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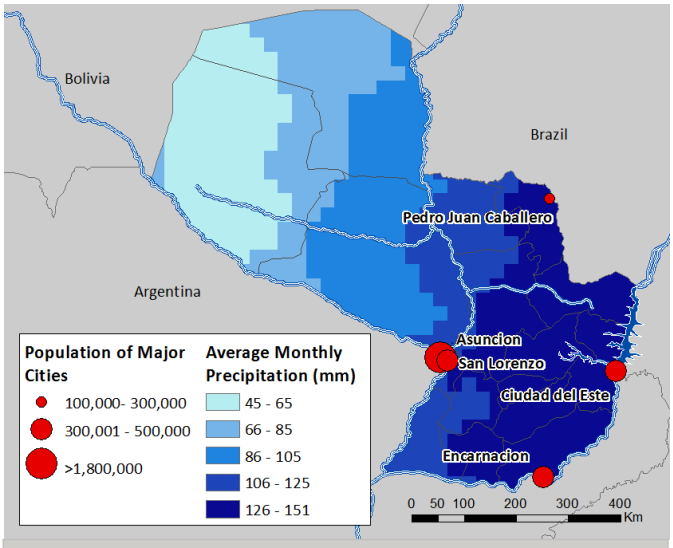
FACT SHEET

CLIMATE RISK PROFILE
PARAGUAY

COUNTRY OVERVIEW

Paraguay is one of two landlocked South American countries, located to the south of Brazil, east of Bolivia, and north of Argentina, and faces numerous development challenges, with the second lowest human development index in South America. Paraguay's economy relies heavily on agriculture and livestock, with shifts in agricultural and ranching productivity directly linked to the country's overall gross domestic product (GDP). Extreme weather events and global climatic variability, such as El Niño periods, already directly impact agricultural and livestock activities in Paraguay. Climate change threatens to introduce greater economic uncertainty, potentially exacerbating already high rates of inequality. Not quite 30 years removed from the long-standing autocratic rule of Alfredo Strossener, increased economic uncertainty could also threaten the country's political stability, which has been marked by relatively free and fair elections despite occasional political infighting and difficulties. The majority of Paraguay's approximately 7 million residents live in the southeastern part of the country with one third of the population residing in the capital city of Asunción. Access to services and utilities, such as clean water, electricity, and telephone have improved for Paraguay's rural poor in the past decade, yet about one third of rural Paraguayans live below the poverty line, and poverty in the country is predominantly concentrated in rural areas. (4,8)



MONTHLY PRECIPITATION IN PARAGUAY

CLIMATE PROJECTIONS

- 0.9–1.9°C increase in temperatures by 2050
- Decrease in dry season precipitation
- Increase in frequency and intensity of precipitation during rainy season

KEY CLIMATE IMPACTS

Agriculture
Crop damage from extreme weather events
Increase in pest populations

Health
Shifts in vector- and waterborne disease burdens
Decreased access to health care services

Livestock
Heat stress induced reduction of meat and milk production
Increase in water demand

Ecosystems
Increased frequency of forest fires
Damage to aquatic ecosystems due to river floods increased turbidity

Infrastructure
Damage to roads and ports from flooding and erosion

Water resources
Damage to infrastructure from flooding and erosion
Decreased hydroelectric output from drought

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CLIMATE SUMMARY

With a maximum elevation of 848 meters (m), Paraguay is a relatively flat country, divided into Eastern and Western Regions by the Paraguay River, and comprised of five distinct terrestrial ecoregions. The Eastern Region has a more humid climate and varied topography. Within the Eastern Region, the Alto Paraná Atlantic Forest ecoregion has the lowest average annual temperature at 21.3°C and highest annual rainfall, with the Itapúa department averaging 1,668 millimeters (mm) annually. By contrast, the Western Region is flat and dry, comprised primarily of the country's driest ecoregion, the Dry Chaco, which encompasses 60 percent of Paraguay's total land area. Within the Dry Chaco, the department of Alto Paraguay has the highest historical[1] average temperature in the country at 25.2°C, and the Boquerón department has the country's lowest annual rainfall at 596 mm. Located along the northeastern edge of the Western Region is the Pantanal, South America's largest wetland, which can receive more than 100 mm of rain in a single month. The centrally-located Humid Chaco ecoregion straddles the Paraguay River with average annual rainfall of approximately 1300 mm per year, although the ecoregion can receive up to 2200 mm of rain annually. Temperatures and precipitation vary across the country's two seasons: a warm rainy season from October through April, with mean monthly temperatures ranging from 23.1°C in April to 27.8°C in January, and rainfall ranging from 105.3 mm in April to 123.6 mm in January; and a cooler dry season from May to September with average monthly temperatures ranging from 18.5°C in July to 22.6°C in September and rainfall ranging from 30.4 mm in August to 89.7 mm in May. (4,7,8,12,20,24)

HISTORICAL CLIMATE

Observed climate trends include:

- Average and maximum temperatures have risen by about 1ºC over the past 50 years in the Dry Chaco region and 1.5ºC in the Alto Paraná Atlantic Forest region.
- In Puerto Casado, observed temperatures have increased at a statistically significant rate of 2.4°C per century since 1940. Other cities have observed an overall increase in temperatures, with varying levels of statistical certainty.
- Nationwide, between 1991 and 2015, average monthly rainfall during the rainy season increased relative to historical averages from 1930 to 1960. The increase was particularly high during January, November, and December (from 114 mm to 132 mm, 110 mm to 135 mm, and 108 mm to 130 mm, respectively).
- From 1960 to present, the number of consecutive dry days has increased in the majority of cities with meteorological stations in Paraguay. (11,20,24)

FUTURE CLIMATE

Projected changes include[2]:

- Days of extreme heat[3] are likely to increase from one every three years to 4-16 per year by 2070.
- Temperature increases are expected to be highest in the rainy season, with temperatures increasing to 30°C in February by 2059, while average temperatures during the dry season are likely to remain low.
- Temperature in the Dry Chaco is anticipated to increase by 1°C to 1.5°C by 2040.
- In the Dry Chaco region, rainy days will likely decrease during the dry season, while the Alto Paraná Atlantic Forest region will likely experience earlier rain, with a more irregular wet season.
- The rainy season is expected to become shorter and more intense.
- Monthly rains in April and October are anticipated to drop from 105 mm to 45 mm by 2059 and from 119 mm to 61 mm by 2059, respectively. Meanwhile, January and December rains are anticipated to increase from 122 mm to 129 mm and from 121 mm to 138 mm by 2059.
- While overall annual precipitation is anticipated to decrease most in the Western Region, rainy season precipitation is expected to increase there, exacerbating flooding. (11,20,24)

[1] Average from 1961-1990

[2] Information on projected climate for Paraguay is relatively limited, though such limited information is generally consistent across models, with most suggesting relatively constant increases in both precipitation and rainfall through 2039. These is, however, some disagreement as to whether the increase in rainfall will remain constant during the period of 2040-2050.

[3] Days with maximum temperature above 42.6°C

SECTOR IMPACTS AND VULNERABILITIES

LIVESTOCK

The livestock industry is nearly 500 years old in Paraguay and 61 percent of Paraguay's land is dedicated to livestock grazing. Representing six percent of Paraguay's GDP, serving as the primary economic activity in the Western Region, and employing many in secondary industries such as meat and leather processing, the sector is severely threatened by increasing temperatures and decreasing precipitation. Increased temperatures can impact the health of the animals and allow for the spread of disease within herds, while heat stress can decrease the weight of cattle and their milk production. Projected drought and more extreme temperatures during the dry season are also likely to decrease the quality of forage and water and reduce the productivity of cattle grazing. Further, with the sector already accounting for approximately 16 percent of water use in the country, decreased precipitation and increased temperatures will likely exacerbate any stress presently placed by the sector on existing water resources. Climate related risks have already impacted the sector, such as wildfires in 2007 causing approximately $30 million USD of damage. The frequency, intensity, and spread of such wildfires may increase in the future due to the combined risk factors of traditional land management practices that include burning pastureland and the projected increases in temperatures and frequency of drought days leading to drier conditions. Additionally, deforestation driven by a complex interaction of factors[4] may exacerbate the effects of climate trends, particularly at the local level, by exaggerating temperature changes (higher high temperatures during the dry season and lower low temperatures during the rainy season). These localized impacts may encourage ranchers to range their cattle further in search of more resources or more hospitable conditions. This, in turn, could potentially encourage even more land use change and contribute to increases in greenhouse gas (GHG) emissions, demonstrating how the country's livestock industry perpetuates a negative feedback loop with regards to land clearing and GHG emissions; ranchers clear land and contribute to changing climatic conditions, while warming temperatures, shifts in precipitation, and increased severity and strength of weather events adversely impact ranching productivity, further pushing ranchers to clear more land. (2,3,14,16,20,22)

Climate Stressors and Climate Risks RANCHING

Stressors	Risks
Rising temperatures	Livestock death
Decreased precipitation during dry season	Reduced meat and milk production
Increased frequency and severity of droughts	Increased prevalence, intensity, and spread of wildfires resulting in damage to pastureland and/or livestock
	Greater water need
Increased flood intensity and rainy season precipitation	Decreased nutritional value of forage
	Increased disease spread

AGRICULTURE

Crop production agriculture is one of the dominant forces in the Paraguayan economy, responsible for 19 percent of total GDP. As the principal livelihood for over 60 percent of the country's rural population, crop production is linked to 82 percent of all employment in Paraguay, and faces substantial threat from changing climate conditions. Only 2.1 percent of cropland is irrigated, leaving the agricultural sector vulnerable to drought and crop failure. This is perhaps most concerning for soy production, which dominates Paraguay's agriculture sector and lost over 50 percent of production from a major drought in 2011. As the fourth-largest exporter of soy in the world, soy cultivation accounts for nearly 78 percent of the cultivated land and 12 percent of the country's overall GDP[5] and is most prevalent in the east and the Alto Paraná Atlantic Forest. Encouragingly, multiple models suggest that projected changes in temperature and rainfall will leave soy yields at current levels or increase its productivity up until 2060 or 2075, perhaps due to soy's reliance on

[4] The growth of soybean production in the 1970s and the introduction of the 2004 Zero Deforestation Law in the Eastern Region are prominent factors that have contributed to pushing ranching activities into new areas within Paraguay's Western Region. This, in turn, has contributed to significant deforestation, particularly in the Dry Chaco ecoregion.

[5] Paraguay's soy is cultivated primarily for livestock feed, and about 96 percent of the cultivated soybeans are exported to the European Union.

warmer temperatures for production. Beyond 2075, these models then project a sharp decrease from the current 2.5 metric tons to around 0.5 metric tons per hectare, a potentially devastating long-term impact. A changing climate, particularly changes in frequency and prevalence of rainfall and humidity and increases in temperature, may result in changes in the distribution and prevalence of insects, pests, and diseases. For example, increasing humidity could lead to greater prevalence of soy rust. Additionally, climate variability and change may result in some crops experiencing decreased resilience due to water or temperature stress, while projected decreases in rainfall and increases in temperature may also result in increased prevalence of wildfires. Wildfires have already significantly impacted agriculture in the northeast and western parts of the country, such as in 2007 when severe fires in San Pedro destroyed crops of nearly half of farmers, particularly impacting maize and orange production. Beyond soy, maize and wheat are Paraguay's most important industrially produced crops, while smallholder farmers tend to produce beans, yucca, sesame, and sugarcane. Wheat is likely to experience an eventual decrease in productivity, while maize productivity is expected to increase and then return to current levels by 2070, similar to projections for soy. The primary smallholder crops are all anticipated to substantially decline in productivity after 2060. In Paraguay, as is common globally, women-led agricultural production typically seeks to meet household nutritional needs.. At the same time, women often have greater challenges than men in Paraguay in accessing necessary financing or credit, increasing their vulnerability in the event of decreased agricultural productivity. In turn, such decreases in agricultural productivity may most acutely impact households that already struggle with food security. (3,11,20,22)

Climate Stressors and Climate Risks AGRICULTURE

Stressors	Risks
Rising temperatures	Crop failure
Increased frequency and severity of droughts	Storm damage to crops and livestock
	Increased frequency, intensity, and spread of wildfires leading to damage of crops or cropland.
Increased rainy season precipitation and flood intensity	Unpredictable growing seasons
	Increased prevalence of pests

WATER RESOURCES

The anticipated climate risks to the Paraguay basin, including increases in temperature, intensity of rain events, and frequency of prolonged droughts, are likely to result in increased sedimentation in the lower basin and adverse impacts to aquatic ecosystems. Paraguay has made incredible gains in improving water access for both rural and populations, with nearly 100 percent of the urban population and 95 percent of those living in rural areas having access to water from improved sources. However, changing climatic conditions may undermine some of these gains. For example, Paraguay may experience increased water scarcity due to greater rainfall variability and increasing temperatures. This would have a particularly acute effect on women, who are typically responsible for water collection in Paraguay, as increased water scarcity will increase the percentage of time and amount of labor spent on water collection for household use. Such climatic changes will also likely have at least short-term effects on water level. From 1905-2009, there was a slight statistical decrease in the volume of the Paraguay river floods as measured in Asunción, though projections of river flow through 2040 are inconclusive. Also in the short term, with anticipated decrease in precipitation during the dry season and increase in precipitation in the rainy season, Paraguay can expect seasonal fluctuations in water level. Heavier storms will increase the likelihood of flooding in the wet season, while projected decreases in rainfall and increased temperatures during the dry season will result in decreased availability of water resources. Such increased flooding may threaten the country's improved water and sanitation

Climate Stressors and Climate Risks WATER RESOURCES

Stressors	Risks
Increased temperatures and reduced rainfall	Decreased water quality
	Water scarcity for agriculture
Increased drought	Decreased electrical output
Increased rainy season precipitation and flood intensity	Economic or political instability
	Damage to downstream communities

infrastructure, particularly in and around Asunción, while higher precipitation rainy seasons and drier dry seasons could significantly impact the energy and agricultural sectors; agriculture and livestock sector use 70 percent of the country's available water resources, while all of Paraguay's energy is sourced from hydroelectricity. Further, Paraguay is one of the leading exporters of hydroelectric energy in the world, taking advantage of the energy potential afforded by the Paraná and Paraguay rivers, and the country's Itaipu dam is currently the largest hydropower installation in the world. A study evaluating the potential impacts of climate change on this dam found that, on an annual basis, there would be an expected monetary loss of approximately $370,000,000 per month between 2010 and 2040 due to increased rainfall seasonality and variations in total runoff (increasing in the wetter season and declining in the drier months). Climate change is also expected to affect the spatial and temporal variability of water resources on a seasonal basis. Historically, swollen, flooded rivers have overwhelmed Paraguay's dams, which have then had to perform large releases, resulting in rapid changes in river levels downstream and risking damage to downstream communities and such risks could persist or increase during heavier rainfall wet seasons. Paraguay also may face increased frequency of droughts. When extreme enough, droughts will decrease river levels, and thus limit the capacity of dams to produce electricity. Because Paraguay exports so much hydropower internationally, this could negatively impact Paraguay's government revenue and broader economy, as well as the economies—and, potentially, political stability—of its neighbors. For example, in nearby Venezuela, such droughts combined with a reliance on hydroelectric power have proven to be a destabilizing factor in the ongoing Venezuelan unrest, and reductions in Paraguay's electrical capacity threaten to likewise adversely impact political stability and governance within and beyond Paraguay's borders. (5,6,8,11,13,15,20,25)

INFRASTRUCTURE

An increase in frequency and intensity of floods due to a changing climate threatens to further degrade the already inadequate transportation and civic infrastructure (such as the material quality and relative proximity of private households and logistical capacity throughout Paraguay. Increases in water volume from intense rains, as well as increases in water flow and current have the potential to submerge and damage port infrastructure. As a landlocked country, Paraguay relies extensively on river transportation of goods, with 20 private ports on the Paraguay and Paraná rivers through which the majority of exports pass. Consequently, damage to port infrastructure could significantly hinder the delivery of Paraguayan goods to foreign markets. Additionally, Paraguay's roads, already rapidly deteriorating[6], may likewise incur even more damage in the face of more frequent or intense flooding and corresponding increases in soil erosion or reduction in soil stability. Of the approximately 60,000 km of roads connecting Paraguay's urban areas, about 54,600 km are unpaved and thus particularly vulnerable to the impacts of frequent flooding and erosion. Floods are expected to be pronounced in the western portion of the country (with 17 to 20 new flood events projected between 2010 and 2039). Most of Paraguay's population and infrastructure sit downstream, in the Eastern Region, with heaviest concentration in Asunción directly adjacent to the Paraguay River. Flood events in these areas could pose overwhelming damage to homes and small-scale infrastructure, most of which is in substandard condition and thus particularly vulnerable. (3,11,19)

Climate Stressors and Climate Risks INFRASTRUCTURE

Stressors	Risks
Increased rainy season precipitation	Damage to transportation infrastructure
Increased frequency and intensity of floods	Damage to energy generation, transmission, and distribution infrastructure
Soil erosion and reduction of soil stability	Damage to river export infrastructure

[6] In 2011 approximately, 68 percent of the paved roads were in good condition, but by 2015 only 59 percent were in good condition.

HEALTH

Climate Stressors and Climate Risks HUMAN HEALTH	
Stressors	Risks
Increased temperatures	Increase in water- and vector-borne diseases
Increased rainy season precipitation and flood intensity	Inability to access health services due to damaged infrastructure (roads, hospitals and/or health centers, ports, energy generation and transmission)

Over the past 35 years the incidence of dengue fever has increased in Paraguay, and further increases in dengue, the potential resurfacing of malaria, and increases in diarrheal diseases are projected in response to changing climatic conditions. While there is variance between high and low emission scenarios, the incidences of selected climate sensitive diseases,[7] notably dengue and diarrhea, are anticipated to increase by approximately 200 percent and 25 percent respectively by 2070 under the high emissions scenario, and absent improvements in access to or quality of treatment methods. Meanwhile, projections also indicate that malaria, which has been largely eliminated from the country, may resurface during the period of 2020 to 2050. At the same time, the incidence of respiratory illnesses is likely to decrease, at least modesty, by 2050. The increased incidence of dengue, malaria, and diarrheal diseases will be distributed unevenly across the country. Dengue is expected to impact Amambay department the most, while increases in diarrhea are projected to be concentrated in Asunción and Alto Paraná and increases in malaria most heavily concentrated in Alto Paraná, Caaguazú, and Canindeyú. The potential of flood damage to roads and river infrastructure could limit delivery of or access to health services and commodities, and projected lower hydropower yields and damage to electrical infrastructure may affect the efficacy or access to hospitals and other health centers. Additionally, damage to sanitation infrastructure, such as sewers, and interruption of municipal waste services due to natural disaster will likely accelerate the spread of both vector-borne and waterborne diseases beyond the anticipated impacts of increased temperature and rainfall alone. (3)

ECOSYSTEMS

Climate Stressors and Climate Risks ECOSYSTEMS	
Stressors	Risks
Increased temperatures	Increased wildfires
Increased intensity of drought	Erosion and flood damage
Increased rainy season precipitation and flood intensity	Damage to aquatic ecosystems

Paraguay is home to five terrestrial ecoregions, the Dry Chaco, Pantanal, Humid Chaco, the Cerrado, and the Alto Paraná Atlantic Forest. Despite this ecological diversity, only 13 percent of the natural habitat remains, largely due to the increase in mechanized cultivation of soy. For example, the Atlantic Forest, which once stretched from Brazil through Paraguay, Argentina, and Uruguay, has lost 93% of its forested area and faces further pressure. The government has passed legal measures to prevent deforestation, however, these are rarely enforced. Not only does land clearing intensify the climate risk through increases in GHG emissions and exacerbation of local climatic changes, but also a loss of forest and other natural ecosystems diminishes the adaptive capacity of the country. With fewer trees and less vegetation, the flooding, erosion, and sedimentation anticipated with climate change will likely increase. Additionally, projected increased temperatures during the dry season may increase susceptibility to forest fires, particularly heightening the risk of uncontrolled spread of fires set for agriculturally-premised land clearing, accelerating already prevalent deforestation and ecosystem loss. Fragmented habitats, like those found in the heavily cleared Dry Chaco, are more vulnerable to extreme weather and dry conditions than intact ecosystems. Finally, Paraguay's aquatic ecosystems are projected to suffer increased turbidity and temperature, as well as increased pulse flows from high rain events, potentially threatening Paraguay's fisheries and its many endangered aquatic species. (17,18,21,26,27)

[7] Climate sensitive diseases included dengue, diarrhea, lower respiratory tract infections, and malaria.

POLICY CONTEXT

Paraguay has several laws in place to address climate risk and related issues, but faces challenges effectively enforcing them. Historically, the legal framework has addressed issues related to climate risk, but has not directly addressed emissions reductions strategies. The Forestry Law (Law 422) passed in 1973, establishes many of the foundations of environmental policy in Paraguay. In 2002, Paraguay passed a Zero Deforestation Law, aimed at halting deforestation in the Eastern Region. However, this law is anticipated to expire in 2018, after which land clearing may legally resume throughout the region, though even in its current state the law has likely failed to prevent forest loss as intended; there is not much forest left in the region as land use focuses on livestock and agriculture. Additionally, an unintended consequence of this law was that it may have transferred pressure to the Chaco region because the law does not apply to the Western Region. Deforestation in the Chaco region is exceedingly high, with a loss of approximately 44,000 square km between 1985 and 2012, and the rate of deforestation nearly doubling in the region (approximately 29,000 square km between 2004 and 2012) after the 2002 Zero Deforestation Law in the Eastern Region was passed. Other climate related laws include: Law 536/95 to promote afforestation and reforestation; Law no. 1561/00 (creating the National Environmental Council); Law 2,748/05 on the promotion of biofuels; Law 3,254/07 for mitigation of environmental impact; and Law no. 5211 (on Air Quality). More recently, in 2017, following Paraguay's ratification of the Paris Agreement, the government passed the "National Law on Climate Change no. 5875" which addresses both climate risk management and adaptation. This law establishes an institutional framework for addressing climate risk. (9,10,12)

INSTITUTIONAL FRAMEWORK

The current environmental institutional framework was established by the 2000 Law 1561. The primary institution for implementing environmental policy is the Ministerio del Ambiente y Desarrollo Sostenible (MADES), an institution that struggles with both financial and professional capacity that limits their ability to implement their responsibilities. Additionally, the "National Law on Climate Change no. 5875" establishes three institutions: the National Commission on Climate Change, an inter-institutional body that establishes policy strategies; the National Directorate on Climate Change which implements policies, and the Climate Change fund to be managed by MADES. (12)

NATIONAL STRATEGIES AND PLANS

- First National Communication 2002
- Second National Communication 2011
- Third National Communication 2017
- Paraguay Intended nationally Determined Contribution and National Development Plan 2015
- Diseño del Plan Nacional de Adaptación al Cambio Climático 2016
- Estrategia Nacional de Adaptación al Cambio Climático 2017

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Map from: Global Precipitation Climatology Centre (GPCC). 2015. GPCC Normal Version 2015 0.25 degrees. https://kunden.dwd.de/GPCC/Visualizer

SELECTED ONGOING EXPERIENCES

Selected Program	Amount	Donor	Year	Implementer
Promoting Risk and Emergency Preparedness (PREP)	$1.3 million	USAID	2017-2018	ACDI/VOCA
Tenure and Global Climate Change (TGCC)	$13.4 million	USAID	2013-2018	Tetra Tech and World Resources Institute
PY Energy Sector Strengthening Project	$125 million	World Bank	2010-2018	ANDE

Selected Program	Amount	Donor	Year	Implementer
Conservation of Biodiversity and Sustainable Land Management in the Atlantic Forest of Eastern Paraguay	$18.29 million	World Bank	2010-2016	ITAIPU Binacional
Estrategia Redd II	$4.1 million	UNDP	2017-2020	PNUD Paraguay
Apoyo a la Reducción de la Deforestación en la Producción de Commodities en Paraguay	$8.26 million	UNDP	2017-2022	PNUD Paraguay