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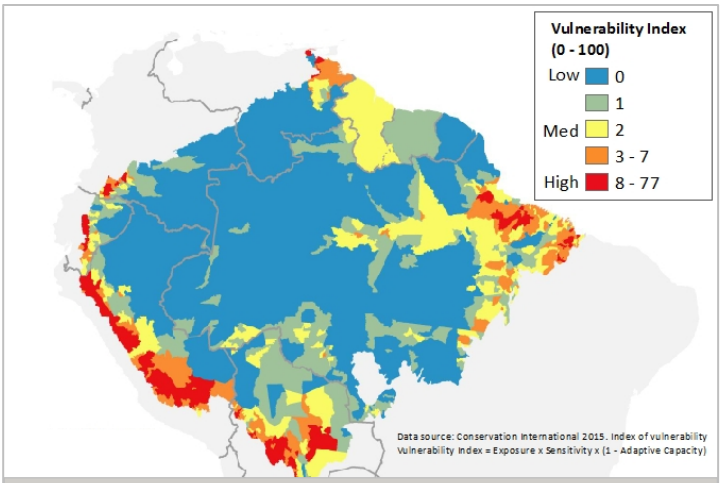
FACT SHEET

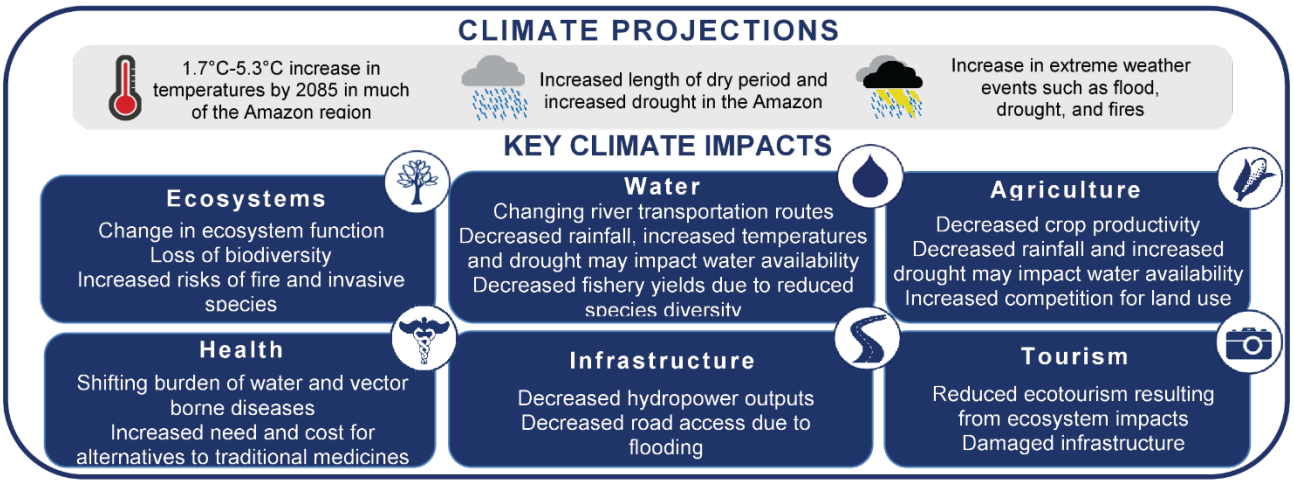
CLIMATE RISK PROFILE
AMAZON BASIN

REGION OVERVIEW



INDEX OF VULNERABILITY IN AMAZONIA

South America is home to one of the most important ecological zones in the world, the Amazon. This climate risk profile focuses primarily on the Amazon region which spans eight South American countries and 1 overseas territory: Brazil (which contains 59% of the biome), Peru (11%), Colombia (7.9%), Venezuela (6.7%), Bolivia (5.9%), Guyana (3.5%), Suriname (2.4%), Ecuador (1.8%) and French Guiana (1.3%). The Amazon basin covers 6.7 million square kilometers (km^2), about 40% of the South American continent and is composed 567 million hectares of dense forest, about 50% of the planet's remaining tropical rainforest and 4,100 miles of rivers. As shown in the figure above, vulnerability to climate change is not uniform across the region. The Andean foothills, which are characterized by sloped areas and are highly prone to increases in water flow and subsequent flooding, have particularly high vulnerability. Likewise, vulnerability is high in northeastern Brazil, which is characterized by a combination of high population density, projected reductions in water resource available, and limited adaptive capacity among those living there. By contrast, more central parts of the region have lesser vulnerability, though that calculus is predicated on there being far less sensitivity due to the largely intact forest areas and the ecosystem services they provide. The ecological health of the Amazon and the planet are intrinsically linked as the Amazon forests act as an important carbon sink and have a major influence on the global carbon cycle. Their capacity in this role is being threatened partially by deforestation and fragmentation and partially



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by changing climate. Studies indicate that climate change may alter the Amazon's status from a carbon sink to a carbon source, which would further exacerbate the effects of climate change globally. About 34 million people live in the Amazon, including 3 million indigenous people that are part of over 350 distinct indigenous groups. The region contains at least 10% of the world's biodiversity, 2.1 million km^2 of protected areas, and is home to over 40,000 plant species and 2,500 species of fish. The Amazon provides invaluable natural resources and ecosystem services to the local and global community. The climate in the Amazon is tropical, consisting mostly of rainforest, floodplain forests, savannas and rivers. Expected climate change impacts vary significantly between regions of the Amazon, but climate change will impact most sectors, including biodiversity, water resources, health, agriculture, infrastructure and tourism (39,40,42).

CLIMATE SUMMARY

The Amazon basin is comprised of a mosaic of ecoregions including moist forest, which makes up most of the region, seasonal forest, flooded swamp and savannah. Most of the Amazon is characterized by high annual precipitation, ranging from 3,000 millimeters (mm) in the west, to 1,700 mm in the southeast. The wet season runs primarily from December to April, with some variability between the northern Amazon and southern Amazon. The wet season in the southern Amazon typically begins earlier, around mid-October. The probability of severe decline in dry season rainfall is about 50% in the southeast Amazon, 30% in Guyana and the eastern region and 10% in the central and west regions. The zone of highest drought risk, the southeast and east Amazon, is also the area that has the most active deforestation. Within the Amazon Basin, the average temperature is 27.9 °C during the dry season and 25.8 °C during the rainy season. The forests of the Amazon recycle 50-75% of annual rainfall back into the atmosphere. This process, if unaffected by deforestation or degradation, puts about seven trillion tons of water per year back into the atmosphere from the soil, forest canopy and bodies of water. This means that the Amazon plays a central role in regulating rainfall in key agricultural regions across South America (10,11,15,22,39,43).

HISTORICAL CLIMATE

- The average temperature across the Amazon has increased by 0.5 °C since 1980, with stronger warming over the southwest and during the dry period.
- The period of 1950-1976 was wet in the northern Amazon; since 1977 the same region has been drier, suggesting longer-term climate variability.
- Rainfall has decreased at the end of the wet season and has increased at the end of the dry season.
- The El Niño/Southern Oscillation (ENSO) drives much of the climate variability. It is associated with dry conditions in the northern Amazon. The Amazon has seen 3 significant droughts in the last 20 years (2005, 2010, 2015/16).
- In the southern Amazon, the standard precipitation index decreased by 0.32 per decade between 1970-1999, suggesting an increase in dry conditions over that timeframe.
- There was a decrease in the mean annual discharge and monthly minimum discharge from 1974-2004 for Tapajos in the southeastern Amazon, the Peruvian Amazon Rivers and the upstream Madeira. (5,11,13,15,19,21,38).

FUTURE CLIMATE

- The annual mean temperature is projected to increase by 1.7°C to 5.3°C across the Amazon by 2085.
- Recent research suggests that overall, the Amazon will be drier in the future.
- By mid-century, precipitation is expected to decrease during the dry months.
- Climate change and global temperature increases could lead to a permanent El Niño-like state, increasing the incidence of drought conditions in the Amazon.
- The western region of the Amazon may become wetter and experience more frequent flooding alternating with periods of drought.
- There will likely be less rain in the east during the dry season and more rain in the west during the rainy season.
- It is likely that the region's dry season is increasing, especially in the southern Amazon, which is predicted to become more arid.
- The river flow and runoff in the northernmost region of the Amazon, and the river mouth region, will likely decrease by 2045-2065 (4,8,15,26,38).

SECTOR IMPACTS AND VULNERABILITIES

ECOSYSTEMS

Climate Stressors and Climate Risks ECOSYSTEMS	
Stressors	Risks
Increased Temperatures	Decreased tree cover, and reduced availability of natural resources for livelihood generation
Decreased rainfall	Increased desertification and forest fires due to more arid conditions
Increased drought	Decrease in biodiversity
More frequent extreme weather events	Increased risk of invasive species establishment

The Amazon, home to roughly half the world's rainforests, contains upwards of 10% of the world's biodiversity, accounts for about 15% of the world's total river discharge into oceans, and provides ecosystem services to its 30 million inhabitants and the broader global community. Local and indigenous communities rely on the Amazon for freshwater, food and livelihoods. The Amazon also helps control local and regional climates, acts as an important carbon sink, provides vast amounts of oxygen and contributes to natural medicines. Projected changes in the climate, such as overall drier conditions, changing rainfall patterns, and increased temperatures, combined with other threats including deforestation, put the Amazon's vast ecosystems at risk. Projected warming and drying will likely contribute to an increase in transpiration by plants (evapotranspiration), which could potentially lead to further drying in the region. These changes can lead to significant shifts in ecosystem types and species loss in many parts of the Amazon. This, combined with land use changes, are likely to accelerate forest and biodiversity loss and decrease ecosystem services. Some climate models project that evergreen forests could be succeeded by mixed forest, savanna and grassland in the eastern Amazon, while savanna landscapes could expand into parts of the west. Climate change may additionally result in a shift of the range and distribution of many Amazon plant species such that by 2095, up to 43% of these species may no longer be suited to live in their current location. Flooded forests, or forests flooded during the rainy season, are ecologically unique areas which are especially sensitive to change and variability during the rainy season. Secondary effects of climate change, such as forest fires, also pose a significant threat to the Amazon forest. Climate change is predicted to lead to droughts, fires and increased release of carbon into the atmosphere, further contributing to climate change. Severe drought can stress and potentially kill sensitive plant species, leading to their replacement by invasive species. Fires in the Amazon can become part of a positive feedback loop in which the fires themselves release carbon into the atmosphere, further reducing rainfall and promoting more drought and fires. Fires increase the forest's susceptibility to recurrent burning through the killing of trees, which increases the penetration of sunlight and drying of the forest interior, subsequently increasing the fuel load on the forest floor. (6,15,16,18,23,38,43)

WATER RESOURCES

Climate Stressors and Climate Risks WATER RESOURCES	
Stressors	Risks
Increased water temperatures	Biodiversity loss in freshwater ecosystems
Decreased rainfall	Changing transportation routes and patterns.
Changing seasonality of rainfall events	Degradation of water-sensitive habitats
	Decreased access to freshwater fisheries

The Amazon, which contains about 20% of the world's freshwater, is the world's largest riverine system. Aside from the Amazon river itself, there are 13 major tributaries, some that are larger than other large global river basins. The average rainfall in the Amazon basin is about 2,300 mm per year and the Amazon river plays an integral role in the water cycle for much of the rest of the continent. Changes in precipitation, extreme rainfall events, or seasonality of events can greatly impact the amount of resources available, timing, and variability of flow. The water resources of the Amazon provide valuable and essential services to the inhabitants of the region. Fisheries serve as an important source of animal protein and income in the Amazon. The rivers and lakes provide nearly all the water supply, including that used for drinking, cooking, bathing and waste removal. The rivers and lakes are

also important for transportation and trading purposes. Climate change threats to the Amazon water resources include: decreased precipitation during dry months, potential increase in flooding in some areas, more variable climate, and more extreme events. Projected increases in water flow in the Andean foothills, coupled with sloped land area, could increase risk of flooding and mudslides. At the same time, anticipated decreases in river discharges in eastern basins will challenge livelihoods and reduce water availability for the populations living there and will particularly threaten those with living in high density areas with limited resources. Warming temperatures will likely increase evaporation from the water surfaces and evapotranspiration, which in turn will result in a more vigorous water cycle (see index of vulnerability map). Further, as water temperatures rise, it will affect temperature dependent species. The distribution of aquatic species is likely to change due to climate change. The changing environment could lead to an increased population of invasive species that may out-compete native species, leading to a decline in species diversity. Recreational and commercial fisheries are at risk from extreme climate events, as these extreme events can have a significant impact on fishing yield. Studies have found significant decreasing mean and minimum annual runoffs from 1990-2005 for southern Andean rivers, and an increase in mean and maximum annual runoffs for northern Andean rivers draining into the Amazon. Further, climate change impacts to the Amazon's water resources could affect areas outside the region. The Andes' 6 km high barrier allows the moist Amazonian summer air to carry water vapor, known as the flying rivers of the Amazon, to a region south of the Amazon that is bounded by Cuiabá, Brazil to the north, São Paulo, Brazil to the east, Buenos Aires, Argentina to the south and the Andes to the west. This region is responsible for 70% of the continent's gross domestic product (GDP) due primarily to agricultural production, and its productivity depends highly on the climate regulation provided by the Amazon rainforests. (26,38,39)

AGRICULTURE

Despite substantial deforestation of Amazonian rainforest for agriculture, many areas within the Amazon rainforest are poorly suited to growing crops for long periods due to nutrient deficient, acidic soils, or poor land use management practices and resultant degradation or erosion of soils. For example, farmers routinely burn agricultural byproduct post-harvest on an annual basis, which can help clear fields and often results in productive soils for a short while. However, as these soils are typically not left fallow to recover over many years, they often become unproductive and subsequently result in forest and agricultural land being converted to pasture and rangelands.

Climate Stressors and Climate Risks AGRICULTURE

Stressors	Risks
Increased temperatures	Reduced crop yields due to evapotranspiration and less water availability
Reduced rainfall	Decreased livestock production due to factors such as heat stress and reduced feed
Increased drought	Increased deforestation for agriculture use due to decreased overall yields

Meanwhile, larger scale farms use fertilizer to grow crops, typically as monocultures, such as soy or sugar cane. Drier conditions and increased temperatures could lead to increased plant evapotranspiration and pest infestation, which can negatively affect agricultural yields. As yields decrease it could lead inhabitants of the region to seek larger areas of land to meet the existing demand for food, in turn increasing the rate of deforestation due to agricultural land use and potentially further accelerating a positive feedback loop of climate change impacts. Reduced water availability and warmer temperatures will negatively affect wheat, maize, and possibly soybean production in Brazil. Additionally, high temperatures and decreased feed from reduced crop yield could impact the health of livestock, in turn adversely impacting livestock production. (10,24,38)

Commercial Agriculture

Soy cultivation is a major commercial-scale activity in the Amazon with around 80% of Amazon soy used for animal feed. Brazil is currently the second largest producer of soybeans in the world, and the largescale production of soy is a major driver of deforestation in the country. With a 4°C mean global temperature increase, soybean production in the Brazilian Amazon is projected to decline by 44% by 2050. With a 2°C temperature increase, production is projected to decline 1.8% by 2050. For all analyzed crop types, including

rice, maize, soybean, and sugarcane, yields are projected to decrease by 31% with a 4°C temperature increase and by 14% with a 2°C increase, both estimates calculated by 2050 (10,26,39).

Subsistence Agriculture

The indigenous communities that live in the Amazon have historically practiced traditional shifting cultivation as well as agroforestry. Shifting cultivation, sometimes referred to as swidden-fallow or slash and burn agriculture, was developed to suit the unique characteristics of the Amazon basin, which include low soil fertility, high precipitation, and fast nutrient leaching. This technique is such that the first crops to be planted after an area is cleared through burning, which adds nutrients to the soils, are crops such as acai, avocado and guava. After the first few years, the land is then cultivated with crops like coffee, cacao, other fruit trees, or rubber (for sap) and Brazil nut (for nuts), which can be harvested for many years after. Often, farmers will return to these areas only decades later to restart the process. This form of agriculture is sustainable when plots are small and activity is limited. This smaller scale subsistence agriculture, which is often the primary livelihood of many indigenous communities in the region, is threatened by the warming and drying that is expected to accompany climate change. Inhabitants of the Cerrado in northeastern Brazil have already been experiencing some of the most severe decreases in agricultural yield in the world. Indigenous women in particular will be affected by the impacts of climate change on horticulture activities, as they are the ones traditionally in charge of this activity. (10,26,41)

HEALTH

Intact ecosystems also play an important role in pest and disease regulation. Research in the Peruvian Amazon has found that malarial mosquito biting rates were more than 278 times higher in deforested areas compared to the rates in heavily forested areas. Expanding protected areas in the Amazon will likely result in decreased incidence of malaria, diarrhea and acute respiratory infection. As climate change and deforestation continue to threaten the Amazon forests through a positive feedback loop, the increase of disease is a significant concern. Some extreme weather events, such as floods, may increase incidence of vector-borne diseases, such as malaria, dengue, and zika, and water borne diseases, such as cholera. In the case of Zika, recent studies have indicated a possible link between climate change, particularly rising temperatures and shifts in rainfall patterns, and changes in vector range, both temporal and spatial. Droughts, and associated wildfires, increase risk of injury and death from burn and smoke inhalation, as well as the indirect effects of air pollution. Cholera outbreaks are often associated with warm temperatures, flooding and drought. Increased rainfall is often linked to an increased cholera risk 4-7 days later. Childhood diarrheal disease is also heavily influenced by temperature, and to ENSO events in the Amazon. The relative risk of childhood diarrheal disease in South America is expected to increase by 5-13% between 2010-2039 with a 1.3°C temperature increase, and by 14-36% between 2070-2099 with a 3.1°C temperature increase. Additionally, the biodiversity of the Amazon leads to the discovery of compounds for new medicinal drugs such as quinine, an anti-malarial drug derived from the bark of the Cinchona tree, and the development of the drug captopril in the 1970s by using the venom of the Brazilian viper. It is also a great source for traditional medicine such as the use of tobacco for ailments such as sinus infections and hundreds of other medicines that have, as of 2017, been captured in the Matsés Traditional Medicine Encyclopedia. As the Amazon is threatened by climate change, so are the current medicinal benefits, and potential medicinal advances yet to be discovered that may exist in this unique habitat. Health impacts due to climate change in the Amazon will vary depending on the size, density, location and wealth of the population. Increased death rates due to extreme events such as drought, fires and floods have been modeled mostly for urban populations because of their susceptibility to temperature extremes and the poor housing conditions in urban

Climate Stressors and Climate Risks HEALTH

Stressors	Risks
Increased temperatures	Favorable conditions for infectious disease
	Increased need and cost for alternatives to traditional medicines
Increased flooding and drought events	Decreased food and water security
	Higher prevalence of heat-related medical conditions
	Decreased access to healthcare

centers. The effects of extreme temperature may be different for rural populations with less access to medical care and air conditioning. To exacerbate the problem even further, increased flooding and drought may decrease access to health care, as floods can impact the roadways and droughts may impact the waterways in the Amazon that serve as important means of transportation. (1,3,26,38,39)

INFRASTRUCTURE

Infrastructure development, specifically the building of highways, began in the mid-20th century in the Amazon. Development at that time was generally driven by commercial interests, such as iron, bauxite and hydropower, though some was also driven by growing populations with higher purchasing power. This growth brought more infrastructure, agriculture, and dams to the region. As of 2015, there were over 500 infrastructure projects under development in the Amazon, including those related to energy, transportation and communications. Power from hydroelectric dams provides about 80% of Brazil's electricity, 79% of Colombia's, 55% of Peru's, 32% of Bolivia's, 55% of Ecuador's, and 68% of Venezuela's. Estimates suggest that in Peru, a 50 percent reduction in glacier runoff would result in a decrease in annual power output of about 10%. With a 2.9°C global temperature increase, river flows in Brazil could decrease by about 11% by 2071-2100, which would lead to a decrease in power output of 3% based on current hydropower generation. Increased temperatures also increase energy demand as people seek to cool their homes with air conditioners or run them longer. Increased flooding and droughts can also limit the use of transportation infrastructure, such as road networks within the region, limiting people's access to a variety of resources, including healthcare, schooling, electricity, and employment. (10,12,26,39)

Climate Stressors and Climate Risks INFRASTRUCTURE

Stressors	Risks
Increased temperatures	Increased energy demands due to increased heat Reduced energy output by hydroelectric sources
Reduced precipitation	Reduced energy output by hydroelectric sources

TOURISM

Tourism is a major economic driver in South America. The total contribution of tourism to GDP in 2016 in each Amazon country[1] was as follows: 10% in Peru, 9% in Venezuela, 8.5% in Brazil, 7.3% in Guyana, 7.1% in Bolivia, 5.8% in Colombia, 5.1% in Ecuador, and 2.7% in Suriname. In the Amazon, the most widespread type of tourism is ecotourism. Oftentimes, revenues from ecotourism are used to support conservation efforts or, as is common in traditional tourism, the revenue is used to bolster the local community. Contributions from ecotourism in the Amazon are currently only significant on a regional level compared to other tourist sites in South America. Ecotourism in the Amazon is greatly dependent on a wide range of factors including: accessibility, comfort and security, all of which vary greatly between the different countries and regions of the Amazon. Ecotourism, though a relatively small industry compared to the greater region of South America, is present in many Amazon communities. As of 2008, the area around the Tambopata National Reserve in the Made de Dios region of Peru had about 37 ecotourist establishments, including lodges, research and education centers, and homestay guest houses. Despite having a large physical presence, the economic contribution of ecotourism to communities in the Amazon is still not substantial. Tourism, as most other sectors, is at risk from various climate change impacts. Most

Climate Stressors and Climate Risks TOURISM

Stressors	Risks
Increased temperatures	Prolonged droughts impacting ecotourism
	Decreased biodiversity
Changes in rainfall	Forest fires decreasing natural attractions
	Changing prevalence of disease
More frequent extreme weather events	Damage to infrastructure, or changing river patterns, leading to reduced access

[1]This considers country-wide tourism and is not specific to the percent of GDP derived from Amazon-based tourism in each of these countries.

importantly, as ecosystems are negatively impacted by climate change, their potential as ecotourism destinations are limited. Increased temperatures and changes in rainfall are expected to cause drought, flooding and forest fires in the Amazon. These climatic events may affect not only ecosystems, but accessibility to ecotourism sites. Tourists may also become less interested in the appeal of ecotourism if there is a decrease in biodiversity of the sites they hope to see. Additionally, the general safety of the ecotourism sites may be impacted both by the incidence of extreme weather events, such as forest fires, and by the possible increase in diseases such as zika, as mentioned above. (14,25,30,31,32,33,34,35,36)

POLICY CONTEXT

In addition to impacts from climate change, the Amazon is at risk from other threats, primarily deforestation. The Amazon countries are working together to address the effects of climate change and most of the Amazon basin countries have submitted their National Communications to the United Nations Framework Convention on Climate Change (UNFCCC).

INSTITUTIONAL FRAMEWORK

There are various intergovernmental organizations that are playing an important role in addressing climate change in the region. Latin American Technical Cooperation Network on National Parks, other Protected Areas and Wildlife (REDPARQUES) is a network of public and private entities that was established in 1983 by the countries of Latin America working in the realm of protected areas and wildlife conservation. One of REDPARQUES programs, “Protected Areas, Natural Solution against Climate Change”, is specifically focused on how the protected areas of the Amazon can play a role in building resilience and mitigating the impacts of climate change. The Amazon Cooperation Treaty Organization (ACTO), is an international organization that is aimed at the sustainable development of the Amazon basin. The member parties include Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela. The treaty was signed in 1978 and ACTO was created in 1995 to strengthen implementation of the treaty. As of 2010, ACTO has started to implement climate change considerations into their Strategic Cooperation Agenda. The Latin American Energy Organization is an intergovernmental public entity that was established in 1973. The organization focuses on the “integration, protection, conservation, rational utilization, marketing and protection of energy resources in the Region”. As an organization, they have programs devoted to climate change and its intersect with the energy sector. (2,20)

NATIONAL STRATEGIES AND PLANS

- Brazil, National Plan on Climate Change (2008)
- Brazil, National Adaptation Plan to Climate Change (2016)
- Brazil, Third National Communication to the UNFCCC (2016)
- Colombia, Climate Change Adaptation Plan (2017)
- Colombia, Third National Communication to the UNFCCC (2017)
- Peru, National Climate Change Strategy (2003)
- Bolivia, National Climate Change Program (2002)
- Bolivia, Second National Communication to the UNFCCC (2009)
- Ecuador, Third National Communication to the UNFCCC (2017)
- Venezuela, Second National Communication to the UNFCCC (2018)
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KEY RESOURCES[2]

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SELECTED ONGOING EXPERIENCES[3]

Below are selected projects focused on climate adaptation in the Amazon in South America.

Selected Program	Amount	Donor	Year	Implementer
Amazon Sustainable Landscapes Project	$60 million	GEF	2017-N/A	Government of Brazil, Ministry of Environment
Taking Deforestation Out of the Soy Supply Chain	$34 million	GEF	2017-2020	Conservation International
Implementation of the Strategic Action Programme to Ensure Integrated and Sustainable Management of the Transboundary Water Resources of the Amazon River Basin Considering Climate Variability and Change	$120 million	GEF	2018-	United Nations Environment Programme
Partnership to Conserve Amazon Biodiversity	$50 million	USAID	2014–2019	Government of Brazil, Ministry of Environment
Amazonía Sostenible Para La Paz (Colombia)	$1.1 million	UNDP	2017-2024	UNDP
Gestión Sostenible De Los Ecosistemas – Amazonia (Bolivia)	$1 million	UNDP	2016-2022	Viceministerio de Medio Ambiente
Eba Amazonía - Cambio Climático en Reservas Comunales (Peru)	$54 million	UNDP	2013-2018	PER-SERNANP Servicio Nacional
Amazonian Fund for Forest and Climate Protection	$10 million	GIZ	2010-2018	Banco Nacional de Desenvolvimento Econômico e Social
Strengthening the regional organization ACTO	$33 million	GIZ	2001-2018	Organization of the Amazon Pact (Organización del Tratado de Cooperación Amazonica)

[3] This "Selected Ongoing Projects" section lists a selection of ongoing development projects and interventions directly or indirectly relevant to climate risk management and adaptation in South America, and particularly in/around the Amazon Basin. Projects were identified primarily via desk review of USAID, multi-lateral development bank, and other international donor programming. Projects listed are not meant to be comprehensive.