

CLIMATE RISK COUNTRY PROFILE

PARAGUAY

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This profile is part of a series of Climate Risk Country Profiles developed by the World Bank Group (WBG). The country profile synthesizes most relevant data and information on climate change, disaster risk reduction, and adaptation actions and policies at the country level. The country profile series are designed as a quick reference source for development practitioners to better integrate climate resilience in development planning and policy making. This effort is managed and led by Veronique Morin (Senior Climate Change Specialist, WBG) and Ana E. Bucher (Senior Climate Change Specialist, WBG).

This profile was written by Fernanda Zermoglio (Senior Climate Change Consultant, WBG) and MacKenzie Dove (Senior Climate Change Consultant, WBG). Additional support was provided by Jason Johnston (Operations Analyst, WBG) and Yunziyi Lang (Climate Change Analyst, WBG).

Climate and climate-related information is largely drawn from the [Climate Change Knowledge Portal \(CCKP\)](#), a WBG online platform with available global climate data and analysis based on the latest [Intergovernmental Panel on Climate Change \(IPCC\)](#) reports and datasets. The team is grateful for all comments and suggestions received from the sector, regional, and country development specialists, as well as climate research scientists and institutions for their advice and guidance on use of climate related datasets.

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FOREWORD

Climate change is a major risk to good development outcomes, and the World Bank Group is committed to playing an important role in helping countries integrate climate action into their core development agendas. The World Bank Group is committed to supporting client countries to invest in and build a low-carbon, climate-resilient future, helping them to be better prepared to adapt to current and future climate impacts.

The World Bank Group is investing in incorporating and systematically managing climate risks in development operations through its individual corporate commitments.

A key aspect of the World Bank Group's Action Plan on Adaptation and Resilience (2019) is to help countries shift from addressing adaptation as an incremental cost and isolated investment to systematically incorporating climate risks and opportunities at every phase of policy planning, investment design, implementation and evaluation of development outcomes. For all International Development Association and International Bank for Reconstruction and Development operations, climate and disaster risk screening is one of the mandatory corporate climate commitments. This is supported by the Bank Group's Climate and Disaster Risk Screening Tool which enables all Bank staff to assess short- and long-term climate and disaster risks in operations and national or sectoral planning processes. This screening tool draws up-to-date and relevant information from the World Bank's Climate Change Knowledge Portal, a comprehensive online 'one-stop shop' for global, regional, and country data related to climate change and development.

Recognizing the value of consistent, easy-to-use technical resources for client countries as well as to support respective internal climate risk assessment and adaptation planning processes, the World Bank Group's Climate Change Group has developed this content. Standardizing and pooling expertise facilitates the World Bank Group in conducting initial assessments of climate risks and opportunities across sectors within a country, within institutional portfolios across regions, and acts as a global resource for development practitioners.

For developing countries, the climate risk profiles are intended to serve as public goods to facilitate upstream country diagnostics, policy dialogue, and strategic planning by providing comprehensive overviews of trends and projected changes in key climate parameters, sector-specific implications, relevant policies and programs, adaptation priorities and opportunities for further actions.

It is my hope that these efforts will spur deepening of long-term risk management in developing countries and our engagement in supporting climate change adaptation planning at operational levels.



Bernice Van Bronkhorst

Global Director

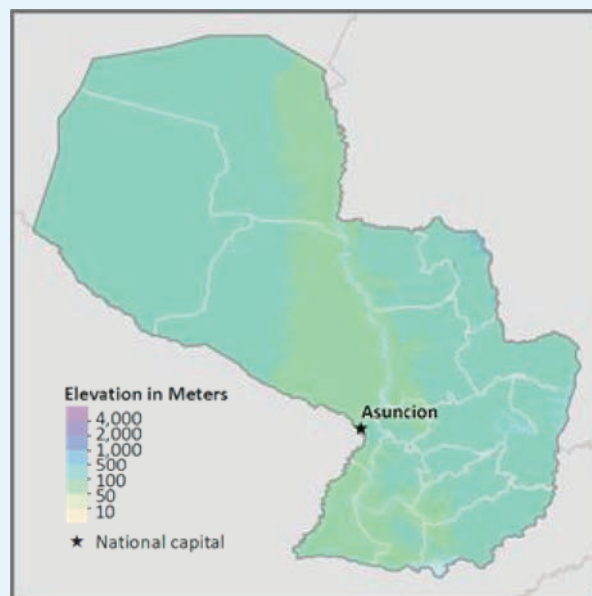
Climate Change Group (CCG)

The World Bank Group (WBG)

COUNTRY OVERVIEW

The Republic of Paraguay, a landlocked country in South America, is bordered by Argentina, Brazil, and Bolivia, and has a Mediterranean climate with almost seven million inhabitants.¹ 60% of the country lives in the urban centers of Encarnación, Ciudad del Este, and the capital city of Asunción. Political and economic stability have given the country the largest economic growth in Latin America in the last 30 years. Considered an upper middle-income economy, in recent years the country has positioned itself as an attractive and orderly place for investments, further fueling economic growth. Paraguay is a country of countless natural resources, with a growing and productive agricultural and livestock sector. Clean and renewable energy is abundant and exported regionally. As shown in **Figure 1**,

FIGURE 1. Topography of Paraguay²



the country is largely flat with low-lying hill regions 62% of Paraguay's approximately 7 million inhabitants reside in urban areas, and the annual urban growth rates are 1.7%.³ Population projections for 2030 point to an additional 1 million people living in the country, and a 65.7% residing in urban areas, while in 2050, the country's estimated population will top 9 million inhabitants, of which 74.3% will reside in urban areas. Paraguay has made significant strides in poverty reduction and lowering inequality, reducing the number of people living in poverty in 2011 from 37% to 24.2% in 2018 (**Table 1**).⁴ GDP per capita in 2017 was estimated to be US\$5,335 with an annual growth rate of 4.8%.^{5,6} Nevertheless, significant challenges regarding access to land and the inequitable

TABLE 1. Data snapshot: Key development indicators

Indicator	2018
Life expectancy at birth, total (years)	74.1
Population density (people per sq. km land area)	17.5
% of Population with access to electricity	100%
GDP per capita (current US\$)	\$5,805.70

¹ World Bank (2020). Open Data, DataBank-Paraguay. [Data Retrieved: July 2020]. URL: <https://data.worldbank.org/country/paraguay>

² World Bank Group (2019). Internal Climate Migration Profile – Paraguay.

³ World Bank (2020). Open Data, - Paraguay. [Data Retrieved August 2020]. URL: <https://databank.worldbank.org/source/world-development-indicators>

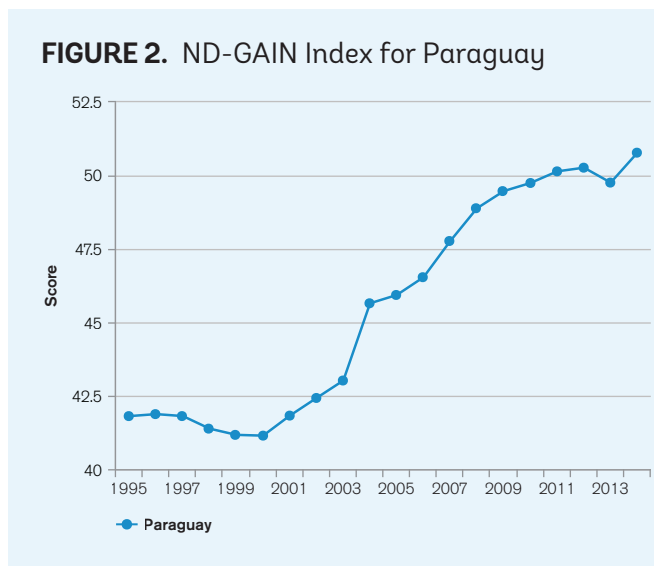
⁴ World Bank (2020). Open Data, DataBank – Paraguay. [Data Retrieved July 2020]. URL: https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&gm=n&country=PRY

⁵ CIA Factbook (2020). Paraguay. URL: https://theodora.com/wfbcurrent/paraguay/paraguay_economy.html

⁶ FOCUS Economics (2020). Paraguay. URL: <https://www.focus-economics.com/countries/paraguay>

distribution of the country's wealth remain. Major economic sectors are principally commodity based, and include exports of energy, beef and soy. The country has taken significant steps in recent years to diversify the economy and has a growing informal commerce and services sector. With the support of the World Bank, the Paraguayan government aims to promote sustainable growth and institutional strengthening, while supporting investments in human capital and advancing the fight against corruption.⁷ The ongoing drought in Paraguay (beginning in late 2018 and projected to continue through early 2012), has hit the country's production and trade of key economic staples particularly hard, causing Paraguay's central bank to cut back its annual growth projections.⁸

The ND-GAIN Index⁹ ranks 181 countries using a score which calculates a country's vulnerability to climate change and other global challenges as well as their readiness to improve resilience. This Index aims to help businesses and the public sector better identify vulnerability and readiness in order to better prioritize investment for more efficient responses to global challenges. Due to a combination of political, geographic, and social factors, Paraguay is recognized as vulnerable to climate change impacts, ranked 95 out of 181 countries in the 2019 ND-GAIN Index. The more vulnerable a country is the lower their score, while the more ready a country is to improve its resilience the higher it will be. Norway has the highest score and is ranked 1st. **Figure 2** is a time-series plot of the ND-GAIN Index showing Paraguay's progress



Paraguay's economic reliance on agriculture, animal husbandry and hydroelectric energy production make it particularly vulnerable to the impacts of increasing climate variability and climate change. The country's high rate of deforestation, especially for a growing agriculture and livestock sector, is significant. More frequent extreme events such as intense rainfall and heat waves are increasingly common, negatively impacting all sectors. Additionally, a significant increase in total annual rainfall has been reported for the summer months of November to December, corresponding with ENSO (El Niño Southern Oscillation) events, which are also associated with floods. La Niña events bring the increasing occurrence and intensity of droughts.¹⁰

⁷ World Bank (2020). Paraguay Country Partnership Strategy. URL: <https://www.worldbank.org/en/country/paraguay/overview#2>

⁸ Desantis, D. (2019). Amid 'many shocks,' Paraguay cuts 2019 growth outlook again due to drought, trade. Reuters. URL: <https://www.reuters.com/article/paraguay-economy/amid-many-shocks-paraguay-cuts-2019-growth-outlook-again-due-to-drought-trade-idUSL2N2780ZP>

⁹ University of Notre Dame (2020). Notre Dame Global Adaptation Initiative. URL: <https://gain.nd.edu/our-work/country-index/>

¹⁰ Baéz Benítez, J. (2014). Analysis of Meteorological Drought Episodes in Paraguay. URL: <https://link.springer.com/article/10.1007/s10584-014-1260-7>

Paraguay submitted its [Nationally Determined Contributions](#) to the UNFCCC in 2016 and its [Third National Communication](#) (NC3) in 2017, in support of the country's efforts to realize its development goals and increase its resilience to climate change by enhancing mitigation and adaptation implementation efforts.¹¹ Adaptation is a priority in the National Development Plan (2014–2030) across the following sectors: water resources, forests, agriculture and livestock production, territorial planning, energy, infrastructure, health, disaster risk management and early warning systems.¹²

Green, Inclusive and Resilient Recovery

The coronavirus disease (COVID-19) pandemic has led to unprecedented adverse social and economic impacts. Further, the pandemic has demonstrated the compounding impacts of adding yet another shock on top of the multiple challenges that vulnerable populations already face in day-to-day life, with the potential to create devastating health, social, economic and environmental crises that can leave a deep, long-lasting mark. However, as governments take urgent action and lay the foundations for their financial, economic, and social recovery, they have a unique opportunity to create economies that are more sustainable, inclusive and resilient. Short and long-term recovery efforts should prioritize investments that boost jobs and economic activity; have positive impacts on human, social and natural capital; protect biodiversity and ecosystems services; boost resilience; and advance the decarbonization of economies.

CLIMATOLOGY

Climate Baseline

Overview

Paraguay's climate overall is characterized by high humidity and warm temperatures year-round, with hot and rainy summers, and mild winters with significant temperature variability that can bring both frosts to practically the entire national territory, as well as heat waves.¹³ Paraguay's landscape is characterized by three distinct ecosystems, bordering the southward flowing Paraguay River. The eastern landscape is one of a humid sub-tropical climate

¹¹ Paraguay (2016). Contribuciones Nacionales de la Republica del Paraguay. URL: <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Paraguay%20First/Documento%20INDC%20Paraguay%2001-10-15.pdf>

¹² Paraguay (2016). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

¹³ Paraguay (2018). Segundo Informe Bienal de Actualización del Paraguay. URL: https://unfccc.int/sites/default/files/resource/56910784_Paraguay-BUR2-1-Informe%20Bienal%20de%20Actualizacion_PY_Dic%202018_.pdf

composed of verdant hills, meadows and forests, and include the great Parana Plateau, reaching altitudes of 300–600 meters (m) above sea level. Lowland plains, subject to annual floods, characterize the easternmost reaches of the country, which have a tropical savanna climate. To the west lie the dry, vast alluvial plains and dry grasslands of the Gran Chaco characterized by a hot, semi-arid climate.¹⁴

Average temperatures increase from south to north, while rainfall decreases from east to west. Warm temperatures are present throughout most of the year, as average annual temperatures exceed 20°C throughout the country. In the Eastern Region, the annual average temperature is between 20°C and 24°C, while in the Chaco or Western Region, average annual temperatures hover around 25°C. The two periods of maximum rainfall in most of the country are from March to May and from October to November. Rainfall in the Paraná region (southern Paraguay) is abundant, averaging 1,900 millimeters (mm) per year and is regularly distributed across the year.¹⁵ Rainfall in the central region, where the capital city of Asuncion is located, is typically 1,400 mm per annum and distributed across all but the coldest months of the year (June–July). Downpours are common from September to April, where a large amount of rain falls in a few minutes and generally this occurs when tropical air masses are dominant, and humidity is high. Light rains are common during the winter months, from May to August. In the Chaco, average annual rainfall is between 500 to 1,000 mm, but concentrated in the summer months, bringing floods to this typically dry region in winter.¹⁶

Analysis of data from the World Bank Group's Climate Change Knowledge Portal (CCKP) (**Table 2**) shows the latest historical climatology for the period between 1991–2019. Mean annual temperature for 24.7°C. Mean annual precipitation is 2,652.8 mm, with year-round rainfall; the lowest rainfall occurs during the winter months June to August (**Figure 3**).¹⁷ **Figure 4** presents the spatial variation of observed average annual precipitation and temperature.

TABLE 2. Data snapshot: Country-level summary statistics

Climate Variables	1991–2019
Mean Annual Temperature (°C)	24.7°C
Mean Annual Precipitation (mm)	2,652.8 mm
Mean Maximum Annual Temperature (°C)	29.3°C
Mean Minimum Annual Temperature (°C)	20.2°C

¹⁴ GERICS (2020). Climate-Fact Sheet: Paraguay. GERICS Climate Service Center. URL: https://www.climate-service-center.de/products_and_publications/fact_sheets/climate_fact_sheets/index.php.en

¹⁵ Paraguay (2012). Political Nacional de Cambio Climático de Paraguay. URL: <https://www.undp.org/content/dam/paraguay/docs/Politica%20Nacional%20CC.pdf>

¹⁶ FAO (2020). Analysis and Mapping of Impacts Under Climate Change for Adaptation and Food Security Project: Paraguay. URL: <http://www.fao.org/in-action/amicaf/en/>

¹⁷ WBG Climate Change Knowledge Portal (CCKP, 2020). Paraguay Historical Data. URL: <https://climateknowledgeportal.worldbank.org/country/paraguay/climate-data-historical>

FIGURE 3. Average monthly temperature and rainfall of Paraguay for 1991–2019¹⁸

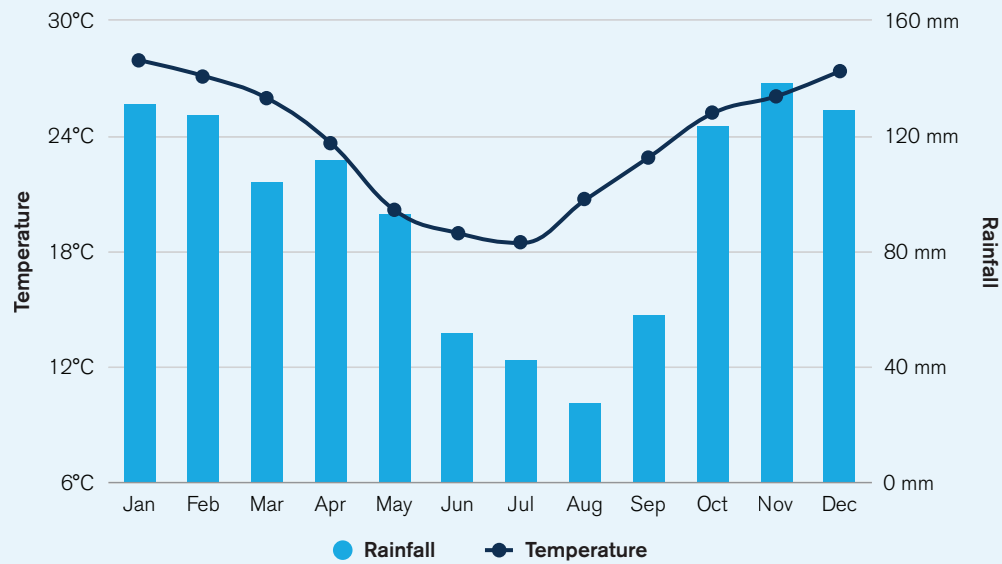
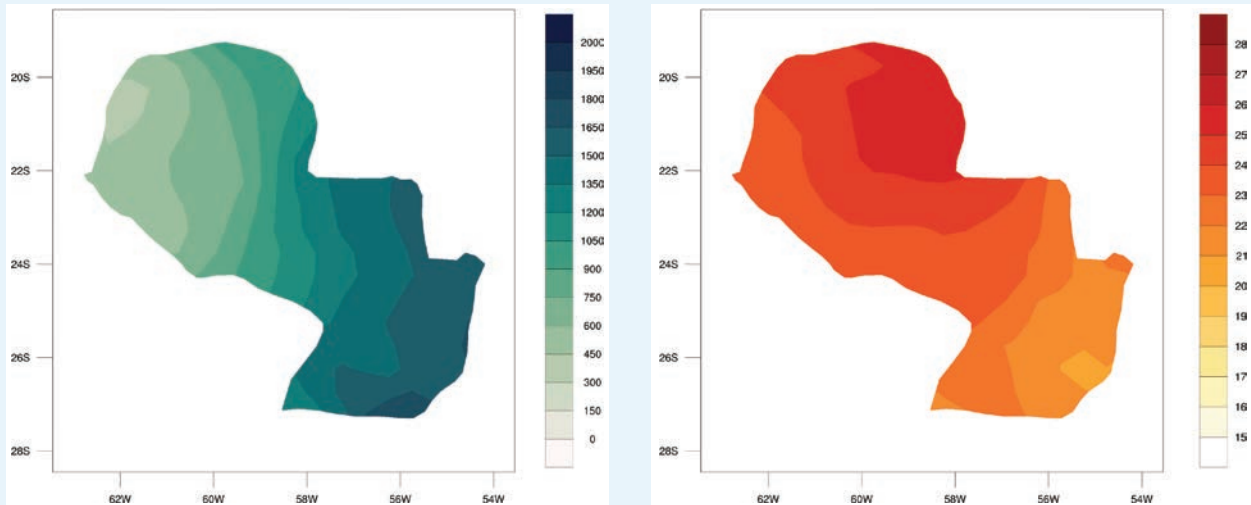


FIGURE 4. Map of average annual precipitation (left); annual temperature (right) for Paraguay, 1901–2019¹⁹



¹⁸ WBG Climate Change Knowledge Portal (CCKP, 2020). Paraguay Historical Data. URL: <https://climateknowledgeportal.worldbank.org/country/paraguay/climate-data-historical>

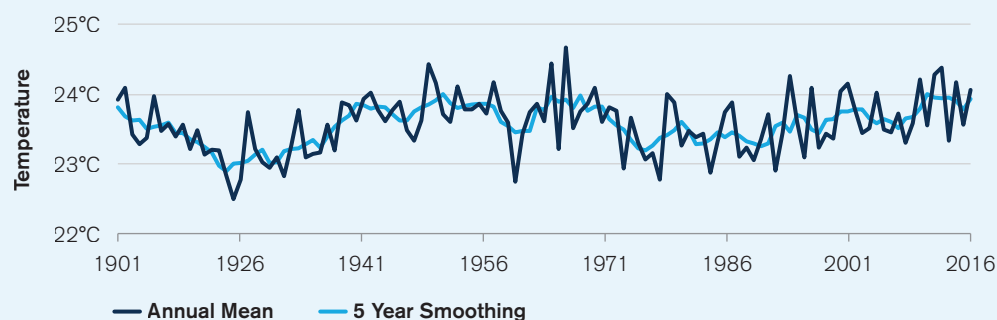
¹⁹ WBG Climate Change Knowledge Portal (CCKP, 2020). Paraguay Historical Data. URL: <https://climateknowledgeportal.worldbank.org/country/paraguay/climate-data-historical>

Key Trends

Temperature

Temperatures in Paraguay, particularly maximum temperatures, were observed to increase from 1960 to 2010 in both winter and summer months, with greater increases seen in summer months.²⁰ (Figure 5). Average maximum temperatures, likewise, have also increased. The number of warm nights²¹ have increased, while the number of cold nights²² have decreased.²³

FIGURE 5. Observed temperature for Paraguay, 1901–2019²⁴



Precipitation

Precipitation patterns exhibit a high degree of inter-annual variability in Paraguay. For example, annual rainfall in Asuncion can vary between 2,000 mm and 500 mm. An increase in total annual rainfall has been reported for the summer months of November to December, corresponding with ENSO (El Niño Southern Oscillation) events, which are also associated with floods. La Niña events bring droughts. All locations also point to an increase in the number of days receiving heavy rainfall.²⁵

²⁰ Paraguay (2016). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

²¹ "Warm: night is defined by the temperature exceeded on 10% of days or nights in current climate of region or season.

²² "Cold" night is defined by the temperature below which 10% of days or nights are recorded in current climate of that region or season.

²³ Paraguay (2016). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

²⁴ WB Climate Change Knowledge Portal (CCKP, 2020). Paraguay URL: <https://climateknowledgeportal.worldbank.org/country/paraguay/climate-data-historical>

²⁵ Paraguay (2019). Tendencias de la precipitación y temperature en Paraguay. URL: http://www.iea.usp.br/midiateca/apresentacao/sic2_julianbaez.pdf/at_download/file

Climate Future

Overview

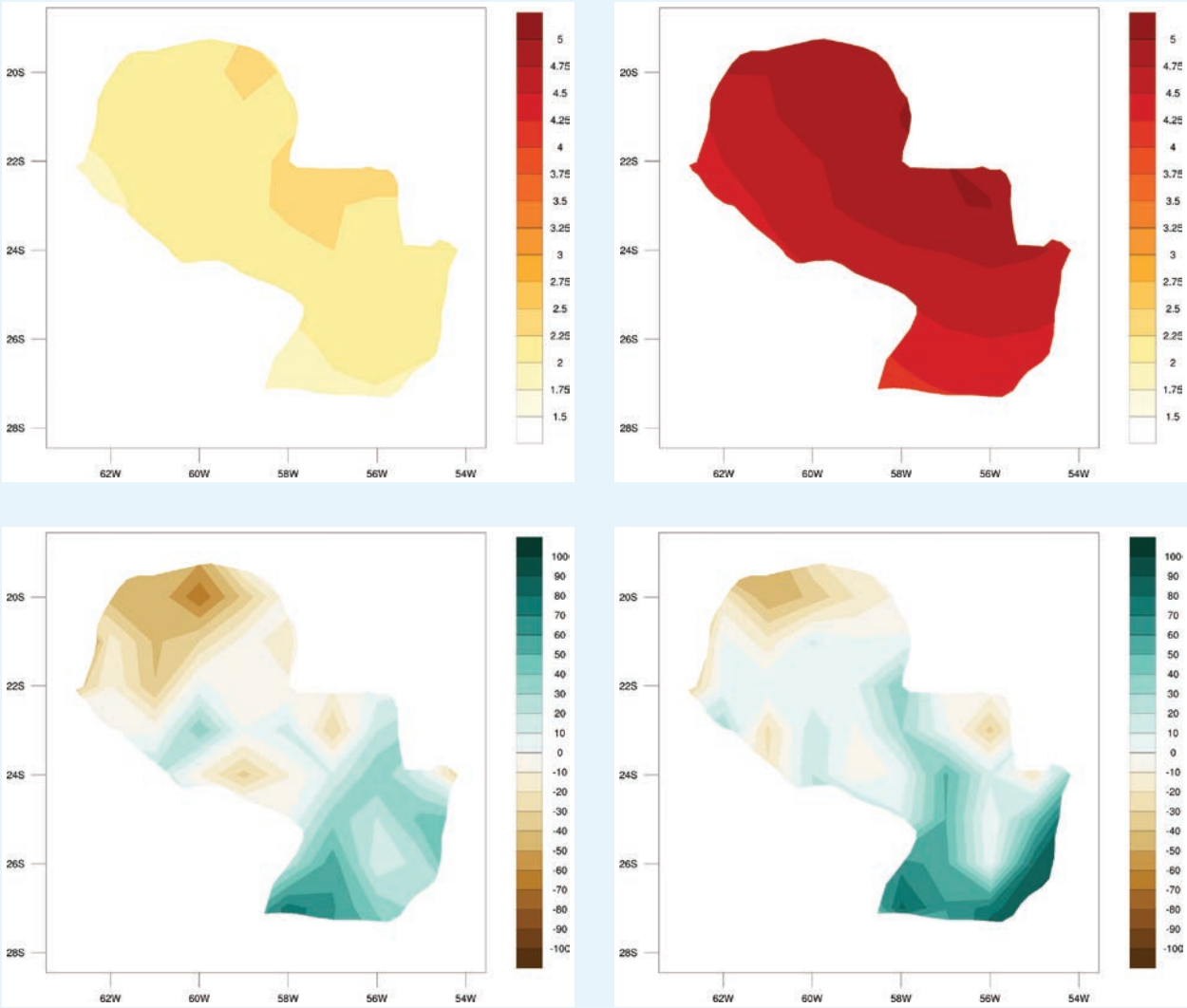
The main data source for the World Bank Group's Climate Change Knowledge Portal is the CMIP5 (Coupled Inter-comparison Project Phase 5) data ensemble, which builds the database for the global climate change projections presented in the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). Four Representative Concentration Pathways (i.e. RCP2.6, RCP4.5, RCP6.0, and RCP8.5) were selected and defined by their total radiative forcing (cumulative measure of GHG emissions from all sources) pathway and level by 2100. The RCP2.6 for example represents a very strong mitigation scenario, whereas the RCP8.5 assumes business-as-usual scenario. For more information, please refer to the [RCP Database](#). For simplification, these scenarios are referred to as a low (RCP2.6); a medium (RCP4.5) and a high (RCP8.5) emission scenario in this profile. **Table 3** provides CMIP5 projections for essential climate variables under high emission scenario (RCP 8.5) over 4 different time horizons. **Figure 6** presents the multi-model (CMIP5) ensemble of 32 Global Circulation Models (GCMs) showing the projected changes in annual precipitation and temperature for the periods 2040–2059 and 2080–2099.

TABLE 3. Data snapshot: CMIP5 ensemble projection

CMIP5 Ensemble Projection	2020–2039	2040–2059	2060–2079	2080–2099
Annual Temperature Anomaly (°C)	+0.3 to +2.1 (+1.2°C)	+0.7 to +3.2 (+2.1°C)	+1.3 to +5.0 (+3.2°C)	+1.7 to +6.6 (+4.3°C)
Annual Precipitation Anomaly (mm)	-17.3 to +20.5 (-0.2 mm)	-19.0 to +22.9 (1.0 mm)	-20.2 to +28.0 (1.4 mm)	-21.8 to +33.3 (4.3 mm)

Note: The table shows CMIP5 ensemble projection under RCP8.5. Bold value is the range (10th–90th Percentile) and values in parentheses show the median (or 50th Percentile).

FIGURE 6. CMIP5 multi-model ensemble projected change (32 GCMs) in annual temperature (top) and precipitation (bottom) by 2040–2059 (left) and by 2080–2099 (right), relative to 1986–2005 baseline under RCP8.5²⁶



²⁶ WBG Climate Change Knowledge Portal (CCKP, 2020). Paraguay Projected Future Climate. URL: <https://climateknowledgeportal.worldbank.org/country/paraguay/climate-data-projections>

Key Trends

Temperature

Temperatures across Paraguay are projected to continue rising, with mean monthly temperatures projected to rise by +2°C by the 2050s and by 4°C by the end of the century under a high-emissions scenario (RCP8.5). Rising temperatures are projected across all months. The highest temperature rise is projected for the northeast along the Paraguay river watershed. Rising temperatures will have significant implications for water resources management and hydroelectric power generation, as evaporation increases.²⁷ Of critical importance is the increase in the number of very hot days (where temperatures are above 35°C, which are projected to increase from approximately 24 to 113 days of the year by the end of the century.²⁸

Across all emissions scenarios, temperatures are projected to continue to rise in Paraguay, through the end of the century. As seen in **Figure 7**, under a high-emissions scenario (RCP8.5), average temperatures are projected to rise rapidly after the 2040s. High temperatures, analyzed in terms of the number of days above 25 degrees, are expected to rise significantly across the seasonal cycle, with the most pronounced changes occurring during May to August (**Figure 8**). Rising temperatures and extreme heat conditions will result in significant implications for human and animal health, agriculture, water resources, and ecosystems.

FIGURE 7. Historical and projected average temperature for Paraguay from 1986 to 2099²⁹

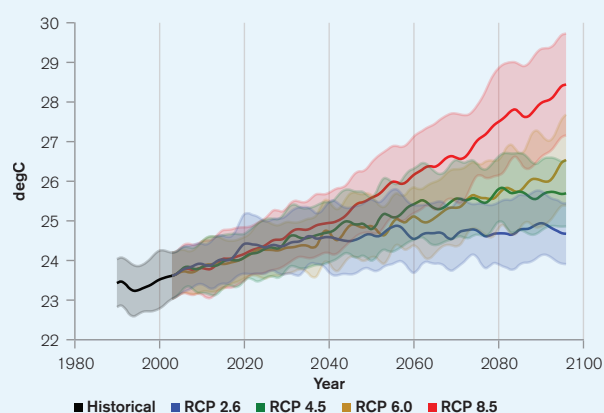
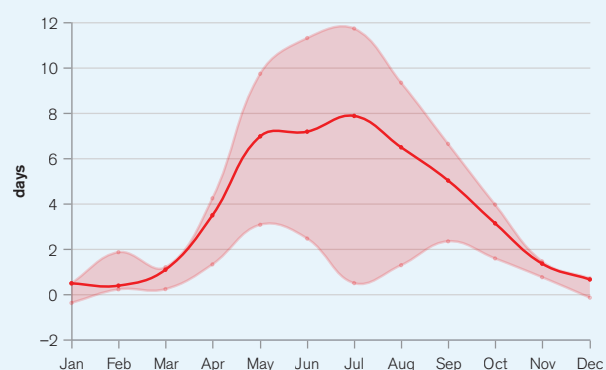


FIGURE 8. Projected change in summer days (Tmax > 25°C)³⁰



²⁷ Pezzoli, A. et al. (2016). Vulnerability and Resilience to drought in the Chaco, Paraguay. URL: https://iris.polito.it/retrieve/handle/11583/2654744/129731/Chapter%204_published_20161031.pdf

²⁸ Paraguay (2016). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

²⁹ WBG Climate Change Knowledge Portal (CCKP, 2020). Interactive Climate Indicator Dashboard - Transportation. URL <http://crme.rap.ucar.edu/CRMePortal/web/agriculture>

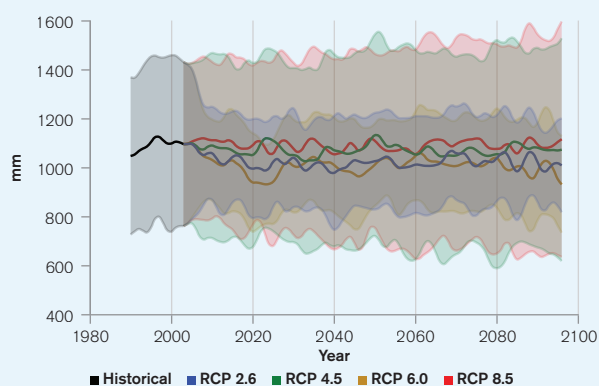
³⁰ WBG Climate Change Knowledge Portal (CCKP, 2020). Interactive Climate Indicator Dashboard - Agriculture: Paraguay URL <https://crme.rap.ucar.edu/CRMePortal/web/agriculture>

Precipitation

Rainfall in Paraguay is subject to significant interannual variability due to the El Niño Southern Oscillation, which brings floods and cooler weather, whereas La Niña episodes are associated with droughts and warmer weather in Paraguay. Average monthly precipitation in the austral winter months (June-August) are projected to increase significantly, particularly in the North, East and Southeast, while precipitation during the austral summer months is projected to either remain constant or slightly decrease in the northeastern regions.³¹

Additionally, the amount of rain (maximum 5-day rainfall totals) will see a slight increase across the 21st Century. As shown in **Figure 9**, there is significant uncertainty on the future of rainfall patterns for Paraguay³² with most scenarios pointing to an average projected increase in annual precipitation by the end of the century under a high emissions scenario for Paraguay as a whole (RCP8.5). However, projections point to significant regional variability.

FIGURE 9. Annual average precipitation in Paraguay for 1986 to 2099³³



CLIMATE RELATED NATURAL HAZARDS

Overview

Paraguay's diverse landscape is subject to the impacts of extreme events. The alluvial plains and hills where most of the country's population is concentrated, are subject to landslides and significant flooding due to increased surface run off from extreme rainfall on degraded forest and riparian ecosystems, which increase sediment loads.³⁴ Droughts are also common in the western zone, particularly during La Niña events and during the months of December through February, leading to water supply shortages for human, agriculture and livestock needs.³⁵ In Paraguay, intense droughts can significantly reduce hydroelectric outputs. Abnormal climatic conditions associated with the El Niño phenomenon can produce high temperatures and severe floods, particularly between the months

³¹ Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

³² CEPAL (2014). The economics of climate change in Paraguay. URL: https://repositorio.cepal.org/bitstream/handle/11362/37101/1/S1420018_es.pdf

³³ WBG Climate Change Knowledge Portal (CCKP, 2020). Climate Data-Projections. Paraguay. URL: <https://climateknowledgeportal.worldbank.org/country/paraguay/climate-data-projections>

³⁴ Paraguay (2016). Plan Nacional de Gestion de Riesgo de Desastres: 2015–2025. URL: <https://repositorio.gestiondelriesgo.gov.co/bitstream/handle/20.500.11762/756/PNGRD-2016.pdf?sequence=27&isAllowed=y>

³⁵ Ortigoza, J.G. (2019). Bases para la Estrategía Nacional de Sequía. URL: https://knowledge.unccd.int/sites/default/files/country_profile_documents/1%2520FINAL_NDP_Paraguay.pdf

of November and December, damaging agricultural output and threatening operations at the hydroelectric power projects which generate domestic energy supplies. Climate related disasters comprise most of the emergencies reported in the country and represent significant economic and human losses. The floods of the Paraguay River that occurred in March of 2019, for example, damaged 347 schools, forced 19,500 families to evacuate, affected another 69,534 families and killed 16 people.³⁶

Paraguay's Third National Communication (2017) prioritized five departments with respect to their vulnerability to climate driven disasters when combined with local socio-economic conditions: Very High Vulnerability (Index >3.5), Caazapá, and High Vulnerability, Concepción, Canindeyú, Caaguazú and Itapúa (Index 2.5–3.5).³⁷

Data from the Emergency Event Database: EM-Dat,³⁸ presented in **Table 4**, shows the country has endured various natural hazards, including droughts, floods, extreme temperatures, storms and wildfires.

TABLE 4. Natural Disasters in Paraguay, 1900–2020

Natural Hazard 1900–2020	Subtype	Events Count	Total Deaths	Total Affected	Total Damage ('000 USD)
Drought	Drought	9	16	1,791,290	
Epidemic	Viral Disease	9	97	244,326	
Flood	Riverine Flood	17	36	1,316,647	5,820
Extreme Temperature	Cold Wave	3	20		
Storm	Convective Storm	7	7	147,980	27,000
Wildfire	Forest Fire	2	8	125,000	30,000

Key Trends

As the climate changes, weather related disasters are likely to continue, exacerbating existing vulnerabilities in Paraguay. Rising temperatures and altered rainfall patterns, particularly more intense rainfall events will pose a significant challenge for water resource management and likely affect all sectors of society, especially the critical sectors of agriculture and livestock, as well as energy production. The most significant disasters for the country include droughts, extreme heat and floods, primarily riverine along the Paraguay river, and the Bermejo and Pilcomayo rivers in the Chaco. Urban flooding is also a problem and is a result of drainage systems overwhelmed by intense rainfall events (**Figure 10**). In 2019, for example, heavy rainfall flooded the Distrito Capital in Asuncion city, displacing at least 2,000 people.³⁹ Studies suggest that climate change could increase the frequency of occurrence and the intensity of these phenomena. As such, the country is working to understand, anticipate and

³⁶ ECHO (2019). Floods- Emergency Response Coordination Centre (ERCC). ReliefWeb: Paraguay. URL: <https://reliefweb.int/map/paraguay/paraguay-floods-emergency-response-coordination-centre-ercc-dg-echo-daily-map-17062019>

³⁷ Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

³⁸ EM-DAT: The Emergency Events Database - Universite catholique de Louvain (UCL) - CRED, D. Guha-Sapir, Brussels, Belgium. http://emdat.be/emdat_db/

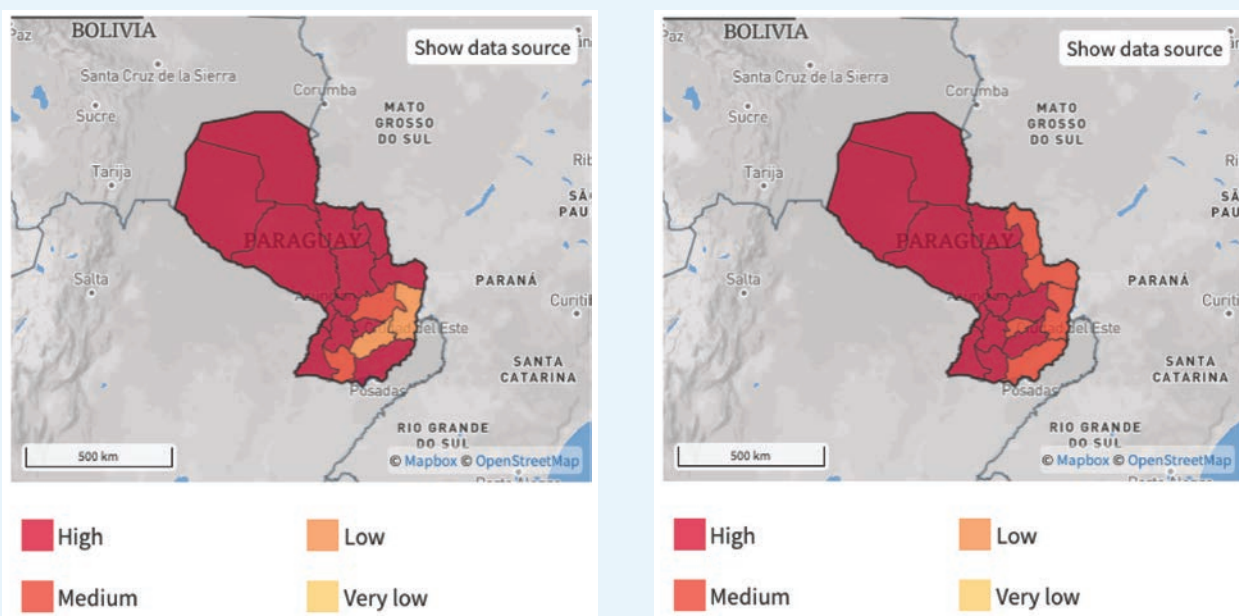
³⁹ ReliefWeb (2019). Paraguay Floods – March 2019. URL: <https://reliefweb.int/disaster/fl-2019-000033-pry>

take action to reduce their impacts. An increase in extreme rainfall events will likely continue to cause localized flooding events. Coupled with the effects of the El Niño Southern Oscillation phenomenon, both the frequency of floods and droughts will likely increase, increasing the risks for erosion and desertification.⁴⁰

The areas most affected by the La Niña phenomenon (which generates shortages of rainfall and drought) are those of the Central Chaco and the Pilcomayo River area, the districts of Irala Fernández and Mariscal Estigarribia. In general, the western regions are the most affected by droughts. For example, during the December 2010 to January and February 2011 quarter, the rainfall deficits in the northern Chaco brought about significant droughts.⁴¹

Extreme heat, resulting in heat stress, will continue across Paraguay and combined with high humidity levels, can affect the productivity of people and crop.⁴² As temperatures rise, these will likely (i) exacerbate existing tensions for water between agricultural and livestock needs as well as human populations needs, especially during the drier seasons; (ii) alter water quality from available surface sources; and (iii) increase pressures on urban zones as urbanization rates grow. Soy farmers and livestock producers are particularly vulnerable to the effects of climate change.

FIGURE 10. Risk of Urban Flood (left),⁴³ Risk of Extreme Heat (right)⁴⁴



⁴⁰ Ortigoza, J.G. (2019). Bases para la Estrategía Nacional de Sequía. URL: https://knowledge.unccd.int/sites/default/files/country_profile_documents/1%2520FINAL_NDP_Paraguay.pdf

⁴¹ Ortigoza, J.G. (2019). Bases para la Estrategía Nacional de Sequía. URL: https://knowledge.unccd.int/sites/default/files/country_profile_documents/1%2520FINAL_NDP_Paraguay.pdf

⁴² Paraguay (2016). Plan Nacional de Gestion de Riésigo de Desastres: 2015–2025. URL: <https://repositorio.gestiondelriesgo.gov.co/bitstream/handle/20.500.11762/756/PNGRD-2016.pdf?sequence=27&isAllowed=y>

⁴³ ThinkHazard! (2020). Paraguay – Urban Flood. URL: <https://thinkhazard.org/en/report/194-paraguay/UF>

⁴⁴ ThinkHazard! (2020). Paraguay – Extreme Heat URL: <https://thinkhazard.org/en/report/194-paraguay/EH>

Implications for DRM

Addressing these compounded risks will require a coordinated set of actions that begin with institutional strengthening to improve emergency response capabilities in urban areas to floods.⁴⁵ Additionally, local risk management with sub-basin groups and communities needs to be promoted. Improved knowledge of the local risks and profiles of vulnerability can help to identify critical hotspots for adaptation. Coordination, advocacy, and communication, particularly for transboundary water management is required in order to build resilience and reduce risks. With regards to the increased number and intensity of heat waves, measures should be taken to adapt building codes and design and change working practices for outdoor workers to reflect the realities of the changing risk.⁴⁶ The stress of urban heat islands can be reduced with architectural practices that promote wind flows across the city and green spaces. Identifying extreme heat and developing adequate forecasting systems can offer advance warning for at risk populations, such as the elderly, pregnant women and children. These early warning systems can be linked to trigger protocols (i.e. the deployment of heat health action plans and emergency response plans) to mitigate the impacts of heat waves.

CLIMATE CHANGE IMPACTS TO KEY SECTORS

Paraguay is highly vulnerable to seasonal variability and long-term climate change. Increasing vulnerability is expected to result in cumulative impacts across the country's political, security, social, economic, and environmental structures⁴⁷. Heavy rainfall and floods, as well as droughts in particular will continue to have significant consequences on the environment, society, food security, and the wider economy.⁴⁸ Significant impacts are expected for the country's water resources, agriculture, health, and energy sectors. Extreme heat, flooding, increased aridity, and soil erosion puts both urban and rural communities at risk, particularly for poor and vulnerable groups. Environmental degradation, impacted water resources, and loss of biodiversity and ecosystem services constitute serious obstacles to the country's continued development and responsible management of its natural resources. In addition, the increase in temperature will also have a negative impact on key parts of the economy, e.g. forestry, agriculture and livestock.

Projected trends of climate variability and longer-term change are likely to exacerbate these concerns, as most agricultural production is rainfed, and provides livelihoods for the majority of the population. Increased temperatures and variable rainfall will also impact the country's forests, also critical to livelihoods and ecosystem services, which are already under threat from land use change and growing demand for land as the soy frontier extends. More extreme weather events such as intense rainfall after prolonged dry spells can lead to erosion and flash flooding, damage roads and infrastructure, wipe out crops and put additional lives at risk.⁴⁹

⁴⁵ Paraguay (2016). Plan Nacional de Gestion de Riésigo de Desastres: 2015–2025. URL: <https://repositorio.gestiondelriesgo.gov.co/bitstream/handle/20.500.11762/756/PNGRD-2016.pdf?sequence=27&isAllowed=y>

⁴⁶ Paraguay (2016). Plan Nacional de Gestion de Riésigo de Desastres: 2015–2025. URL: <https://repositorio.gestiondelriesgo.gov.co/bitstream/handle/20.500.11762/756/PNGRD-2016.pdf?sequence=27&isAllowed=y>

⁴⁷ Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

⁴⁸ FAO (2013). Paraguay Country Profile. URL: <http://www.fao.org/3/a-bp554s.pdf>

⁴⁹ FAO (2020). Analysis and Mapping of Impacts Under Climate Change for Adaptation and Food Security Project: Paraguay. URL: <http://www.fao.org/in-action/amicaf/en/>

Gender

An increasing body of research has shown that climate-related disasters have impacted human populations in many areas including agricultural production, food security, water management and public health. The level of impacts and coping strategies of populations depends heavily on their socio-economic status, socio-cultural norms, access to resources, poverty as well as gender. Research has also provided more evidence that the effects are not gender neutral, as women and children are among the highest risk groups. Key factors that account for the differences between women's and men's vulnerability to climate change risks include: gender-based differences in time use; access to assets and credit, treatment by formal institutions, which can constrain women's opportunities, limited access to policy discussions and decision making, and a lack of sex-disaggregated data for policy change.⁵⁰

Agriculture

Overview

Agriculture accounts for more than 10% of Paraguay's GDP (2018),⁵¹ employs 27% of the country's workforce and constitutes 90% of registered exports.^{52,53} The majority (91%) of producers are small rural families (1–50 hectares [ha]), focused on beans, manioc, sugarcane, maize, tobacco and sesame. Nevertheless, these rural producers use only 6% of the total cultivated area in Paraguay. The other 94% of the cultivated areas in Paraguay are dedicated to larger farming enterprises, which specialize in soy, primarily for the export market and livestock production.⁵⁴ Farming in Paraguay is mainly rainfed although in recent years this situation is changing. Paraguay is among the world's five largest soy producers, occupying over 80% of agricultural lands. In some cases, corporate, owned soy farms have benefited from incentives, tax exemptions and greater access to credit, which has contributed to exacerbating tensions between small rural food producing farms and large enterprises.⁵⁵ The soy producing sector continues to expand rapidly, doubling in the last decade. The expansion and success of soy production in the country has benefited from the development of new soybean varieties as well as from the use of herbicides and fertilizers.^{56,57}

⁵⁰ World Bank Group (2016). Gender Equality, Poverty Reduction, and Inclusive Growth. URL: <http://documents1.worldbank.org/curated/en/820851467992505410/pdf/102114-REVISED-PUBLIC-WBG-Gender-Strategy.pdf>

⁵¹ World Bank (2020). Open Data: DataBank- Paraguay. URL: https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&gm=n&country=PRY

⁵² FAO (2013). Paraguay Country Profile. URL: <http://www.fao.org/3/a-bp554s.pdf>

⁵³ FAO (2017). Socio-economic context and role of agriculture. URL: <http://www.fao.org/3/a-i7752e.pdf>

⁵⁴ FAO (2013). Paraguay – Marco de Programacion Conjunta. URL: <http://www.fao.org/3/a-bp554s.pdf>

⁵⁵ WWF (2016). Social, Economic and Environmental Analysis of Soybean and Meat Production in Paraguay. URL: http://d2ouvy59p0dg6k.cloudfront.net/downloads/social__economic_and_environmental_analysis_of_soybean_and_meat_production_in_paraguay_1.pdf

⁵⁶ WWF (2016). Social, Economic and Environmental Analysis of Soybean and Meat Production in Paraguay. URL: http://d2ouvy59p0dg6k.cloudfront.net/downloads/social__economic_and_environmental_analysis_of_soybean_and_meat_production_in_paraguay_1.pdf

⁵⁷ WWF (2016). Social, Economic and Environmental Analysis of Soybean and Meat Production in Paraguay. URL: http://d2ouvy59p0dg6k.cloudfront.net/downloads/social__economic_and_environmental_analysis_of_soybean_and_meat_production_in_paraguay_1.pdf

Livestock production in Paraguay is extensive and benefits from the natural pastures of the country's landscape. Recently, livestock production has expanded rapidly and significantly into the forested regions of the central and northern Chaco. In the Chaco and southern regions of Misiones and Ñeembucú. While cattle raising is a historically traditional activity with only 0.3 head per hectare, the sector has modernized substantially with significant increases in stocking rates due in part to implemented grasses, advances in animal husbandry and more intensive ranching practices. The Paraguayan cattle herd totaled 13.8 million head in 2019, roughly 300,000 head more than the previous year, albeit the first increase since 2014. The industry is heavily focused on beef production for export to Chile, the Russian Federation, Taiwan and the European Union. Mennonite communities in the north western regions provide nearly half of the country's dairy products.⁵⁸

Climate Change Impacts

The agriculture and livestock sectors are among the most vulnerable in Paraguay due to their dependence on the natural environment and because they constitute one of the main economic activities of the country. The impacts on agricultural production arise from more extreme and more frequent rainfall events, and more frequent high temperatures and heat waves. Soy yields, for example, are likely to decrease as temperatures rise.⁵⁹ Furthermore, it is likely that the negative impacts of climate change due to increased temperature, droughts and floods will offset the potential gain in yield from increased CO₂ in the atmosphere, resulting in an overall decrease in soy yields in Paraguay. Extreme weather presents the largest risk factor for crop production, especially from droughts and floods. Projections for precipitation show a significant increase in rainfall from June to August, particularly in the northern, eastern and southern regions of the country. This is expected to impact agricultural regions, with heavy rainfall and flooding expected to impact key crops such as soy, affecting domestic markets and potentially forcing some farmers to need to source alternative food for livestock.⁶⁰

A 2020 study conducted by the Food and Agriculture Organization of the United Nations revealed significant heterogeneity in terms of the future impacts on crop yields at the department level due to climate change. In the case of upland rice, significant reductions in yields are projected in the departments of Itapúa and Canindeyú. Irrigated rice yields, on the other hand, are projected to increase in the departments of Cordillera and Misiones. Sugar cane yield projections point to widespread decreases, especially in the departments of Amambay, Caazapá, Caaguazú, Canindeyú and Concepción Departments under a low emissions scenario (RCP4.5), while future yields are projected to rise in the department of Paraguairí under high emissions scenario (the RCP8.5). Cassava yields are projected to increase under both emissions scenarios in the Departments of Alto Paraguay, Amambay, Canindeyú, Caazapá and Concepción, offering a view of a positive future for a crop central to small scale subsistence farming communities. Other crops included in the study, namely corn and wheat, showed no significant differences between historical and future modelled yields.⁶¹

⁵⁸ USDA (2019). GAIN Report: Paraguay Beef. URL: https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Livestock%20and%20Products%20Annual_Buenos%20Aires_Paraguay_8-16-2019.pdf

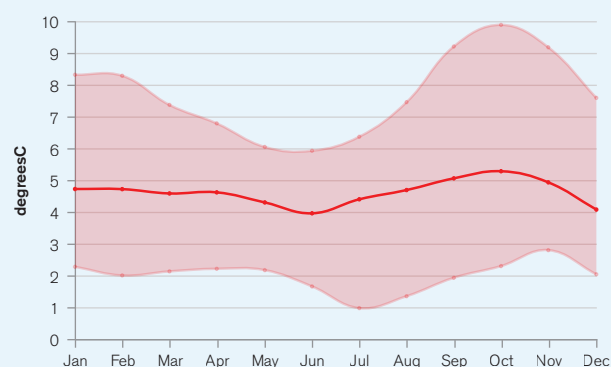
⁵⁹ Paraguay (2017). Tercera comunicación Nacional de la República de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

⁶⁰ FAO (2020). Analysis and Mapping of Impacts Under Climate Change for Adaptation and Food Security Project: Paraguay. URL: <http://www.fao.org/in-action/amicaf/en/>

⁶¹ WWF (2016). Social, Economic and Environmental Analysis of Soybean and Meat Production in Paraguay. URL: http://d2ouvy59p0dg6k.cloudfront.net/downloads/social_economic_and_environmental_analysis_of_soybean_and_meat_production_in_paraguay_1.pdf

The livestock industry, which occurs throughout the country but is concentrated in the western regions, is a key employment source for the country's population and accounts for approximately 6% of Paraguay's GDP. Droughts, frosts and high temperatures negatively affect productivity. For example, the National Service of Health and Environmental Quality (SENACSA) determined that in the year 2013 high temperatures (even as frosts continued to occur in other areas of the country) caused the loss of 5,216 cattle heads.⁶² Climate variability can also negatively impact pasture management, which is dependent on summer rains. Additionally, rising temperatures and more frequent heat waves can decrease carrying capacity (cattle per hectare) by 0.1361 units in the departments of Concepción, Caaguazú, Caazapá, Itapúa and Canindeyú. Rising temperatures, particularly daily maximum temperatures, pose an increased risk of heat stress for livestock and could significantly reduce critical crop yields for rural populations. Between 2005 and 2014, rising temperatures and heat waves are attributed to have caused the loss of 0.1361 livestock per hectare in the departments of Concepción, Caaguazú, Caazapá, Itapúa and Canindeyú.⁶³ Under present climate conditions, heat stress already poses challenges for heat dissipation in livestock populations, rendering them vulnerable to heat stress during certain periods of the year. Heat stress can reduce milk production and reproduction, particularly for cattle. As heat increases, so is the likelihood of altered growing seasons. **Figure 11** shows the projected change in average daily maximum temperatures for Paraguay across the seasonal cycle. What is clear is that higher temperatures are expected throughout the year.

FIGURE 11. Average daily max temperature for Paraguay⁶⁴



Adaptation Options

Adaptation strategies in the agricultural systems of Paraguay, particularly the highly profitable soy, cotton and sugarcane crops should be implemented to make productivity more resilient to both current and projected changes in climate.⁶⁵ The uncertainty associated with future climate is compounded by the fact that climate change is occurring on top of significant existing interannual variability in climate. One approach is to pair a package of locally relevant climate-smart agricultural practices with improved climate and weather information for decision-making.⁶⁶ This way, farmers can decide what will be the most effective adaptive strategy in a specific year given their local context and constraints. The provision of climate and weather information to farmers and other stakeholders within the value chain at decision-relevant timescales could safeguard agriculture and livestock

⁶² Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

⁶³ Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

⁶⁴ WBG Climate Change Knowledge Portal (CCKP, 2020). Paraguay Agriculture. Dashboard URL: <http://crme.rap.ucar.edu/CRMePortal/web/agriculture>

⁶⁵ Paraguay (2016). Contribuciones Nacionales de la Republica del Paraguay. URL: <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Paraguay%20First/Documento%20INDC%20Paraguay%2001-10-15.pdf>

⁶⁶ FAO (2020). Analysis and Mapping of Impacts Under Climate Change for Adaptation and Food Security Project: Paraguay. URL: <http://www.fao.org/in-action/amicaf/en/>

productivity.⁶⁷ To strengthen the country's capacity to adapt to climate change, investments should be focused on data collection, capacity development, national programming, and comprehensive research. Strategies include: dedicating necessary resources among the different ministries and institutions to update the basic data collection in the field and collect new data; building capacity and ensure the resources to strengthen the institutional and technical competences in terms of water management; strengthening national programs and plans such as National Plan for the Disaster Risk Management⁶⁸ to support small-scale family agriculture and rural extension offices; building synergies among universities, research centers and government organizations in order to implement lines of research that could include all dimensions of food security and promote adaptation to local conditions and climate change.⁶⁹

Water

Overview

Paraguay's extensive hydrographic network dominated by the Paraguay and Parana rivers makes the country technically water rich. Both surface waters and water extraction, especially from the Patiño aquifer are used, particularly across the major cities of Asunción, Fernando de la Mora, San Lorenzo, Capiatá, Itauguá, Ypacaraí, Limpio, Luque, Villa Elisa, Ñemby, San Antonio, Ypané and Guarambaré. Nevertheless, reliance on the Patiño aquifer is challenging, as an estimated 50% of the recharge is contaminated. Wells are used extensively across the country for water provision. Nevertheless, surface waters remain the predominant source for the country and their critical source springs, wetlands and associated territories face continual pressures from inadequate resource management including deforestation, increased sedimentation and contamination from agrochemicals.^{70,71} Water availability and quality is important both for human consumption and for agricultural use. Currently, over 75% of the Paraguayan population has access to piped water, while only 15% has access to sanitation. Despite abundant water resources, access to potable water varies significantly. For example, in the departments of Concepción, Caaguazú, Caazapá, Itapúa, and Canindeyú, 475,345 people have access to improved drinking water, representing approximately 29% of the population of these departments. There are also differences on access to water services between urban (87%) and rural areas (58%). In the hot and dry Chaco region, surface water sources are limited during the dry periods and underground resources are often saline. Rainwater harvesting is common, though rainfall amounts of approximately 400 mm per year, it is insufficient to meet demands. The competing demands of water for human consumption, livestock rearing, and agriculture pose a significant challenge for water resources management across Paraguay, but especially in the Chaco, in spite of the new aqueduct system that was recently built.⁷²

⁶⁷ Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

⁶⁸ Paraguay (2018). Plan Nacional de Gestion y Reducción de Riesgos (2018). URL: https://www.sen.gov.py/application/files/8015/9188/4586/Politica_Nacional_de_Gestion_y_Reduccin_de_Riesgos_2018.pdf

⁶⁹ FAO (2020). Analysis and Mapping of Impacts Under Climate Change for Adaptation and Food Security Project: Paraguay. URL: <http://www.fao.org/in-action/amicaf/en/>

⁷⁰ Secretaría Técnica de Planificación - Dirección General de Estadística, Encuestas y Censos (DGEEC) (2012). URL: <https://www.dgeec.gov.py/>

⁷¹ Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

⁷² Género y agua: la experiencia de l inclusión del enfoque de género en los proyectos de agua potable y saneamiento en Paraguay (2020). Documento para Discusión Nro IDB-00756. URL: https://publications.iadb.org/publications/spanish/document/G%C3%A9nero_y_agua-La_experiencia_de_la_inclusi%C3%B3n_del_enfoque_de_g%C3%A9nero_en_los_proyectos_de_agua_potable_y_saneamiento_en_Paraguay.pdf

Climate Change Impacts

Altered rainfall patterns will inevitably impact water resource availability across Paraguay. Although projected increases in rainfall will likely increase river flows. Nevertheless, the potential gains from these rising flows are likely to be offset significantly by the loss of forests, increased siltation, and pollution, particularly from agrochemicals. Flows of the Paraná and Paraguay rivers will be altered as temperatures rise as well as changes in run off from critical source streams.⁷³ A compounding challenge is that 90% of the Parana's basin is in Brazilian territory, subject to changes in land use practices outside of the country. Nevertheless, the future of water resources in the country under a changing climate remains uncertain, except for in Paraguay's northern and central Chaco regions, where flows are projected to reduce significantly by a combined change in rainfall and rising temperatures. Floods, particularly in areas with limited sanitation, can pollute water courses, carrying away human waste and exposing the population to disease transmitting vectors and water borne illnesses such as diarrhea.⁷⁴ Paraguay has worked to improve sanitation services and access, however while 80% of populations in urban areas are served by network water connections, only 15% of urban residents have access to network sewage connections as of 2019. In contrast, just 44% of rural populations have access to network water connections and with extremely limited basic sanitation services available for rural communities.⁷⁵

In general, the Western Region, with ephemeral water resources, is the most affected by droughts brought about by the La Niña phenomenon (which brings drought conditions). This includes the Central Chaco and the Pilcomayo River area, the districts of Irala Fernández and Mariscal Estigarribia. During the December 2010 - January and February 2011 quarter, the center and north of the Chaco were influenced by rainfall deficits from La Niña.⁷⁶ The country is currently undergoing a severe drought, which is projected to continue through at least February 2021. Water deficits for the Paraguay River as especially dire, impacting river activities and water usage in Paraguay as well as neighbors which also rely on the river's resources. Deficits are most pronounced in central and eastern Paraguay as well as into much of northern Argentina.⁷⁷

Paraguay's Third National Communication established a water scarcity index that incorporated population as well as livestock and agriculture needs, as well as those of industry, and identifies the most vulnerable departments across all emissions scenarios for the near future (2021–2030) to be: Alto Paraguay, and Boquerón, while the Departments of Presidente Hayes, Ñeembucú, Concepción in addition to Alto Paraguay will face increasing water scarcity through the 2050s.⁷⁸ Likewise, a basin analysis pointed to the Rio Apa basin is likely to be most affected by projected changes in rainfall and temperatures.⁷⁹

⁷³ Paraguay (2018). Plan Nacional de Gestión y Reducción de Riesgos (2018). URL: https://www.sen.gov.py/application/files/8015/9188/4586/Politica_Nacional_De_Gestion_y_Reducion_de_Riesgos_2018.pdf

⁷⁴ Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

⁷⁵ World Bank (2019). Addressing Challenges in Water, Road and Energy Infrastructure in Paraguay – Results Briefs. [October 16, 2019]. URL: <https://www.worldbank.org/en/results/2019/10/16/addressing-challenges-in-water-road-and-energy-infrastructure-in-paraguay>

⁷⁶ Pezçoli, P.E. (2016). Vulnerability and resilience to drought in the Chaco, Paraguay. URL: https://iris.polito.it/retrieve/handle/11583/2654744/129731/Chapter%204_published_20161031.pdf

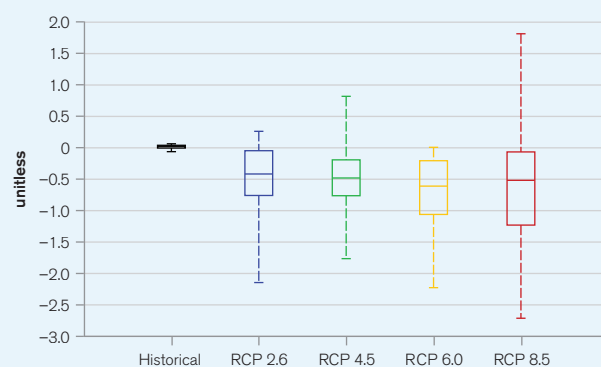
⁷⁷ iSciences (2020). South America: Intense water deficits on the Paraguay River. [June 19, 2020]. URL: <https://www.isciences.com/blog/2020/06/15/south-america-intense-water-deficits-on-the-paraguay-river>

⁷⁸ Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

⁷⁹ Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

Figure 12 shows the projected annual Standardized Precipitation Evapotranspiration Index (SPEI), an index which represents the measure of the given water deficit in a specific location, accounting for contributions of temperature-dependent evapotranspiration and providing insight into increasing or decreasing pressure on water resources. Negative values for SPEI represent dry conditions, with values below -2 indicating severe drought conditions, likewise positive values indicate increased wet conditions. This is an important understanding for the water sector in regards to quantity and quality of supply for human consumption and agriculture use as well as for the energy sector as reductions in water availability impacts river flow and the hydropower generating capabilities.

FIGURE 12. Annual SPEI Drought Index in Paraguay for the period, 1986 to 2099⁸⁰



Adaptation Options

Even though the potential impacts of climate change on water resources for Paraguay will likely be limited, the multiple pressures on the resource from increased deforestation, poor territorial planning as well as livestock and agricultural expansion, already places significant pressures on the quality and quantity of the available resources. Paraguay is committed to increase water resource assess and promote the safeguard access to water for human consumption and production. To guarantee the access, quality and sustainable management of water resources. Increased sediment loads, contamination and inadequate protection of critical streams and wetlands is rampant, already compromising water quality and limits flows during the dry season. Additionally, the basin of the Pilcomayo river suffers from significant variability, as the river meanders in a braided network between Argentine and Paraguayan territories, bring either floods or droughts with its flows, all subject to more variable rainfall patterns.⁸¹ International cooperation and water allocation planning can safeguard the available resources for all populations. Protection or reforestation of riparian habitats can reduce soil erosion and sediment loads. When combined with integrated basin management planning, the population and land use pressures can be managed so as to improve water quality and availability. Paraguay continues to be committed to improving sanitation infrastructure and clean water access. The Water and Sanitation Sector Modernization Project has so far rehabilitated 57 km of water distribution networks and 8.4 km of sanitation networks in Great Asuncion.⁸² National efforts are also focused on the decentralization of the National Environmental Sanitation Services and have developed actions plans to support Water and Sanitation Units in the municipalities in Chaco in support of long-term technical, institutional and financial support to communities.⁸³

⁸⁰ WBG Climate Change Knowledge Portal (CCKP, 2020). Paraguay Agriculture Sector Dashboard. URL: <https://climatedata.worldbank.org/CRMePortal/web/agriculture/crops-and-land-management?country=PAR&period=2080-2099>

⁸¹ Paraguay (2016). Contribuciones Nacionales de la Republica del Paraguay. URL: <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Paraguay%20First/Documento%20INDC%20Paraguay%2001-10-15.pdf>

⁸² World Bank (2020). Drawing the Roadmap for Universal Sustainable Water and Sanitation in Paraguay – Results Brief. [March 9, 2020]. URL: <https://www.worldbank.org/en/results/2020/05/05/drawing-the-roadmap-for-universal-sustainable-water-and-sanitation-in-paraguay>

⁸³ World Bank (2019). Addressing Challenges in Water, Road and Energy Infrastructure in Paraguay – Results Briefs. [October 16, 2019]. URL: <https://www.worldbank.org/en/results/2019/10/16/addressing-challenges-in-water-road-and-energy-infrastructure-in-paraguay>

Energy

Overview

Paraguay's energy sector is exclusively water-powered, which could exacerbate the vulnerability of the country to reduced flows.⁸⁴ The large Itaipú dam, which Paraguay shares with Brazil, accounts for over 90% of the country's electrical supply. Surplus electricity is sold to Brazil and Argentina and contribute significantly (~7%) of GDP. According to the Latin American Energy Organization (OLADE) Paraguay is the only country in Latin America whose energy consumption is entirely based on renewable energies.⁸⁵ Paraguay is a net exporter of hydropower and a net importer of hydrocarbons for transport and industry. National demand is met through three hydroelectric plants: Central Acaray (property of Paraguay), Yacyretá (shared with Argentina) and, mainly, Itaipú (shared with Brazil). Energy distribution and transmission is managed by the National Electricity Agency (ANDE). Itaipu is a world leader in the production of clean and renewable energy; producing more than 2.3 thousand million megawatts (MW) since the beginning of its operation, in 1984. With 20 generating units and 14,000 MW of the installed power, provides about 15% of the energy consumed in Brazil and 75% of that used in Paraguay. Nevertheless, with a limited distribution network, at local scales, energy consumption is dominated by traditional biomass: carbon or wood (50%) hydrocarbons (36%) and electricity (14%).⁸⁶ In urban areas with electrical service, quality, as measured by service interruptions, is good, although losses in transmission and leaks in the distribution system are a concern. Nevertheless, given the high reliance on hydro power, the droughts brought by phenomena such as La Niña could affect the country's energy sustainability. Paraguay's National Development Plan (2014–2030),⁸⁷ aims to diversify the country's energy resources and ensure a reliable energy supply by diversifying the energy mix to biomass, wind, and solar photovoltaic energy generation. In 2018, Paraguay received a USD\$125 million loan from the Inter-American Development Bank to modernize Acaray, one of its largest hydropower plants, however investments in smaller scale, alternative renewable energies has been limited. While the country has looked to diversifying its mix of renewable energy generation, investment regulations and legislation has hindered widespread investment and uptake. The 2040 Energy Policy was developed to help guide the further energy development in line with the country's social and economic development efforts.⁸⁸

Climate Change Impacts

Altered rainfall patterns will inevitably impact water resource availability across Paraguay. Gradual alterations in precipitation patterns, especially lower average precipitation will also affect the resource base of hydropower by leading to declining runoff and reduced river flows, which in turn affect the volume and timing of water availability. For example, the 2014 droughts and the reduced flows on the Parana river, linked to a La Niña episode reduced output of Itaipú dam by 8.7%.⁸⁹ Additionally, higher temperatures, through evaporation, can significantly reduce water available from reservoirs. Additionally, floods resulting from heavy rains can damage critical energy infrastructure. Runoff levels

⁸⁴ Secretaría del Ambiente Dirección Nacional de Cambio Climático (2018). Guía para la Elaboración de Planes Sectoriales de Adaptación Ante el Cambio Climático, Paraguay. URL: <http://dncc.mades.gov.py/wp-content/uploads/2018/08/Gu%C3%ADa-para-planos-sectoriales-de-adaptaci%C3%B3n-al-cambio-clim%C3%A1tico.pdf>

⁸⁵ OLADE (2018). Panorama Energético de America Latina y El Caribe (2019). URL: <http://biblioteca.olade.org/opac-tmpl/Documentos/old0434b.pdf>

⁸⁶ IHA (2019). HYDROPOWER: Paraguay. URL: <https://www.hydropower.org/country-profiles/paraguay>

⁸⁷ Paraguay (2014). Plan Nacional de Desarrollo 2030. URL: <https://www.stp.gov.py/pnd/wp-content/uploads/2014/12/pnd2030.pdf>

⁸⁸ IHA (2019). 2019 Hydropower Status Report – Paraguay. URL: https://www.hydropower.org/sites/default/files/publications-docs/2020_hydropower_status_report.pdf

⁸⁹ Paraguay (2018). Plan Nacional de Gestión y Reducción de Riesgos (2018). URL: https://www.sen.gov.py/application/files/8015/9188/4586/Politica_Nacional_de_Gestion_y_Reducion_de_Riesgos_2018.pdf

are expected to rise in many parts of the country, negatively impacting energy infrastructure along riparian areas via floods and landslides, and the increasing the occurrence of natural disasters such as droughts.⁹⁰

Vulnerability analyses conducted in Paraguay's Third National Communication combined three indicators to estimate the level of vulnerability at the departmental level to climate induced risks: 1) percentage of road infrastructure 2) efficiency of the population's agriculture, livestock and tourism infrastructure living on the banks of rivers, 2) availability of water. Nevertheless, only in the 2014 droughts did power generation suffer significantly from reduced flows.⁹¹

Cooling Degree Days show the relationship between daily heat and cooling demand, typically sourced through a form of active cooling or an evaporative process. The change in cooling degree days provides insight into the potential for extended seasons of power demand or periods in which cooling demand (power demands) will increase. As seen in **Figure 13**, seasonal increases for cooling demands are expected to increase throughout the year. The Warm Spell Duration Index represents the number of days in a sequence of at least six days in which the daily maximum temperature is greater than the 90th percentile of daily maximum temperature. As shown in **Figure 14**, warm spells are expected to sharply increase in the second half of the century.

FIGURE 13. Change in cooling degree days (65°F) in Paraguay for the period 2040–2059⁹²

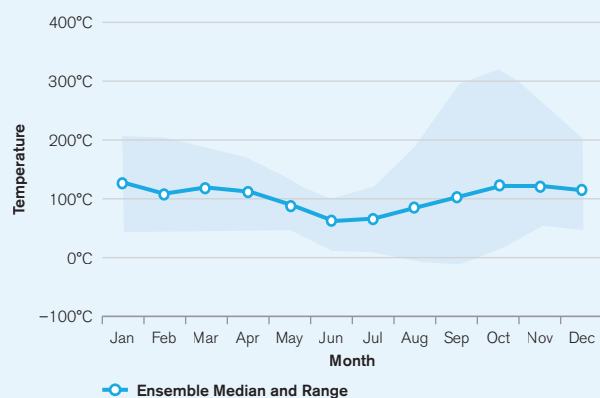
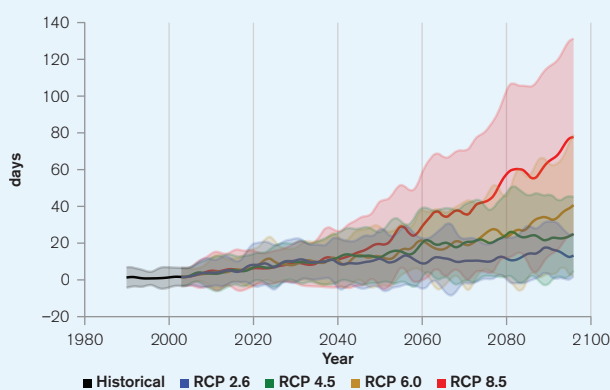


FIGURE 14. Warm Spell Duration Index in Paraguay for the period 1986 to 2099⁹³



Adaptation Options

Adaptation options for the energy sector should focus on improved water resource management under changing conditions. Additional investments may need to be made in building more storage capacity, improving turbine efficiencies or other engineering measures to reduce transmission losses.⁹⁴ Integrated water use management will be required as competing demands for water beginning to come into play through increased demand for water

⁹⁰ IHA (2019). HYDROPOWER: Paraguay. URL: <https://www.hydropower.org/country-profiles/paraguay>

⁹¹ Paraguay (2014). Plan Nacional de Desarrollo 2030. URL: <https://www.stp.gov.py/pnd/wp-content/uploads/2014/12/pnd2030.pdf>

⁹² WBG Climate Change Knowledge Portal (CCKP, 2020). Paraguay – Energy. URL: <https://climateknowledgeportal.worldbank.org/country/Paraguay/climate-sector-energy>

⁹³ WBG Climate Change Knowledge Portal (CCKP, 2020). Paraguay Energy Sector Dashboard. URL: <https://climatedata.worldbank.org/CRMePortal/web/energy/oil-gas-and-coal-mining?country=PAR&period=2080-2099>

⁹⁴ Paraguay (2014). Plan Nacional de Desarrollo 2030. URL: <https://www.stp.gov.py/pnd/wp-content/uploads/2014/12/pnd2030.pdf>

for other uses such as irrigation and urban demands. Paraguay has committed to incorporate climate change management into public and private decisions to advance in a climate-resilient and low-carbon development path that reduces the risks of climate change and allows opportunities to be seized.⁹⁵ Adaptation options emphasized with respect to the energy sector include the promotion of integrated water resources management, including educating the public on the impacts of climate change on energy supplies and implementing behavioral techniques to increase energy use efficiency in tandem with water conservation. Small hydroelectric plants could provide alternative power supply to sites away from load centers and increase electricity use in rural households, however, studies need to be conducted to determine the hydraulic potential of Paraguay's inland rivers.⁹⁶

Health

Overview

The human health sector is considered one of the most vulnerable to climate variability and change in Paraguay.⁹⁷ While Paraguay is a middle-income country, it still faces one of the highest inequality rates in the world, making the health of the country's population vulnerable to climate change impacts. The climate change projections point to continued rising temperatures, more frequent intense rainfall events and other extreme weather events. Impacts are expected for food and water security, water quality human settlements, infrastructure and ecosystems, as well as health, the latter particularly through increasing heat stress, the altered range, seasonality and distribution of vector-borne diseases including malaria, zika, chikungunya, as well as water-borne illnesses such as cholera and diarrheal disease.⁹⁸ Poor environmental practices such as inadequate waste management and cultural practices the expansion of dengue fever across the country.⁹⁹ The same is true for other vector borne illnesses transmitted by the *Aedes Aegypti* mosquito such as zika and chikungunya.¹⁰⁰ Further, acute heat stress is already a growing cause of stress for vulnerable populations, especially the elderly and pregnant women and children. Ambient air pollution in the country, caused by wildfires during dry seasons, burning due to land clearing, commercial industries, as well as indoor air pollution from biomass burning for cooking in rural areas,¹⁰¹ significantly affects the health of infants and children.¹⁰²

Climate Change Impacts

Climate change projections point to continued rising temperatures, more variable rainfall, rising seas and more frequent extreme weather events. Impacts from climate variability and change affecting the health sector include changes to food and water security, heat stress, the altered range and distribution of vector borne illnesses (i.e. zika,

⁹⁵ Paraguay (2016). Contribuciones Nacionales de la Republica del Paraguay. URL: <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Paraguay%20First/Documento%20INDC%20Paraguay%2001-10-15.pdf>

⁹⁶ Paraguay (2016). Paraguay Plan Nacional de Adaptación al Cambio Climático (PNACCC) URL: https://www4.unfccc.int/sites/NAPC/Documents/Parties/Plan%20Nacional%20de%20Adaptaci%C3%B3n%20al%20Cambio%20Clim%C3%A1tico_Paraguay_final.pdf

⁹⁷ Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

⁹⁸ WHO (2018). Climate change and health. URL: <https://www.who.int/es/news-room/fact-sheets/detail/climate-change-and-health>

⁹⁹ ReliefWeb (2020). Paraguay Dengue outbreak, DREF operation. URL: <https://reliefweb.int/report/paraguay/paraguay-dengue-outbreak-dref-operation-n-mdrpy021-update-n-1>

¹⁰⁰ IAMAT (2020). Paraguay Health Risks. URL: <https://www.iamat.org/country/paraguay/risk/dengue>

¹⁰¹ PAHO (2016). Household Air Pollution – Paraguay Country Profile. URL: <https://www.paho.org/en/documents/household-air-pollution-paraguay-country-profile>

¹⁰² Climate & Clear Air Coalition (2020). CCAC Activities – Paraguay. URL: <https://www.ccacoalition.org/en/partners/paraguay>

chickungunya) as well as water borne diseases that proliferate from poor sanitation infrastructure during floods, like cholera and diarrheal diseases are expected in food and water security, human settlements, infrastructure and ecosystems, as well as health, the latter particularly through increasing heat stress, the altered range, seasonality and distribution of vector-borne diseases including malaria, zika, chikungunya, as well as air pollution and associated respiratory illnesses, as well as water-borne illnesses such as cholera and diarrheal disease.¹⁰³ In 2019, for example, a significant increase in dengue cases was reported in Paraguay. According to the Pan-American Health Organization's (PAHO) report for Epidemiology Week No. 7 (EW7 until February 15), dengue cases increased to 106,127 suspected cases, 20,837 new cases (EW7) and 20 people who died from the disease. These figures surpassed the security ranges and epidemiological trends of past years, with the cases drastically increasing in the first seven weeks of 2020. On February 18, the Government of Paraguay declared a State of Health Emergency throughout the country in response to the dengue epidemic for 90 days.¹⁰⁴

Extreme heat and heat waves affect the body's temperature-regulating mechanisms of sweating and breathing. As the body struggles to compensate for higher ambient temperature, it pushes the regulatory mechanisms, such as heart rate and function, harder to release internal heat. In highly humid environments such as those in Paraguay, excess temperatures can lead to dehydration and chemical imbalances that increase risk for heat-related illnesses. In Paraguay, the annual distribution of days with a high-heat index provides insight into the health hazard of heat. **Figure 15** shows the expected Change in Number of Heat Days to 2080–2099; showing a sharp increase. Nighttime temperatures are also increasing for the country resulting in decreased opportunity for natural cooling. Increased health threats can be projected and monitored through the frequency of tropical nights (>20°C) (**Figure 16**), which shows the projected increase in tropical nights for different emission scenarios (CMIP5 ensemble) to demonstrate the difference in expected numbers of tropical nights.

FIGURE 15. Days with a Heat Index >35°C¹⁰⁵

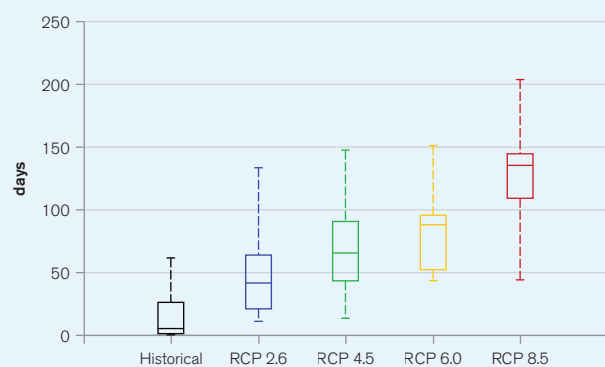
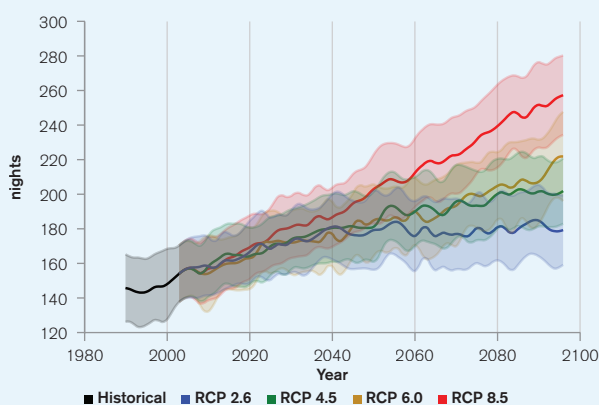


FIGURE 16. Number of Tropical Nights (Tmin >20°C)¹⁰⁶



¹⁰³ WHO (2018). Climate change and health. URL: <https://www.who.int/es/news-room/fact-sheets/detail/climate-change-and-health>

¹⁰⁴ ReliefWeb (2019). Central and Latin America: Dengue Outbreak – June 2019. URL: <https://reliefweb.int/disaster/ep-2019-000072-hnd>

¹⁰⁵ WBG Climate Change Knowledge Portal (CCKP, 2020). Paraguay Health Sector Dashboard. URL: <https://climatedata.worldbank.org/CRMePortal/web/health/systems-and-service?country=PAR&period=2080-2099>

¹⁰⁶ WBG Climate Change Knowledge Portal (CCKP, 2020). Paraguay Health Sector. URL: <https://climateknowledgeportal.worldbank.org/country/Paraguay/climate-sector-health>

Adaptation Options

Adaptation measures and actions in the health sector include: strengthening institutional capacities to address climate sensitive health outcomes at national and local levels; promoting research on the relationship between key diseases and climate variability and change; improving the health information system (epidemiological surveillance) and response plans for the prevention, control and treatment of climate sensitive diseases; investing in improved basic sanitation (drinking water, effluent treatment, waste collection); building additional infrastructure and capacity in health systems access; and developing early warning systems for climate sensitive illnesses.¹⁰⁷ The magnitude of the challenges with heat-related mortality will increase in a warming climate. This elevates the importance of investing in heat wave early warning and response systems and in other interventions (e.g., green space to reduce UHIs) to protect human health, which Paraguay currently does not have established.¹⁰⁸

ADAPTATION

Institutional Framework for Adaptation

Paraguay's National Climate Change Policy (2018) outlines the framework for adaptation and mitigation activities in the country.¹⁰⁹ The country's National System of the Environment (Sistema Nacional del Ambiente – SISAM) and the Environmental Secretary (Secretaría del Ambiente – SEAM) coordinate the national climate change response. SISAM includes several departmental and municipal entities that are tasked with addressing environmental issues in Paraguay and has a special role in coordinating so as to avoid overlap and inter-institutional conflicts. The National Climate Change Program (PNCC in Spanish), led by the Environment Secretary, coordinates actions on the ground through: The National Commission on Climate Change (CNCC), an interinstitutional working group and the National Office of Climate Change (Oficina Nacional de Cambio Climático – ONCC).¹¹⁰

Policy Framework for Adaptation

Paraguay's National Development Plan (PND) was designed to respond to the economic and social challenges of the country for the period 2014–2030.¹¹¹ The National Development Plan is organized around three pillars (i) poverty reduction and social development; (ii) inclusive economic growth; and (iii) promoting international

¹⁰⁷ Paraguay (2016). Contribuciones Nacionales de la República del Paraguay. URL: <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Paraguay%20First/Documento%20INDC%20Paraguay%2001-10-15.pdf>

¹⁰⁸ Secretaría del Ambiente Dirección Nacional de Cambio Climático (2018). Guía para la Elaboración de Planes Sectoriales de Adaptación Ante el Cambio Climático, Paraguay. URL: <http://dncc.mades.gov.py/wp-content/uploads/2018/08/Gu%C3%ADa-para-planos-sectoriales-de-adaptaci%C3%B3n-al-cambio-clim%C3%A1tico.pdf>

¹⁰⁹ Paraguay (2018). Política Nacional de Cambio Climático de Paraguay. URL: <https://www.undp.org/content/dam/paraguay/docs/Politica%20Nacional%20CC.pdf>

¹¹⁰ Paraguay (2016). Paraguay Plan Nacional de Adaptación al Cambio Climático (PNACCC) URL: https://www4.unfccc.int/sites/NAPC/Documents/Parties/Plan%20Nacional%20de%20Adaptaci%C3%B3n%20al%20Cambio%20Clim%C3%A1tico_Paraguay_final.pdf

¹¹¹ DNCC (2018). Políticas Públicas de Cambio Climático. URL: <http://dncc.mades.gov.py/politicas-publicas-de-cambio-climatico>

markets. It is also supported by a medium-term economic plan that provides for sustainable fiscal policies and promotes more effective social protection policies. Paraguay's national frameworks and plans regarding climate change reflects a desire to reduce the adverse effects of climate variability and change.¹¹²

Paraguay submitted its Third National Communication to the UNFCCC in 2018 and its Nationally Determined Contributions in 2016. Paraguay is committed to integrating climate change into its development plans and strategies, strategies outlined in the country's National Climate Change Adaptation Plan of 2018.¹¹³ To reach its adaptation goals, Paraguay envisages a holistic approach, integrating adjustment of national policies and strategies, improvement of the legislative and regulatory frameworks, and capacity development in certain priority areas. Continued adaptation efforts are focused on its most vulnerable sectors, agricultural and livestock, energy, water and health, and on increasing the country's resilience capabilities, and strengthen the country's social and economic structures against vulnerability.¹¹⁴ Paraguay has also undertaken several projects, funded through the Green Climate Fund, focused on climate change adaptation and mitigation efforts throughout the country.¹¹⁵

National Frameworks and Plans

- [Third National Communication](#) (2017) (Spanish)
- [Nationally Determined Contributions](#) (2016) (Spanish)
- [National Adaptation Plan](#) (2016) (Spanish)
- [National Development Plan 2030](#) (2014) (Spanish)
- [National Environmental Policy](#) (2018) (Spanish)
- [National Climate Change Policy](#) (2012) (Spanish)
- [National Plan for Disaster Management \(2015–2025\)](#) (2016) (Spanish)

Recommendations

Research Gaps

- Support research initiatives focused on the impacts of climate variability and change on water resources and their interdependencies at the regional scales¹¹⁶
- Perform a sectoral energy and water demand analysis to use as the basis for determining actions to build improvements in water and energy distribution systems
- Carry out economic-environmental feasibility studies to promote the use of clean energy in industries

¹¹² Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

¹¹³ Paraguay (2016). Paraguay Plan Nacional de Adaptación al Cambio Climático (PNACCC) URL: https://www4.unfccc.int/sites/NAPC/Documents/Parties/Plan%20Nacional%20de%20Adaptaci%C3%B3n%20al%20Cambio%20Clim%C3%A1tico_Paraguay_final.pdf

¹¹⁴ Paraguay (2018). Política Nacional de Cambio Climático de Paraguay. URL: <https://www.undp.org/content/dam/paraguay/docs/Politica%20Nacional%20CC.pdf>

¹¹⁵ Green Climate Fund (2020). Paraguay - Projects and Programs. URL: <https://www.greenclimate.fund/countries/paraguay>

¹¹⁶ Paraguay (2017). Tercera comunicación Nacional de la Republica de Paraguay. URL: <https://unfccc.int/sites/default/files/resource/NC3%20PARAGUAY.pdf>

Data and Information Gaps

- Document and disseminate successful experiences in water management and rainwater harvesting in the western regions
- Establish an open access, shared agro-hydrometeorological monitoring network coordinated, in critical river basins
- Develop hotspot maps with information on critical vulnerabilities and ecological conditions in support of territorial zoning
- Conduct research into adaptation options that could be implemented in priority sectors including their cost-benefit ratios. Promote and facilitate research and analysis of technological measures and applicable solutions to adapt to the effects of climate change, particularly those addressing food security issues
- Promote the effective inclusion of the issues of climate change across all educational levels
- Establish a centralized information system to provide historical, current and future climate information for stakeholders to use as the basis for planning¹¹⁷

Institutional Gaps

- Establish and enforce resources regulations, particularly regarding the protection of water courses and groundwater resources
- Build the capacity of the national emergency management service to address changing risk profiles due to climate variability and change
- Improve compliance with existing ordinances and/or create the necessary land management plans (zones of floods, swamps and riverine areas of the country, including the Central Department, Ñeembucú, Itapúa, Conception)
- Strengthen the institutional capacities of the parties that make up the National Commission of Climate Change, with emphasis on planning, execution and implementation and monitoring capacities. This is especially important at the National Office of Climate Change
- Promote partnerships and synergies between linked institutions and sectors in an effort to secure climate finance for the implementation of the National Climate Policy
- Develop and implement a communication strategy internal and external of the Programme National Climate Change Program to strengthen the interaction of the member institutions and enhance the program's link with civil society¹¹⁸

¹¹⁷ Paraguay (2018). Política Nacional de Cambio Climático de Paraguay. URL: <https://www.undp.org/content/dam/paraguay/docs/Politica%20Nacional%20CC.pdf>

¹¹⁸ Paraguay (2016). Contribuciones Nacionales de la Republica del Paraguay. URL: <https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Paraguay%20First/Documento%20INDC%20Paraguay%2001-10-15.pdf>

CLIMATE RISK COUNTRY PROFILE

PARAGUAY