Colombia
Climate and Health Vulnerability Assessment
2024

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ACRONYMS AND ABBREVIATIONS

AQI	Air Quality Index
CHVA	Climate Health Vulnerability Assessment
CMIP	Coupled Model Intercomparison Project
COI	Cost-of-Illness
CONASA	*Consejo Nacional de Salud Ambiental*, National Council of Environmental Health
COP	Colombian Pesos
DALY	Disability-Adjusted Life Years
DHS	Demographic Health Survey
ERV	Emergency Room Visits
GHG	Greenhouse Gas
HCED	Health, Climate, Environment, and Disasters
HIS	Health Information System
HNP	Health, Nutrition, and Population
INS	*Instituto Nacional de Salud*, National Institute of Health
IPCC	Intergovernmental Panel on Climate Change
LAC	Latin America and the Caribbean
MoH	Ministry of Health
NAP	National Adaptation Plan
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organization
OECD	Organization for Economic Cooperation and Development
RCP	Representative Concentration Pathway
RR	Relative Risk
SISCLIMA	*Sistema Nacional de Cambio Climático*, National Climate Change System
SSP	Socioeconomic Pathways Scenario
US	United States
VBD	Vector-borne Diseases
VSL	Value of Statistical Life
WASH	Water Sanitation and Hygiene
WHO	World Health Organization

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INTRODUCTION

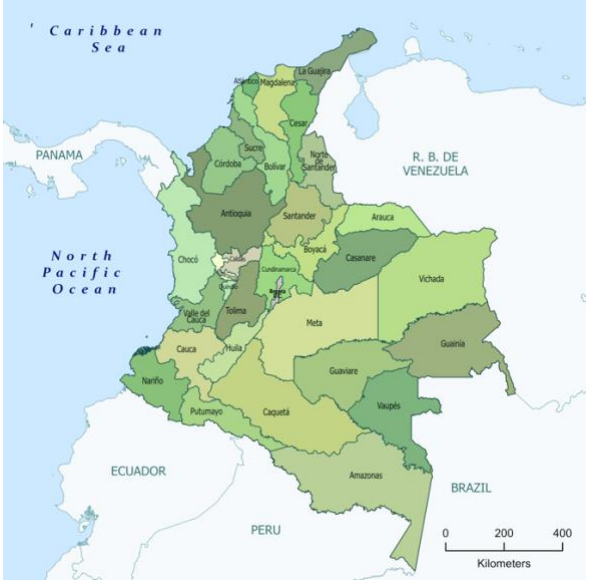
Recognized as a megadiverse country with a wide range of ecosystems and topographies, Colombia is highly vulnerable to the impacts of climate variability and change—not only on the environment but also, critically, on population health. Located in the northwest corner of South America, Colombia faces numerous climate-related hazards influenced by its location in the Intertropical Convergence Zone, where trade winds converge; the complex topography of the Andes; and the presence of the El Niño phenomenon. Colombia has the highest occurrence of extreme events in South America and the vast majority of Colombians (84 percent) are exposed to more than two natural or climate-related hazards.[1] Landslides and flooding are major hazards in the mountainous region along the Andes (one of two vulnerability hotspots in Colombia, along with the Caribbean), where the majority of the country's population is concentrated. The impacts on health are only expected to grow, as glacier loss due to increased temperatures affect water availability and increase the occurrence of landslides and floods due to surface run-off from snow melt. Climate change has already had significant impact on Colombia: in the last half century, intense flooding has worsened during La Niña periods, while droughts have increased 2.2 times during El Niño periods.[2] Climate-related hazards are only expected to worsen in Colombia as the climate crisis intensifies, with projections pointing to continued rising temperatures, more variable rainfall, rising seas, and more frequent extreme weather events. Population health is under increasing threat from climate change, with extreme events and shifting disease burdens leading to overburdened health systems and challenges for health service delivery.

Compounding these challenges, climate change also threatens to increase the health and economic inequalities experienced by Colombia's most marginalized populations. While Colombia is a middle-income country, it faces high poverty rates and one of the highest rates of inequality in the world (the highest in the Latin America and the Caribbean, or LAC, region). Climate change is likely to exacerbate the country's present situation: it is estimated that roughly 2.5 million Colombians will be pushed to extreme poverty due to climate-related impacts on health alone.[3] The health and economic impacts of climate change are disproportionately felt by the country's most vulnerable, as certain groups are at greater risk than others. These include the poor (39.3 percent of the total population), rural populations (23.5 percent), those living in informal urban settlements, women (51.3 percent), young children (18.5 percent), the elderly (13.9 percent), those living with pre-existing conditions and disabilities, and displaced populations, which are a key group for Colombia (around 13 percent of the population has been displaced due to the armed conflict in the country). As the climate crisis accelerates, its devastating health and economic impacts will also accelerate—particularly for these vulnerable groups. In Colombia, additional measures are needed to strengthen the health sector's ability to adapt to climate change amid these growing challenges, with

careful consideration of groups that would directly benefit from or may be disadvantaged by adopted measures.

The objective of this Climate and Health Vulnerability Assessment (CHVA) is to assist decision-makers in Colombia with planning effective adaptation measures to deal with climate-related health risks. This assessment includes sub-national considerations for health-related climate action (see Annex A for the methodology). Sub-national considerations are given for Colombia's 32 departments (see Figure 1). It also incorporates data from a Climate and Health Economic Valuation conducted by the World Bank to estimate of the potential economic costs of health impacts arising from projected changes in temperature and precipitation (see Annex B for the methodology). The findings from this CHVA are organized under four sections. Section I characterizes the climatology in Colombia, highlighting observed and projected climate exposures relevant to health. Section II describes key climate-related risks to health, including nutrition and food security, vector-borne diseases (VDBs), water-borne diseases, increasing temperatures, air quality, and zoonotic diseases. Section III analyzes the adaptive capacity and readiness of Colombia's health system to prevent and manage climate-related health risks. Recommendations are discussed in Section IV.

Figure 1. Administrative Boundaries of Colombia's Departments



Source: World Bank's Cartography Unit

SECTION I.
Climate

Colombia is located in the northwest corner of South America and is a topographically diverse country traversed by the Andes Mountains. Considered the 25th largest nation in the world, Colombia covers 1,138,910 square kilometers (km^2) of land and features five main topographic regions: the Amazon in the south, the Orinoco in the east, the Caribbean in the north, the Pacific in the west, and the Andes along the country's central spine. The northwestern edges of the tropical rainforests in the Amazon and Orinoco River basins occupy lowland plains in Colombia's south and east. The Caribbean region extends from the north of the Andean foothills to the Caribbean Sea, while the Pacific region extends from the western Andean slopes to the Pacific Ocean, encompassing a combined 3,208 km of coastline. The Andes Mountains bisect the country from southwest to northeast and geographically include the oil-rich, lower-elevation Magdalena River Valley, which splits the mountain chain.[4] The country's topographic diversity is categorized by three main climatic zones: the high elevation cold zones (*tierra fria*), located above 2,000 meters (m) in elevation, with mean annual temperatures ranging between 13°C–17°C; a temperate zone (*tierra templada*), located between 1,000 m–2,000 m, with mean annual temperatures of approximately 18°C; and a tropical zone (*tierra caliente*), which covers all areas below 1,000 m, with mean annual temperatures of 24°C–27°C.[5]

Observed and Projected Climatology

Colombia's climate features a wide range of temperature distributions and one to two rainy and dry seasons annually, depending on the region. The country's climate is impacted by several strong influencing factors, including the Intertropical Convergence Zone; the Andes' complex topography, which affects atmospheric circulation patterns; and the El Niño Southern Oscillation.[6] Between 1991–2020, Colombia experienced a mean annual temperature of 25.00°C. On average, the warmest month is March and the coolest month is July. However, there is notable sub-national variability. Its climate is tropical along the coast and the eastern lowlands, but becomes subtropical, temperate, and polar as altitude increases. Since most departments encompass more than one climatic zone within their boundaries, they tend to reflect a blend of different climatic characteristics. Colombia's five largest population centers occupy all three elevation zones across different topographic areas.[7] Mean annual precipitation in from 1991–2020 was 2,562.17 millimeters (mm), but there are significant regional patterns and seasonal distributions. The Pacific coast and western slopes of the Andes (including Antioquia and Risaralda) received the highest annual rainfall amounts, followed by the Amazon Basin (all greater than 2,600 mm per year), while the drier Northern Caribbean departments

received approximately 1,000 mm per year. Annual precipitation patterns are varied, with some areas of the country displaying bimodality while others are unimodal (i.e., experiencing two wet seasons or one west season every year, respectively).[8] During El Niño, dry seasons can become more intense and longer, leading to droughts and warmer weather,[9] while La Niña increases the intensity and length of wet seasons, leading to floods and cooler weather particularly between June and August.[10]

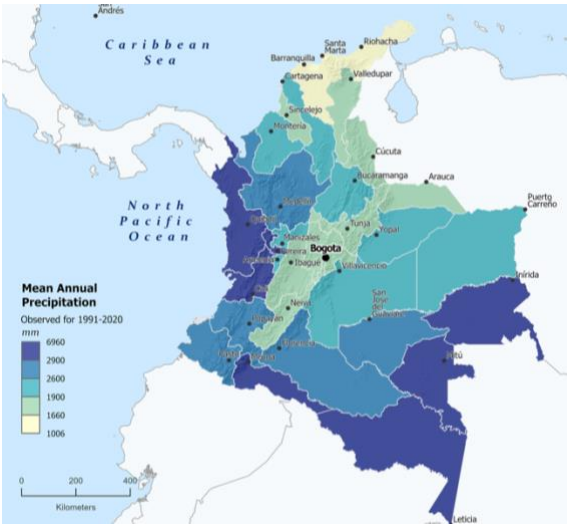
The box below summarizes observed changes in Colombia's temperature and precipitation patterns between 1971 and 2020, as well as projected changes in temperature and precipitation.

Climatology	
Temperature	
Observed	**Projected**
Between 1971 and 2020, Colombia's average mean temperature increased by 0.22°C per decade, with the greatest changes observed in the Caribbean and North Andes regions, especially during the winter months.[11]	Under a SSP3–7.0 scenario, mean temperature nationwide will increase from 24.73°C (reference period 1995–2014) to 25.44°C (50th percentile) for the period 2020–2039 (+0.71°C), and to 26.14°C (50th percentile) for the period 2040–2059 (+1.41°C).[12] Minimum and maximum temperatures increase homogeneously, but during winter months there are large increases in maximum temperatures across the Caribbean, Central and Northern Andes, and Orinoco regions.[13] (See Figure 3 for the observed temperature and projected anomaly at the sub national level for the 2030s and 2050s).
Precipitation	
Observed	**Projected**
Over the 50-year period from 1971–2020, Colombia experienced significant decreases in precipitation per decade across the Orinoco, Caribbean, and Northern Andes regions, but precipitation trends varied seasonally both within and across Colombia's departments.[14] The Orinoco region observed the largest total decreases in precipitation per decade in Casanare (-149.72 mm), Arauca (-141.23 mm), and Meta (-113.93 mm), with the strongest effects seen during the summer months. A few departments observed significant precipitation increases over the	Projected precipitation patterns under SSP3–7.0 reflect regional shifts in the annual onset, duration, and intensity by midcentury. Nationally, there is a projected decrease of -16.35 mm by the 2050s. However, the extent of all wet and dry shifts are heterogeneous across the country and display a wide range of uncertainty.[16] The Amazon, Orinoco, Eastern Caribbean, and Eastern Andes (Cordillera Oriental) regions are expected to experience an annual decrease in precipitation by 2040–2059 under SSP3–7.0, while the Western Caribbean, Western Andes (Cordillera Occidental and Central), and Pacific

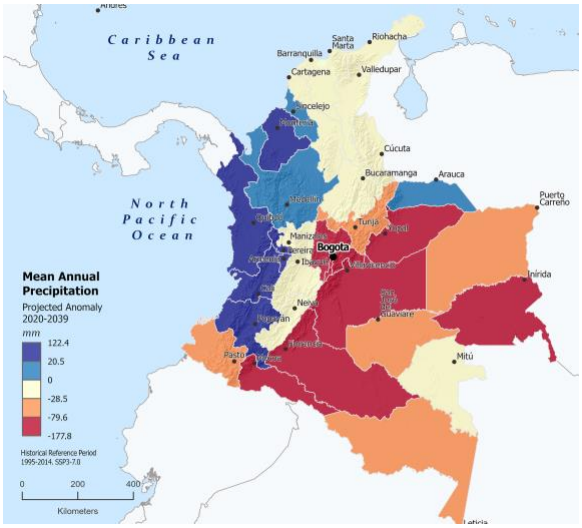
same time period, including several along the southwest Pacific coast (Buenaventura, Valle del Cauca) and Western Cordillera.[15]	regions are expected to experience an annual increase in precipitation. Trends in each of their anomalies differ seasonally, but wetter seasons typically become wetter while drier seasons become drier[17] (see Figure 2 for the observed precipitation and projected anomaly at the sub-national level for the 2030s and 2050s).

Figure 2. Mean Annual Precipitation for Observed Period 1990–2020, and Projected Anomaly to 2020–2039 and 2040–2059[18]

Observed period 1990–2020



Projected anomaly 2020–2039



Projected anomaly 2040–2059

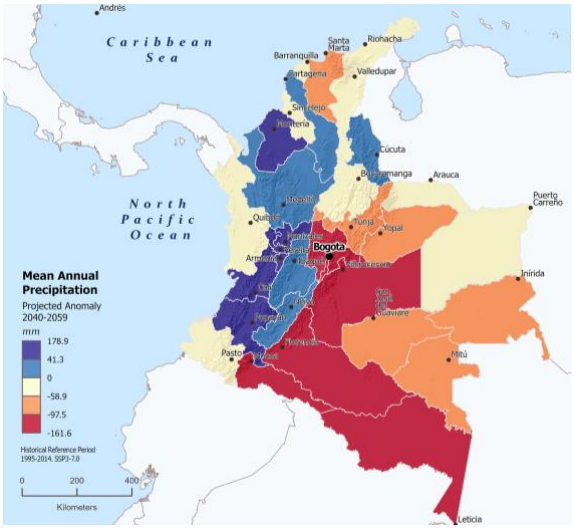
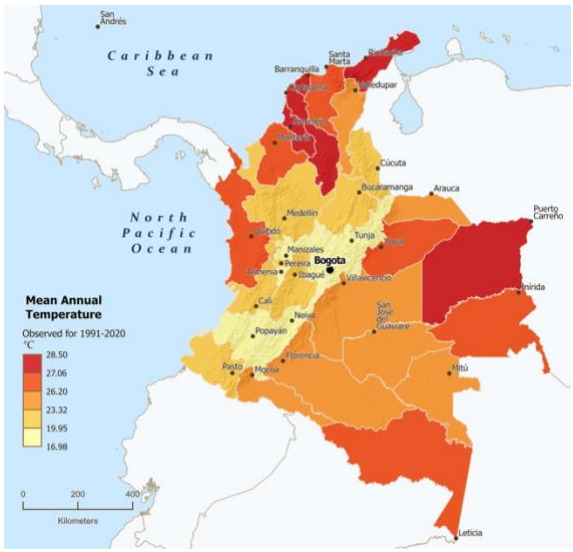
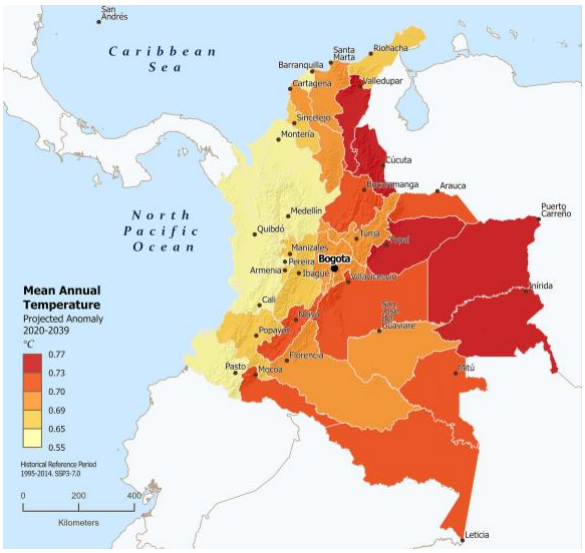


Figure 3. Mean Annual Temperature for Observed Period 1990–2020, and Projected Anomaly to 2020–2039 and 2040–2059[19]

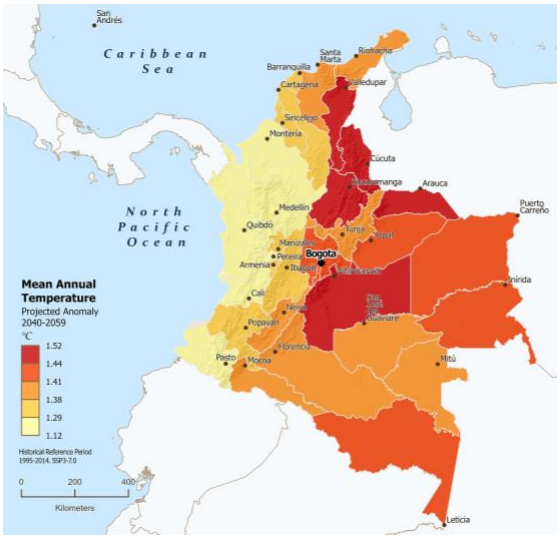
Observed period 1990–2020



Projected anomaly 2020–2039



Projected anomaly 2040–2059



Climate Hazards

Climate-related disasters comprise nearly 90 percent of emergencies reported in Colombia between 1998–2011 and cause significant economic losses.[20] With its diverse landscape, Colombia is highly vulnerable to extreme events. Highland areas, where the majority of the country's population is concentrated, are subject to landslides and significant flooding due to increased surface run-off from snow melt and extreme rainfall on degraded high-elevation forest ecosystems, which increases sediment loads. As temperatures continue to rise in the future, critical glaciers are likely to disappear, further contributing to water shortages in the highlands. This will pose a significant challenge for water resource management and likely affect all sectors of society.[21] Along Colombia's coastal areas, rising seas, coupled with increased storm surges, can lead to localized flooding. As the climate changes further, climate-related disasters are expected to continue in Colombia and risk exacerbating existing vulnerabilities across the country, such as infrastructure built on unstable mountains, which could add to the damage and loss from disasters such as landslides and avalanches.

The boxes below capture observed and projected changes for climate-related hazards impacting Colombia, many of which are growing in frequency and intensity. Key climate-related hazards for Colombia include extreme temperatures, extreme precipitation and floods, landslides, and sea level rise and sea surface temperature.

Extreme Temperatures
For the 2040–2059 period, many departments are expected to experience a dramatic increase in the number of days surpassing the Heat Index (above 35ºC). This is due to high atmospheric moisture content during the summer and fall months nationwide, and yearlong in the Pacific, Amazon, and Western Caribbean. The regions with the greatest expected increases are the Amazon, Orinoco, and Caribbean, with Atlántico department in the Western Caribbean projected to increase 169.55 days (50th percentile) (69.74 days and 215.44 days for the 10th and 90th percentiles, respectively) by midcentury.[22] The number of tropical nights with a minimum temperature above 20ºC is projected to increase not only in the Caribbean and eastern lowlands, but also in parts of the high-elevation Andes.[23] Under the SSP3–7.0 scenario, most departments are expected to experience an increase of more than 150 days on the Warm Spell Duration Index by midcentury, with an increase of more than 200 days expected annually in San Andrés y Providencia and Chocó.[24]

Figure 4. Projected Number of Hot Days with Tmax > 35ºC Anomaly for the Periods 2020–2039 and 2040–2059[25]

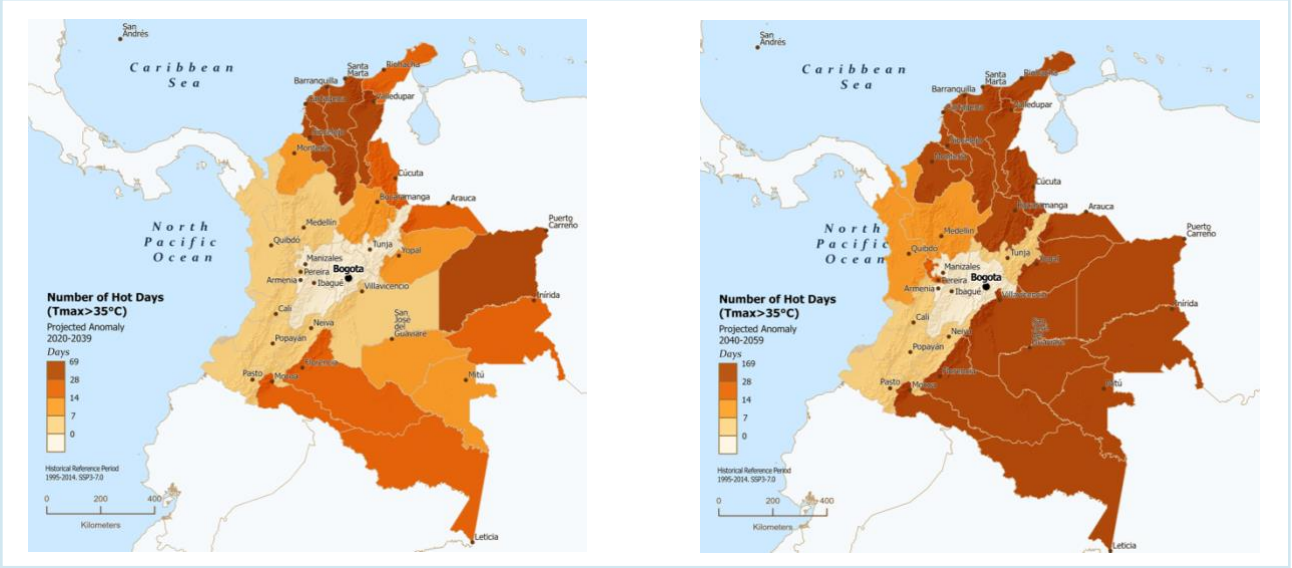
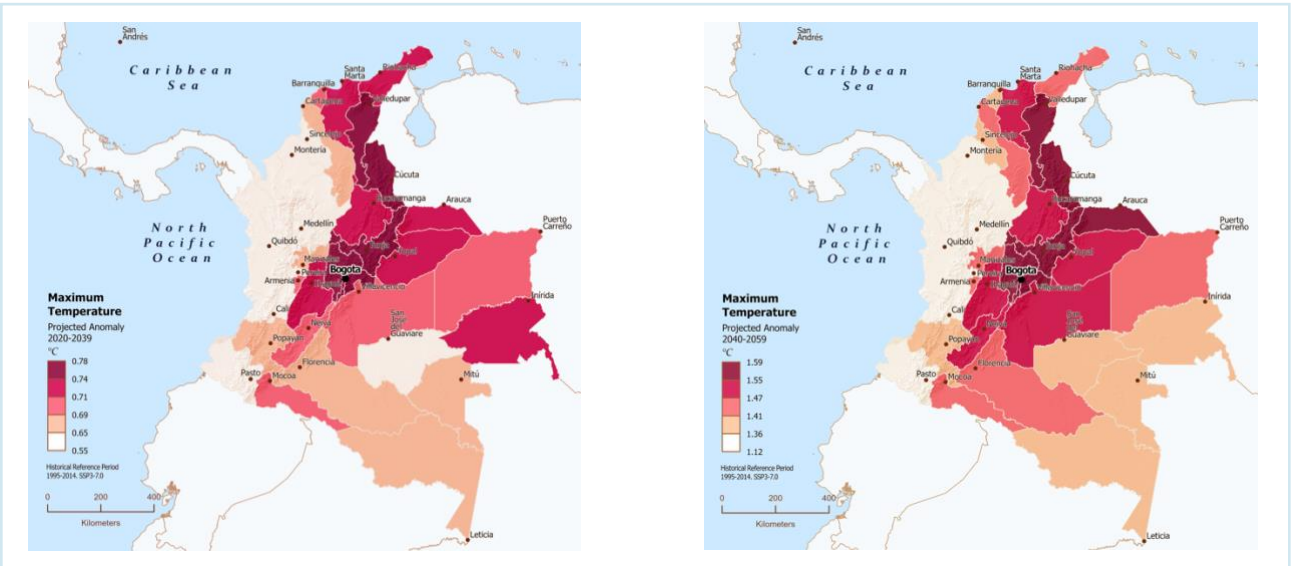


Figure 5. Projected Maximum Temperature Anomaly for the Periods 2020–2039 and 2040–2059[26]



Extreme Precipitation and Floods

Riverine floods, already a hazard across the country, are likely to become more pronounced as snow melts faster from the country's glaciers due to rising temperatures.

For the period of 2035–2064, the largest 1-day precipitation amounts associated with 50-year and 100-year historical return periods are projected to be nearly two times more likely to occur in the Western Caribbean, the Central and Northern Andes, and parts of the Pacific coast. The greatest changes are projected in Antioquia, Santander, and Córdoba. However, the rate of change is lower for 10-year and 25-year events. The Andes region is expected to experience the greatest increases in average largest 1-day precipitation by midcentury, with the largest monthly increases occurring at the end of the year.[27,28]

Landslides

Landslides and various types of mass movement can be influenced by an array of factors, including seismic activity, geology, water saturation, and erosion—all of which can be exacerbated by human activities. According to the national government, the departments with the greatest percentage of land area exposed to high-hazard landslides are located in northern parts of the Cordillera Oriental (Norte de Santander, Santander, Boyacá, and Cundinamarca) and Cordillera Occidental (Chocó, Antioquia, Caldas, Risaralda, and Cauca).

Between 1970 and 2011, landslides resulted in over 5,200 fatalities. In 2017, a mudslide caused by heavy rain and erosion associated with deforestation in Mocoa, Putumayo (Amazon) resulted in 273 deaths, underscoring the importance of precipitation and land management as key factors in assessing for landslide hazard risk.[29,30]

Droughts

Droughts are common in Colombia, particularly during drier seasons occurring between January and March and between July and September and can lead to water supply shortages for human and agricultural needs. Abnormal climatic conditions associated with the El Niño phenomenon can produce high temperatures and severe droughts in Colombia, damaging agricultural output and threatening operations at hydroelectric power projects which generate most domestic energy supplies.[31] Notably, La Guajira has been heavily impacted by the El Niño phenomenon; between 2012 and 2015, La Guajira experienced a severe multi-year drought that resulted in substantial losses in agriculture and severely affected livelihoods.[32] Nationally, drought-related conditions have increased in frequency by roughly 2.2 times compared to previous years.

As temperatures rise, these will likely (i) exacerbate existing tensions for water between agricultural and livestock needs and human population needs, especially during dry seasons; (ii) alter water quality from available surface sources; and (iii) increase pressures on urban zones as urbanization rates rise.

Sea Level Rise and Sea Surface Temperature

Sea level rise and coastal inundation will increasingly threaten Colombia's coastal zones. In terms of observed sea level changes along Colombia's coastline, the average annual anomaly steadily increased from 30.01 mm in January 1993 to 107.71 mm in January 2015. Under a Representative Concentration Pathway 8.5 scenario (CMIP5), sea level rise is projected to increase by 0.29 m (0.26 m, 0.34 m) by 2050 and 0.76 m (50th percentile) (0.67 m, 0.86 m for the 10th and 90th percentiles, respectively) by 2099. Rising sea levels are projected to flood 4,900 km^2 of lowland coasts and 5,100 km^2 inland, affecting an estimated 1.4 to 1.7 million people, 80 percent of which are living on the Caribbean coast and the other 20 percent on the Pacific coast.

Furthermore, more than 45 percent of Colombia's areas of coastal mangroves, grasslands, scrublands, and lagoons are vulnerable.[33]

SECTION II.
Climate-Related Health Risks

Colombia's burden of disease is caused primarily by non-communicable diseases, which accounted for 70 percent of total disability-adjusted life years (DALYs) in 2019, followed by injuries (18 percent) and communicable diseases (12 percent). Colombia has gone through an epidemiological transition and successfully reduced the burden caused by communicable diseases, including maternal and child conditions. However, infectious disease outbreaks—notably the COVID-19 pandemic—continue to pose a significant risk to population health.[34] Life expectancy in Colombia increased from 57 years to 77 years between 1960 and 2019, but fell to 75 years in 2020, driven by the COVID-19 pandemic.[35] The country's burden of disease is also influenced by the socioeconomic determinants of health, such as income, environmental factors, access to basic services, and urbanization. Some of these determinants were negatively impacted by the COVID-19 pandemic; for instance, the pandemic contributed to an increase in the proportion of people living below the national poverty threshold, which rose from 35.7 percent in 2019 to 42.5 percent in 2020.[36]

Colombia's CHVA focusses on six climate-related health risk categories: (a) nutrition and food security, (b) VDBs, (c) water-borne diseases, (d) impacts of increasing temperatures on non-communicable diseases, (e) air quality, and (f) zoonotic diseases. Each category is assessed in terms of current and future risk, with considerations for national and sub-national variation, where possible. It is important to note that these risk categories represent only a sample of the most pressing health risks to the population of Colombia, as expressed in key policy documents and during meetings held with key stakeholders. Other climate-related health risks have not been included in this assessment; these include, but are not limited to, direct injuries and mortality associated with natural hazard events and air quality morbidity and mortality.

Nutrition and Food Security

Weather and climate are foundational drivers of healthy and sustainable diets. The mechanisms through which climate change affects nutrition via the food system are profound and include both acute and chronic effects on agricultural production, storage, processing, distribution, and consumption. Nutritionally secure and stable diets depend not only on agricultural production, but also on the complex interactions of demand, economics, legislation, conflict, food waste, nutrient losses, food safety, and access. Climate variability is already contributing to increases in global hunger and malnutrition. While a comprehensive analysis of climate change's impact on the food system is beyond the scope of this assessment, this CHVA examines climate and nutrition linkages through a food security lens in Colombia as it relates to weather and

climate impacts on agricultural and fishing productivity. Agricultural productivity is a key determinant of food availability and economic productivity in Colombia and is affected by weather and climate patterns.[37] In 2022, 18 percent of the country's population lived in rural areas,[38] and in 2021, 16 percent of employment was in the agriculture sector,[39] signaling that a significant number of livelihoods are vulnerable to the impacts of climate change. Short-term shocks (e.g., natural disasters) pose a significant threat, as they can drastically reduce yields or redefine spatiotemporal patterns of crop suitability. Current and projected risks related to nutrition and food security are discussed below.

Nutrition and Food Security	
Current	**Projected**
Approximately 12.7 percent of children in Colombia experience stunting and 1.6 percent experience wasting—figures that are above the LAC average. Within Colombia, La Guajira, Chocó, and Arauca departments have the highest percentage of stunted children, with 30 percent, 23 percent and 17 percent, respectively.[40] 15.5 million people in Colombia are food insecure, and approximately half of the total population is marginally food secure. This means that they are vulnerable to becoming food insecure if there is no improvement in conjunctural factors in the short term or if shocks occur, including those linked to climate. The departments with the highest prevalence of food insecurity are concentrated on the Atlantic Coast, and include Cordoba (70 percent), Sucre (63 percent), and Cesar (55 percent).[41]	Globally, it has been estimated that the risk of hunger and malnutrition will increase by 20 percent by 2050.[42] In Colombia, climate change is likely to impact crop suitability and the food system overall. By 2050, it is projected that roughly 3.5 million Colombians will be affected, due to the impact on agro-industries, supply chains, and food and nutritional security. According to projections, the present lack of adaptation measures in the food system will put 80 percent of the country's crops at risk, and more than 60 percent of land currently used for agriculture will experience an overall decline in crop yield.[43] In Bogotá, Colombia's capital, crops such as mango, papaya, corn, and plantain—food staples in the country—will see a decrease of 19 percent to 47 percent suitability. Sugarcane and coffee, which are particularly sensitive to heat, will likely be the most affected.[44] It is projected that changes in precipitation and temperature will affect fishing and food production in coastal communities, where marine products are an important source of protein. More than 1.5 million people work in Colombia's fishing sector and associated industries.[45] It is estimated that climate change alone could contribute an additional 80,000 cases of stunting in the year 2030 and 127,000 cases in the year 2050 in Colombia, and an additional 150 deaths in 2030 and 2050 each. The economic cost of the impacts of climate change on stunting are projected to reach over US$250 million per year between 2030 and 2050.[46]

Vector-Borne Diseases

Weather and climate are critical drivers of spatiotemporal VBD distribution and transmission dynamics. Climate variability causes vector and host ranges to expand or contract, shifting disease distribution, seasonality, and/or facilitating the emergence or re-emergence of VBDs. Considering that the main dengue vector in Colombia is Aedes Aegyptis, the optimal vector temperature for reproduction and survival is between 22–32ºC.[47] The species will cease all biting at 15ºC and will die at temperatures above 40ºC.[48] Given that temperature projections for the 2050s are between 20.06ºC (min) and 29.45ºC (max), with a mean temperature of 25.51ºC, this would create an optimal range for vector reproduction in Colombia. The box below discusses current and projected risks related to VDBs.

Vector-Borne Diseases	
Current	**Projected**
Vector-borne diseases are a critical challenge for the health system and livelihoods of Colombians. Dengue represents 0.14 percent of total deaths in the country. There is a higher rate of deaths nationally (0.73 deaths per 100,000) when compared to the regional average (0.23 per 100,000), and the death rate has seen an annual increase of 8.61 percent. Notably, dengue disproportionately impacts children under five years of age (2.24 deaths per 100,000), and females (2.45 deaths vs. 2.04 deaths for males).[49] Malaria has decreased in Colombia, falling from 20.98 per 100,000 DALYs to 8.03 per 100,000 DALYs between 2009 and 2019. However, it still yields 0.12 deaths per 100,000.[50] Moreover, the prevalence of malaria has increased in higher elevation areas in the northwest region of the country.[51]	Considering the increasing temperatures, vectors such as Aedes Aegypti and Anopheles will have more suitable areas for reproduction, especially in the Andean region, as temperatures will allow the mosquito to survive at higher altitudes. The relative vectorial capacity for dengue is projected to increase from 0.66 to 0.76 by 2070 under a high emissions scenario.[52] It is estimated that in the year 2050, Colombia will experience an additional 178,000 cases of dengue and 111,000 cases of malaria as a result of climate change alone. These two diseases are projected to result in approximately 2,000 additional deaths in the year 2050. In this same year alone, the economic cost of climate change on dengue and malaria is projected to reach over US$4 billion.[53]

Water-Borne Diseases

Water quality, which is in part affected by climate-related hazards such as floods and landslides, has been associated with an increased incidence of water-borne diseases. Colombia faces a significant burden of water-borne diseases such as diarrhea, dysentery, cholera, food poisoning, and parasitic infections, which disproportionately impact children under five years of age. Current drivers of water-borne diseases throughout the country are attributable to many factors, including water sources, quality and quantity of drinking water, sanitation facilities, and hygiene practices, each of which can be negatively affected by climate-related factors. Current and projected risks related to water-borne diseases are summarized in the box below.

Waterborne Disease Risks	
Current	**Projected**
In the 2010 Demographic and Health Survey (DHS), Colombia reported that 16.4 percent of children experienced diarrhea in the three years preceding the survey. Sub-nationally, most cases of diarrhea were reported in Amazonas (30.4 percent of children experiencing diarrhea), Vichada (25.6 percent), Putumayo (23.6 percent), Chocó (22.5), Caquetá (22.2), and Magdalena (22.2).[54] Households using unimproved water sources are at increased risk for water-borne diseases. Nationally, 7.6 percent of households use unimproved water sources. Notably, Putumayo and Guajira departments have the fewest households with access to improved water sources, at 26.9 percent 22 percent, respectively. Nationally, around 10 percent of households have limited sanitation services. Departments such as Casanare, Guaviare, and Putumayo have more households that lack access to adequate sanitation services, at 22.1 percent, 20.7 percent, and 17.9 percent respectively.[55]	Although data are scarce and there are many confounding factors, projections for the relative risk of diarrhea in South America suggest that for each 1° C of warming, the risk of diarrhea will increase from 1.09 relative risk (RR) for the period 2010–2039 to 1.17 RR for period 2040–2069, and to 1.25 RR in period 2070–2099.[56] In Colombia, it is estimated that climate change will contribute an additional 89,000 cases of diarrhea in the year 2030 and 271,000 cases in the year 2050. The economic cost due to diarrhea because of climate change is projected to reach US$15 million in the year 2050.[57]

Increasing Temperatures

With rising temperatures and an increasing frequency of extreme temperatures projected in Colombia, the country's population faces increased risk of heat-related illness. Notably, extreme weather events can worsen chronic non-communicable conditions, such as cardiovascular and respiratory diseases, contributing to increased emergency room visits (ERVs) and higher burden on the health system. The current and projected risks related to increasing temperatures are summarized below.

Increasing Temperatures	
Current	**Projected**
Between 1998 and 2013, 267,730 deaths in Colombia were attributed to heatwaves.[58] Health effects caused by heat include the acute exacerbation of pre-existing conditions, including respiratory and cardiovascular diseases, heat rash, cramps, exhaustion, and dehydration. Approximately, 85,154 ERVs (1.5 percent of all ERVs) were attributed to increasing mean temperatures in the period 2010–2019.[59]	Projections under business-as-usual models highlight that heat-related mortality will increase by more than 2000 percent by the 2080s, considering a high population growth scenario. Notably, the impact of humidity, which can be high in certain regions of Colombia, can exacerbate the impacts of heat on health and wellbeing.[60] Under a SSP3–7.0 scenario, Colombia is projected to experience 380,565 ERV for the period 2020–2039—a projected increase of around 440 percent.[61] Considering the projections for the number of ERV attributable to temperature, it is estimated that the economic burden will increase to 50,000 million Colombian Pesos (COP) by 2039 (point estimate); however, it could reach up to 250,000 million COP considering the prediction interval.

Air Quality

Both ambient (outdoor) and indoor air pollution pose a major threat to health, whether from fine particular matter (PM2.5) or inefficient indoor stoves. Colombia has a prevalence of respiratory illnesses, making air pollution a significant concern for the country. Current and projected risks related to air quality are discussed below.

Air Quality Risks	
Current	**Projected**
Air and water quality are the main environmental risk factors for Colombia, jointly causing around 17,549 deaths per year and representing 8 percent of total annual mortality.[62] The Air Quality Index (AQI) 2023 shows a moderate concentration of PM2.5 in Colombia (AQI=14.6 μg/m^3), which exceeds the World Health Organization recommended guidelines of 10 μg/m^3. Ambient air quality can be impacted by smoke from wildfires. Droughts and increased temperatures can increase the frequency, intensity, geographic proximity, and length of the wildfire season in Colombia, worsening wildfire-induced air pollution. Indoor air pollution is a major concern in Colombia. According to the latest available DHS from 2015, 11.7 percent of households used solid fuel for cooking (solid fuel is made up of coal/lignite, charcoal, straw/branches/grass, or agricultural residues). This percentage is higher in rural areas (47.9 percent) due to the lack of access to gas pipes.[63]	There are no projections of indoor air pollution exposure due to climate change. However, given the high prevalence of respiratory illnesses in Colombia, it is essential to better understand the exposure pathway and the influence of climate change. In 2019, chronic respiratory diseases accounted for 37.2 deaths per 100,000 in Colombia, while respiratory infections and tuberculosis accounted for 18.48 deaths per 100,000.[64]

Zoonotic Diseases

Colombia is the second most biodiverse country in the world, with more species of birds, amphibians, butterflies, and frogs than any other country. In addition, the Colombian agricultural sector has expanded in recent years, driven by the growth of poultry and pig farming. Expansions in land used for agriculture or construction can result in changes in wildlife habitats, increasing exposure pathways for zoonotic diseases.[65] In Colombia, both the rich biodiversity and trends in the agricultural sector have increased the country's vulnerability to zoonotic diseases.[66] Zoonotic diseases can impact society in numerous ways, including by affecting agricultural productivity and livelihoods, trade, and human and animal health. Changes in precipitation and temperature patterns can also affect the capacity of ecosystems and species to adapt to evolving burdens of zoonotic diseases.

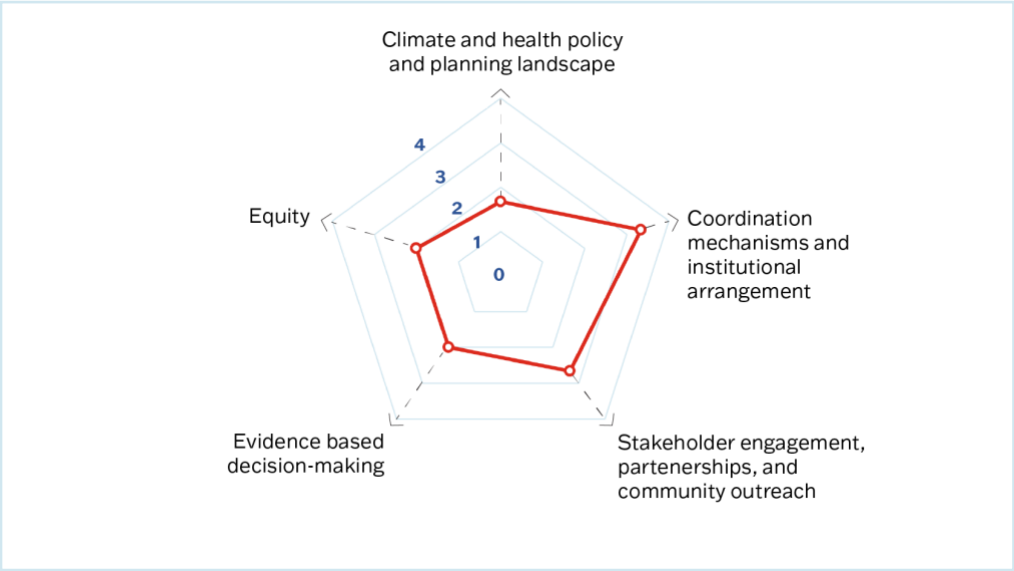
SECTION III.
Adaptive Capacity and Readiness

The extent to which Colombia's health system is prepared for and has the capacity to manage changes in climate-related hazards and exposures will determine the country's resilience in coming decades. This section analyzes the adaptive capacity and readiness of the health system to prevent and manage climate-related health risks across four key building blocks, while assessing equity as a cross-cutting component. The building blocks include:

1. Leadership and Governance
2. Health Financing
3. Health Information Systems
4. Service Delivery

Leadership and Governance

Figure 6. Leadership and Governance Capacity Scores



Source: Elaborated by authors from Adaptive Capacity and Readiness scores

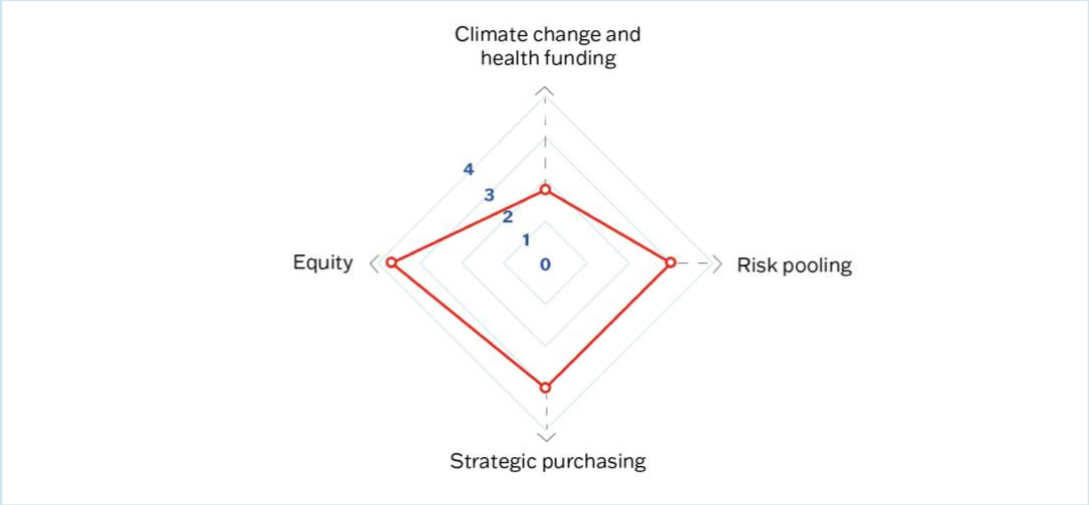
While Colombia has been timely in developing key policy documents such as the National Determined Contributions (NDCs), Long-term Strategy Colombia 2050, National Adaptation Plan (NAP),[67] and Climate Change policy and law, the country has not yet developed a comprehensive climate and health strategy or plan. While the Environmental Health Department within the Ministry of Health (MoH) has been active in leading the country's efforts on climate change and health, the lack of a comprehensive climate and health strategy, and limited financing and technical capacities suggests points to potential limitations. Currently, the work on climate and health is guided by the NAP and the NDCs, which outline priorities and strategies.

Relevant sectors such as emergency preparedness and response; water, sanitation, and hygiene; and agriculture have their own sector-specific plans and there is a lack of integration and alignment of efforts and resources. The National Department of Planning acts as a catalyzer of these cross-sectoral coordination efforts and provides technical support for developing plans in the face of climate change. However, technical support is limited due to a lack of human and financial resources. Moreover, at the sub-national level, governance, capacity, and resources are more varied, and in most territories, there is a lack of leadership and advocacy for the integration of climate change into health strategies and activities. The territorial units under the SISCLIMA (National Climate Change System) and the CONASA (National Council on Environmental Health) do not adequately articulate efforts for ensuring effective implementation and allocation of resources for departments and for the populations most vulnerable to climate change and climate-related health risks.

Decision making and prioritization of climate and health interventions and strategies is mainly conducted by the MoH's Environmental Health Department, with limited involvement by non-governmental stakeholders, such as private health service providers, non-governmental organizations (NGOs), or community-based organizations in decision-making process related to climate change and health risks and adaptation. Notably, there are no direct channels for feedback from or accountability between communities and the MoH. Nevertheless, regarding emergency responses, there is a framework for bridging different stakeholders that includes community leaders under the Unified Leadership Post, or *Puesto de Mando Unificado*. Furthermore, climate change and health strategies and activities do not incorporate information or target specific vulnerable populations for the development of activities or the allocation of resources.

Health Financing

Figure 7. Health Financing Capacity Scores



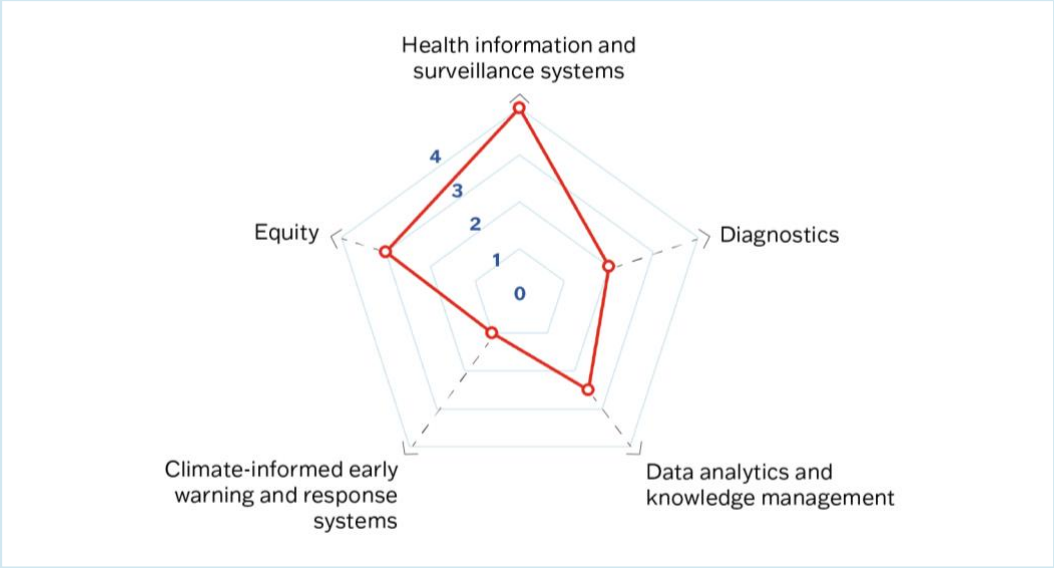
Source: Elaborated by authors from Adaptive Capacity and Readiness scores

Colombia does not have an exclusive budget line for climate and health activities, and there has been minimal change in the budget allocated for the Environmental Health Department within the MoH, highlighting a low financing capacity for climate change and health strategies. Climate and health activities and strategies depend mostly on donors and international organizations, such as the World Bank, Inter-American Development Bank, Center for Disease Control and Prevention, German Agency for International Cooperation, United States Agency for International Development, and Health Care Without Harm. This hinders continuity of strategies and plans for strengthening the health system in the face of climate change, fragmenting and projectizing different efforts.

Contingency funds in the country for climate-related emergencies are mostly used for infrastructure outside the health sector, and investments for health are minimal. Moreover, these emergency resources are allocated mostly to response activities, leaving preparedness and risk mitigation with scarce resources and limited planning. There are some formal provisions available to reallocate funds during an emergency to meet changing needs, including a fund managed by the National Institute of Health or *Instituto Nacional de Salud* (INS), but there are delays and differences in deployment and implementation at the sub-national level (Law 1523 enables the reallocation of resources in the face of emergencies and called for the formation of the Disaster Risk Management Unit). Strategic purchasing and procurement of essential medicines have limited articulation with the private sector and with development partners, especially for emergency preparedness. Essential medicines stocks and procurement plans exist, but there are no considerations or specific contingencies that account for climate-related hazards. Notably, the deployment and implementation of contingencies varies considerably at the sub-national level.

Health Information Systems

Figure 8. Health Information System Capacity Scores



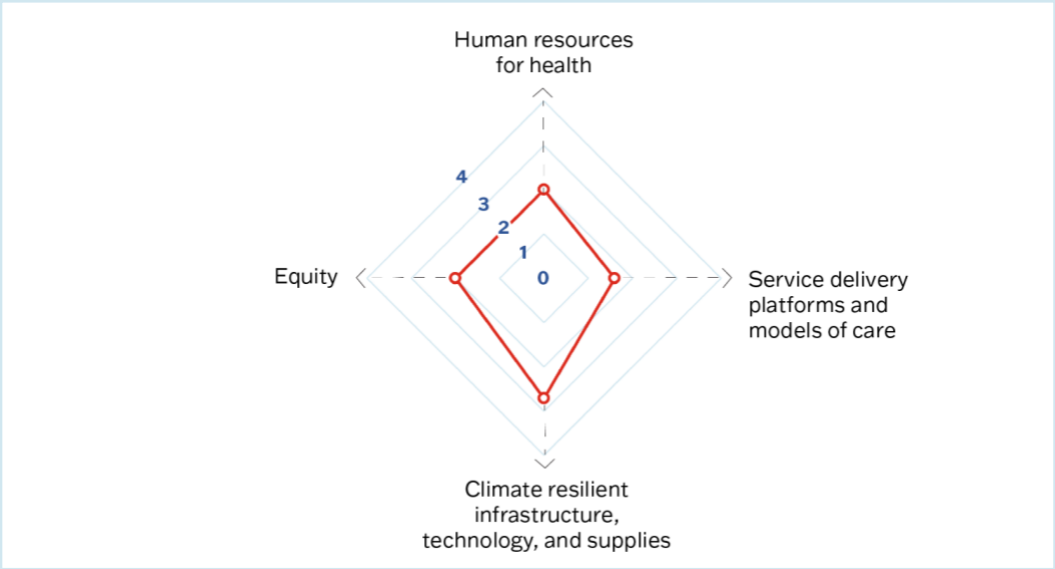
Source: Elaborated by authors from Adaptive Capacity and Readiness scores

Colombia has functioning health information and surveillance systems that have the capacity to aggregate data for health and climate, but there are opportunities for improvement regarding digitalization and integration across sub-systems. Regional disparities in the deployment of the HIS also exist. Concerning climate change and health diagnostics, Colombia does not conduct risk assessments beyond some municipal-level data analysis. Capacity to test and analyze climate-sensitive diseases is limited in terms of geographical standardization and coverage. Although the INS has adequate capacity, capacity beyond the Institute is limited. **There is currently no integration of data for climate change and health**. Although Colombia generally collects good quality data across these areas, data sources are heavily fragmented and there have not been prioritized efforts to create an integrated health and climate database.

There are existing and largely adequate HISs related infrastructure (such as power, information and communications technology, and hardware), but there are significant gaps, particularly at the sub-national level. Key challenges are the reliance on paper records and the lack of trained and skilled personnel to ensure timely data collection and sharing. The mandate for data management and analytics falls on the INS, which has limited capacity and resources. There is a lack of sufficient staff capable of producing analytics for evidence-based planning and decision making. Currently, there are no real-time dashboards to track climate change and health risks and adaptation interventions, and there is no functional early warning and response system for health risks beyond some regional initiatives.

Service Delivery

Figure 9. Health Service Delivery Capacity Scores



Source: Elaborated by authors from Adaptive Capacity and Readiness scores

National health workforce density is below LAC and Organization for Economic Cooperation and Development (OECD) averages and is particularly low in rural areas of the country. The law governing health workforce planning dates to 2007 and does not adequately include considerations related to climate change and health. There has not been a national effort to assess the knowledge or awareness level of climate and health among staff. Training and capacity building protocols are being updated as part of the Health NAP currently under preparation, but the comprehensive implementation of training programs in Colombia is challenging due to high informality and high turnover of staff.

There is no national surge capacity plan in place, which constrains Colombia's emergency response capacity. The current normative framework limits flexibility for procurement, receipt of donations, and partnerships with the private sector. There are also no national-level mechanisms for monitoring the delivery of health services during periods of disruption, which leads to the unavailability of necessary data to inform the deployment of human and capital resource reserves. Partnerships with private facilities occur during emergencies and disruptive events in an ad-hoc manner, but there are no formal mechanisms or processes to facilitate these partnerships.

Colombia has a vast regulatory framework to respond to emergency situations, such as the COVID-19 pandemic, with a strong focus on primary health care, but there is a high degree of variability in existing governance capacity at regional and local levels in practice due to unclear roles and responsibilities and lack of meaningful citizen

and social participation. There are some programs to organize the provision of services for certain vulnerable groups, such as migrants or populations in malnutrition-prone regions. However, there are no articulated programs targeting specific climate-vulnerable populations.

Outside of a limited number of initiatives at the regional and municipal levels, there have not been nationwide investments to retrofit health care facilities considering climate change impacts. Updated building codes under preparation include sustainability features that will contribute towards incorporating climate considerations in new and existing constructions. Nevertheless, the forthcoming new building codes will apply only to new infrastructure, having limited monitoring and enforcement of codes to existing infrastructure.

SECTION IV.
Recommendations

This section outlines recommendations for Colombia, based on assessments of the magnitude of current and projected climate-related health risks and of existing gaps in the adaptive capacity and readiness of Colombia's health system to manage and/or prevent these risks.

1. **Mobilize and allocate resources to the MoH's Environmental Health Department for the forthcoming Integrated Climate Change Management for the Health Sector Plan.** While the upcoming World Bank Program-for-Results project in Colombia will finance the development of a Climate Change Plan for the health sector, it is critical to allocate resources for implementation.

2. **Expand the technical personnel within the Environmental Health Department to increase capacity for engaging in cross-sectoral coordination and for strengthening the monitoring of climate and health strategies' implementation in the territories.** The Environmental Health Department needs increased capacity to ramp up efforts in support of the climate change and health agenda, and for ensuring implementation at the sub-national level.

3. **Engage globally and regionally on initiatives for climate change and health to leverage funding opportunities that would enable necessary resources for implementation.** Funding opportunities include tapping into global funds, such as the Green Climate Fund, Climate Investments Fund, or the Green Environmental Facility.

4. **Redesign procedures and regulations for emergency procurement and resource utilization to minimize disruption of health services by ensuring availability of resources for health service provision amid extreme weather events.** Current emergency funds are mostly directed towards infrastructure outside of the health sector, and resources must be directed across the health system.

5. **Prioritize the roll out of the Integrated Environmental Health Information System, or SUISA, ensuring deployment at the sub-national level.**

6. **Scale up the national-level monitoring system for health service delivery to produce timely information during periods of disruption to guide effective decision making.** Availability of timely information amid climate-related or natural hazards is critical to inform the deployment of human and capital resources.

7. **Establish standard practices for coordinating with private facilities during emergencies to ensure efficiency and reduce service disruption for patients.**

8. **Ensure enforcement of upcoming new building codes on existing infrastructure.** This can be accomplished through three strategies:

    a. Conduct a needs assessment for existing infrastructure.
    b. Establish a financing mechanism to fund retrofitting work.
    c. Establish a committee for monitoring of the adoption of the new building codes in existing infrastructure.

ANNEX A.
Methodology

Aims of Assessment and Conceptual Framework

The objective of this CHVA is to assist decision-makers with planning effective adaptation measures to address climate-related health risks. Where available, these measures are provided at a sub-national level to assist regional health planners. The recommendations of this CHVA are aimed at the health sector and related sectors that influence health risks from climate change, such as disaster risk management.

Adaptation priorities need to run alongside fundamental and urgent action to mitigate climate change. It is important to stress how complex the climate challenge is and how hard it is to precisely predict the magnitude of how severe climate exposures facing populations will become. Many factors could slightly slow or significantly speed up rates of change, including positive feedback effects and, most worrying of all, cascading climatological tipping points. For this reason, mitigating existing GHG emissions and developing and implementing measures to protect human development from the changing climate are, in addition to adaptation measures, of paramount importance.

Investment in adaptation strategies to proactively address the effects of climate change on health outcomes is critical. This assessment is concerned with climate risks to health and health systems, the adaptive capacities in place to deal with these risks, and recommendations to meet identified gaps. The primary focus of this assessment is, therefore, on climate adaptation and resilience measures. However, as the Intergovernmental Panel on Climate Change (IPCC's) *Sixth Assessment Report*[68] makes clear, "Global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered." Mitigation is no longer a sufficient strategy, regardless of the pace with which governments and communities around the world act. Adaptation is now a critical part of climate action as mitigation. This report, therefore, focuses on adaptation measures but, where possible, also includes recommendations that reduce GHGs or facilitate the decoupling of emissions for progress toward human development goals.

This assessment follows a stepwise linear approach. The first step characterizes the **climatology** in Colombia, highlighting the observed and future climate exposures relevant to health. The second step examines **climate-related health risks,** including identifying vulnerable populations most at risk. The final step assesses the **adaptive capacity of the health system,** identifying gaps to manage current and future climate-related health risks. The assessment was conducted using desk-based available sources such as scientific published literature, national statistics, and meetings with key government stakeholders.

Climatology

This section describes observed climatic changes and projected climate trends, highlighting the priority climate-related hazards in relation to human health risks in Colombia. Climate information is acquired from the World Bank Group's Climate Change Knowledge Portal. Observed climate data are presented at a 50km x 50km spatial resolution for 1901–2020. Model-based climate projection data are derived from the Coupled Model Intercomparison Project Phase 6 (CMIP6), and projections are shown through five Shared Socioeconomic Pathways (SSPs). This assessment explores projected climate change under SSP3–7.0 for the short- (2030s; 2020–2039) and medium- (2050s; 2040–2059) terms. The SSP3–7.0 is a high GHG emission scenario in which countries are increasingly competitive and emissions continue to climb, doubling from current levels by 2100.

Adaptive Capacity

The extent to which the health system in Colombia is prepared for and has the capacity to manage changes in hazards, exposure, and susceptibility will determine its resilience in coming decades. In this assessment, Colombia's adaptive capacity[69] to prevent and manage climate-related health risks is examined using the Adaptive Capacity Assessment Tool which focuses on four main building blocks while considering Equity as a cross cutting component: (1) Leadership and Governance, (2) Health Information Systems, (3) Service Delivery, and (4) Health Financing. It should be noted that several factors outside the scope of the health sector can also drive reductions in adaptive capacity to manage the health risks of climate change in Colombia's institutions and people. These include the country's economic challenges, changing demographic patterns, and slowly improving social conditions. Promotion of equity as a cross-cutting theme for enhancing adaptive capacity and resilience to the health risks of climate change is also critical. Adaptive capacity is likely to be greater when access to resources within a community, nation, or the world is equitably distributed.

ANNEX B.
Estimating the Impacts of Climate Change on Health

The World Bank has supported the development of the *Climate and Health Economic Valuation Tool* (CHEVT) to provide an estimate of the potential economic costs of the health impacts arising from the projected changes in temperature and precipitation. A brief outline of the CHEVT methodology is provided below.

Methodology

Climate Data and Scenario

Climate data (temperature and precipitation projections) were obtained from the latest projections made available by the Coupled Model Intercomparison Project (CMIP6). Results from the climate models participating in CMIP6 form the foundation of the climate change projections presented in the Sixth Assessment Report of the IPCC.

Five priority scenarios are used by IPCC: SSP1–1.9, SSP1–2.6, SSP2–4.5, SSP3–7.0, and SSP5–8.5. This assessment retained the SSP3–7.0 scenario, as it was considered to be the most relevant and realistic pathway for modeling purposes.

Estimating the economic cost of the health impacts of climate change employs a two-step approach.
The first step consists of estimating the impacts of projected climate change on the number of cases of both mortality and morbidity. This estimation is performed for the year 2030 and 2050, using 2020 as a baseline.

Estimating the Number of Deaths and Cases
The future incidence or probability of death associated with the above diseases is estimated based on the methodology presented by the World Health Organization (WHO) (2014).[70] Except for stunting, these future incidences are estimated using the dose-response functions presented below.

Dengue

The dose-response function is:

$$\mathrm{Ln}\left[\frac{P_{Dengue}}{(1-P_{Dengue}}\right] = \mathrm{Constant} + F_{(Temperature,Precipitation)} + 0.059\mathrm{Ln}(GDP_{pc})$$

where:

P_{Dengue}	Probability of dengue transmission
F	Spline function[71]
Temperature	Annual average temperature
Precipitation	Annual total precipitation
GDP_{pc}	Gross domestic product per capita in purchasing power parity (PPP) terms

Malaria

The dose-response function is:

$$\mathrm{Logit(Malaria)} = \beta_0 + \beta_1 T_{min} + \beta_2 PR_{max} + \beta_3 GDP_{PC}^{1/2}$$

where:

Logit(Malaria)	Probability of malaria
T_{min}	Mean temperature of the coldest month
PR_{max}	Mean precipitation of the wettest month

Diarrhea

The dose-response function is:

$$n_{c,t} = N_{c,t}\,\frac{\exp(\beta\Delta T_{c,t}) - 1}{\exp\,(\beta\Delta T_{c,t})}$$

where:

$n_{c,t}$	Number of diarrhea deaths attributable to climate change among children aged under 15 years in country c in year t
$N_{c,t}$	Number of diarrhea deaths in children aged under 15 years in a future without climate change in country c in year t
$\Delta T_{c,t}$	Temperature anomaly in country c in year t
$\beta = \log(1+\alpha)$	Mid-estimate of the log-linear increase in diarrheal deaths per degree of temperature increase, with α being the linear increase in diarrheal deaths per degree of temperature increase

Stunting

The study used regional stunting data for cases and deaths due to climate change from the WHO (2014) study to derive country-level data. WHO (2014) established the links between climate change and undernutrition by using a range of models. The results of the analysis are reported as the percentage of children aged under five in 2030 and 2050 who are moderately or severely stunted, as well as the number of deaths of children due to stunting for both scenarios—with and without climate change.

Estimated future incidence levels (obtained from the dose-response functions) are applied to the national country populations projected under SSP3 to estimate the numbers of both morbidity and mortality cases for each of the diseases stated above.

The methodological approach is used to estimate the number of both mortality and morbidity cases for the year 2020 (serving as a base year), and for the year 2030 and 2050. These estimates inform policy makers of the future burden that may confront healthcare systems.

The methodological approach is also used to estimate the number of both mortality and morbidity cases for the year 2030 and for the year 2050 in a scenario with climate change and in a scenario without climate change. These estimates provide a measure of the health impacts directly attributable to climate change and may in turn provide policymakers with a climate rationale for justifying access to climate financing.

Data for 2020 pertaining to total number of deaths and cases for malaria, dengue, and diarrhea were extracted from the Global Burden of Disease website. For stunting, the WHO 2014 percentage estimates of stunting cases and deaths per region were used to derive the country estimates.

Economic Valuation of Deaths and Cases

The *second* step transforms these estimated numbers of cases and deaths into economic costs. The cost-of-illness (COI) approach and the value of statistical life (VSL) are used to estimate the economic costs of morbidity and mortality, respectively.[72] WHO (2014) does not provide an assessment of the economic costs arising from their quantitative assessment. The COI and VSL values are specific to each of the countries, while the national VSL values are based on an estimated VSL of USD6 million[73] in the United States (US) in 2020 and then adjusted for each country based on the adjustment factor being the ratio of US and national GDP per capita.

For both stunting and extreme heat, the estimated economic costs include only the economic cost of mortality, not the economic cost of morbidity. There is very limited information from the literature to derive COI for developing countries on stunting and extreme heat. For the purpose of estimating the morbidity cost arising from diarrhea, it is estimated that only 0.5 percent of all cases of diarrhea require treatment.[74]

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[5] Ibid.

[6] Ibid.

[7] The capital Bogotá is located in the Central Andes, Medellin is located in the Northern Andes, Cali is located in Southern Andes and Pacific, Barranquilla is located in the Western Caribbean, and Cartagena is located in Western Caribbean.

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[13] Ibid.

[14] Ibid.

[15] Ibid.

[16] Ibid.

[17] Ibid.

[18] Map elaborated by the World Bank, using data from the Climate Change Knowledge Portal

[19] Map elaborated by the World Bank, using data from the Climate Change Knowledge Portal

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[69] Adaptive capacity is defined by the IPCC as, "the ability of a system to adjust to climate change, moderate potential damages, take advantage of opportunities, and cope with the consequences" (IPCC *Fifth Assessment Report*). The related term, resilience, is the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events. People and communities with strong adaptive capacity have greater resilience. This assessment makes use of the term adaptation and adaptive capacity to encompass both terms.

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[71] A spline function is used to draw a risk function curve, which allows for a flexible relationship and interaction between climate factors (temperature and precipitation) and the probability of dengue transmission areas.

[72] Cost-of-illness (COI) is an approach used in economics to estimate the cost of morbidity. It includes the direct cost of treating illness as well as the indirect cost (lost productivity). Being a cost-based approach, COI provides an under-estimate of the true economic (social) cost of morbidity. The value of statistical life (VSL) represents aggregate demand for reductions in mortality risk, i.e., how much individuals (in aggregate) are willing to pay for a very small reduction in the probability of death. Since individuals' willingness to pay is positively correlated to their income, VSL increases with income per capita. VSL certainly does *not* measure the value of life.

[73] Viscusi (2020) uses a VSL of USD11 million. The use of USD6 million would lead to under-estimating the economic cost of mortality in this assessment. Source: Viscusi, W Kip. 2020. "Pricing the Global Health Risks of the COVID-19 Pandemic." *Journal of Risk and Uncertainty* 61(2): 101-128. https://doi.org/10.1007/s11166-020-09337-2

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