (2011).
Identifying Interventions

To identify interventions that have the potential to address the challenges of climate change in the health sector, a two-step approach was used. First, a literature review was conducted to identify interventions that have been proposed and/or implemented internationally, and a review was conducted of regulatory developments and other initiatives that have been proposed in Colombia as strategies to deal with climate change. For the literature review, a scoping review was conducted with the aim of systematically mapping the available literature on interventions related to climate change and the health sector. An exhaustive bibliographic search was carried out in electronic databases (PubMed, Scopus, and Web of Science), using search terms related to climate change, the health sector, and interventions. Studies published in English and Spanish were included. Inclusion criteria were initially applied by reviewing titles and abstracts, and then relevant studies were selected for full review. Key data was extracted from the selected studies, such as author, year of publication, country of origin, interventions evaluated, and whether data on the effectiveness of the intervention and its costs are reported. The findings are presented in a descriptive manner, highlighting the identified interventions and grouping them thematically.

Results

The Cost of Climate Change Impacts

The CHEVT results indicate that the economic (social) cost of mortality and morbidity arising from malaria, dengue, diarrhea, stunting and extreme heat is estimated to increase from COP 7.1 trillion in 2020 to COP 31.5 trillion in 2050. This economic cost represents 0.7 percent of GDP in 2020 and is estimated to increase to 1.6 percent of GDP in 2050. Not all of this increase in the economic cost is attributed to climate change. Changes in total population, changes in the structure of the age pyramid, and changes in gross domestic product also explain the significant increase in health costs. In Colombia, CHEVT estimates indicate that 46 percent of the health costs in 2050 are directly attributed to climate change. Thus, climate change will contribute 0.8 percent of GDP to health costs in 2050.

The CHEVT results indicate that among selected outcomes, dengue represents the greatest burden, with an estimated cost of COP 4.7 trillion in 2020. This is followed by stunting, with a cost of COP 580 billion and extreme heat with COP 122.9 billion. Climate change does not uniformly affect all outcomes. The increase in cost due to climate change is primarily explained by heat and vector-borne diseases (dengue, malaria), but less so by diarrhea or stunting, where the cost difference between scenarios with and without climate change is relatively small.
Figure 9. CHEVT Results, Colombia

(A) Dengue

(B) Malaria
**Costs of Intervention**

To illustrate the magnitude of the intervention costs, the costing of the specific health targets set forth in the NDC were taken as a starting point. Costing exercises to support the development and implementation of a health surveillance system that integrates climatic data and meteorological models were reviewed. The costing exercise also supports the development of an early warning system for climatic events, as well as knowledge management and the production of guides and action plans. Figure 10 illustrates the costs of implementing these actions over a 10-year horizon, with an estimated value of COP 39 billion in net present value (Ricardo Energy-Ecoversa 2020).

Figure 10. Climate-Aware Integrated Health Surveillance Implementation Costs (10-year horizon)

To address the second goal of Colombia’s NDC, the costing exercise included a vulnerability assessment to identify the healthcare providers subject to mitigable and non-mitigable risks, and the design and implementation of adaptation measures. Figure 11 shows the estimated costs for implementation over 10 years; the total cost in net present value amounts to COP 184 billion (Ricardo Energy-Ecoversa 2021).

Figure 11. Health Care Providers’ Adaptation Implementation Costs (10-year horizon)
Discussion

The results from this analysis show that implementation costs are dwarfed by the costs associated with the consequences of climate change on people’s health and the health system. For example, while the economic burden attributable to sub-optimal temperature ranges between COP 0.6–3.3 trillion over a 10-year period, enhancing climate-sensitive disease prevention efforts through strengthening integrated, conscious early warning and surveillance systems of the weather, would cost around COP 43 billion. Although the evidence on the effectiveness of these types of interventions in addressing the consequences of climate change is still accumulating, the potential benefits are large enough to suggest that it is likely to be a good investment.

Colombia has set a clear path with the NDC goals specific for the health sector and the PIGCCTs as a key vehicle to assess, prioritize and define measures and actions for adaptation and mitigation of climate change, to be implemented in the local contexts. Yet, it is important to accelerate the pace of its implementation. In particular, the development of a climate-aware integrated surveillance system is one of the measures in line with NDC’s goals that is yet to be a reality. The national government should lead the development and implementation of such a system, to strengthen the current surveillance system that, despite its many strengths, still does not comprehensively and systematically include climatic information. Such a system should include early warning systems for climate-relevant hazards, implemented at scale, building on some of the pilot experiences already tried out in Colombia. Recognizing that many of the measures that can ultimately reduce the health effects of climate change must be implemented at the local level and tailored to the local context, the development of fully-fledged PIGCCT for the health sector should be a priority. The national government should lead the strategy to spur the formulations of such plans throughout the country and accompany the subnational governments in charge of the development of the plans through technical assistance and the creation of spaces to share the experiences with other sub-national governments and the civil society in general.
REFERENCES

Introduction


Component 1


Component 2


IMPACT OF CLIMATE CHANGE IN HEALTH IN COLOMBIA AND RECOMMENDATIONS FOR MITIGATION AND ADAPTATION

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Component 4


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