McGraw Hill

Adaptation to CLIMATE CHANGE RISKS IN IBERO-AMERICAN COUNTRIES

RIOCCADAPT REPORT

EDITORS
J.M. Moreno
C. Laguna-Defior
V. Barros
E. Calvo Buendía
J.A. Marengo
U. Oswald Spring

Summary for Policymakers

José M. Moreno (Spain), Clara Laguna-Defior (Spain), Paulina Aldunce (Chile), Vicente Barros (Argentina), Bibiana Bilbao (Venezuela), Mercedes Bustamante (Brazil), Eduardo Calvo Buendía (Peru), Inés Camilloni (Argentina), Omar Darío Cardona (Colombia), Jorge Cortés (Costa Rica), Gian Carlo Delgado (México), Íñigo Losada (Spain), José A. Marengo (Brasil), Carlos Mena (Ecuador), Jaime Mendo (Peru), Ana Rosa Moreno (Mexico), Úrsula Oswald Spring (Mexico), Germán Poveda (Colombia), Fabio R. Scarano (Brazil), Miguel A. Taboada (Argentina), and Sebastián Vicuña (Chile).

This text should be cited as:

Moreno J.M., C. Laguna-Defior, P. Aldunce, V. Barros, B. Bilbao, M. Bustamante, E. Calvo Buendía, I. Camilloni, O.D. Cardona Arboleda, J. Cortés, G.C. Delgado Ramos, I. Losada, J.A. Marengo, C. Mena, J. Mendo, A.R. Moreno, Ú. Oswald Spring, G. Poveda, F.R. Scarano, M.A. Taboada, and S. Vicuña, 2020: Summary for policy makers –RIOCCADAPT Report. In: *Adaptation to Climate Change Risks in Ibero-American Countries — RIOCCADAPT Report.* [Moreno, J.M., C. Laguna-Defior, V. Barros, E. Calvo Buendía, J.A. Marengo, and Ú. Oswald Spring (eds.)], McGraw Hill, Madrid, Spain (in press).

SUMMARY – TABLE OF CONTENTS

A) Introduction

Report presentation

The purpose of the RIOCCADAPT report is to assess the climate change adaptation actions being carried out in the member countries of the Red Iberoamericana de Oficinas de Cambio Climático (Ibero-American Network of Climate Change Offices or RIOCC), i.e., Spanish- and Portuguese-speaking countries in the Americas, the Caribbean, and the Iberian Peninsula (**Figure 1**).

The adaptation analysis has focused on some of the main sectors and systems that are relevant to RIOCC countries, and includes the more important extreme weather and climate risks and key sectors such as urban settlements and coastal areas (**Table 1**). Each chapter includes several case studies whose experiences provide useful conclusions for adaptation.

To contextualize adaptation actions, the report also includes an analysis of vulnerabilities, as well as of climate change risk and impacts.

Climate change adaptation within a risk framework

Climate change carries risks that arise as a result of the interaction of three components: hazard exposure and vulnerability (**Box 1, Figure 2**). Risks are materialized in the form of impacts that, in turn, can affect development and governance pathways, or in the form of hazards themselves either directly or indirectly originating from climate change.

Climate change adaptation (CCA) refers to any action, activity, plan, or program whose final aim is to reduce or prevent climate change risks and their subsequent impacts through risk management, or to exploit opportunities arising as a

Figure 1. Member countries of the Red Iberoamericana de Oficinas de Cambio Climático (RIOCC). Source: compiled by the authors based on SMHI (2008).

Table 1. Report content by chapter.

Subject area	Chapter	Topics addressed in each chapter
I. General Introduction	1	Conceptual Framework and Regional Context
	2	Society, Governance, Inequality, and Adaptation
II. Natural Systems	3	Terrestrial and Freshwater Ecosystems
	4	Coastal and Marine Ecosystems
	5	Biodiversity
III. Managed Systems	6	Water Resources
	7	Agriculture Sector
	8	Fishing Resources
IV. Climate Disaster Risks	9	Storms and Hurricanes
	10	Floods and Droughts
	11	Slope Instability and Landslides
	12	Wildfires
V. Other Key Areas and Sectors	13	Urban and Rural Settlements
	14	Coastal Areas
	15	Tourism
	16	Human Health

consequence of climate change (**Figure 3**). Adaptation is conceived as something that is planned in order to face a future that will be different.

On the other hand, people, either individually or collectively, and communities react to the adversities they face, prompting them to develop actions with an adaptive value. Adaptation actions are often em bedded within other policies. In fact, the most attractive adaptation actions are usually those that also offer development benefits, such as a reduction in vulnerabilities.

B) Context of RIOCC Countries

RIOCC countries cover areas from 43°N to 55°S, with altitudes reaching 6,960 m (Aconcagua, Argentina), and comprise ecosystems ranging from high altitude plateaus (Altiplano, 3,800 m) to great plains (Amazonia, Los Llanos, La Pampa), the most extreme deserts (Atacama) to extremely rainy areas (El Chocó, Colombia). Thanks to this diversity, there is a great representation of the planet's climates and of its terrestrial or marine biomes. For practical purposes, the study area was divided into nine subregions (**Figure 4**).

RIOCC countries have large socioeconomic differences between and within themselves. Poverty is widely spread. Life expectancy is lower than in more developed countries. Gender inequality still predominates. RIOCC countries are a source of migration within the region and abroad.

The region has been experiencing widespread temperature rises associated with greenhouse gas emissions of anthropogenic origin. Changes in precipitations are more varied and include both increases (southeast South America) and decreases (Spain, Chile, Mexico, northeast Brazil).

In the medium term (mid-21st century or when global warming exceeds 1.5°C), climate change is expected to continue to increase global surface temperature, although to a varying degree in terms of its magnitude in the different subregions. Precipitation will continue to increase where it already has done so (southeast South America) and decrease in the semi-arid subtropical areas, both in the Americas and in Europe (Chile, Mexico, Iberian Peninsula), or in the tropical areas of northeastern Brazil and Central America.

Box 1. Some key concepts related to risk and adaptation

Hazard: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services and resources, infrastructure, or economic, social or cultural assets in places and settings that could be adversely affected.

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Risk: The potential for consequences where something of human value (including humans) is at stake and where the outcome is uncertain. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends (**R=P∗C;** where R= risk, P=probability, C=consequences or impacts). Risks result from the interaction between hazard, exposure, and vulnerability, and they are expressed as: **R=H∗E∗V** (R=risk; H= hazard; E= exposure; V= vulnerability).

Risk Management: Plans, actions, or policies applied to reduce the likelihood or consequences of risks or to respond to their consequences.

Adaptation: The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or prevent harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

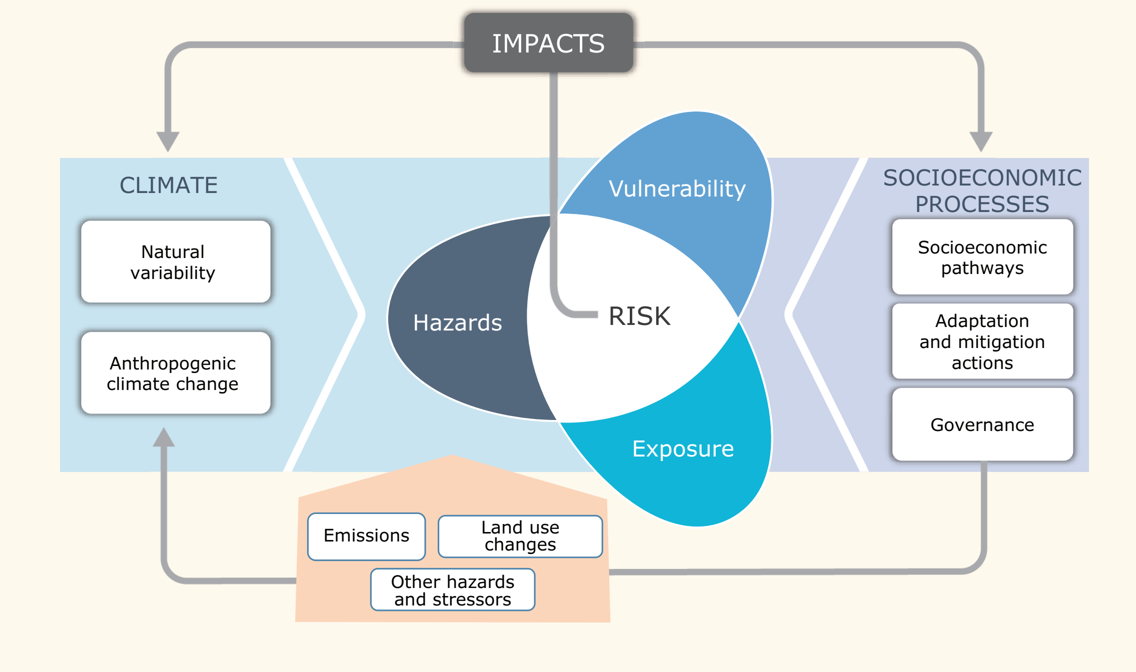


Figure 2. Conceptual risk framework, expressed as the product of the interaction between climate and climate change hazards, exposure, and vulnerability, which in human systems mostly depend on socioeconomic processes that determine the socioeconomic pathways, adaptation and mitigation actions, and governance. Risks materialize into impacts that, in turn, may affect climate or socioeconomic processes. These may affect other factors that also contribute to the risk, insofar as greenhouse gas emissions, changes in land-use, and other hazards and stressors affect climate change or through direct actions on the risks themselves. Source: modified from Chap. 19, AR5, WG2, IPCC, 2014 (Oppenheimer et al., 2014).

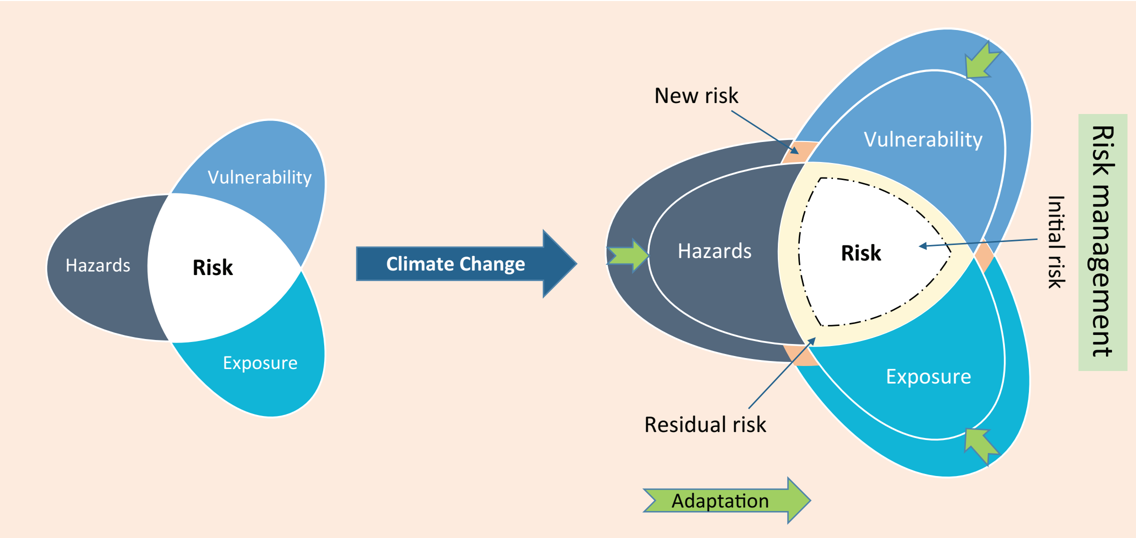


Figure 3. Climate change brings about risks that are greater than those already in existence or new risks all of which require management in order to reduce, where possible, the corresponding impacts. Adaptation, therefore, seeks to act upon all three risk components. An intervention on climate hazards may be less feasible and therefore actions applied to the other two risk components will be more important. Even with adaptation, it will be impossible to mitigate risk in its totality, meaning there will be a residual risk that needs to be addressed. Source: compiled by the authors based on Chap. 19, AR5, WG2, IPCC, 2014 (Oppenheimer et al., 2014).

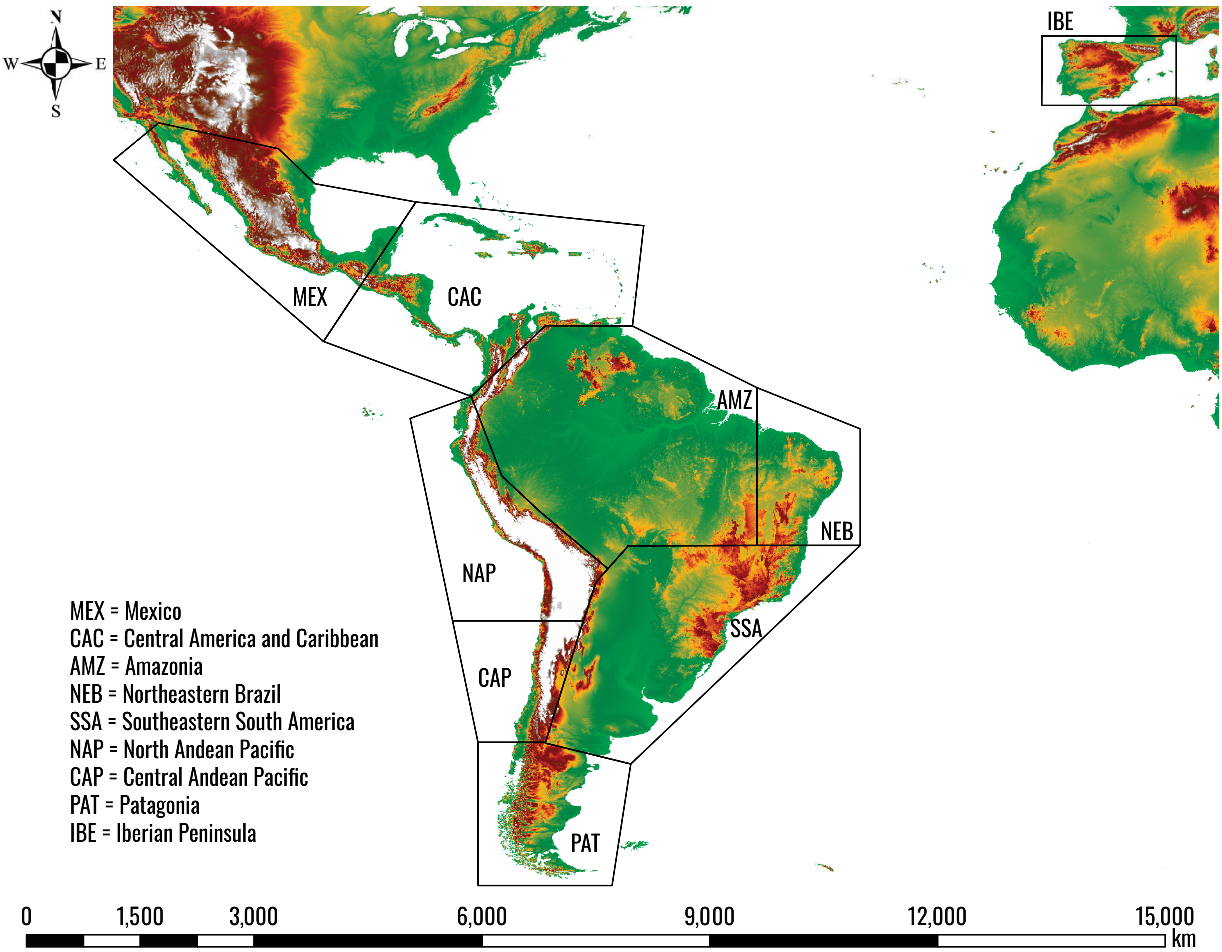


Figure 4. Topographical map of RIOCC countries and geographical division used in this report. Source: compiled by the authors based on Magrin et al. (2014) and Seneviratne et al. (2012).

Greenhouse gas emissions are increasing in certain countries, although average emissions per person are much lower than those of more developed countries. Emissions from land-use changes are extremely high in certain countries.

The political framework for cooperation and coordination of climate change policies is poorly developed. In general, the fight against climate change has not been a priority goal for the various regional entities and bodies in which the region's countries participate.

C) Relevance of the Sectors and Systems Included in the Report

Society, governance and inequality

Widespread economic and social inequalities, pockets of urban and peri-urban poverty, a rural population—dominant in few countries—dependent on a practically subsistence-based farming, as well as the numerous indigenous populations and gender inequality are, among others, some of the main characteristics of the societies of many RIOCC countries. Moreover, many of these populations are located in risk areas and are therefore highly exposed and not very resilient to climatic change due to the abundance of low quality, self-constructed housing. This makes them highly vulnerable to climate-related hazards.

Natural systems

The terrestrial and freshwater ecosystems of RIOCC countries contain nearly 800 million hectares of forest areas, 570 million hectares of wild savannas, 700 million hectares of productive land, over 30% of the planet's available freshwater, and about 40% of total renewable water resources. These are one of the region's most valuable assets due to their strategic importance in sustainable development. They constitute the foundation of a wide range of human activities, such as agriculture, fishing, and tourism, among others, which produce market goods and services, and they are an important source of income and employment.

RIOCC countries harbor an extraordinary diversity of coastal and marine ecosystems that contribute extraordinary socio-economic services. This diversity of ecosystems include, among others, mangroves, estuaries, marshes, seagrass beds, coral reefs and macro-algae forests, as well as deep-sea regions.

Ibero-America is exceedingly rich in biodiversity. The Americas in general house 29% of all seed plant species on the planet, 41% of birds, 35% of mammals, 51% of amphibians and 35% of reptiles, the overwhelming majority of which are found in South America, Mesoamerica and the Caribbean. The Amazonian rainforest is estimated to host around 1/10 of all plants and animals. Northern Andes alone house around 45,000 species of plants of which 44% are endemic. The Iberian Peninsula is also the most species rich area in Europe, with over 50% of all plants and animals of the continent. To this it must be added the extraordinary biodiversity of the Canary, Azores and Madeira islands. This biodiversity is essential for the flow of ecosystem services and their functions, and is vital for food security, the economy and cultural and identity values, among others.

Managed systems

The region has a heterogeneous distribution of available water resources. Central and South America are regions with a high average availability of water resources, but distributed heterogeneously within the region and within each country. The amount of resources, in terms of per capita availability, is very different between countries, nearing the water stress limit in certain countries (especially in the Caribbean and the Iberian Peninsula).

The primary water-using sector in the region is agriculture, with values nearing 70% of total water use, despite rain-fed agriculture being the main cultivation type, and in some cases representing more than 90% of water resources. Its use for hydropower generation is also a relevant factor in the region compared to other regions of the world. Despite improvements in access to drinking water in urban areas, access to it water in rural areas remains a major challenge in many countries of the region.

The rural population in RIOCC countries reaches 130 million people, with a proportion that varies from 8% to 47%, according to the country. This rural population produces a total of 250.8 million tons of cereals and oilseeds, of which four countries (Brazil, Argentina, Mexico and Spain) account for 84% of the production. Three RIOCC countries together (Brazil, Argentina and Mexico) account for 68.8% of all agricultural land in the region. These lands are mostly used (72.5%) to produce livestock fodder (pastures and grazing land). The agricultural sector is responsible for 10% to 60% of countries' greenhouse gas emissions, where enteric fermentation of ruminants is the main source (34%-55%).

The agricultural sector of RIOCC countries is very heterogeneous. In most Latin American and Caribbean countries, a more or less high proportion of the rural population carries out a type of small-scale agriculture that has little or no bearing on international markets. It often revolves around subsistence-based family and peasant farming, using ancestral practices, although some family farms also engage in capitalist production. In contrast, there are countries with a smaller rural population and a larger land area (e.g., Argentina, Brazil and Paraguay) that have a more entrepreneurial type of high-tech agricultural activity, with a strong focus on exportation.

Fisheries and aquaculture are extremely significant sectors in some of the region's countries, contributing more than 10% of the world's fishery production. In Latin America and the Caribbean alone, this sector provides jobs for almost 2.4 million people. Of the 25 leading countries in the world catch ranking, 6 of them belong to Ibero-America, in the following order of importance: Peru (5th world producer), Chile (12th), Mexico (16th), Spain (19th), Argentina (22nd) and Ecuador (23rd).

The Humboldt Current System (Pacific South East) is the most productive marine ecosystem in terms of fisheries at a global level and is dominated by a single species (*Engraulis ringens* or anchovy) that contributes more than 30% to the total catches of RIOCC countries. This species is mainly intended for fishmeal and fish oil production used in the production of feed for aquaculture, poultry and livestock, among others.

Climate disaster risks

Hurricanes and storms constitute one of the greatest hazards in Latin America and the Caribbean. Between 1970 and 2010, 70 climate-related natural disasters occurred in the region, 31 in Central America and Mexico, 16 in South America, and 23 in the Caribbean. Of these, 40 were caused by storms and hurricanes, 14 by El Niño periods, only 3 by La Niña periods, and 14 by neutral periods. Disasters caused by storms and hurricanes accounted for 50.2% of the deaths, 37.3% of the affected population, 41.3% of damages, and 38.4% of total losses associated with climate-related disasters. Disasters caused by El Niño and La Niña accounted for 4.1% of the deaths, 48.8% of the affected population, 47.8% of damages, and 52% of total losses. In the Iberian Peninsula, southwestern and polar front storms in winter, as well as intense storms in summer and autumn, particularly in the Mediterranean area, also cause heavy losses.

The costs of damages and losses caused by climate-related disasters in Latin America and the Caribbean during the 1972-2010 period are estimated at US$106.427 billion, of which US$21.012 billion are the result of hurricanes and storms in the Caribbean, US$17.64 billion in Central

America, and US$3.754 billion in Mexico. Damages from the El Niño totaled US$42.471 billion in South America and US$4.013 billion in Central America, and from La Niña US$5.478 billion in South America. For extreme precipitation (floods and landslides), the cost of damages amounted to US$10.974 billion.

In recent decades, floods have caused almost half of the climate-related disasters around the world. Their relative importance has also increased during this period, either in terms of economic losses, reinsurance losses or the number of reported flood events. However, it is not yet clear why these observed changes happen. Possible causes include increases in the magnitude or frequency of extreme precipitation. In the last two decades, 548 flood events were recorded in Latin America and the Caribbean, affecting a total of 41 million people and causing US$26 billion worth of damage. The most affected countries in recent times have been Brazil, Mexico, Colombia and Peru, with increases in maximum daily flows observed in the Rio de la Plata or Amazon basins.

In recent decades, Mexico, Amazonia and northeast Brazil, central and southern Chile, Patagonia and the Iberian Peninsula have experienced greater frequency of droughts. Conversely, northern Argentina and Uruguay have experienced a drop in frequency. The meteorological droughts were more severe in parts of Patagonia and southern Chile, northeastern Brazil, Nicaragua, Honduras, southern Mexico, Baja California, and the Iberian Peninsula. Conversely, southeastern Brazil experienced less severe droughts. Between 2005 and 2015, drought caused US$13 billion in damages to crops and livestock in Latin America and the Caribbean.

The Andes mountains and other mountain systems of Latin America are especially susceptible to the emergence of slope instability processes or landslides, due to their geodynamic and climatic characteristics. Risks are due not only to excess rainfall but also to environmental deterioration, deforestation, basin degradation, and the increase of multiple physical and social vulnerability processes associated with human settlements, which are also risk drivers. In recent decades, risks due to slope instability accounted for at least 12.6% of all disasters with more than 10 deaths.

Disaster risk management and climate change adaptation are integral, inter-institutional, multi-sectoral and interdisciplinary processes. They generally result in public policies that have the same objectives. It is not appropriate to speak of adaptation to slope instability or landslides generically without referring to disaster risk management. Promoting risk management is equivalent to promoting adaptation, although the risk of slope instability is not necessarily associated with climate change in all cases.

Wildfires are present in a large part of the region's terrestrial ecosystems and their impacts can be beneficial or adverse, depending on the type and regime of fires and the context in which they occur. Fire is a tool used in landscape management and many indigenous and rural communities depend on it for their survival. Certain ecosystems require fire for their stability (e.g. savannas, oak or pine forests in certain areas of RIOCC countries).

In places where fire is not a natural part of the ecosystem's disturbances, or where human activity produces changes to its natural regime—making fires more frequent, extensive or severe—fire represents a disturbance that can produce serious impacts on ecosystems, altering their composition and structure, the functions and services they provide or their capacity as a sink for greenhouse gases, as well as affecting goods, assets and human lives.

The current levels of fire incidence in Ibero-America are high to very high. Each year more than 40 million hectares are burned, representing 7%-14% of the area burned worldwide. The causes of fire ignition are mostly human, although lightning is an important cause in certain areas. In terms of areas burned each year, the most affected countries are Brazil and Bolivia (4% of their territories), followed by Portugal (1.6%). The estimate of the number of active fires based on satellite records taken in recent decades reveals that Guatemala, Paraguay and Honduras lead in terms of the number of fires per unit of surface area in the region.

Other key areas and sectors

The RIOCC region is highly urbanized and it is expected that it will become more so. In 2050, about 90% of the population will be urban in countries such as Mexico, Costa Rica, Argentina, Spain, and Brazil. Despite this, the weight of the rural population will continue to be considerable in some countries, particularly in Central America and the Caribbean. The high degree of population living in large conurbations of more than 5 million inhabitants is also noteworthy to the point that except in Central America and the Caribbean, about 20% of the population of the remaining Latin American countries of the RIOCC region lives in them.

Many major cities have experienced a disorderly growth in recent decades; this has been characterized by self-construction, poor quality housing, deficient services, insecurity, a high degree of poverty and marginal livelihoods. There are around 124 million urban poor (living between non-extreme and extreme poverty). The rural world is also characterized by a lack of services, low-tech agriculture in certain countries (Central America) or parts of certain countries (Brazil), and high poverty, with an estimated 58 million rural poor, where indigenous populations experience the most acute poverty.

The coast of RIOCC countries is more than 70,000 km long. It is an area where some of the most valuable and unique habitats on the planet are found and also where intensive development, an important part of the economic activity of many RIOCC countries, is located, along with high levels of poverty.

Based on population data from the year 2000, it is estimated that between 29 and 32 million people live in the first 10 m of elevation on the coast of Latin America and the Caribbean, and more than 6 million in the 100-year return period floodplain, not taking into account hurricanes. In Colombia, Venezuela, Costa Rica, El Salvador and Panama, more than 30% of the total population lives in these first 10 m of elevation of the coast.

Population trends and projections of mean sea level rise indicate that, by mid-century, and in the absence of adaptation, 10 million people will be living in the coastal floodplain.

The tourism industry of RIOCC countries is one of the most important economic sectors from an economic point of view. In 2019, the average contribution of this sector to the GDP was 11.7% in Ibero-American countries, where Portugal (22.9%), Uruguay (18.5%) and Spain (16.2%) are the most noteworthy. Nature, Sun and the beach, cultural, sports and ecological tourism are increasingly represented in the region.

There are significant differences in the strength of the health systems and the level of poverty between RIOCC countries. On the one hand, there are countries with better developed health systems and low levels of poverty (Spain, Portugal, Uruguay, Chile), and on the other hand, there are those where the health system is weak and poverty is high (a substantial part of Central American countries). Up to one third of the Latin American population have limited access to health services. Access is more deficient in rural and remote areas, which also have unsafe housing and less access to drinking water.

D) Components of Climate Change Risk and Impacts

Society, governance and inequality

The hazards of climate change through changes in both temperature and precipitation, particularly in terms of their extreme values, as well as through sea level rise, translate into negative impacts on livelihoods, into food insecurity and malnutrition, particularly in children, and into increases in migration, morbidity and mortality.

Impacts are generally more pronnounced in socio-politically marginalized populations, such as women, indigenous people and those living in poverty. This is due to the fact that these groups often have many of their basic needs unmet, suffer from energy poverty, lack the power to participate in any decision-making, are physically and socially isolated, suffer from discrimination and forced displacement, and have limited access to education, natural resources and financial capital. Women, moreover, are exposed to gender-based violence.

Indigenous people are also vulnerable because of the denial of their rights and of their material and spiritual relationship with the environment. This differentiation needs to be included in the vulnerability assessments conducted by RIOCC countries, because it has been found that this component has not yet been sufficiently considered or is still considered as a secondary issue in these assessments.

Natural systems

Land use changes are predominant in the region. During the first decade of this century, deforestation of humid and dry forests, savannas and scrublands affected more than 0.54 million km^2, which were converted into crops or pasture. It is the world's region with the highest rate of deforestation. At the same time, abandonment has also occurred in dry or too sttep slope areas for agriculture, affecting 0.36 million km^2.

The combined effects of climate change and habitat loss represent a great threat to the terrestrial and freshwater ecosystems of RIOCC countries. Projected climate changes envisage a decline in productivity in the short term and degradation in the long term. Inadequate management and fragmentation diminish ecosystem functions, while making them more vulnerable to climate change.

Ecosystems of the high mountains (e.g., paramos, puna) are critical for water regulation in large areas and have a high carbon absorption capacity. Their permanence is threatened by over-exploitation and climate change. Tropical forests, notably Amazonia, are threatened by drought, particularly under high emission scenarios as well as by fires that previously did not occur. Temperate forests are threatened by the loss of climatic niche, as well as by fire. Arid ecosystems face an increased risk of aridification (e.g. the Caatinga, Brazil) and livestock pressure, rendering them even more vulnerable.

Freshwater ecosystems face changes in the flow regime, which will modify their seasonality. This is due to the loss of glacial ice mass (Andes, Patagonia). Sediment in tropical Amazon rivers, as well as downstream productivity in floodplains, are expected to decrease. In temperate zones, extreme droughts in response to climate change or more frequent El Niño events can cause major changes in the aquatic communities. A rise in water temperature will also lead to changes in water quality (e.g., reduced oxygen dissolving capacity).

Temperature is rising, as are sea levels, while the water is becoming more acidic. Consequently, the distribution of some species, their behavior and reproduction are changing. Ocean current patterns are also being disrupted. The outcome of these transformations affects coastal marine ecosystems, significantly reducing their resilience and jeopardizing their ability to provide goods and services. This includes reduced economic benefits owing to the migration of capture species, reduced employment, loss of traditional knowledge of the coastal populations and reduced social cohesion of coastal communities, which will ultimately lead to greater inequality in the region.

Coastal marine ecosystems of RIOCC countries are already being directly and indirectly impacted by human activities and by the effects of climate change. Shellfish farming, dam construction, large-scale salt mining and contaminated effluent discharges into the sea, deforestation and land conversion for agriculture, among other stressors, intensify climate change-related impacts on the region's coastal marine environments.

Climate change impacts on marine and coastal ecosystems of RIOCC countries are more apparent in a context of pre-existing vulnerability. Vulnerability derives from the human activities that take place around coastal marine ecosystems (tourism, unplanned urban expansion, pollution from land-based sources and the aquaculture boom). These represent a threat to fish, coral and mangrove populations. Some of these impacts have already been observed in the region, such as coral bleaching in the Caribbean as a result of rising temperatures and loss of mangrove cover.

Sea surface temperatures is expected to continue to rise, along with sea heat waves, water acidification, sea level and hypoxic areas. This will cause the displacement of marine species to more northern latitudes, along with the local extinction of species in the tropics and enclosed seas and coral bleaching, which coupled with rising sea level will place them at high risk. Ocean net productivity will be redistributed, with a tendency to decrease the higher the greenhouse gas emissions. This will lead to a reduction in the services provided by the sea in terms of fish catches.

Despite considerable sub-regional variation, ecosystems (e.g., high altitude, coastal, freshwater, urban, the Amazon) and taxonomic and functional groups (corals, vertebrates, plants) vulnerable to climate change are present across the region. Ecosystems with restricted geographic ranges and with high endemism are among the most vulnerable systems. Biodiversity hotspots (i.e., areas with great species diversity that show high habitat loss and high levels of species endemism), eight in total in the region, are among the most vulnerable places in the world. The Mediterranean basin, the Caribbean Islands, the Brazilian Cerrado, and the Tropical Andes are among the most vulnerable hotspots in the world.

Climate change directly impacts biodiversity by causing distribution shifts or by triggering extinction processes. Among taxonomic groups, amphibians and reptiles are already in decline, and face greater extinction under different scenarios by 2100. Among plants, tall trees are particularly vulnerable, as well as high altitude species. Under high emission scenario, more than 25% of the species in Latin America face extinction risk by 2100. Risks are high also for species in the Iberian Peninsula and the Atlantic islands (Canary, Azores, Madeira).

Managed systems

As for water resources, reductions in the flows of certain rivers in the Iberian Peninsula, Colombia, Mexico, Central those to central and southern Chile and Argentina have been observed. These changes are mainly generated by a reduction in precipitation and are accentuated by changes in the cryosphere (glaciers and snow), generating disruptions in the seasonality of flows, reducing flows in the dry season, and increasing them in the wet season.

A reduction in water resource availability is expected, with a high level of consistency among models in some areas of the region, such as Mexico, Central America and the Caribbean, Northeast Brazil, the Central-Andean Pacific region, Patagonia and the Iberian Peninsula. The increase in temperature accelerates the melting of snow and glaciers, altering the seasonality and quantity of flows. Extreme events and changes in water quality are also a hazard. Rainfall increases are also expected in the tropical countries of the Pacific (Peru, Ecuador, Colombia), as well as in the Río de la Plata basin.

In the agriculture sector, the main climate hazards are related to the increase in thermal and water stress of crops and livestock, with crop and livestock losses due to erosion, droughts and floods, and an increased spread of pests and diseases. However, in some regions, new opportunities have also emerged due to increased precipitation (southeastern South America), or due to the possibility of exploiting new varieties (megathermal or tropical species) in areas where, until now, their cultivation had not been commonplace.

The level of exposure to these climatic hazards varies greatly depending on the socio-economic level of the affected population, the relative rigidity or flexibility of their productive systems to vary or adopt technology, and the possibility of being assisted by such technology and its availability, among other aspects. Poor populations are most at risk, a situation often exacerbated by a lack of land tenure, or by settling on mountain slopes, flood plains or arid areas. More rural countries (e.g. Central America, Central Andes) have fewer options than more technologically advanced countries (e.g. Argentina, parts of Brazil, Spain).

Potential threats to fisheries and aquaculture are: (i) changes in sea temperature at the local level; (ii) ocean acidification; (iii) sea level rise; (iv) changes in oxygen concentration in aquatic systems; (v) increase in storm intensity and frequency; (vi) changes to the circulation patterns of marine currents; (vii) changes in rainfall patterns; (viii) changes in river flows; (ix) changes in biogeochemical (nitrogen) flows; and (x) increased frequency of extreme El Niño and La Niña events.

In Atlantic Iberian waters, changes in species composition and distribution are translating into important changes in fisheries, which will have an effect on fishing communities and consumers. Mussel production faces a high risk of loss of productivity due to, among other things, increased outcrops of toxic algae and the acidification of seawater.

Overfishing, pollution, the introduction of exotic species and the misuse of water bodies in the region, especially in Latin America, are non-climatic stress drivers that exacerbate the impacts of climate change.

Climate disaster risks

The increase in air and sea temperatures is contributing to the intensification of major category hurricanes and an increase in the frequency, intensity and duration of extreme storms, with numerous electrical discharges. Sea level rise is contributing—and will increasingly continue to contribute in the short- and medium-term—to the destruction of coastal infrastructure, to the reduction of mangroves on the Caribbean, Central American and Mexican coasts, both Atlantic and Pacific, and to the salinization of coastal aquifers. Ocean acidification will also contribute to the destruction of coral reefs. All of this will increase the socio-ecological vulnerability to hurricanes.

The impacts of hurricanes are multiple, among them: loss of human lives, increase in the number of refugees, destruction of infrastructures, loss of essential services (light, water, communications), water pollution, increase in diseases (e.g. gastrointestinal infections), loss of crops and domestic animals, among others.

The total costs of the impacts of climate change in the face of a 2.5°C increase in Latin America and the Caribbean could amount to between 1.5% and 4.3% of the GDP, while costs of adaptation would not exceed 0.5% of the regional GDP. In the Iberian Peninsula, an increase in storms on the west coast and episodes of "cold drop" are expected, as well as more humid winds and a warmer Mediterranean, leading to torrential rains on the Mediterranean coast and Balearic Islands and the so-called "medicanes" (Mediterranean hurricanes). This singles out the need to implement adaptation plans that should be coordinated with the priorities of the Sendai Framework on Disaster Risk Reduction 2015-2030 and with achieving the Sustainable Development Goals.

As for droughts and floods, the available climate scenarios for the foreseeable future indicate that changes in the different components of the water cycle will continue to affect RIOCC countries unevenly. Increases in peak flows are projected for the rivers of Colombia, Venezuela, Ecuador, the coastal region of northern Peru, the Plata basin, Central America and the Iberian Peninsula (except the Mediterranean coast) and increases in the occurrence of droughts in Amazonia, northeast Brazil, the Mediterranean region, Central America and Mexico.

The countries with the largest populations exposed to floods recently have been Guatemala, El Salvador, Honduras and Colombia. The Latin American countries with the largest populations exposed to drought have been Guatemala, Chile, Ecuador, Mexico and Nicaragua.

Population growth, rapid urbanization of informal human settlements, lack of well-planned and quality infrastructure, high rates of social inequality and poverty, agriculturally dependent economies and inadequate environmental practices are all socio-economic factors that enhance vulnerability and result in water deficit and excess events that have an even greater impact.

In terms of landslides, the increase in precipitation intensity and frequency due to global warming is a driver that amplifies the slope instability hazard and, therefore, the risk to exposed elements. However, the hazard increase is also due to environmental deterioration and human action, therefore this hazard is considered to be a socio-natural one. The risk increase is also due to increased vulnerability resulting from social processes and inappropriate occupation of land; in other words, this type of risk is not only due to climate variability and change.

In terms of wildfires, a reduction in fire activity has been observed globally in recent decades, as well as in some countries (e.g. Spain), despite an increase in weather hazards and, in some areas, vegetation cover. Nevertheless, in several natural, rural or rural-urban interface regions of RIOCC countries, wildfires have increased in number, duration, extent and severity, and the fire season is becoming longer.

Ecosystems that are vulnerable to fire, such as tropical, subtropical, high Andean and Andean-Patagonian rainforests and tropical and Mediterranean forest plantations have increased their exposure to fire in Ibero-America. Fire-prone ecosystems, such as tropical savannas and pine and oak forests in the Americas, or Mediterranean pine and shrub forests in Spain and Portugal, have also increased their exposure. The abandonment of rural areas and traditional fire practices by indigenous or rural communities, fire exclusion, plantations and the introduction of highly flammable invasive species or intense and prolonged droughts are resulting in particularly devastating fires (megafires) (e.g. Chile and Portugal, 2017; Amazonia 2010, 2015, 2016, 2019).

The components of society most at risk from fires are the poorest sectors, such as indigenous and rural communities in Latin America, the populations of urban-rural interfaces and forest firefighters of the entire region. Children, the elderly and pregnant women are the most vulnerable due to air pollution resulting from the emission of gases and particles produced by the combustion of biomass from the fire, even in urban and rural sectors located far from fire sites.

Globally, climate change is expected to further increase the danger of fire-inducing weather, the higher the level of emissions. The areas of greatest fire danger within the region will be the Iberian Peninsula, Mexico, Amazonia and central Chile. Projections claim that the fire season will be more prolonged and the number of extreme hazard days will increase. The effectiveness of such an increase will be greater in productive areas where wildfires have been limited by unfavourable weather conditions unfavorable to fire spread.

Other key areas and sectors

The degree to which climate change impacts are felt varies between rural and urban settlements, and between cities with different urban sprawl patterns. Moreover, the vulnerability and potential risks associated with climate change are not only a function of the typology and intensity of potential hazards, but also of the social, economic, political, and cultural characteristics of each place, explaining why there is no one single solution but only common challenges.

The biophysical characteristics of each region and location determine to a great extent the hazards to populations, their temporal scale of formation (fast or slow), and potential impacts (e.g. constructions on unstable slopes or in flood zones). Population dynamics, land uses and the characteristics of the built space that derive from ongoing socio-economic, political, institutional, technological and cultural conditions, unevenly exacerbate vulnerabilities.

The human settlements that will experience greater vulnerability are those of rapid growth, little planning and, above all, those that are more informal or located in risk-prone areas lacking infrastructure, services or appropriate adaptive action. In the short term, floods, landslides, coastal erosion and heat waves are the main hazards at the local level. In the long term, sea level rise, water shortages and the potential spread of infectious vectors can be added to the above.

The risks of climate change to coastal systems in RIOCC countries are determined by the increase in three climate-related drivers: mean sea level, sea surface temperature and acidification. Existing observations of these drivers show high geographical variability in the region. Future projections indicate consistent increases for higher representative concentration pathways of greenhouse gases and more distant time horizons.

Flooding and erosion induced by extreme weather-based wave and storm surge events are the prevailing climate-based impacts on socioeconomic systems located on the coast. These impacts are exacerbated by anthropogenic action. Due to the mean sea level rise, these extreme events will become more frequent and as such the associated impacts will continue to increase in the future.

Sea level rise, changes in precipitation regimes and alterations in the marine climate are responsible for the shifts in the hydro-sedimentary and nutrient balances that increase the salinization of coastal aquifers and affect coastal morphology. As a result of these processes, a decrease in freshwater availability and changes in or loss of coastal ecosystems are expected.

Rising sea surface temperatures, changes in hydro-sedimentary regimes, variations in water quality and acidification are processes that alter the types, extent and health of coastal ecosystems. While in many areas the dominant impacts will originate from temperature increases, the combined action of these drivers is the main risk inducer on coral reefs, dune vegetation, mangroves and seagrass beds. Mortality in some coastal ecosystems will also rise due to the increase in extreme events.

Among the main climate change hazards that can affect the tourism sector are rises in temperature, the mean sea level, or extreme weather or climate events, such as heat waves, intense rains or lack of rain in the form of snow or water (drought). These changes can manifest themselves in alterations to habitats and changes in species, as well as in diseases. Each of these hazards and changes can affect different types of tourism in different ways.

Changes in the weather conditions at touric destinations are important, but so are those that occur at the origin, thus making the end result depend on the interaction between both places. For example, improvements in weather conditions during the summer in the places of origin could showcase and place value on its own resources versus those of the destination. Thus, Sun and beach tourism can use local resources and decrease the flows to the traditional destination, which could suffer from a worsening climate. Consequently, in order to understand the impacts of climate change on tourism, it is necessary to know how these will occur jointly in the origin and destination.

Some of the major tourist destinations in Latin America are located in highly exposed areas. This is the case in the Caribbean and the Pacific coast, which are affected by hurricanes that cause enormous losses to the sector, especially when these reach high intensities, as is expected to occur with climate change. Rising mean sea levels affect the stability of beaches and threaten coastal assets and ecosystems, undermining the very resource of tourism. Some snow destinations are threatened by the lack of resources, due to a decrease in rainfall. Excess heat in the summer can reduce climate comfort, diminishing outdoor activities.

Vulnerability varies according to the type of tourism. While Sun and beach and city tourism are based on a well-developed hotel sector, environmental tourism in a broad sense is more based on community systems, with more informal jobs and a population of fewer resources, whose lives depend largely on this resource. Climate change also threatens the sector specifically, as it can directly affect the resource, for example, through the loss of an emblematic species that migrates elsewhere. This makes this type of tourism and the population that depends on it particularly vulnerable.

The most significant hazards to human health from climate change are rising temperatures, heat waves, lack of water quantity (drought) and quality, floods and air pollution. Some of these hazards exert their effects directly (extreme heat) and others indirectly, for example through changes in disease vector distribution, water pollution or food insecurity.

From a health viewpoint, populations living in conditions of poverty and with deficient infrastructure (deficient housing, sanitation, health system); indigenous populations (who on account of their poverty situation and marginalization often have very limited access to primary health services); and, in connection with the effects of heat waves, the elderly, children, and people with pre-existing cardiovascular diseases, are more vulnerable to climate change. Urban areas can augment the impacts of heat waves through the urban heat island effect.

E) Main Climate Change Risks

Below is a list of the main risks identified for each sector or system analyzed. **Figure 5** shows a selection of some of these risks, the climatic drivers that determine them, their importance, urgency and the areas most affected (for further details see the risk table in each chapter).

Society, governance and inequality

The main risks in the field of society, governance, inequity and adaptation are: 1) risk of food insecurity and malnutrition of the population, especially of girls and women, due to an adverse climate; 2) risk of loss of livelihoods and other economic losses due to extreme weather events, such as floods; and 3) risk of migration from rural to urban areas, due to the loss of livelihoods.

Natural systems

The main risks to terrestrial and freshwater ecosystems include: 1) risk of loss of primary productivity in natural and managed systems due to an increase in the frequency and intensity of extreme weather or climatic events, as well as the loss of species' climatic niche conditions; 2) risk of habitat loss in ecosystems and displacement of their borders between adjacent systems; and 3) risk of instability due to the loss of species and changes in the disturbance regimes, particularly by fire.

The main risks to coastal marine ecosystems include: 1) risk of loss of local biodiversity due to the migration of species that lose their ecological niche; 2) risk of loss of critical ecosystems, such as coral reefs, sea grasses or macro-algae forests as a result of increases in temperature, acidification and sea level; and 3) risk of loss of primary productivity due mainly to temperature rise.

The main risks to biodiversity and ecosystems in Ibero-American countries include: 1) risk of biome shifts and species displacements; 2) risk of species extinctions; and 3) risk of alterations in ecological processes rates. Such risks are present all across the region, be it in terrestrial, freshwater or marine ecosystems, and impose consequent direct and indirect risks to human livelihoods and wellbeing.

The main risks to water resources are: 1) risk of reduction of water resources in subtropical areas of North and South America, the Iberian Peninsula, and the northeast of Brazil; 2) risk of changes in seasonality, particularly in rivers dependent on high-mountain ice; and 3) risk of a decrease in water quality due to extreme rain fall events.

Managed systems

The main risks to the agricultural sector include: 1) risk of yield losses of crops and livestock due to thermal stress caused by an increase in the average and minimum daily temperatures (less night cooling) and heat waves; 2) risk of yield losses of crops and livestock on account of water stress in crops and thirst in livestock due to the decrease in rainfall or the increase in continuous days without rain, coupled with competition with other water uses which can create restrictions on the availability of water for irrigation and animals; 3) risk of crop losses due to an increased incidence of pest outbreaks and diseases as a result of climate tropicalization; and 4) risk of crop displacement and replacement with others due to loss of climatic conditions.

The main risks to the fishing sector are: 1) risk of change in species composition in marine fishing grounds as a result of changes in temperature and the consequent effect on the type of catches; 2) the risk of loss of fishing potential as a result of the decrease in productivity due to physiological changes in species; 3) risk of an increase of hypoxic areas due to thermal stratification and eutrophication; 4) risk of coral bleaching and lack of calcification in other species as a consequence of ocean acidification; and 5) risk of increased mass mortality of plants and animals due to extreme temperature events.

Climate disaster risks

The main risks related to hurricanes and storms include: 1) risk of loss of human life caused by wind, tidal waves and their effects, as well as by floods; 2) risk of loss of infrastructure, goods, equipment, crops, livestock and services essential for life; 3) risk of morbidity and mortality due to increased diseases as a result of floods and water pollution; and 4) risk of social unrest.

The main risks related to floods and droughts are: 1) risk of loss of human life caused by floods; 2) risk of loss of infrastructure, goods and services due to floods; 3) risk of loss of crops and livestock due to droughts; and 4) risk of food insecurity due to droughts.

The main risks related to slope instability or landslides are: 1) risk of loss of life and economic damage due to the destruction of housing and other exposed buildings, mainly in precarious and marginal human settlements in large and intermediate cities located on slopes; 2) risk of loss of life and economic damage and destruction of exposed infrastructure and public water and sewage service networks in human settlements of different scales in cities and small towns in mountainous areas; 3) risk of damage to and destruction of exposed transport infrastructure and networks, roads, railways, viaducts, polyducts, power towers, in mountainous areas; 4) risk of deterioration of watersheds due to erosion and uncontrolled geodynamic processes in rural areas, loss of soil, impacts on ecosystems, crops and other livelihoods; and 5) risk of loss of life and economic damage and destruction of housing and other exposed buildings in small urban centers and human settlements in rural areas in mountainous areas.

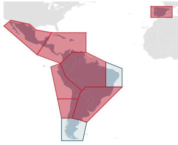
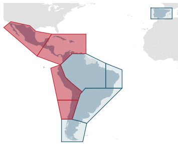
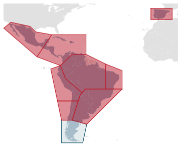
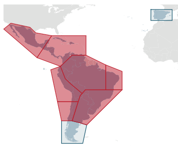
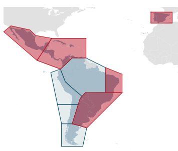
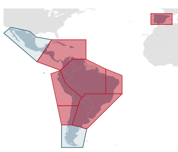
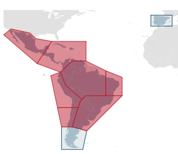
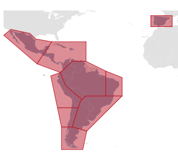
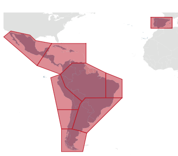
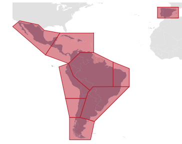
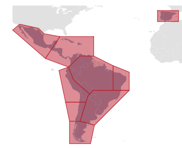
Main risks identified	Main climatic driver	Urgency	Extension (most affected regions)
Losses of human lives and increases in climatic refugees			
Economic damages, destruction of homes and infrastructure and losses of human lives due to landslides			
Flooding in poorly planned urban settlements			
Increased incidence of vector-borne diseases			
Thermal stress of crops and livestock			
Decrease in fish catches due to changes in marine productivity			
Malnutrition of the population, particularly in women and girls			
Losses in ecosystem primary productivity			
Changes in biodiversity due to the displacement of species			

Figure 5. Selection and characterization of some of the risks identified for the different systems and sectors analyzed. *(Continue in the next page).*

Main risks identified	Main climatic driver	Urgency	Extension (most affected regions)
Changes in ecosystem composition, structure, and function due to increased frequency or intensity of forest fires	Temperature Rise, Precipitation Decrease, Extreme Temperatures, Drought	●	
Loss of nature-based tourism due to the degradation of the ecosystems that sustain it	Temperature Rise, Precipitation Increase, Precipitation Decrease, Intense Storms and Hurricanes, Sea Level Rise, Ocean acidification	●	

Main climatic drivers:

- Temperature Rise
- Precipitation Increase
- Precipitation Decrease
- Extreme Temperatures
- Intense Storms and Hurricanes
- Flooding
- Drought
- Sea Level Rise
- Ocean acidification
- Changes in seasonality
- CO_2 fertilization

Urgency; one of the following three levels was assigned:

- imminent (that may be occurring or occur at any time),
- medium-term (that is expected to occur in the medium term, by mid-century, or when 1.5°C is exceeded),
- long-term (that is expected to occur after mid-century or when 2°C of warming is exceeded).

Extent:

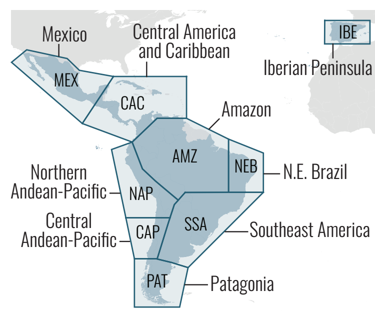


Figura 5. Selection and characterization of some of the risks identified for the different systems and sectors analyzed. Source: compiled by the authors. *(Continues).*

The main risks arising from an increase in the frequency or intensity of wildfires are: 1) risk of ecosystem instability, including the appearance of critical points (leading to non-recovery of the ecosystem); 2) risk of loss of biodiversity, environmental functions and services (e.g., decreased capacity of vegetation and soil to store carbon); 3) risk of loss of forest products in forests and plantations; 4) risk of loss of the livelihoods of native populations in traditionally fire-managed areas; 5) risk of morbidity and mortality of people living in fire exposed areas, including those living at a distance, as a result of exposure to smoke; and 6) risk of loss of property and assets in the rural-urban interface.

Other key areas and sectors

The main risks related to rural and urban settlements are: 1) risk of urban flooding due to extreme precipitations combined with deficient drainage systems and inadequate planning; 2) risk of urban water stress due to deficient infrastructure and increased demand; 3) risk of morbidity and mortality as a result of heat waves favored by the thermal island effect of cities; and 4) risk of erosion and coastal invasion in cities with deficient planning and high urban demand, such as certain beach tourism areas.

The main risks of climate change to coastal areas are: 1) risk of coastal flooding with the ensuing loss of life and property due to sea level rise, adverse weather in terms of storms and cyclones, and growing urbanization of the coastal area; 2) risk of loss of infrastructure operativity due to continued sea level rise and increased extreme events; 3) risk of coastal erosion caused by sea level rise coupled with local changes in wind and current patterns; and 4) risk of loss of ecosystem services due to the loss of mangrove, coral or dune systems, which are critical in reducing the impact of storms and cyclones.

The main risks to tourism are: 1) risk of change in seasonality in mountain, country, lake, city and outdoor destinations due to rises in temperature and a decrease in the indexes of climate comfort in the regular seasons; 2) risk of loss of tourist resources and flows to the destination due to the deterioration of resources (erosion of beaches, loss of natural ecosystems, migration or extinction of species that are emblematic for nature-based tourism, lack of snow); 3) risk of loss of flows to the destination due to an increase in extreme events (hurricanes, heat waves, droughts, floods);

4) risk of loss of flows due to deterioration in health and hygiene conditions on account of a lack of water resources or the outcrop of diseases; and 5) risk of loss of tourist flows due to favorable changes in climate conditions at the origin of tourist flows.

The main risks to health are: 1) risk of morbidity and mortality in vulnerable people, such as children, the growing population of the elderly, individuals with pre-existing diseases, low-income populations and outdoor workers, particularly in urban areas as a result of heat waves; 2) risk of morbidity and mortality from vector-borne diseases due to the shifting distribution of mosquito populations and resulting climate changes, affecting the bite and survival rate, shortening or lengthening the development time of the pathogens of malaria, dengue, zika, chikungunya, leishmaniasis and chagas, among others; 3) risk of morbidity and mortality from air pollution caused by combustion products and their transformed elements (urban areas), including smoke from wildfires (urban or rural environments); 4) risk of morbidity and mortality from increased infectious diseases (cholera, typhoid fever, shigellosis, hepatitis, diarrhea, giardiasis, salmonella, campylobacter, etc.) due to contaminated food or water.

F) Adaptation Options and Actions

Society, governance and inequality

More than adaptive, the response to climate change, particularly in the face of severe risks, must be transformational. This is because there are limits to adaptation. Transformational adaptation is understood as any adaptation based on profound changes to social structures. Incremental adaptation and transformational adaptation do not compete with one another, rather they complement each other, as each is needed according to the magnitude of the impacts.

Autonomous adaptation emerges mainly at the local level and oftentimes is the result of the need to respond to adversities in the face of weak or inexistent state institutional frameworks. Against the backdrop of insecurity, populations are forced to act to reduce the impacts of climate change. Some of the practices carried out are diversification of livelihoods; greater efficiency in water use; crop substitution; use of drought-resistant seeds; and support for mother-headed households, among others. Changing social roles can also generate conflict, therefore governance needs to be reinforced.

Natural systems

Ecosystem-based adaptation (EbA) has proved to be an effective strategy to cope with the impacts of climate change on terrestrial ecosystems. EbA combines the use of biodiversity and ecosystem services for the conservation, restoration and sustainable management of ecosystems. It also facilitates an integrated approach with actions at the key territorial scale (basin level) to reduce the adverse effects of climate change on the region's terrestrial ecosystems.

F_032 Natural protected areas are fundamental to ensure the persistence of ecosystems to climate change. Adaptation measures for terrestrial ecosystems must include actions to reduce other non-climatic stresses, thereby increasing their resilience and maintaining connectivity between disrupted areas. The national adaptation plans of several RIOCC countries include adaptation measures and programs that address the conservation and restoration of ecosystems, both terrestrial and freshwater, including EbA measures.

The effective implementation of adaptation strategies to counteract climate change impacts on ecosystems requires a clear understanding of how climate change will influence the future functioning and distribution of ecosystems. The loss of connectivity between fragments of native ecosystems, the introduction of invasive species, coupled with strong climate variability, threatens ecosystem functions and their biodiversity. The current spiral of environmental degradation is progressively depleting ecosystem services and reducing their capacity to adapt to climate change.

Several Ibero-American countries have examples of climate change adaptation strategies that include management tools and measures for recovering freshwater ecosystems, such as rivers and wetlands, and managing forest recovery. There are cases of successful basin conservation programs that include actions on native vegetation, agro-ecological management of crops, rivers and wetlands, and mechanisms for local community participation. Other actions include reforestation in micro-basins and some actions of the Reducing Emissions from Deforestation and Forest Degradation (REDD/REDD+) program, although aimed at mitigation, involve adaptation measures.

The sustainable and integrated management of coastal environments constitutes one of the pillars of ecosystem-based adaptation that enables enhancing their functions and ecosystem services. Ecosystem-based adaptation is a common practice in marine and coastal areas and is important for the management of mangroves, seagrass beds, coral reefs and sandy beaches. These ecosystems have the natural capacity to regulate or mitigate the impacts of, for example, storms and floods, or the effect of rising sea levels. The sustainable management of coastal environments (for example, fishing and aquaculture) contributes with ecosystem-based adaptation by maintaining ecosystemic functions and services.

Marine protected areas are one of the main mechanisms for the adaptation of marine and coastal ecosystems. In protected conservation regions, the recovery of species, populations and ecosystem functions has been achieved thanks to the regulated use of marine and coastal organisms. RIOCC countries have a significant proportion of coastal marine ecosystems under some form of legal protection, although in some cases this protection is not put into practice. In any case, this is a good practice to increase adaptation in these ecosystems.

Adaptation options in coastal marine ecosystems include the restoration of key ecosystems and the re-establishment of species and populations in order to increase the resilience of these ecosystems, following an ecosystem-based adaptation. Several RIOCC countries have projects focused on restoring altered ecosystems, so that they contribute to climate change adaptation and mitigation. There are also sustainable fisheries and aquaculture projects in place that could lead to the recovery of ecosystem services.

Adaptation options for biodiversity include: 1) Nature-based solutions: the use of natural elements to foster sustainability in urban and rural areas can help with adaptation to climate change. 2) Ecosystem-based adaptation: local initiatives in the region, both urban and rural, are ecosystem-based adaptation initiatives, showcasing the value for adaptation to climate change. 3) Ecosystem-based disaster risk reduction: ecosystems (restoration of mangroves, hillsides, coastal vegetation, riverine vegetation, etc.) are being used across the region to reduce disaster risk caused by climate change.

There is a range of policy options, innovations and tools across the region to address biodiversity risks and vulnerabilities to climate change, and also to promote the use of biodiversity and ecosystems to foster societal adaptation. These include: 1) Development or implementation of tools regarding monitoring of biodiversity to inform adaptation strategies, and also to define priorities for ecosystem-based adaptation policies. 2) Collaboration networks (scientific and policy networks) to address nature-based solutions to combat climate change. 3) Adaptation planning based on biodiversity and ecosystems has been incorporated to national and sub-national adaptation plans.

Managed systems

The main adaptation tool for water resources in the majority of RIOCC countries consists of the design of adaptation plans at the national, regional, and local scales that include future climate scenarios and adaptation actions to cope with possible impacts. These plans include both improving the supply of water resources and improving management to make it more efficient and to promote a culture of sustainable water use.

Climate change adaptation actions in the agricultural sector include: preventive measures regarding soil erosion; climate-smart agriculture, which aims to improve yields while reducing inputs and greenhouse gas emissions; climate early warning systems; changes to sowing areas in response to changes in rainfall; change in crop varieties and transfer; direct sowing or zero tillage for better soil conservation; improvement of pasture varieties and livestock breeds.

Planned adaptation actions for the fishing and aquaculture sector, especially in Latin America and the Caribbean, are scarce, and mostly autonomous adaptation actions have been recorded. There is a wide portfolio of public policies on climate change, both as regards adaptation and mitigation, in RIOCC countries. However, despite governments' efforts, their practical implementation in the fisheries sector is incipient.

Adaptive capacity in the fisheries sector is limited by certain anthropogenic stress factors related to the globalization of fisheries and, in the case of RIOCC developing countries, to the lack of public infrastructures, the high incidence of diseases, pollution, poverty, weak governance and overfishing. Accordingly, climate change adaptation strategies should emphasize the need to eradicate poverty and food insecurity in fishing communities.

The main options for adaptation in the fisheries and aquaculture sector are the cultivation of species with greater thermal, saline and hypoxia tolerance; the formulation of new foods for carnivorous species that do not use low value fish; cultivation of herbivorous species; adaptive and ecosystem-based management plans; spatial monitoring and evaluation of the state of marine resources and biodiversity; reduction of discards and incidental fishing; risk analysis in management plans; adaptation of port infrastructure; establishment of insurance systems for extreme weather events; promotion of consumption of low commercial value fish species; use of friendly fishing gear and equipment; protection of critical or essential habitats such as mangroves and estuaries; improvement of governance systems (co-management); and diversification of the livelihoods of fisheries-dependent populations.

Climate disaster risks

The adaptive capacity in the region in terms of storms and hurricanes is mostly low. This is due to the lack of robust early warning systems, an increase in population in areas with urban sprawl in coastal and mountain areas, and deforestation. Other drivers include: marginality and poverty; institutional weakness and lack of coordination; precarious risk management; lack of preventive culture and poor preparation in rescue tasks; scientific and technological backwardness in hydro-meteorological monitoring and forecasting tasks; lack of human and technological capacities and lack of a culture of insurance against risks.

Adaptation plans in the RIOCC region show very different degrees of development and implementation. Some show progress in their creation (though not necessarily in their implementation), and many others exhibit major shortcomings and considerable delays.

Hurricane and storm adaptation measures comprise actions of various types, i.e., based on ecosystems (green adaptation), infrastructure (hard adaptation) or legislation and information/training (soft adaptation). Main measures include:

1) preserving and restoring coastal ecosystems (wetlands, dunes, mangroves and coral reefs) to reduce the impact of cyclonic waves; 2) replenishing beaches and improving coastal protection infrastructure; 3) raising the defenses of vulnerable buildings and constructions to reduce flood damage; 4) designing structures resistant to high winds and flying debris; 5) enacting policies that discourage development in vulnerable areas; 6) preparing before the arrival of a storm by covering windows and cleaning properties of potential flying debris; and 7) having an evacuation plan in place.

Improvements in risk management, both preventive and reactive, with decisive support for monitoring and forecasting are fundamental. These measures include implementing early warning and risk management systems. These should include: 1) zoning exposed areas and their degree of susceptibility and vulnerability; 2) development of communication programs, channels and strategies (pre- and post-events) through mass media, social networks, community cell phone networks and amateur radio; 3) social appropriation of evacuation plans and climate refugee attention plans; 4) update local and regional risk management activities and maintain evacuation drills; 5) establish permanent hydrological and atmospheric monitoring programs; 6) deploy weather radar networks for continuous monitoring of storms and hurricanes; and 7) maintain a hydrometeorological forecasting program for river floods, flood zones and landslides.

Adaptation is highly cost-effective and capable of coping with the challenges of both climate variability and climate change. For this reason, RIOCC countries should expedite relevant scientific research, allocate adequate budgets, and make the necessary institutional arrangements to implement adaptation tasks.

Improvements in training and prevention by halting deforestation and valuing its services are other important adaptive measures. Specifically, these measures include: 1) funding scientific education and training at the graduate level in oceanography, atmospheric sciences, meteorology, climatology and hydrology; 2) stopping deforestation, developing reforestation and ecological restoration programs for forests and other biomes, mangroves and coral reefs; and 3) increasing access to payment for environmental services as an economic instrument to stop deforestation and environmental degradation.

Despite considerable uncertainties about future changes with respect to the occurrence of droughts and floods, adaptation processes must be developed based on the best available scientific knowledge. Consequently, tools are required to anticipate flood and drought events in the medium and long term.

There is a variety of climate change adaptation measures of different scales in relation to droughts and floods that have already begun to be implemented in Ibero-America. These include improving the quality of forecasts, early warning systems and climate information services, plans for reducing vulnerability and increasing the resilience of exposed populations, developing strategic infrastructure, as well as production and conservation systems, and the sustainable use of ecosystems and their environmental services.

The effectiveness of slope instability risk management, or of adapting to slope instability risks in a climate change context, has a great deal to do with the use of correct information and the ideal application of models that allow for a correct and appropriate diagnosis for decision making. The use of information that fails to bring about clear intervention actions leads to maladaptation. Proper hazard and risk assessment contributes to adequate land zoning, the relocation of exposed human settlements, improvement of neighborhoods, the design and construction of stability and erosion control works, the implementation of both structural and non-structural prevention measures, and collective insurance and landslide warning systems, among others.

Hazard intervention, vulnerability reduction and the increase in resilience are concurrently the objectives of slope instability risk management and planned adaptation. However, there are also examples of autonomous adaptation associated with the way certain communities have implemented measures to avoid slope instability and put effective community-based warning systems into place in cases where the population has been appropriately involved. In the case of slope instability or landslides, the risk and risk management and adaptation actions are essentially local.

In different parts of the Andes and other mountainous locations of the region, communities have developed stability and terracing techniques using stone and wood, and even bamboo, materials that in some cases have been successful, but which are also perishable, causing the subsequent inconveniences when they lose their capacity. Radio systems for communication between observation sites and exposed populations have made it possible to implement simple warning systems with sirens and even loudspeakers, which are activated by electrical contacts or wire breaks that act as sensors. Risk management systems with a mainstream vision, associated not only with emergency preparedness and response but also with land use planning, urban planning, and risk transfer, have proven to be effective in achieving adaptation in cases of slope instability and landslides.

There are numerous supranational initiatives, both in Latin America and the Caribbean and in the European Union for cooperation between different RIOCC countries or with third parties in wildfire risk management. At the European level, the European Commission's European Forest Fire Information System is noteworthy, storing statistics and providing regular hazard warnings. In Latin America and the Caribbean, the most noteworthy systems are the Latin American Network of Remote Sensing and Wildfires, in which nine RIOCC countries participate; the Mesoamerican Environmental Sustainability Strategy (EMSA), in which all countries from Mexico to Colombia, both inclusive, participate and whose objective is to develop technical capacities and public policies in fire management; and the International Cooperation Strategy in Fire Management (Project TCP/RLA/3010/FAO, 2005) which