Resilient Settlements for the Urban Poor (RISE UP)

Multilayered Vulnerability Profile Charagua, Bolivia

Climate, Urban, and Biodiversity Dimensions

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Climate, Urban, and Biodiversity Dimensions
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Multilayered Vulnerability Profile: Charagua, Bolivia

Abbreviations

ABT	Authority for Supervision and Social Control of Forests and Land
AMT	Mother Earth Plurinational Authority
CAF	Development Bank of Latin America and the Caribbean
CBO	Community-Based Organization
DRR	Disaster Risk Reduction
GADSC	Autonomous Departmental Government of Santa Cruz
GAIOC	Autonomous Indigenous Originary Peasant Government Charagua Iyambae
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
IIED	International Institute for Environment and Development
ILO	International Labour Organisation
IADB	Inter-American Development Bank
MMAyA	Ministry of Environment and Water
MPD	Ministry of Development Planning
MOPSV	Ministry of Public Works, Services and Housing
NGO	Non-Governmental Organisation
NUA	New Urban Agenda
PDES	The Economic and Social Development Plan
UAGRM	Gabriel Rene Moreno Autonomous University

Definition of Terminologies

Districts: Refers to the municipality first division or an area of a city, especially one regarded as a distinct unit because of a particular characteristic.

Indigenous autonomy: It consists of self-government as an exercise of self-determination of nations and native indigenous peasant peoples, whose population shares territory, culture, history, languages, and their own legal, political, social and economic organization or institutions.

Municipality: Is the territorial unit, politically and administratively organized, in the jurisdiction and with the inhabitants of the Provincial Section, the basis of the territorial organization of the unitary and democratic Bolivian State.

Neighborhood: Area of a town that surrounds someone's home, or the people who live in this area. In relation to districts, these are frequently sub divided by neighborhoods.

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Executive Summary

This report is part of the "Accelerating the Implementation of the Paris Agreement by Building the Climate Resilience of the Urban Poor" RISE UP project. It presents a comprehensive analysis of the vulnerability profile of Charagua, Bolivia. The RISE UP project, implemented in collaboration with the Spanish Agency for International Development Cooperation (AECID), seeks to confront the multifaceted and interrelated challenges posed by climate change, urbanization, and biodiversity loss, which are particularly acute in urban areas of the Global South.

As cities grapple with the escalating impacts of climate change — such as rising temperatures, increased flooding, and more frequent extreme weather events — it is crucial to assess the vulnerabilities faced by their inhabitants. Urban areas often exhibit complex socio-economic dynamics and infrastructure limitations that heighten these vulnerabilities, especially for the urban poor in informal settlements. This report focuses on selected secondary and tertiary cities within these five countries to highlight local contexts of multilayered vulnerability and identify critical intervention areas for enhancing climate resilience.

The selected cities were chosen due to their significant exposure to climate-related risks and the urgent need for enhanced adaptive capacity, particularly among the urban poor residing in informal settlements. By addressing the unique challenges faced by these communities, this analysis serves as a foundation for developing targeted strategies that foster systemic resilience, mobilize and allocate resources, and meaningfully engage stakeholders in coordinated actions.

By highlighting the current vulnerability landscape, the report aims to equip local and subnational governments, community organizations, and international partners with the data, insights and understanding needed to implement targeted and effective interventions that safeguard urban populations, infrastructure, and ecosystems, and promote sustainable urban development. The findings are anticipated to inform broader climate adaptation policies and practices, ultimately contributing to the long-term sustainability and resilience of urban environments.

Supported by the Spanish Agency for International Development Cooperation (AECID), RISEUP's assessment in Bolivian cities Cobija and Charagua aligns with the New Urban Agenda's vision for an inclusive and sustainable urban future. The assessment also supports the achievement of the 2030 Agenda for Sustainable Development, where 65% of the Sustainable Development Goals (SDGs) relate to urban and territorial development, specifically SDG 11 on sustainable cities and communities. This focus is additionally tied to compliance with the Paris Agreement, connecting the New Urban Agenda to the broader frameworks of the 2030 Agenda.

Charagua Pueblo, located in Bolivia's Chaco region, in the department of Santa Cruz, is distinct for its autonomous Indigenous governance structure, with a predominantly rural population of approximately 3,000. Due to limited official data—a common issue in Bolivia's smaller towns—the assessment incorporates surveys of residents and workshops with local government officials.

Charagua faces significant climate threats, including drought, landslides and rising temperatures, all intensified by climate change. Projected increases in rainfall may lessen drought intensity, but the change necessitates proactive planning.

RISE UP's multilayered vulnerability assessment of Charagua Pueblo identified the 1ro de Mayo neighborhood, the municipality's most underserved area, as a primary study site. Home to 300 families, this spontaneously developed human settlement lacks essential services including access to electricity and water, making it vulnerable to landslides and limited urban planning.

The assessment examines Urbanization, Climate Change and Biodiversity, producing maps as key outputs. Previously inexistent, these maps will enable the municipality to coordinate with local actors, identifying "hotspots" where prioritized actions can enhance Charagua's resilience to climate threats. The Barrio 1ro de Mayo neighborhood will serve as the pilot project to initiate this transformation.

Executive Summary

Urban Dimension

Charagua Pueblo is a town with low density across its districts, including the study area, located in its southern part next to the Charagua River. Barrio 1ro de Mayo is Charagua Pueblo's newest neighbourhood, where land use is mainly residential. It has only one health centre and no other infrastructure or markets. The sole urban planning instrument in Charagua Pueblo is the *"Community territorial management plan to live well from the autonomous indigenous government, originally from Charagua Iyambae, 2021 – 2025"*.

In terms of population distribution, only 10.9% of residents in Charagua are considered urban. Around 60.3% of the population lives across 82 rural communities, with 22.6% in Mennonite colonies, 16.3% in Charagua Estación and Charagua Pueblo, with the remainder residing in private properties or agricultural farms. Charagua Pueblo, therefore, is not classified as a city but a town.

Climate Change Dimension

Climate change poses a substantial threat to Charagua Pueblo, and particularly to Barrio 1ro de Mayo, heightening the risks of drought, landslides, and rising temperatures. Currently, the municipality lacks both a risk management plan and climate change adaptation strategies, meaning disaster response relies on regional government support. Preventive measures are urgently needed, but limited human, economic, and financial resources are barriers. Projections indicate a temperature increase of 2.77% and an 8% rise in precipitation, which may reduce drought vulnerability but increase landslide risks in parts of Barrio 1ro de Mayo.

Climate change disproportionately affects vulnerable groups, including the elderly, people with disabilities, and children. Observations and site visits revealed that some households in Barrio 1ro de Mayo are inhabited by older people living alone under precarious conditions.

Biodiversity Dimension

Charagua's biodiversity is threatened by unplanned urban expansion, exemplified by Barrio 1ro de Mayo. This growth has compromised the ecological integrity of the area, raising risks of habitat loss. Proximity to national parks means wildlife, especially bird species, are commonly observed in the town. However, some human-wildlife conflicts have arisen, including bird poisoning. Additionally, tree removal is ongoing as wood is commonly used for construction, further impacting the local ecosystem.

Projected increases in rainfall could have positive effects on biodiversity, potentially lessening drought impacts in the coming decades and improving Charagua Pueblo's natural resilience to climate change.

Overlapping Vulnerabilities

The convergence of urban, climate change, and biodiversity challenges creates compounded vulnerabilities, forming distinct hotspots within Charagua Pueblo. These areas require targeted interventions prioritized for the greatest impact, particularly in the study area, which encompasses an entire neighborhood.

Beyond the mapping and analysis outputs, a significant outcome of this multilayered vulnerability assessment has been active and meaningful stakeholder engagement. Local government, local communities, and civil society organizations have greatly contributed insights to better profile the area's unique dynamics. This collaborative foundation is expected to lead to viable, high-impact projects that will support Charagua Pueblo and Barrio 1ro de Mayo in building systemic resilience to climate hazards through community-driven approaches.

01

INTRODUCTION

Background and Context

Climate Change, Urbanization and Biodiversity

The climate emergency is fundamentally an urban crisis, affecting every aspect of city life. With over 55% of the global population living in cities—expected to exceed 67% by 2050—urban areas face increasing vulnerability to climate change. Rising temperatures, sea levels, and extreme weather events are straining infrastructure, disrupting services, and impacting housing, livelihoods, health, and wellbeing. These pressures are exacerbated by rapid urbanization, population growth, migration, rising poverty, inequality, and biodiversity degradation. Addressing these interconnected issues through urban climate adaptation and resilience building remains one of the most significant challenges faced by cities, particularly in the global South.

Over 90% of cities lie within the world's 36 global biodiversity hotspots, where urban expansion threatens both biodiversity and climate resilience. The loss of natural habitats accelerates as human settlements expand, further exacerbated by climate hazards. Cities are increasingly recognizing the importance of spatial planning and urban land management in safeguarding ecosystems and natural assets. These strategies not only support biodiversity but also enhance climate resilience, delivering co-benefits for both people and nature. Effective spatial planning is crucial to prevent the degradation of settlements that rely on the ecosystem services that biodiversity provides. Targeted pro-biodiversity interventions are urgently needed, both within and beyond urban areas, backed by robust tools and strategies.

UN-Habitat emphasises the necessity of a multidimensional, multidisciplinary approach to understanding and addressing these overlapping challenges in cities, with a focus on building resilience for the one billion urban poor in informal settlements. These marginalized communities are particularly vulnerable to climate hazards and disaster risks, living in fragile areas where unplanned urban growth encroaches on natural habitats. Informal urbanization deepens their vulnerability, while also intensifying the challenges of climate change, urban poverty, and biodiversity loss.

Addressing urban poverty, spatial inequality, and informality is crucial to building systemic climate resilience and promoting sustainable urban futures.

Resilient Settlements for the Urban Poor Programme

In a rapidly urbanizing world facing the climate emergency, RISE UP is UN-Habitat's flagship programme, driving critical investments to build climate resilience and create sustainable urban futures. Supported by key partners such as the Adaptation Fund, Green Climate Fund, The Spanish Agency for International Development Cooperation (AECID), and The Swedish International Development Cooperation Agency (SIDA), RISE UP has mobilized over USD 150 million to accelerate global climate action, particularly in cities most vulnerable to climate change.

RISE UP projects range from constructing flood-resistant infrastructure in South-East Africa to enhancing green spaces in Malaysia and restoring mangrove ecosystems in urban Cambodia. These efforts underscore the interconnectedness of climate resilience and biodiversity. Urban ecosystems like wetlands and green spaces play a critical role in mitigating climate impacts and providing essential services for human wellbeing. Since 2019, RISE UP has worked in over 28 countries, reinforcing UN-Habitat's commitment to urban resilience and biodiversity conservation.

RISE UP delivers impact through the following key pillars:

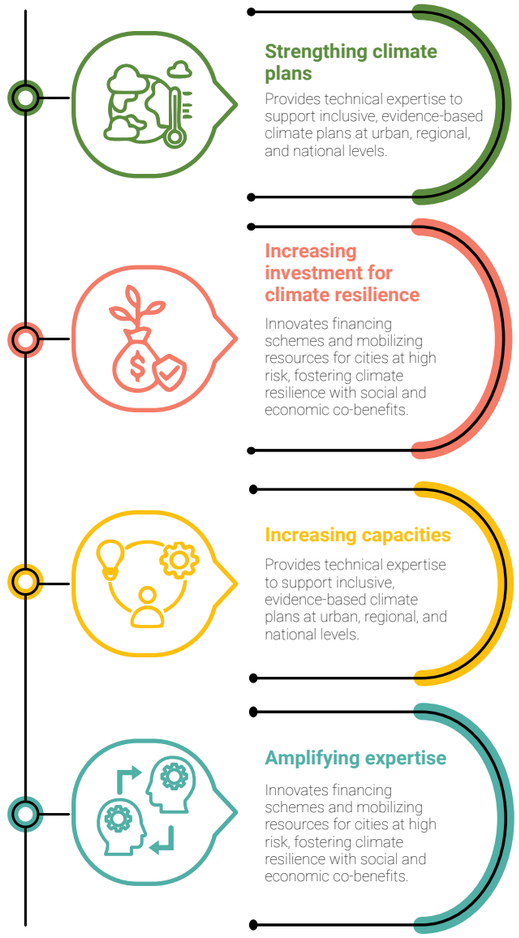


Fig. 1: RISE UP objectives
Source: UN-Habitat. 2024.

Through these initiatives, UN-Habitat fosters transformative urban resilience and impactful climate action for a sustainable, inclusive future.

Assessing Multilayered Vulnerabilities in Cities and Urban Areas

Multilayered vulnerabilities in urban environments encompass various interconnected challenges that extend beyond physical infrastructure to include spatial, social, economic, climatic, environmental, political, and technological dimensions. Issues like income inequality, environmental degradation, inadequate housing, and insufficient emergency preparedness contribute to a city's multidimensional vulnerabilities.

In this context, multilayered vulnerability refers to the extent to which an urban system, community, or ecosystem is exposed to, sensitive to, and unable to cope with the adverse impacts of interrelated climate change, urbanization, and biodiversity loss. Factors such as geographical location, socio-economic status, infrastructure quality, and governance structures influence this vulnerability. The aggregation of multiple and cascading vulnerabilities exacerbates the overall susceptibility, risk, and adaptive capacity of people, infrastructure, and the environment.

Addressing these challenges to strengthen urban resilience requires comprehensive urban planning and management strategies. Policymakers and practitioners face several obstacles in conducting multilayered vulnerability assessments, including:

- The fragmentation of climate change, biodiversity, and urbanization in policy and practice.
- A lack of evidence-based approaches to mapping multidimensional and interrelated vulnerabilities.
- Limited capacities and resources for conducting comprehensive assessments.
- The urban poor and residents of informal settlements being the most affected yet least engaged in decision-making processes.
- Insufficient tools for predicting future land-use changes and urban growth patterns.

- A lack of coordination and cooperation in transboundary and multidisciplinary planning.

- Minimal application of coherent, prioritized interventions and solutions.

These challenges highlight the need for a more integrated approach to vulnerability assessment and management. To address this, UN-Habitat's RISE UP programme has developed the Multilayered Vulnerability Assessment (MVA) tool, whose purpose is to help communities, cities, and local leaders to comprehensively map and assess multilayered vulnerabilities. The tool addresses the nexus between climate change hazards and risks, urbanization and spatial trends and characteristics, and biodiversity loss and land degradation to identify vulnerability hotspots arising from spatial overlaps and conflicts.

By deploying the MVA tool in communities, cities, and urban areas, local and national leaders and policymakers in climate-vulnerable cities and communities can better plan and deliver inclusive, sustainable, and resilient urban development strategies for human and non-human inhabitants. This enables decision-makers to make informed choices about urban expansion and adapt to urgent climate-related challenges.

Multilayered Vulnerability Assessment Tool

This report is part of the "Accelerating the Implementation of the Paris Agreement by Building the Climate Resilience of the Urban Poor in Bolivia, Colombia, Ethiopia, Jordan, and Tunisia" RISE UP project in collaboration with the Spanish Agency for International Development Cooperation. It presents the vulnerability profile of Charagua, Bolivia, detailing the outcomes of Stages 1 and 2 of the MVA, including preparation, and mapping and analysis, that will inform Stage 3: action planning.

The project engages communities in Cobija and Charagua in Bolivia, San Juan de Pasto in Colombia, Debre Birhan in Ethiopia, Sahab Municipality in Jordan, and Kerkennah in Tunisia. The selection of these locations was guided by several critical factors:

- **High vulnerability:** Each area is characterized by significant vulnerability and exposure to the impacts of climate change, urbanization trends, and biodiversity loss, highlighting the need for intervention.

- **Community engagement:** There is a demonstrated need and interest from local communities in enhancing their adaptive capacity, ensuring that project efforts align with local resilience priorities.

- **Government collaboration:** Each location benefits from established governmental structures and policies, facilitating effective collaboration among local stakeholders and the RISE UP headquarters team for a coordinated approach.

- **Implementation capacity:** The Regional and Country Offices possess the capacity to support activity implementation and manage component funds, which is essential for executing the project effectively and maximizing the impact of interventions.

The MVA implementation in Bolivia lays the groundwork for targeted climate resilience interventions. With a focus on high-risk areas, strong community engagement, and collaboration with local governments, the project leverages local capacities for effective action.

Climate Change, Urbanization and Biodiversity in Charagua, Bolivia

The Gran Chaco is a geographic region located in south-central South America that extends through parts of Argentina, Bolivia, Brazil and Paraguay. It encompasses the central area of northern Argentina, known as the Argentine Chaco region, the southern portion of Bolivia's eastern plains, a small section of the Brazilian southwest, and the western region of Paraguay.

In the Gran Chaco region, increasing climate variability and more frequent, severe and longer-lasting extreme weather events, such as floods and droughts, adversely impacting both populations and production systems,

with loss of agricultural productivity, damage to public infrastructure, and the disappearance of entire towns due to river overflows and disrupted development processes.

Although the Bolivian Chaco is traditionally a dry area with high temperatures, in the last two years temperatures in the region have reached between 45°C to 50°C. According to historical climatic and meteorological data for the municipality of Charagua, the highest temperature previously reached was 35°C. Each year, heat records are being broken in this region.

Some of the primary causes of climate change/ rising temperatures in the municipalities of Chaco are deforestation, the expansion of the agricultural frontier, and forest fires. Additionally, the production and use of fossil fuels, industrial pollution, the agricultural advancement by Mennonite communities, and a lack of respect for ecological cycles are significant contributing factors. This drastic rise in temperatures not only exacerbates heat stress but also poses severe public health risks, including increased mortality from heat-related illnesses, and further threatens the region's ecosystems and agricultural productivity. The increased heat stress also leads to heightened demands for cooling, energy, and water, straining aging, inadequate infrastructure such as power grids and water supply systems, while ecosystems face heightened risks of degradation and loss of biodiversity.

Charagua is unique as it operates under indigenous governance, a structure uncommon in other parts of Bolivia. This autonomous framework enables the local community to manage its territory based on principles of self-determination. This analysis focuses on the study area of Charagua Pueblo, a small town whose resilience to climate threats will be assessed in the context of "urban" growth trends and biodiversity loss due to environmental degradation, which has even impacted the Gran Chaco Kaa-Iya National Park.

Source: Vice Presidency of Bolivia

Context Analysis

Location and Geography

Charagua is located on the South American continent, in the southern hemisphere, between 18° 56′ 07″ and 20° 30′ 17″ south latitude and between 58° 45′ and 63° 20′ west longitude. It has an average elevation of 735 meters above mean sea level (AMSL). It is a municipality in the country of Bolivia, located in the Cordillera Province of the Santa Cruz Department, in the Chaco region. Charagua is the largest municipality in Bolivia, with an area of 74,424 km², covering approximately 23% of the department of Santa Cruz and 6.53% of Bolivian territory.

The municipality of Charagua encompasses three major physiographic groups: the Sub-Andean Belt, the Transition Area, and the Chaco Plain. To the west lie the initial foothills of the Andes Mountain range, while the Chaco plain extends to the east. To the southeast, Charagua borders Paraguay. The municipality features diverse topography, including narrow valleys with alluvial terraces, mountain ranges, slopes, plateaus, and the extensive plains in the far east.

The Guarani Charagua Iyambae Autonomic Government organizes its territory into "zones", consisting of four rural areas included in community or collective lands, and the remaining areas are considered urban. The Charagua Pueblo zone comprises the city of Benemérita de Charagua and the growing urban area of Charagua Estación. The administrative centre is Charagua Pueblo, located in the transition area at an approximate altitude of 800 to 900 meters above sea level, characterized by a smooth, gently undulating landscape. It has an urbanized land area of 140.1ha.

Fig. 2: Location of Charagua, Bolivia
Source: UN HABITAT, 2024

Fig. 3: Urban area in Charagua
Source: UN HABITAT, 2024

History of City Development and Growth

Between the 15th and 16th centuries, a major population migration occurred as large groups of Guaraní peoples left Paraguay to settle in what is now the Bolivian Chaco. The mingling of these Guaraní newcomers with the Chané communities, who already inhabited the area, was significant; the Guaraní conquest and integration of the Chané marked a key moment in the ethnogenesis of the Guaraní people in Bolivia.

The Spanish colonial system employed multiple strategies to expand its control over the Chaco, with warfare and religious missions being the most prominent. While military campaigns often failed, religious missions eventually succeeded in establishing a Spanish presence in Guaraní territory, although both approaches encountered resistance. Ultimately, the defeat of Kuruyuki in 1892 and the introduction of cattle by landowners enabled the subjugation of the Guaraní in the Chaco region, especially in Charagua.

At the time of Bolivia's independence, Charagua remained under the authority of native caciques who resided around the Plazuela del Estudiante and served as chiefs. However, the area quickly became populated by migrants from Santa Cruz, other regions, and foreign settlers, transforming it into a true colony.

In response to the unsanitary conditions in the community of Obaí, Father Ramón Barba ordered the parish priest of the Mission of Piritíí, Father Juan Bautista Parada, to relocate the Mission to Charagua on April 30, 1864. Thirty years later, on September 6, 1894, the Second Municipal Section of the Province of Cordillera was established, with Charagua as its capital. This section included the cantons of Isosog, Parapetí Grande, Saipurú, and Charagua.

The Chaco region has been contested between Paraguay and Bolivia since the establishment of both republics, as both countries sought control over territory believed to contain vast oil reserves. From 1932 to 1935, clashes occurred in Charagua, leading to the exodus of the local population.

In 1950, a railway opened, connecting Charagua to the Bolivian Chaco and the city of Santa Cruz de la Sierra, which significantly boosted the local economy and stimulated regional development. In 1956, the Yacuiba-Santa Cruz de la Sierra Railroad was inaugurated, passing just 7 km from Charagua Pueblo.

On August 11, 1971, Charagua was designated a *"Meritorious City"* by Supreme Decree No. 09845. Subsequently, on March 4, 1988, it was declared *"Meritorious City of the Homeland"* by Supreme Decree No. 09845/88.

In a referendum held on December 6, 2009, the municipality of Charagua voted to initiate the process of native indigenous peasant autonomy, receiving 55.66% approval. On September 20, 2015, the autonomous statute of the Guaraní Charagua Iyambae autonomous government was approved in a subsequent referendum, garnering 53.25% approval. This made Charagua the first municipality in Bolivia to implement indigenous autonomy.

Indigenous autonomy in Bolivia is a political exercise of self-government and territorial rights, which is based on the self-determination of indigenous peoples. The Political Constitution of the Plurinational State of Bolivia (CPE) recognizes native indigenous peasant autonomy (AIOC) and the conditions for its inclusion in decision-making.

The AIOC can be obtained in the following ways: Municipal conversion or Regional autonomy.

The AIOC is characterized by:

- Be an exercise of self-determination of indigenous peoples
- Share territory, culture, history, languages, and own legal, political, social and economic organization or institutions
- Have the capacity for self-government

Indigenous peoples have the right to have their culture, traditions, stories and aspirations reflected in public education and the public media. This form of autonomy

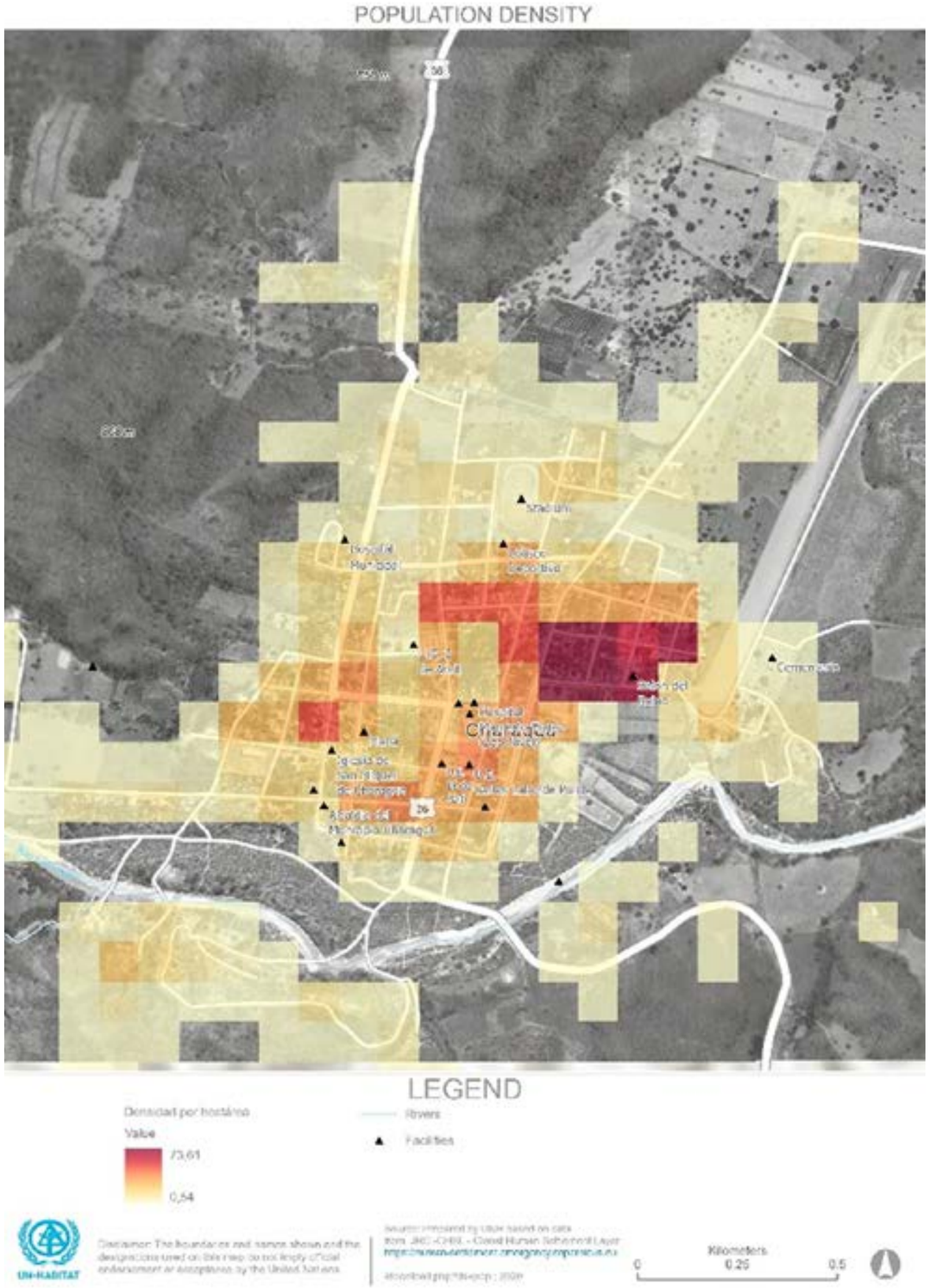


Fig. 4: Population density of urban Charagua
Source: UN HABITAT, 2024

not only empowers indigenous communities to manage their natural resources more sustainably but also enables them to better address environmental challenges, such as land use changes, heat stress and climate change, by integrating their traditional knowledge and practices into governance and decision-making processes.

Demographics

The Charagua municipality has a population of 32,186, according to the National Population and Housing Census conducted in 2012. The population is composed of 48.1% males and 51.9% females, with a significant majority of 89% living in rural areas. The total population of Charagua Pueblo is 3,496, with a gender distribution closely mirroring that of the greater area: 48.03% female (1,679 individuals) and 51.97% male (1,817 individuals).

The population pyramid of Charagua indicates that the highest proportion of the population falls between 6 and 39 years old (62.23%), for both men and women. The same distribution trend is also observed in Charagua Pueblo. This youthful demographic profile indicates a high dependency ratio, where a significant portion of the population relies on a smaller group of economically active adults, potentially straining resources and services. Additionally, such a population structure can lead to challenges in planning for future needs, including education, healthcare, and employment opportunities, as the large youth population will eventually transition into adulthood and require support systems to be in place. Furthermore, this demographic composition may increase the region's sensitivity to climate change due to the vulnerability of dependent younger populations. On the other hand, adaptive capacities of the population could be enhanced if the younger workforce can be empowered with climate-resilient skills and knowledge.

In the municipality of Charagua, the socio-cultural units are organized based on their cultural identity, which can be broadly categorized into three groups: the Guarani population, the Mennonite colonies, and the Andean population.

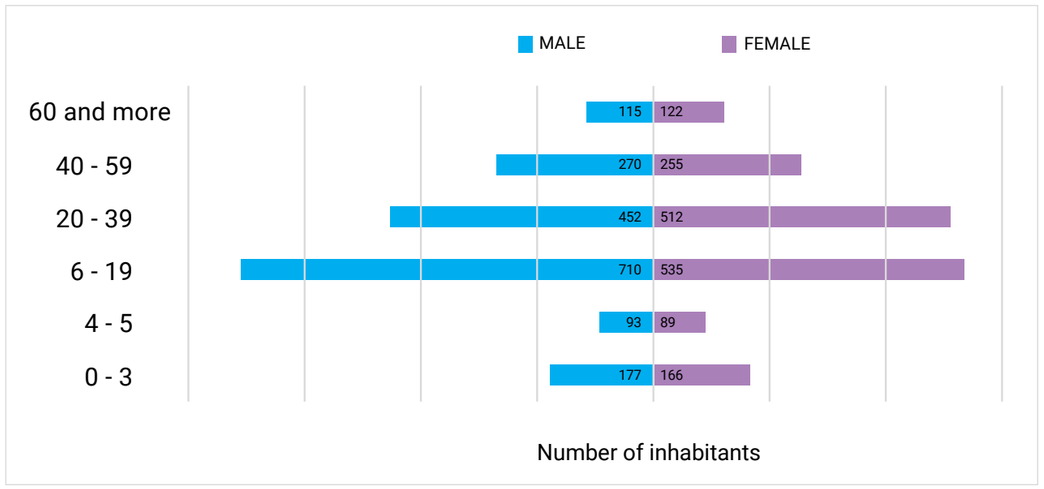


Fig. 5: Population Pyramid of Charagua
Source: Guarani Autonomous Government of Charagua Iyambae, 2023.

Approximately 60.3% of the population resides in 82 communities, with 22.6% living in Mennonite colonies, 16.3% in urban centers (Charagua Estación and Charagua Pueblo), and the remainder in private properties and agricultural farms. In many areas within these localities, housing is in poor condition, often informal and built with poor materials, in environmentally precarious and climate-vulnerable areas, with limited or no access to basic services like sanitation, water supply, power, or socioeconomic infrastructure, such as schools and healthcare facilities. Actually the most inhabited neighborhood in Charagua Pueblo which is Barrio 1ro de mayo has emerged as an informal part of the town.

Temporary and seasonal migrations primarily result from economic opportunities. Inhabitants of the Charagua Norte, Parapitiguasu, and Isoso areas migrate temporarily to Santa Cruz for agricultural work, such as sugar cane harvesting, and other non-permanent job opportunities. Internal migration is also common, with rural residents moving to population centers like Charagua Pueblo and the Mennonite colonies, to gain access to municipal services and amenities, and employment opportunities. This trend has been particularly noticeable in recent years due to labor demand from communities for the construction of the Boyuibe–Charagua–El Espino highway.

Regarding economic conditions, of the 30,431 individuals surveyed for Unmet Basic Needs (NBI), 70.4% are classified as poor, while 29.6% have their basic needs satisfied. This high poverty rate reflects the widespread lack of access to essential services such as sanitation, clean water, electricity, and healthcare, which are critical for improving living standards and reducing vulnerability to external shocks and stresses like climate change hazards. Additionally, the unmet basic needs statistics highlight disparities in infrastructure and social services, underscoring the urgent need for targeted interventions to address structural inequalities and improve overall welfare in Charagua.

A 2008 study indicated that income from the sale of labor and transfers or remittances accounts for 63% of family income in the region, compared to 37% derived from agricultural, livestock, and other territorial management activities. Another study conducted in 2011 reported that families had an annual income of Bs. 16,887.00 for the 2010–2011 period, with 65% stemming from net production value, 13% from the sale of labor, and 22% from other sources. This discrepancy between families' primary activities and their income sources suggests a crisis in local agricultural production systems, particularly affecting Guarani families. Increasingly unpredictable rainfall patterns and intensity of extreme weather events, is likely to exacerbate this crisis by further reducing agricultural productivity and increasing reliance on external income sources, thereby heightening economic vulnerability.

In Charagua Pueblo, 1,178 inhabitants engage in various economic activities, comprising 58.49% men and 41.51% women. The main economic activities include "Other Services" (41.85%), "Trade, Transport, and Warehousing" (19.86%), and "Agriculture, Livestock, Hunting, Fishing, and Forestry" (10.10%). The remaining 28.18% is involved in sectors such as "Construction" and "Manufacturing Industry."

In terms of education, Charagua Pueblo has a school attendance rate of 82.07% (540 boys and 481 girls). The 17.93% of individuals not attending school includes 169 boys and 54 girls. Among the residents of Charagua, 97.80% (1,774 men and 1,645 women) reside locally, while 2.17% live elsewhere in the country, and 0.03% reside abroad. That numbers show the percentages of people registered in Charagua that do not necessarily live in the town but elsewhere.

Key Economic Sectors

According to the 2013 Agricultural Census, the primary productive economic activities in Charagua, in order of importance, are agriculture, livestock, and poultry. While hunting, gathering, fishing, forestry, and extractive activities are also present, they account for a very small percentage of the overall economic activities.

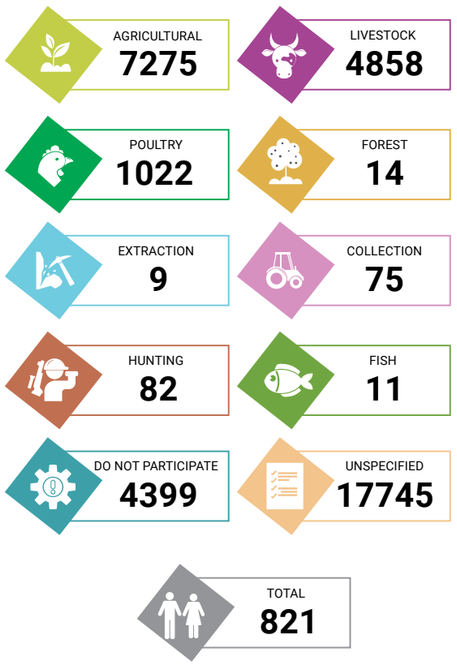


Table 1: Main economic activities (number of people)
Source: Censo Agropecuario 2013, INE.

Agricultural activity is the primary source of income for Guarani families, although there are variations across different areas: 63% in Charagua Norte, just over 40% in Alto and Bajo Isoso, and 29% in Parapitiguasu. In the areas of Charagua Estación and Charagua Centro, the economy is mainly tied to the provision of services and commerce, some of which are linked to the Mennonite colonies. Only 23% of the members of Agricultural Productive Units identify agriculture as their main activity.

Most households in the Guarani communities of Charagua seek to diversify their income due to the limited socioeconomic conditions for agricultural production and other activities in which they predominantly engage. One method of income diversification is to pursue employment in various economic sectors. The vast majority of the population has a secondary activity in "other services," which largely involves the sale of labor, both within and outside Charagua. Many families find seasonal employment in productive units in the north of Santa Cruz. In some communities, men work on cattle ranches adjacent to their communities, while others secure temporary jobs supporting Mennonite colonies. A few individuals even find employment with oil companies in the region.

In urban areas, activities are also linked to the sale of the population's labor force, with jobs available in public and private institutions, small self-employed initiatives, and various technical trades. Among the Mennonite population, there is also the development of complementary or diversified activities related to the provision of services to the local community, such as masonry, plumbing, carpentry, and the manufacture of agricultural machinery.

In Charagua Pueblo, a total of 1,178 inhabitants are engaged in some economic activity, comprising 58.49% men and 41.51% women. The main economic activities are: "Other services" at 41.85%, "Trade, transport, and warehouses" at 19.86%, and "Agriculture, livestock, hunting, fishing, and forestry" at 10.10%. The remaining 28.18% are involved in "Construction," "Manufacturing Industry," and other sectors. The primary categories of employment are: "Worker" at 41.26%, "Self-employed" at 29.71%, and "Domestic worker" at 3.65%. Notably, the "Unspecified" category accounts for 19.86%, while the remaining categories collectively reach 5.52%. The workers in these sectors, particularly those in agriculture and related activities, are highly sensitive to climate change impacts, which can lead to significant losses in income, livelihoods, and food security.

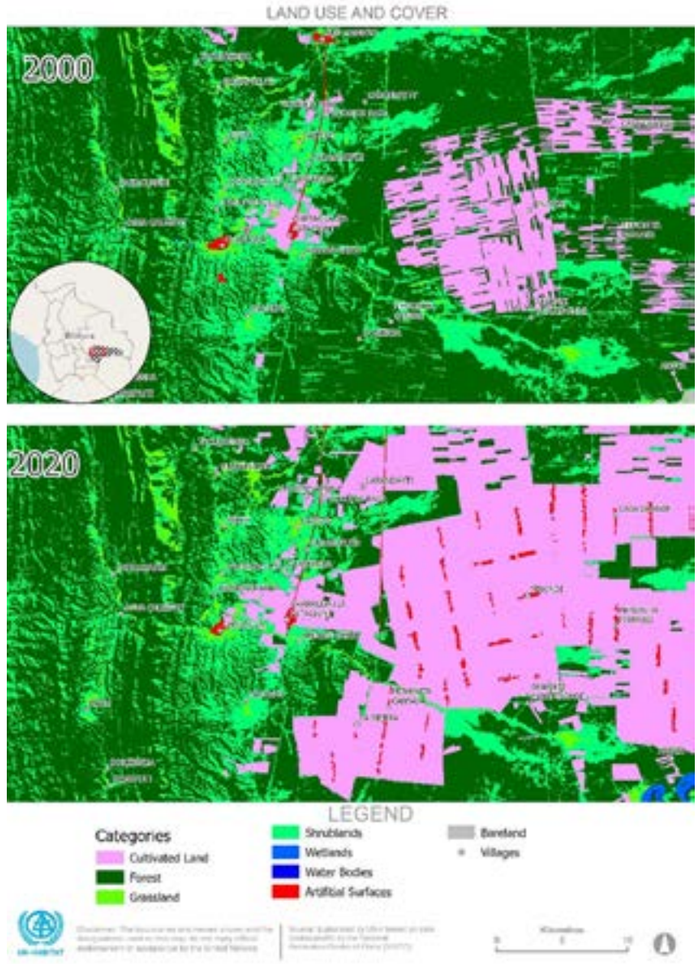


Fig. 6: Land use in Charagua
Source: UN HABITAT, 2024

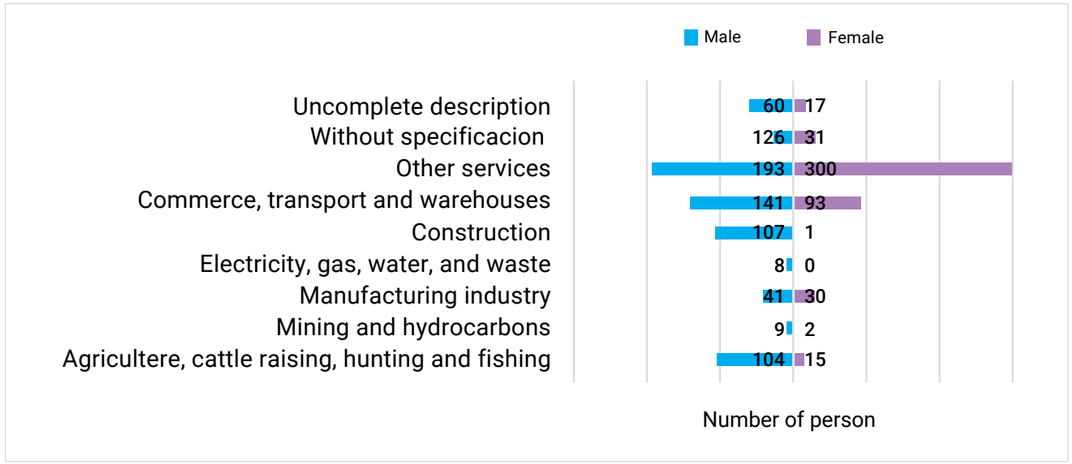


Fig. 7: Pyramid of Economic Activity, Charagua Pueblo
Source: Censo Nacional de Población y Vivienda 2012 – INE.

Environment, Biodiversity, and Climate

Physiography

Charagua is situated in the Bolivian Chaco region, characterised by a tropical dry forest in the southwest of the territory. This region encompasses three significant physiographic units: the sub-Andean zone, foothills, and Chaco plains.

Hydrography

The Charagua Iyambae territory lies within various hydrographic basins of the Chaco region, with the Parapiti River basin being the most prominent. Other basins are located within both national and regional protected areas. The municipality features numerous temporary channels that facilitate substantial water flow during the rainy season, leading to erosion and landslide risks. Permanent streams are relatively rare and exhibit medium to low flows that converge into larger collecting channels, lagoons, or the Chaco Plain, where they undergo infiltration. Key rivers in the vicinity include the Ovai and Capihuazuti rivers to the north, the Charagua river to the south, and the Quebrada Lojito to the southwest.

Protected Areas

The Autonomous Indigenous Originary Peasant Government Charagua Iyambae has designated 68% of its territory as conservation areas (National and Autonomous Parks). This includes two national protected areas – ANMI Kaa Iya National Park and ANMI Gran Chaco Kaa-Iya – as well as three recently established areas by GAIOC: the Guarani Area of Irenda Water Management, Guajukaka, and Ñembiguasu Life Area.

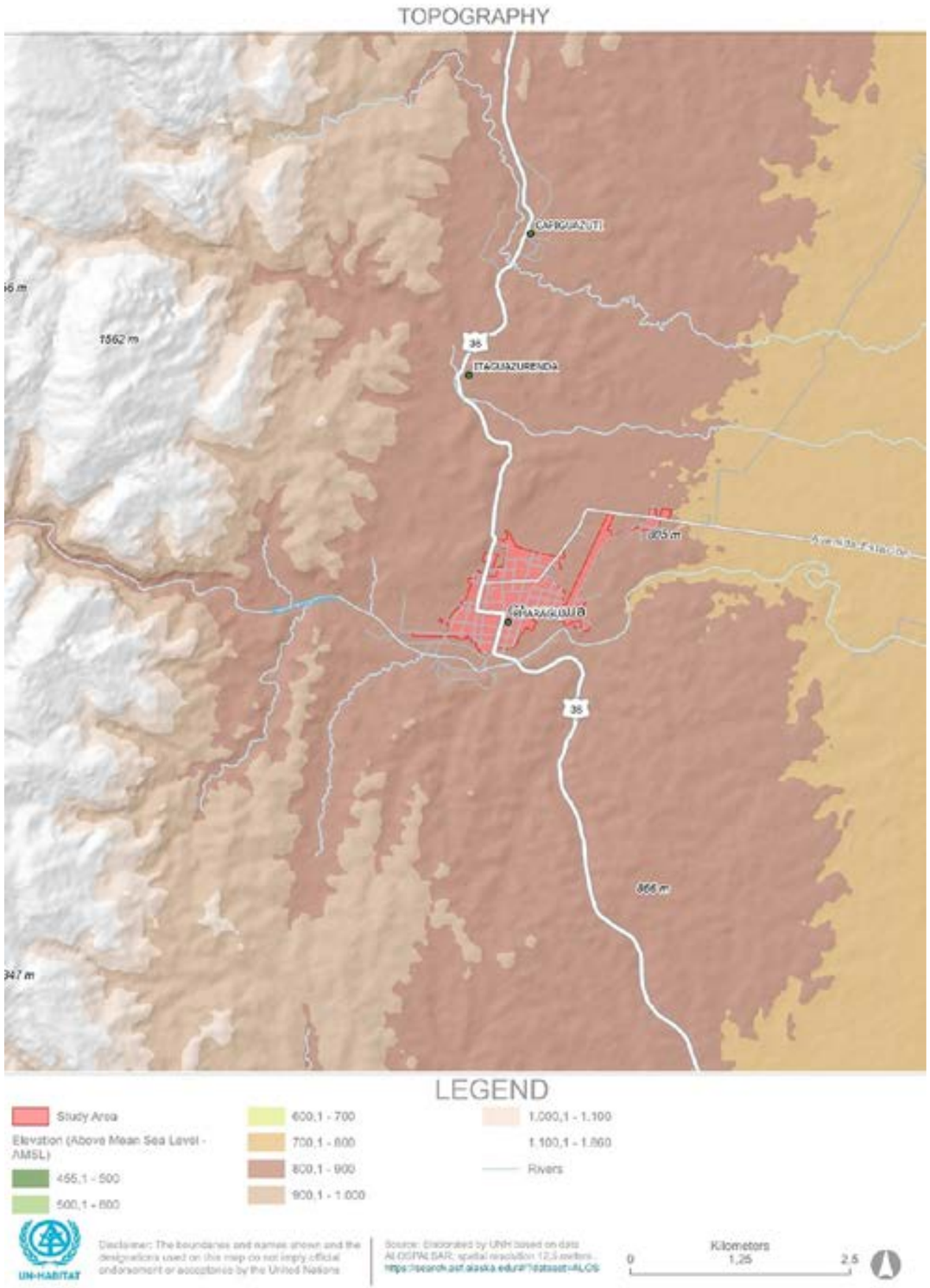


Fig. 8: Topography in Charagua
Source: UN HABITAT, 2024

Charagua Iyambae retains significant natural forests, covering about 40% of the area. However, selective logging has affected timber species such as cuchi mara *(Loxopterygium grisebachi),* soto/quebracho colorado *(Schinopsis quebracho-colorado),* and cedar *(Cedrela lilloi).*

Additionally, the Bañados del Isoso Wetland and the Parapetí River are designated as RAMSAR sites, spanning 615,882 hectares at an altitude of 300 meters above sea level. This wetland is critical as it partially connects to the National Park and Natural Area of Integrated Management KAA IYA of the Gran Chaco, hosting a rich diversity of Chaco flora and fauna. The Bañados del Isoso, which belong to the Parapetí River basin, connect with the Amazon basin during the rainy season, playing a vital ecological role in maintaining the water cycle and supporting biodiversity in a region marked by low rainfall and pronounced water deficits. Beyond their ecological significance, these wetlands also provide essential provisioning services such as fish and other aquatic resources, support cultural practices of local communities like the Izoceño-Guaraní, and offer potential for sustainable tourism and nature-based recreation, which can contribute to local economic development and enhance community livelihoods, though this is undeveloped and has not been formally explored.

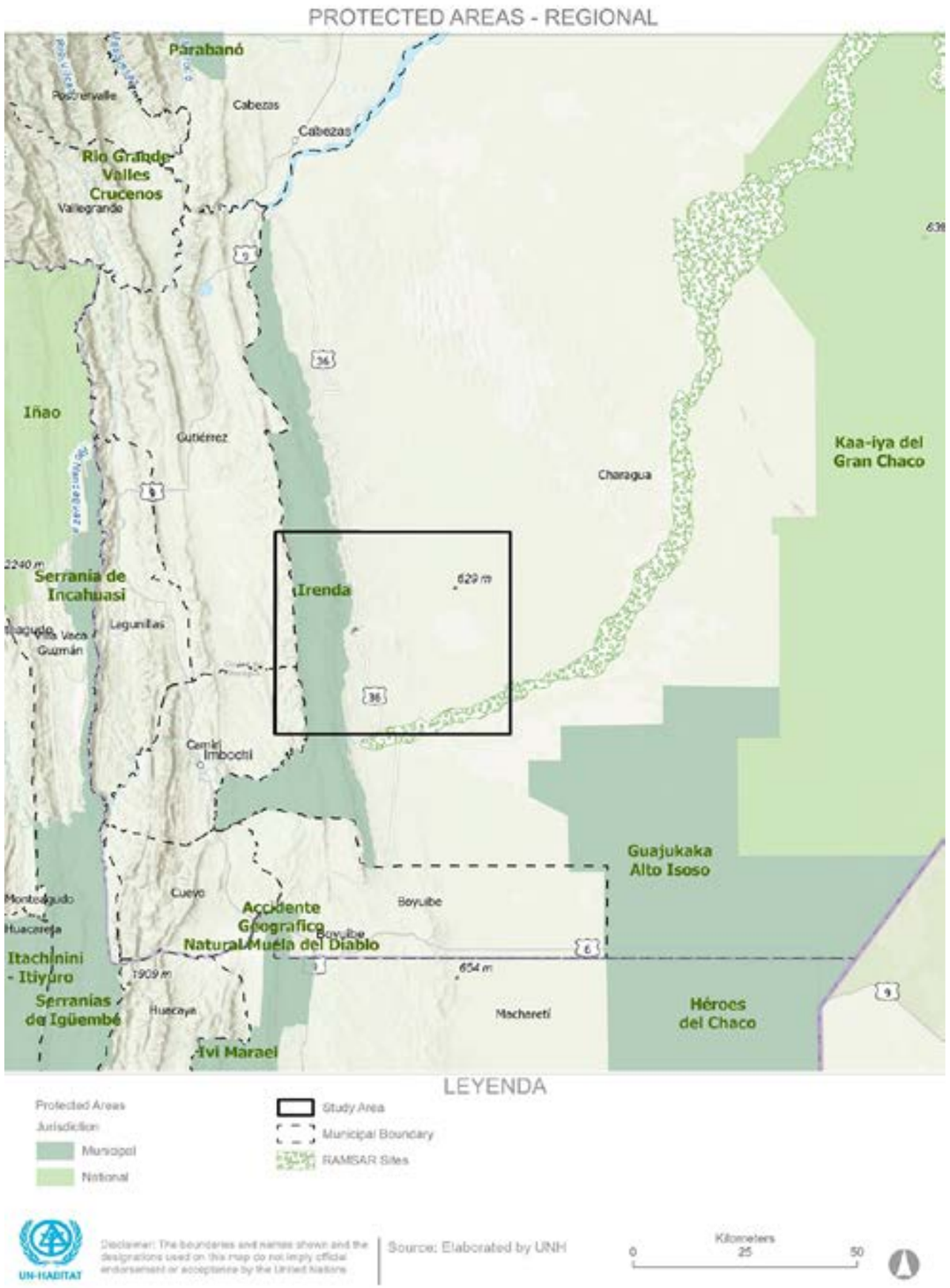


Fig. 9: Protected areas - regional
Source: UN HABITAT, 2024

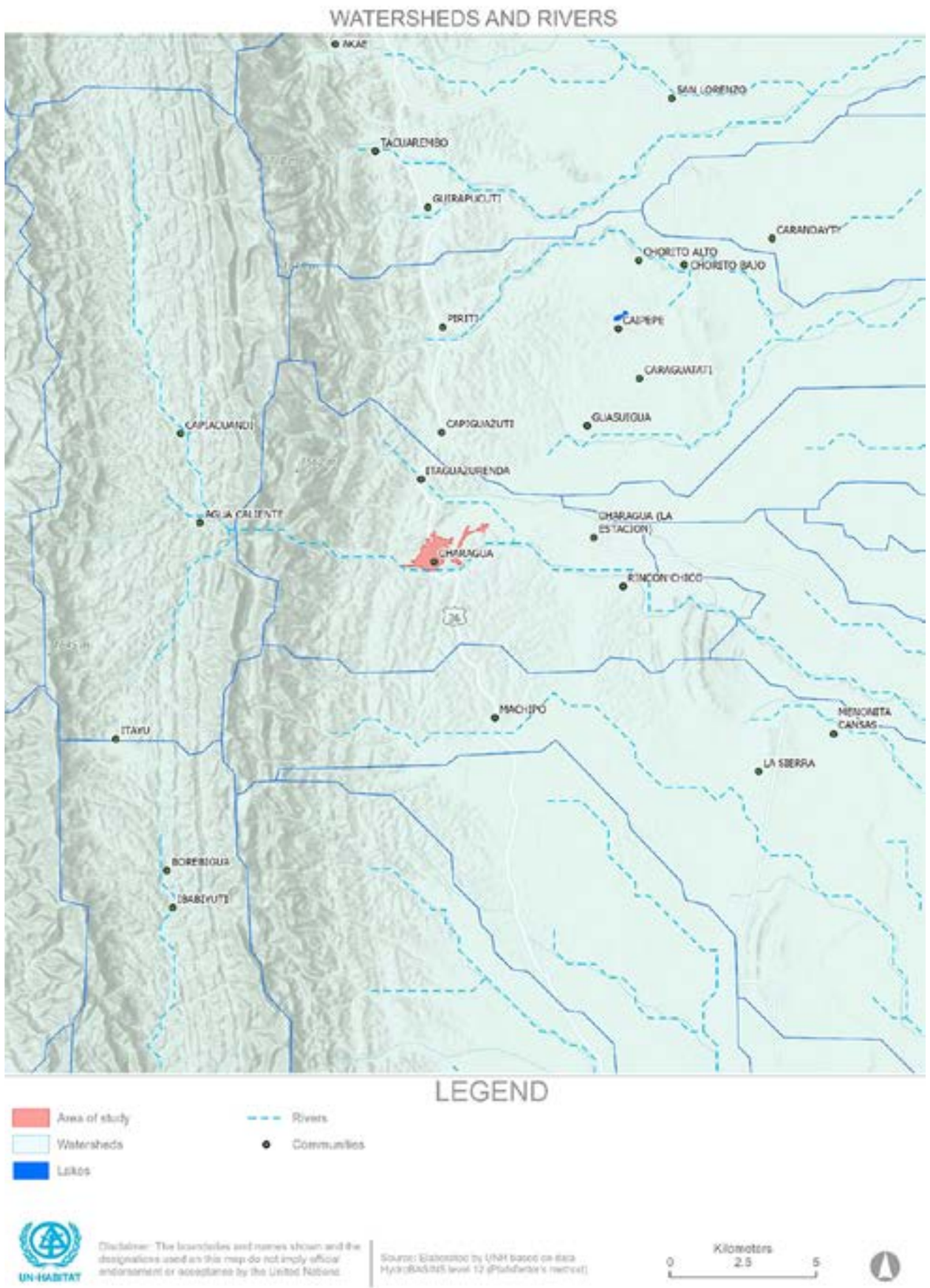


Fig. 10: Water features in Charagua
Source: UN HABITAT, 2024

Fig. 11: Forest cover in urban Charagua
Source: UN HABITAT, 2024

Climatology

According to Köppen's classification, Charagua features three climate types across its physiographic systems:

- **Sub-Andean Belt:** Temperate rainy climate with dry winters and warm summers, transitioning to a savannah climate with periodic rains in the northern regions.
- **Transition Area:** Savannah climate with seasonal rains to the south and dry winters prevalent across most of the area.
- **Chaco Plain:** Semi-arid steppe climate, characterized by hot temperatures exceeding an average annual temperature of 18°C in winter.

Temperature variations range from 21 to 26°C, with an average of 23°C; maximum temperatures can reach 35°C, and minimums can drop to 12°C. Extreme temperatures in November and December can peak at 41°C, while June and July may see lows of -6°C. Elevation affects temperature, for instance; Charagua pueblo is located at Chaco plain, which experiences the maximum temperatures.

Rainfall recorded at the Boyuibe meteorological station indicates a peak between November and March, accounting for 75% of annual precipitation. Monthly rainfall is highly variable, with the driest period occurring from June to August, contributing only 3% to the annual total. Annual rainfall ranges from 560 mm to 1300 mm, with the northeastern part of the territory receiving the most rain and the southeastern part receiving the least. Most communities in Charagua Norte, Parapitiguasu, and Alto Isoso experience rainfall between 560 mm and 810 mm, while Bajo Isoso and the majority of Kaa Iya Park receive between 820 mm and 1,000 mm.

Fig. 12: Algarobilla tree in Charagua
Source: Gota del Chaco, 2024

Vegetation

The region's natural vegetation is influenced by physiographic landscapes, exhibiting variations in density and height. Predominant species include white and red quebracho mistol, pela pela, algarrobilla, and cupesí in lowland and ancient alluvial plains. In the Isoso wetlands, tree vegetation is scarce, and shrubs are dense and tall, featuring species such as choroqueta and carob tree. Drier landscapes exhibit thorny and compact vegetation.

Fauna

The native fauna, particularly larger mammal species, have experienced a significant population decline in recent years due to indiscriminate hunting and vast habitat fragmentation caused by agricultural and livestock expansion, which competes for resources and reduces available space.

Climate change

Recent years have seen considerable discussion among Charagua's population regarding the observable impacts brought about by climate change. Residents report increased rainfall variability, with unpredictable patterns, that disrupt traditional planting seasons, now often occurring between December and March, rather than the formerly stable period of November to January. Water sources, once abundant and reliable, have also seen drying trends. Increasing temperatures and more intense sunlight are perceived to adversely affect agricultural output, and in turn economic productivity, and the development of native flora and fauna.

Drought has emerged as a significant adverse climatic event, undermining traditional rainfed agricultural practices. Residents express concern that while the soils are highly fertile, water scarcity remains a critical issue, compounded by instances of excessive rainfall leading to flooding. The Parapetí River, which runs near approximately twenty communities, has caused extensive flooding in recent years, damaging irrigation systems, leading to erosion and landslides, loss of transport connectivity, disruption to service provision, and livelihood generating activities. Currently, no systematic rainfall measurement mechanisms exist within the territory.

Urbanization Trends

The municipality of Charagua is predominantly rural, with urban development primarily concentrated in Charagua Pueblo, encompassing the city of Benemérita de Charagua and Charagua Estación. Charagua Pueblo serves as the political and administrative center, housing essential services including financial, health, and educational facilities, and consists of ten neighborhoods. Charagua Estación is the second most significant urban center, formed around a historical railway station and growing steadily.

Multitemporal satellite imagery reveals a trend of urban growth: by 1995, Charagua Pueblo's growth extended towards the main square; by 2005, expansion occurred towards the southwest and east; and by 2021, growth was noted in the north, east, south, and southwest. The total consolidated area now measures 140.0577 hectares, with an urban land occupancy coefficient of 40.22% for public use and 59.78% for private use.

The cadastre homologation study indicates excessive unplanned and uncoordinated urban growth and lack of control in land regulation. Consequently, the concentration of transportation infrastructure, such as roads, bridges and public transport networks, and basic services, such as water supply and waste management, remains problematic. Health and education infrastructure struggles to meet the needs of the expanding urban population. The unregulated urban growth and lack of infrastructure provision in Charagua aggregate climate vulnerability by straining services, making communities more susceptible to climate-related stressors such as droughts and floods. This situation heightens the risk of health crises and environmental degradation, as insufficient health and education infrastructure leaves residents poorly equipped to adapt to and recover from climate-related disasters, further threatening their livelihoods and well-being.

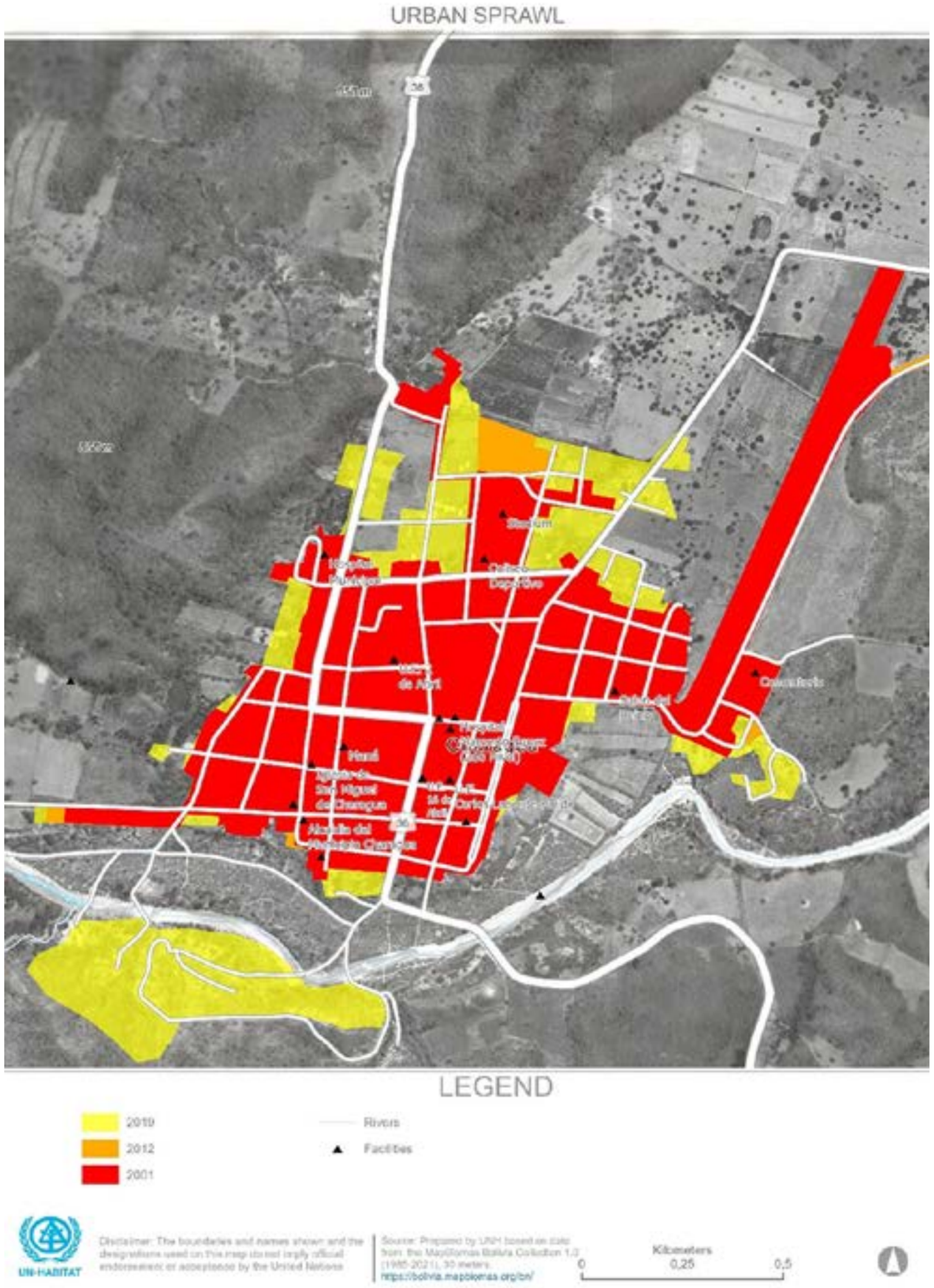


Fig. 13: Urban sprawl in Charagua
Source: UN HABITAT, 2024

Physical and Social Infrastructure Assets

Road Infrastructure Overview

The network of road infrastructure in Charagua consists of fundamental networks (three highways), departmental roads (four sections), and neighbourhood roads (21), all managed by the government. Generally, these roads are unpaved (sandy and clayey), with some sections covered in gravel, and feature minimal infrastructure such as bridges and culverts. A railway crosses Charagua from north to south, passing through Charagua Norte, Estación Charagua, and Parapitiguasu. Users regard this as a regular means of transport throughout the year, although it requires ongoing maintenance to ensure the safety of passengers and drivers.

The road network is impacted during floods so that connectivity and accessibility is disrupted, isolating several parts of the town. For example after a flood or even just a rise in river Charagua, the neighborhood of Barrio 1ro de Mayo is isolated from Charagua Pueblo, avoiding that people reach services.

Electricity Supply1

Charagua is equipped with its own electric power plant, which provides electricity to urban centres and nearby communities, achieving 75% coverage of homes. Solar panels serve communities that are distant from the main grid, particularly in Bajo Isoso, where many new communities lack this service. An isolated mixed electric power system in El Espino (Charagua Norte) supplies electricity to the community and can extend to neighboring areas. Since December 2001, the Rural Electrification Cooperative has provided a permanent energy service to Charagua Pueblo, drawing power from two gas engines, with an additional power generator installed between Charagua Pueblo and the station. Considering the populations of Charagua Pueblo and Charagua Station, 75.18% have permanent domestic electricity service, while 24.82% do not.

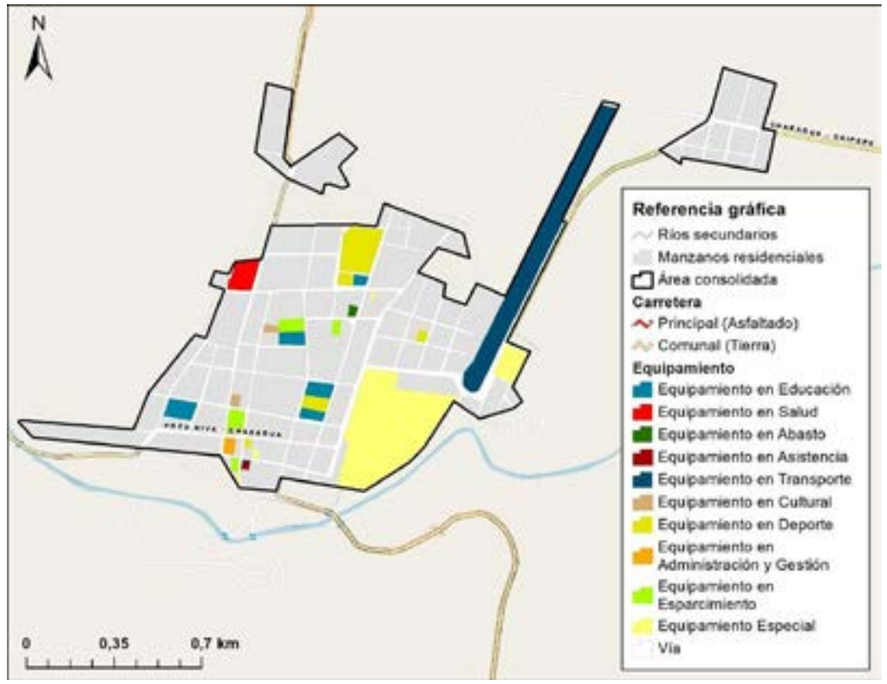


Fig. 14: Urban equipment in Charagua Pueblo
Source: Guarani Autonomous Government of Charagua Iyambae, 2023.

Media and Communication

The media landscape in Charagua has expanded in terms of diversity and coverage, primarily due to the Internet; however, the signal quality remains poor, with connectivity issues even in Charagua Pueblo.

Basic Services

Regarding basic services, 90.9% of households have access to water (from mains, public basins, wells, or waterwheels with pumps), while 65.9% have access to basic sanitation (sewerage, septic tanks, or cesspools). In Charagua Pueblo, 90.03% of homes rely on the electricity company network, with 9.30% lacking this service and 0.67% using alternative sources. The predominant fuel for cooking is piped gas (52.96% of homes), followed by bottled gas (31.00%), and firewood or other sources (16.04%). The main water source for households is mains pipes (96.90%), with public pools at 2.56%, and rainwater, rivers, springs, or ditches at 0.54%. Sanitation services are managed through the sewer system (56.81%), cesspools (32.46%), and septic tanks (10.29%). Garbage disposal is primarily conducted through public collection services (71.70%), burning (12.53%), littering in vacant lots or streets (5.53%), and other methods (10.24%).

Education and Health Infrastructure

The Charagua Educational District comprises 70 educational units grouped into 11 educational centres. The majority (90%) of these units are located in rural areas, with only 10% situated in urban areas. The health infrastructure includes 37 health facilities, predominantly in rural regions (97%), with just 3% in urban areas.

Community Facilities

The facilities in Charagua can be classified as follows:

- **Educational Equipment:** 6 administrative buildings.
- **Health Equipment:** 1 municipal hospital. There is one ambulance and no fire fighters service.
- **Supply Equipment:** 1 municipal market.
- **Child Protection Equipment:** 1 building housing the Office of the Ombudsman for Children.
- **Transport Equipment:** 1 airstrip (for domestic flights operated by private little planes) and 1 bus terminal.
- **Cultural Facilities:** 1 Church of San Miguel and 1 music school.
- **Sports Facilities:** 1 stadium, 1 basketball court, 1 futsal and soccer court, 2 additional basketball and futsal courts, and 1 coliseum.
- **Public Administration Facilities:** Building of the Municipal Government of Charagua.
- **Recreational Equipment:** 3 parks and 2 vacant lots.
- **Special Equipment:** Former municipal slaughterhouse, infantry regiment, land designated for a prison, YPFB district station, and the General Charagua Cemetery.

Unfortunately, there are not emergency service equipment nor a plan for different disasters.

Institutional and Policy Frameworks

The Plurinational State of Bolivia has adopted decentralisation processes to grant autonomy to its nine different departments, enabling them to pursue their own sustainable development goals.

The Political Constitution of the State is the supreme law of the country, establishing the general principles for the functioning of the state. Based on this constitution, the following laws are most relevant to the definition and organisation of territory, environmental management, and climate change activities:

- **Law 1580 (1994):** Approves and ratifies the Convention on Biological Diversity, signed by the Government of Bolivia on 6 October 1992 during the United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil.

- **Law 031 – Framework Law of Autonomies and Decentralisation "Andrés Ibañez" (2010):** Establishes the competencies of regional and municipal governments within their jurisdictions.

- **Law 777 – Framework Law of the Integral Planning System of the State (2015):** Aims to establish the Comprehensive State Planning System (SPIE), which conducts the planning process for the comprehensive development of the Plurinational State of Bolivia within the framework of "Living Well."

- **Law 300 – Framework Law of Mother Earth and Integral Development of Living Well (2012):** Establishes a regulatory framework for the preservation of the environment (Mother Earth), ensuring the continuity of the regeneration capacity of its components and habitats.

- **Law 1333 – Law of the Environment (1992):** Aims to protect and conserve the environment and natural resources, regulating human actions concerning nature and promoting sustainable development to improve the quality of life for the population.

- **Law 602 – Law of Risk Management (2014):** Establishes the institutional framework and regulations for risk management, including prevention, mitigation, recovery, and response to disasters or emergencies due to natural, socio-natural, technological, and anthropogenic threats, as well as addressing social, economic, physical, and environmental vulnerabilities. This law defines the principles that govern risk management, prioritising the care of vulnerable populations.

- **Law 835 (2017):** Ratifies the "Paris Agreement," adopted on 12 December 2015 during the Twenty-First Conference of the Parties (COP 21) of the United Nations Convention on Climate Change.

- **Plurinational Climate Change Policy (2016):** Aims to promote management of the climate crisis at all levels of government, including mitigation, adaptation, and resilience actions, as well as response measures to address the impacts, damages, and losses caused by this crisis—all within the framework of comprehensive development to "Live Well" in harmony with Mother Earth.

Charagua Iyambae is the first Indigenous Autonomy established in the Plurinational State of Bolivia. The political horizon of the Charagua Iyambae Indigenous Autonomy is articulated in Article 2 of its Statute, which states that its purpose is YAIKO KAVI PÄVE (To live well).

Within this regulatory framework, the municipality of Charagua has developed the Municipal Development Plan: "Community Territorial Management Plan to Live Well from the Autonomous Indigenous Government of Charagua Iyambae, 2021 – 2025."

Currently, Charagua lacks a climate and/or agri-food risk management plan and local regulations in this field. While some initiatives exist at the level of other institutions and the Guarani organisation, their impact and scalability have not yet been realised.

Structure and Organisation of the GAIOC in Charagua

The local government is constituted by its own rules and procedures, as specified in its Statute, which was approved in a referendum on 20 September 2015. This structure is established from the bottom up, encompassing communal, zonal, and interzonal levels. The organisation is divided into three bodies:

1. Collective Decision Body: This zonal organic body is responsible for collective decision-making regarding the planning, monitoring, control, and supervision of plans, programmes, and projects for communities or territorial organisations within a zone.

2. Legislative Body: This body regulates the procedures and decisions defined by the Ñemboati Reta (Collective Decision Body). It possesses deliberative, legislative, and supervisory powers.

3. Executive Body: This body is responsible for executing the approved plans, programmes, and projects according to participatory community planning. It comprises six executives. The Zonal Executive is responsible for the execution of public management and administration plans, programmes, and projects within each zone.

02

METHODOLOGY

Approach and Methodology

The Multilayered Vulnerability Assessment (MVA) tool employs a three-stage methodology designed to help countries, cities, and communities effectively incorporate, adapt, and operationalize the assessment. This structured and phased approach facilitates improved resilience planning and decision-making. Each stage comprises specific steps and activities, outlined as follows:

Stage 1: Preparation

This stage focuses on establishing the groundwork for the MVA and the framework for the assessment process. Key contributors are identified, and relationships necessary for completing the MVA and analysis are established. This initial phase is crucial for ensuring that the assessment is comprehensive, well-organized, and aligned with the goals and objectives of the organization or community involved. Stage 1 consists of three steps (e.g., Step 1.1: Set up delivery team and steering committee; Step 1.2: Conduct rapid diagnostic of the city or urban area) and eight activities.

Stage 2: Mapping and Analysis

This stage involves sourcing and applying data to provide a detailed analysis of vulnerability hotspots within urban areas, examining factors related to climate change, biodiversity, and urban dimensions. The maps produced in this stage are key outputs of the MVA, allowing for the overlaying of outputs to identify and analyze areas of conflicting vulnerabilities and vulnerability hotspots. Stage 2 is articulated in five steps (e.g., Step 2.2: Data acquisition and collection; Step 2.3: Mapping historic, current, and future vulnerabilities; Step 2.5: Interpretation and analysis of vulnerability hotspots) and encompasses 19 activities.

Stage 3: Intervention Planning

In this final stage, the findings from Stage 2 are transformed into bankable projects aimed at enhancing resilience to current and future climate, urban, and biodiversity shocks and stresses. Collaborating with a diverse range of stakeholders, this stage involves developing 10 to 12 resilience-building actions that are both financially and technically feasible, addressing the intersecting vulnerabilities identified in the MVA. Stage 3 comprises three steps (e.g., Step 3.1: Visioning and objective setting; Step 3.2: Develop resilience action plans) and includes 12 activities.

The MVA provides a clear, phased methodology that guides countries, cities, and communities through effective resilience planning. The tool's three-stage approach—preparation, mapping and analysis, and intervention planning — provides a clear framework for systematically identifying urban vulnerabilities and transforming insights into actionable, bankable projects. This method ensures that resilience-building actions are well-targeted, feasible, and aligned with local priorities, making it a critical tool for addressing the complex challenges posed by climate change, urbanization, and biodiversity loss.

Customization to Local Context

The MVA methodology was customized to address the limitations in data availability for Charagua, a small town that historically lacks a planning culture and has limited resources for urban planning. Consequently, the project activities are organized into interconnected workstreams:

- The global methodology was tailored for Charagua, addressing the lack of available data and information by incorporating primary data collection through mechanisms such as aerial imagery drone mapping, field-based observations and surveys, and participatory vulnerability mapping through workshops and surveys.

- In Charagua, the approach began by understanding the territory of this small town located in the Chaco Region, which has a unique governance structure based on indigenous autonomy.

- One significant challenge was obtaining official information. This task proved difficult, as there was minimal up-to-date, accurate geospatial data

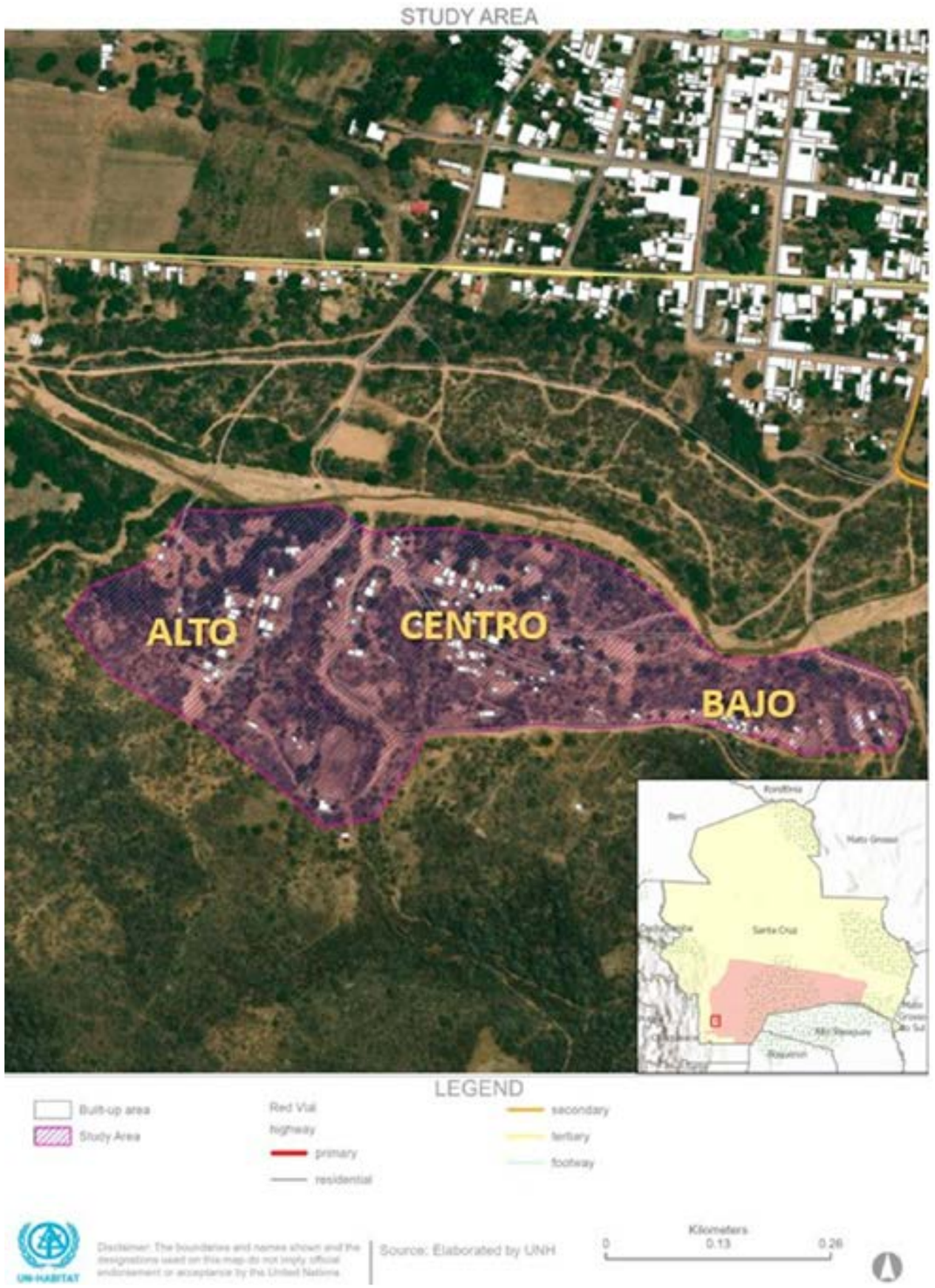


Fig. 15: Intervention area in Charagua
Source: UN-Habitat

or climate change, urbanization and biodiversity information publicly available – only a document that could be considered a draft, which served as the baseline for the vulnerability assessment. One of the main issues was obtaining high quality datasets at the desired temporal and spatial scale and resolution.

- The chosen strategy involved gathering as much information as possible and generating primary own data through fieldwork. Surveys of local citizens were the primary method for data collection. Additionally, an UN-Habitat official mission provided an opportunity to convene some members of the Steering Committee to undertake community asset and vulnerability mapping and social cartography across three dimensions: urbanization, climate change, and biodiversity.

- Due to the lack of local information for the development of some indicators and the construction of maps, it was necessary to use information from global, open-source databases. For the ***urban dimension,*** the Global Human Settlement Layer was used in the population density indicator. In the ***climate change dimension,*** data from the Coalition for Disaster Resilient Infrastructure and Google Earth Engine datasets were used to construct the landslide and drought indicator. Additionally, data from Iowa State University's DataShare and WorldClim were used for the temperature change indicator. In the ***biodiversity dimension*** for the Mean Species Abundance (MSA) indicator, data from the Global Biodiversity Model for Policy Support were used.

- Likewise, to complement the geographic and cartographic information of the municipality, it was necessary to carry out an innovative approach to data collection with a drone and the *Light Detection and Ranging* method (LiDAR[1]). With which higher spatial resolution images and a digital elevation model were obtained, to prepare the basic cartography and the maps of the MVA.

Geographic Scope

The geographic scope of the assessments focused on the most vulnerable areas affected by climate change hazards. The selected area is a neighborhood known as Barrio 1ro de Mayo, which is considered the poorest neighborhood in Charagua Pueblo. This selection was made during a Steering Committee meeting held as part of the UN-Habitat staff mission in August 2024. Then the following analysis will focus on Barrio 1ro de Mayo and in Charagua Pueblo in general.

Barrio 1ro de Mayo began as an informal settlement and is now regarded as part of Charagua Pueblo. It started with 30 families and is currently divided into three zones:

- **Barrio 1ro de Mayo Bajo:** The lowest-lying area in relation to the Charagua River.

- **Barrio 1ro de Mayo Medio:** The area located at mid-elevation, between Barrio 1ro de Mayo Bajo and Barrio 1ro de Mayo Alto.

- **Barrio 1ro de Mayo Alto:** The highest area in relation to the Charagua River.

Fig. 16: Example of households in Barrio 1ro de Mayo
Source: Own based in local visit

03

VULNERABILITY DIMENSIONS

Vulnerability Dimensions

Climate risk, biodiversity loss and rapid urbanization are intrinsically linked. The following assessment provides an integrated analysis of current and future vulnerabilities related to climate change, urbanization and biodiversity for Charagua municipality.

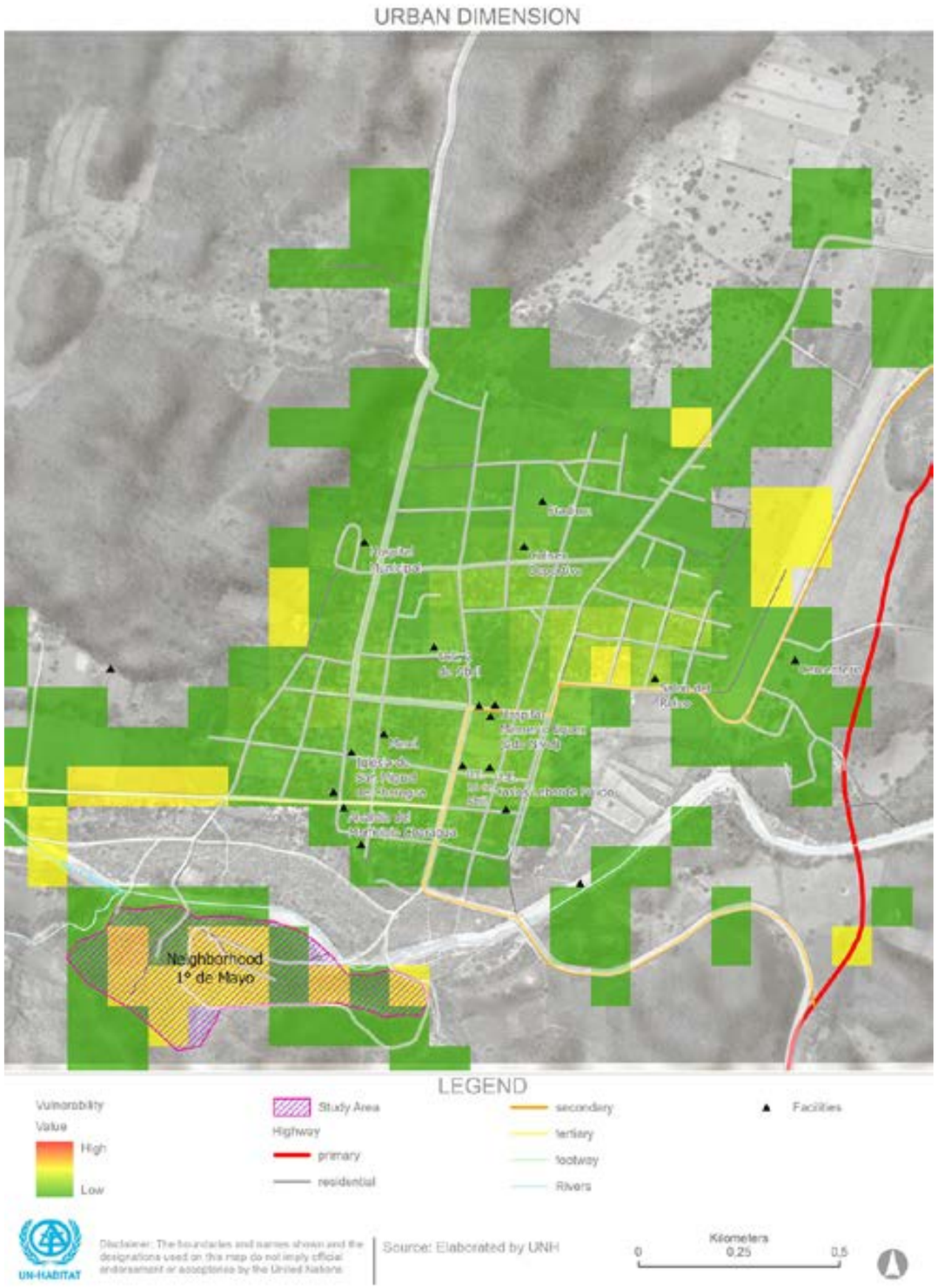
Urban Dimension

The urban dimension of the Multiple Vulnerability Assessment (MVA) for the Charagua municipality encompasses a series of indicators that reveal the vulnerability of the city to the challenges of urbanization, population growth and socioeconomic pressures. This dimension reflects the complex interaction of factors such as population density and urban growth, which influence the capacity of Charagua to adapt to the pressures of urban growth.

Bolivia is experiencing a rapid urbanization process, with nearly 70% of its inhabitants living in cities. UN-Habitat has helped the country in the development of the National Policy of Comprehensive Development of Cities, which was recently approved in 2024, after a participatory process with all 339 municipalities. At the national level, the national government plays a crucial role in setting national policies and development strategies. The Ministry of Development Planning (MPD) coordinates between international donors, financial institutions, and government bodies to ensure that development projects are funded and implemented according to national priorities. The Vice Ministry of Housing and Urbanism (VMVU) oversees planning in general for municipalities, and urban policies. VMVU depends on the Ministry of Public Works, Services and Housing, which in turn is responsible for overseeing infrastructure projects such as housing, roads, railways, and airports.

At the local level, the Guarani Indigenous Government Charagua Iyambae (GAIOC) is the entity that governs the municipality in the framework of the Original Indigenous Peasant Autonomy that is a level of sub national government in Bolivia. The case of Charagua is distinct due to its vast territory contrasting with the small, rural nature of Charagua Pueblo, which, despite its slow growth, remains vulnerable to climate-related risks.

The challenges in urban development stem from inadequate governance and insufficient resources for robust town planning and legal enforcement, leading to significant unmet population needs. Furthermore, extensive, and sometimes harmful, agricultural practices, predominantly driven by Mennonite communities, pose significant environmental pressures on the land. This underscores the need for sustainable land use management strategies that balance economic development with environmental stewardship and climate resilience.



Indicators

Indicator 1 – Population density

The population density indicator was chosen to assess how population pressure influences urban growth, provision of, and access to services and goods. High population density can exacerbate problems such as insufficient public services, housing, and income, among others, which contributes to increasing vulnerability. Understanding population distribution is key to planning future urban infrastructure and services and addressing the socioeconomic needs of residents.

High population density amplifies the vulnerability of cities and communities to the adverse impacts of climate change. Densely populated areas encounter challenges such as increased exposure to extreme weather events, overburdened infrastructure, limited green spaces, poor air quality, heightened heat stress, concentrations of marginalized communities, and competition for basic services. In contrast to densely populated areas – and the communities, infrastructure, and ecosystems within them – sparsely populated regions like Charagua, face unique vulnerabilities to climate change, including heightened exposure to extreme weather events due to their remote locations and limited access to emergency services. These areas can also be highly sensitive due to their reliance on natural resources and limited infrastructure, which can be easily overwhelmed by climate-related stressors. Also, such areas often lack the adaptive capacity to recover from such events due to scarce resources and institutional support, a challenge evident in this town.

The population density indicator shows the amount of population in a specific area, to the indicator the observation unit is called a block, that its cover approximately 100 x 100 m. To normalize the indicator, the maximum and minimum values of the records were used, in such a way that the result of the population density gradient for the city and the study area was obtained.

One limitation in this indicator exists, it relies on reports from the European Union (2020) rather than from the Bolivian national census (2012). Furthermore, there is no up-to-date census information for Barrio 1 de Mayo.

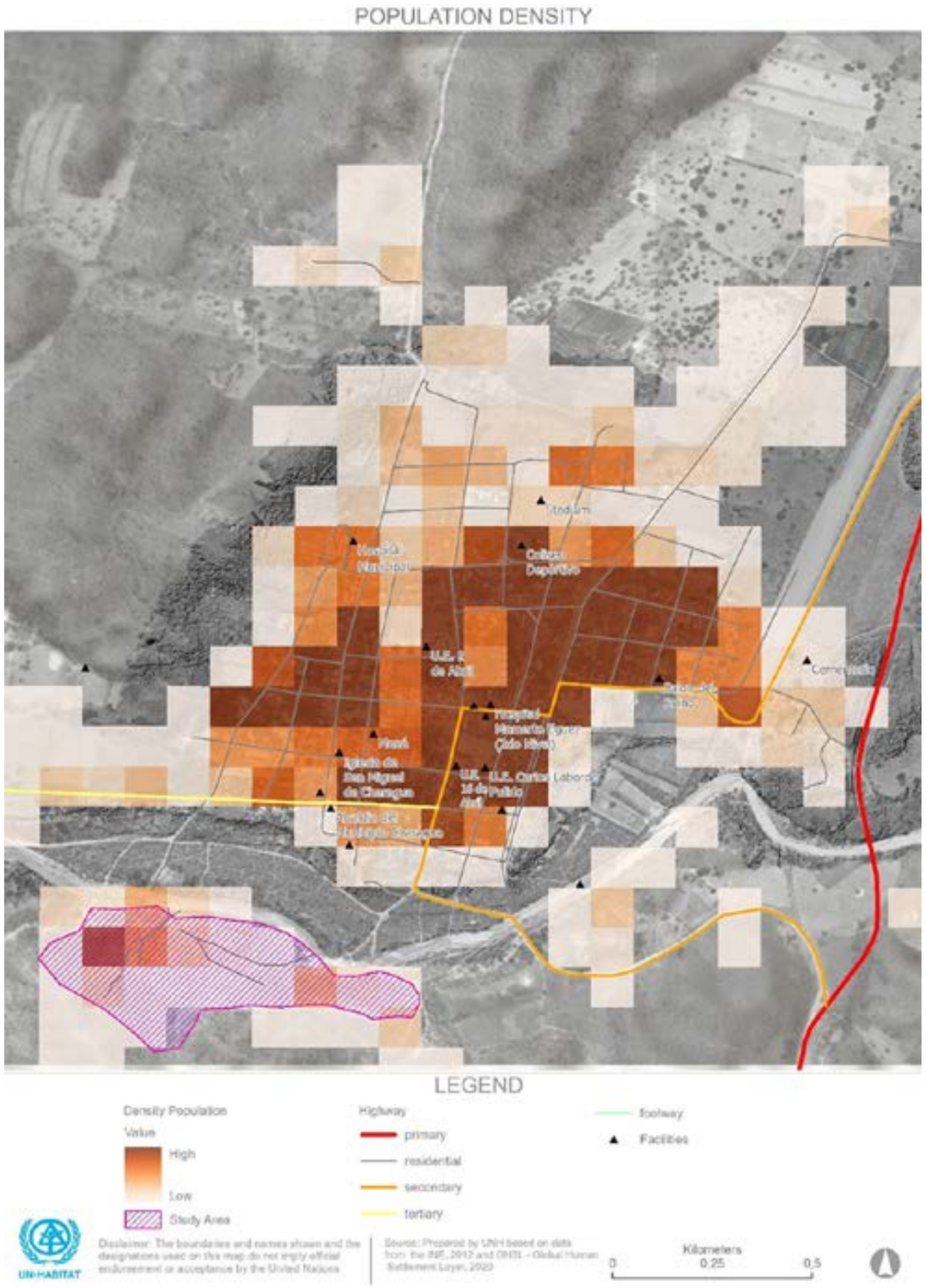


Fig. 17: Population Density in Charagua
Source: UN-Habitat

As illustrated by the above map, Charagua Pueblo is characterized by a low-density urban structure, where residents predominantly live in single-family houses rather than multi-story apartments. This building typology and morphology, combined with the use of materials like wood and clay in many constructions, makes the housing and facilities more vulnerable to climate-related hazards such as flooding, while also straining already limited resources and infrastructure due to the dispersed nature of the population.

In Barrio 1ro de Mayo, the housing stock is characterized by single-level constructions, with about half built primarily from wood and the rest from bricks and mortar. The prevalence of shared housing, where multiple families reside in single-family dwellings, highlights a trend of overcrowding and resource strain. The rapid expansion of Barrio 1ro de Mayo, from 30 to over 300 families in recent years, underscores the challenges of managing urban growth in areas with limited infrastructure and resources. Limited service provision and coverage, particularly in regard to disaster preparedness, emergency response and social protection indicate low adaptative capacity in this area.

Indicator 2 – Urban growth

This indicator reflects changes in land cover and urban growth. Urbanization and urban growth are fundamental to understanding how the municipality of Charagua has expanded and transformed. A comparison of satellite images from 2017 and 2023 was made revealing increasing changes in size in urban coverage.

The spatial expansion of cities and the concentration of built-up infrastructure further exacerbate urban climate vulnerability. Rapid, extensive and unplanned urbanization increases the exposure people, infrastructure and urban systems to natural hazards. Urban sprawl, and the construction of unregulated infrastructure often leads to the loss and fragmentation of natural ecosystems and biodiversity, and reduces the capacity of infrastructure and services to accommodate growing populations or withstand the impacts of climate change.

The indicator's limitation lies in its classification of urban growth horizontally rather than vertically. Vertical urban growth is a significant and important component of urban growth and is not counted here.

As illustrated in the map, Charagua Pueblo is experiencing growth in two distinct areas: the northern part, near the market and hospital, and the southern area, represented by Barrio 1ro de Mayo, which has expanded beyond the natural barrier of the Charagua River. The growth patterns in these areas differ significantly; the northern part features a structured street network, whereas Barrio 1ro de Mayo, having emerged as an informal settlement, is characterized by dirt roads leading up the hill. According to local authorities, Charagua Pueblo is expected to continue expanding in both directions. While the northern area will maintain access to public services, there is a pressing need to improve service coverage and living conditions in Barrio 1ro de Mayo, where residents currently lack adequate infrastructure and services. This dichotomy in urban development poses challenges for equitable service delivery and highlights the need for targeted interventions to address disparities in infrastructure and access to essential services, particularly in informal settlements like Barrio 1ro de Mayo. Furthermore, the continued growth in both areas will require strategic planning to ensure that all residents have access to basic amenities and are protected from environmental and climate-related risks.

Fig. 18: Urban growth in Charagua
Source: UN-Habitat

Urban Dimension Analysis

The following urban dimension analysis considers the 3 components of vulnerability: i) Exposure; iii) Sensitivity; and iii) Adaptive capacity.

Exposure

The objective is to identify how Charagua Pueblo is exposed to changes in the climate today and how it could be in the future in the urban dimension.

Description of current and future changes

Charagua Pueblo is likely to experience significant changes that could impact urbanization processes and trends, as well as social and ecological impacts. Several climate-related hazards pose risks to the town, notably droughts and landslides, which are prevalent in the Chaco region and specifically affect Charagua. These hazards can manifest biophysically, potentially triggering landslides and devastation in the study area. As these events become more frequent, severe and longer-lasting, fragmentation and displacement is likely. This may isolate Barrio 1ro de Mayo from the central area of Charagua Pueblo – and the amenities, services and opportunities located there – worsening the existing socio-economic challenges faced by residents in this community.

As illustrated in Figure 14, the population density in Barrio 1ro de Mayo is currently low, with Barrio 1ro de Mayo Alto having an even lower density. Consequently, Barrio 1ro de Mayo Medio and Bajo are more exposed to climate change hazards due to their relatively higher population concentrations, the lack of networked infrastructure, services, and connectivity, the hillside, precarious topography and terrain, and higher prevalence of low-income households living in informal settlements.

Notably, Barrio 1ro de Mayo Bajo is experiencing the most rapid, but unplanned and unregulated, growth within the study area, which not only increases its vulnerability to climate-related risks but also underscores the need for proactive urban planning to mitigate these vulnerabilities. This growth, combined with the informal nature of the settlement, heightens the urgency for infrastructure development and climate-resilient strategies to protect residents from the impacts of droughts, landslides, and other climate-related stressors.

Identification of people, places, institutions and sectors that are exposed to climate hazards

The table 2 summarizes identification of climate hazards and exposed features and sectors.

Accessibility to essential services in Barrio 1ro de Mayo is severely limited due to its physical isolation from the Charagua Pueblo centre, as residents must cross the Charagua River on foot or by vehicle (as there is no bridge) to access basic amenities, employment or income-generating activities, socioeconomic and administrative services. This lack of connectivity is compounded by inadequate urban planning, which has largely neglected the needs of Barrio 1ro de Mayo, providing only a rudimentary health post as the sole public service.

The absence of markets, schools, and stores further exacerbates the challenges faced by the approximately 300 families residing in the area, who rely on limited water supply and electricity as their primary basic services. Food security also becomes a critical issue when connectivity is disrupted or suspended. This peripheral location heightens their vulnerability to climate-related hazards, as they lack access to comprehensive emergency services and infrastructure that could mitigate the impacts of extreme weather events, such as flooding. The socio-economic disparities resulting from this neglect highlight the urgent need for inclusive urban planning that addresses the fundamental needs of marginalized communities like Barrio 1ro de Mayo.

Climate Change Hazard	Current Weather Data	Climate Scenario Projections	Impacts	Exposed features, people and sectors
Drought/ Landslides/ Temperature rise	**Precipitation:** 560 mm to 1300 mm	**SENHAMI projections:** · Precipitations increase: 8%[2] · Temperature increase: 2,77%[3]	**Displacement of households**	**Inhabitants of Barrio 1ro de Mayo**
	Temperature From 21 to 26ºC, which varies from east to west. The average temperature is 23ºC, the average maximum is 35ºC and the average minimum is 12ºC		**Disruption of regular services** (e.g. electricity, water, transport) and administrative functions	**GAIOC**
			Disruption of health services	**In Charagua Pueblo´s hospital and in the only health post in Barrio 1ro de Mayo**
			Disruption of education services	**In Charagua Pueblo´s there is only one school and there is not one at Barrio 1ro de Mayo**
			Disruption of products supply and gastronomy services	**Stores, markets and restaurants**
			Closing	**e.g. Bank office**

Table 2: Identification of climate hazards and exposed features and sectors in urban dimension
Source: Own elaboration

Sensitivity

The objective is to identify how people, places, institutions, and sectors within Charagua's urban dimension are currently being impacted, and the degree to which they could be impacted in the future. There are 3 considerations: i) Demographic; ii) Housing; iii) and iii) Production and investment.

Demographic

Regarding **Gender,** according to the latest National Population and Housing Census (CNPV, 2012), the Municipality of Charagua has a population of 3,496 inhabitants, of which 1,679 are men (48.03%) and 1,817 are women (51.97%). In absolute terms, the female population are likely to be disproportionately affected in the event of disasters since there are more female inhabitants. As women represent the majority of inhabitants in the municipality, it is critical to understand the specific and interconnected physical, social-economic and ecological challenges they face when adversely impacted by that might get affected by disasters.

Women are further disproportionately affected by climate change due to gender-based inequalities in access to resources, decision-making, and economic opportunities. Social norms and power structures often restrict women's control over land, financial services, and other critical resources, limiting their ability to adapt to climate impacts (UNFCCC, 2013). Additionally, women bear a disproportionate share of unpaid care work, a burden that intensifies during climate-induced disasters as they take on extra responsibilities to support recovery efforts. Moreover, traditional gender roles and behaviors increase women's vulnerability to natural disasters, further exposing them to the compounded risks of climate change (UNFCCC, 2013). In Charagua, these intersectional challenges faced by women are all prevalent, and it is highly likely that they are significantly more sensitive to urban and climate shocks and stresses compared to their male counterparts.

In terms of the **proportion of children and the elderly,** there is no segregated data available for specific age ranges; only aggregated data is provided, which includes ages 0 to 5 years old and 6 - 19 years old. Combined, these age groups represent 50,63% of the population. In absolute terms, this means that for every 10 people, 5 are extremely vulnerable to the hazards and disasters associated with climate change. Elderly people (60 years or more) represent the 6.78% of the total population. For children and the elderly living in informal settlements or on precarious hillside land in Barrio 1ro de Mayo, sensitivity to floods, landslides, and drought is increased due to their potentially limited mobility, higher health vulnerabilities, and greater dependence on external support. These conditions are made worse due to the poor quality housing, inadequate infrastructure, and restricted access to essential services in such areas.

In terms of **household literacy** and **education levels,** the data for Charagua is not directly related to literacy rates but rather to attendance at school. According to official information, the urban center reports a school attendance rate of 82.07% with 540 male and 481 female students. The percentage of those who do not attend school or whose attendance status is unspecified is 17.93%, comprising 169 males and 54 females). Those who do not attend school may be at higher risk to climate hazards because lower education levels can often limit their ability to access, understand, and act on critical early warning systems, disaster preparedness measures, and adaptation strategies. Education provides essential knowledge on risk reduction, emergency response, and sustainable resource management, which are crucial in a region prone to floods, landslides, and drought. Additionally, limited schooling reduces economic opportunities, increasing household vulnerability by restricting income diversification and access to climate-resilient livelihoods

Regarding the **proportion of economically active household members,** the available data indicates that the total population engaged in economic activities consists of 1,178 inhabitants - 689 (58.49%) men and 489 (41.51%) women. This means that of the total population, only 33.7% are currently working. The main economic activities are: "Other services" with 41.85% (193 men and 300 women), "Commerce, transportation and warehouses" with 19.86% (141 men and 93 women) and "Agriculture, livestock, hunting, fishing and forestry" with 10.10% (104 men and 15 women). The remaining 28.18% of the population (251 men and 81 women) works in sectors such as "Construction", "Manufacturing Industry", etc. The primary categories are: "Worker or employee" with 41.26% (311 men and 175 women), "Self-employed worker" with 29.71% (203 men and 147 women) and "Domestic worker" with 3.65% (43 women). It is worth noting that 19.86% (134 men and 100 women) fall under the "Unspecified" category. The remaining categories account for 5.52% (41 men and 24 women).

The relatively low proportion of economically active household members (33.7%) in Charagua indicates a high level of economic dependency, which can amplify household vulnerability to climate hazards. Moreover, with a significant share of the working population engaged in the informal sector – particularly in "Other services" (41.85%) and "Commerce, transportation, and warehouses" (19.86%) – many households in Charagua may lack job security, stable incomes, and social protection, limiting their ability to recover from climate shocks such as floods, landslides, and droughts.

Consideration	Variables	Sensitive Features (people, places, institutions) and sectors
Demographics	Gender	The majority of the population is female, therefore quantitatively, female population is more sensitive in quantity, in relation to male population.
	Proportion of children and elderly	Charagua´s population is predominantly young, with a significant portion under the age of 15. As a result, this age group is particularly vulnerable. Elderly people are also a group of the society that is particularly vulnerable. Since they have less resources since they are unemployed and not all have retirement income.
	Proportion of economically active Household members	Employed household dwellers such as male population are as much vulnerable as those that do not work, however; income availability make that economically active inhabitants would have more resources to cope with disasters.

Table 3: Socio-economic sensitivity variables (Demographics) in urban dimension

Source: Own elaboration

The analysis highlights key demographic, socioeconomic, and housing-related factors that influence Charagua's sensitivity to climate hazards. Women, children, and the elderly face heightened vulnerability due to gender inequalities, caregiving responsibilities, limited mobility, and economic constraints. Low school attendance and a high level of economic dependency further exacerbate risks, as limited education and informal employment reduce adaptive capacity and access to recovery resources. Combined with precarious housing and inadequate infrastructure, these factors make certain groups disproportionately susceptible to climate shocks such as floods, landslides, and droughts.

As shown in the above table, the most sensitive to the variables are vulnerable groups of society: Elderly, people with disability, and children particularly those living in Barrio 1ro de Mayo. Intersectional vulnerabilities relating to gender, age, disability, income, education, and ethnic group, place certain residents at severe risk of the adverse physical, and social, economic impacts of climate-related hazards, shocks and stresses. In terms of the institutions of Charagua that are most sensitive, this would be GAIOC, local institutions and local NGOs. The sector that is the most sensitive is the health sector, which requires significant investment and improvement in coverage to meet the health and wellbeing needs of the local population.

Housing

Analysis has been undertaken to assess the sensitivity of housing in Charagua, to provide additional context and nuance of infrastructural vulnerability of the area. This has included site visits and field-based data collection through community interviews and observations. The following information is only for Barrio 1ro de Mayo.

With regards to housing materials, 64.44% of the respondents from the interviewed households in the study area reported that their homes are constructed entirely of wood. Additionally, 20% of the households are built with bricks and cement, while 15.56% are made of mixed materials (wood and bricks). The high reliance on wood as the primary housing material indicates potential structural vulnerability to floods, landslides, and extreme

weather events, as wooden homes are more susceptible to damage, decay, and collapse. While 20% of households built with bricks and cement may offer greater resilience, the 15.56% using mixed materials suggests varying levels of structural stability. These housing conditions, combined with environmental risks, heighten the overall sensitivity of the community to climate impacts.

Regarding housing conditions, the majority of households (51%) are in fair condition, however all the interviewees agreed that more maintenance is needed on a regular basis, suggesting structural weaknesses that could worsen under extreme weather conditions.

With respect to bathroom facilities inside the households, none of the households have a complete bathroom. Instead, 100% of them rely on a blind well system.

With regards to number of occupants: 22% of households in the study areas have 5 people; 20% houses 6 people; 16% of households have 3 people; 11% houses 4 people; 9% are inhabited by 2 people; 7% are the home of 7 people; 5% houses 1 person; 4% of households have 4 people; other 4% have 8 inhabitants; and 2% of the households have 9 dwellers.

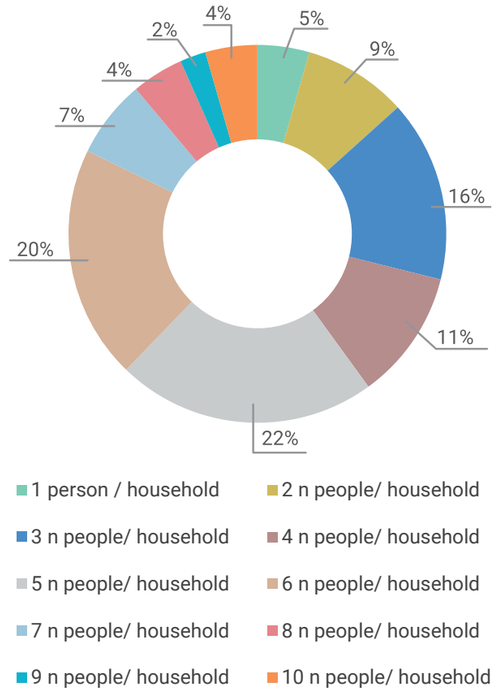


Fig. 19: Households occupants
Source: Own elaboration

Consideration	Variables	Sensitive Features (people, places, institutions) and sectors
Housing	Materials	64.44% of household's walls are made of wood, 20% are made of cement and bricks 15.56% are made of wood and bricks.
	Condition	The majority of households (51%) are in regular condition, but all the interviewees agreed that more regular maintenance is needed. 0% of the households have a bathroom with direct connection to sewerage.
	Number of occupants	22% of the households have 5 people; 20% have 6 people; 16% have 3 people living there, etc.

Table 4: Socio-economic sensitivity variables (Housing) in urban dimension
Source: Own elaboration

The housing conditions in Barrio 1ro de Mayo reveal a heightened sensitivity to climate change impacts due to the predominantly wooden construction of homes. The lack of complete bathroom facilities, with all households relying on blind well systems, poses significant health risks, especially during heavy rainfall or flooding events that could contaminate water sources. Poor irrigation and non-existent waste management in the area further worsens this risk. Additionally, the overcrowding in many households, with a significant proportion accommodating five or more people, increases the strain on limited resources and infrastructure, further exacerbating the vulnerability of residents to climate-related stressors. This situation underscores the need for climate-resilient housing improvements and enhanced access to basic sanitation services to mitigate these risks.

Production and investment

The following table shows considerations between land use areas (Residential; Commercial; Industrial; and Infrastructure[4]) and land values.

Consideration	Variables	Sensitive Features (people, places, institutions) and sectors
Production and investment	Land use areas: residential, commercial, industrial, Infrastructure	Barrio 1ro de Mayo is mainly a residential area. The only commercial activity consists of product sales that dwellers sell at their house. There are no markets or industries in the area.
	Land values	According to respondents, the value of land has not been affected by disasters.

Table 5: Socio-economic sensitivity variables (Production and investment) in urban dimension
Source: Own elaboration

Coping capacity

The objective is to assess how effectively people, places, institutions and sectors can adapt to climate hazards and impacts within Charagua's urban context. The town's capacity to respond to a given climate change impact is based on its level of awareness, knowledge, resources, and skills.

Town plans and policies to adapt to climate hazards

Unfortunately, Charagua Pueblo does not have a climate change adaptation or resilience strategy or any policies that aim to increase resiliency to climate change hazards. There is also no formal or communicated municipal-level disaster preparedness or emergency response plans or strategies. The following organigram outlines the governance structure of the environment and related topics within the area.

As seen, there is no division that is fully responsible or mandate to address climate risks or disaster attention. It is only one officer that oversees multiple themes, including disaster preparedness and emergency response, without adequate human or financial resources to address this challenges effectively.

Response to extreme climate events and disasters

In the context of climate change hazards, Charagua is increasingly affected by drought and landslides. With limited resources (financial, technical, institutional human, etc.), there is little that GAIOC can currently do to assist. The primary financial support that Charagua receives comes from the Regional Government of Santa Cruz, and this is limited. To activate this support, GAIOC must formally declare a municipal disaster, which allows technical assistance and resource mobilization from GADSC. If the scale of the disaster exceeds the capacity of the regional government to respond, the next level of support is the national government. However, for this to be activated, GADSC must declare a departmental disaster. This hierarchical, administrative response system is problematic because it relies on formal declarations of disaster, which can be slow and bureaucratic, and depends on multiple actors across several levels of governance, thereby delaying critical support at time of emergency or crisis. This can reduce the resilience of Charagua to effectively cope or adapt to disaster or emergency events where timely intervention is crucial to mitigate the impacts or support recovery efforts.

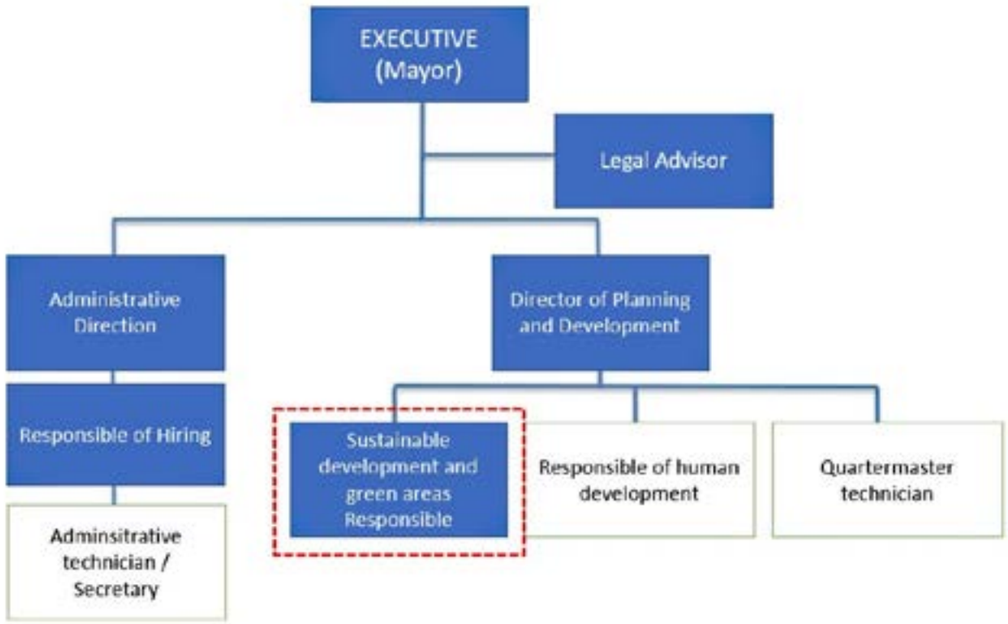


Fig. 20: GAIOC organigram
Source: Own elaboration based on information from GAIOC

Adaptive capacity of the study area

Barrio 1ro de Mayo is located on the most unstable terrain in Charagua Pueblo. Despite this, there is no early warning system or mechanism in place to mitigate the issues, losses and damages caused by extreme weather events and disasters. There is very little awareness or educational campaigns disseminated to dwellers in this area, and as such their capacities to withstand or adapt to severe floods, droughts or landslides is low. Based on the surveys, there are not registry of homes with pile foundations.

Determinant	Description	Relation to climate vulnerability	Status in Charagua
Economic wealth and financial capital	Municipal financial resources, resident incomes and wealth distribution, economic marginalization, fiscal incentives for climate risk management, access to micro-financing and loans for adaptive infrastructures and sectors, private sector investments and public-private partnerships for climate actions	Climate change adaptation with internal funding or external support	Charagua Pueblo is a small town with limited economic resources and almost nonexistent debt capacity. That situation makes it impossible to implement measures to enhance the town's resiliency to climate change hazards.
Access to information and technology	Communication networks and platforms that are open-source, computing tools, freedom of expression, technology transfer and data exchange, data literacy, internet access and connectivity.	Language barriers in information, technical data, data modelling capability, sharing and distribution information on Climate change adaptation	Charagua does not have any higher education institution in its jurisdiction. However, its inhabitants possess extensive knowledge of their territory, since they rely on agricultural activities for their livelihood. While this knowledge provides a solid foundation, it needs to be upgraded with knowledge about resiliency to climate change. It is essential for GAIOC´S civil servants to learn the GIS software to better monitor and understand the measures needed to address climate hazards and risks.
Material resources and infrastructure	Transport system, water and green infrastructures, buildings, sanitation, energy supply and management	Designed, constructed, retrofitted, and managed infrastructures and services to be more adaptable or easier to adapt to climate change impacts and risks	Urban infrastructure was not designed to be resilient, so transport, sanitation and energy supply systems are often heavily affected when a disaster occurs.
Human resources and capacity	Knowledge (scientific, "local", technical, political), education levels, labor.	Scientific understanding and knowledge, local knowledge and skills, human resources, community engagement and participation, active collaboration to undertake climate change planning work.	Lack of effective incorporation of risk management to the urban planning of the town.
Organizational and social capital	State-civil society relations, non-governmental, private and community-based organizations, relationships between institutions.	Collaboration and cooperation between stakeholders (government, non-government, private, vulnerable groups, etc.) towards the same objectives.	One distinctive feature is that the national government and international institutions like AECID are interested in working in Charagua so that new projects and programs would eventually arise. There is a lack of cooperation between GAIOC and the association of neighbors so that a partnership would impulse a collaborative work to improve Charagua Pueblo resiliency towards climate change challenges.
	Modes of governance, leadership, participation, transparency and accountability, adaptive management practices, monitoring and evaluation frameworks, decision and management capacity.	A functional local government that is both capable and willing to enforce municipal laws, plans and regulations Political stability	The mode of governance in Charagua Pueblo allows the mayor or "executive" to govern the town with the supervision of the municipal council. There is willingness to enforce the law, however there are little means to do so.

Table 6: Determinants of adaptive capacity and their relation to climate vulnerability (urban dimension)
Source: Own elaboration

Urban Future Vulnerabilities

Rapid urban expansion and population growth is likely to increase the overall vulnerability of the area to climate change hazards. Therefore, urgent, integrated resilience building actions should be taken to prevent adverse impacts on the population.

Unplanned and unregulated urban growth, particularly in Barrio 1ro de Mayo, heightens the area's vulnerability to climate change hazards, necessitating proactive measures to mitigate adverse impacts on the population. Residents in Barrio 1ro de Mayo express a desire to remain in their neighborhood and do not wish to be relocated elsewhere in the municipality, however they urgently seek improvements in access to essential services, including sanitation, sewage, paved roads, and education facilities. Without such infrastructural improvements, residents will face increasing exposure and sensitivity to climate-related impacts, heightening risks to lives and livelihoods and potentially forcing relocation or displacement despite their strong desire to remain in the neighborhood.

A critical challenge is the lack of a bridge connecting Barrio 1ro de Mayo to Charagua Pueblo, which renders access to markets, employment, and schools impossible during periods of high river flow or flooding, further isolating the community. Moreover, the precarious location of informal households on landslide-vulnerable hills along the riverbank, puts these groups at further risk. Building a bridge to connect Barrio 1ro de Mayo with Charagua Pueblo would not only enhance access to essential services, markets, and employment but also address intersectional challenges by reducing gender, economic, and mobility-related inequalities that disproportionately affect women, children, and other vulnerable groups during climate-induced disruptions

Another notable concern is the absence of garbage collection services has led to accumulating solid waste and burning of waste, posing significant sanitation and health risks for residents. This situation not only increases the risk of waterborne diseases respiratory problems but also creates an environment conducive to the proliferation of disease vectors like rodents and insects, further exacerbating the health challenges faced by the community, especially during periods of heavy rainfall or flooding when waste can contaminate water sources and living spaces

If these issues remain unaddressed, Barrio 1ro de Mayo will not only continue to be highly vulnerable to climate-related stressors but will also experience a further decline in the already compromised quality of life for its residents, exacerbating socio-economic disparities and environmental degradation. Simply put, the urban, infrastructural and socioeconomic conditions, trends, and challenges present in Charagua indicate strong vulnerability both now and in the future.

04

CLIMATE CHANGE DIMENSION

Climate Change Dimension

The climate change dimension of the MVA provides a clearer understanding of how climate change is affecting the city's population, infrastructure and resources. It focuses on key indicators such as landslides, drought and temperature rise. These insights will help guide targeted interventions to improve the city's resilience to future climate challenges.

Bolivia is feeling the effects of climate change. Among the impacts are food and water insecurity, more frequent and impactful natural disasters such as droughts and landslides, increasing numbers of forest fires and the spread of vector-borne diseases to new areas.

Despite having a medium-level exposure, Bolivia is one of the Latin American countries most vulnerable to climate change due to its poor adaptation capacity. This low capacity is due to high economic dependence on agriculture, low gross domestic product, poor inter-institutional coordination and weak institutions generally, high levels of poverty and inequality, and a medium Human Development Index (HDI), according to the Vulnerability and adaptation index to climate change in the Latin American and Caribbean region (CAF, 2014).

In terms of national policy, the Ministry of Environment and Water (MMAyA) manages environmental policies and climate change initiatives, ensuring they are integrated into national planning efforts. There is one entity called Plurinational Authority of Mother Earth, which is charged with elaborating the Plurinational Plan of Climate change and oversees monitoring Bolivia´s NDCs.

At local level, topics related to the environment and climate change at the GAIOC are the responsibility of the Direction of Planning and Development, with an extremely reduced organizational structure that includes one person who is responsible for sustainable development and green areas. Those dependencies, despite the lack of resources, are trying to make Charagua Pueblo more resilient in the face of climate change.

Indicators

Indicator 1 - Landslides

This indicator shows areas that are more prone to precipitation-induced landslides under current climate conditions. The Coalition for Disaster Resilient Infrastructure's precipitation-induced landslide susceptibility map was used for the indicator. Mass movement of rock, debris, soil, or mud down a slope is one of the hazards that occur in the city and can be exacerbated by changes in precipitation.

Landslides present significant risks to public safety, as they can cause injury, loss of life, and severe property damage. Critical infrastructure – such as roads, bridges, utilities, and buildings – are also vulnerable to landslides, which can disrupt transportation networks, water supply systems, and energy distribution. Disadvantaged populations, such as low-income communities and residents of informal settlements, are disproportionately affected by landslides, compounding their existing vulnerabilities.

The landslide susceptibility is based on the model developed by NGI (Nadim et al., 2006, 2013; Jaedicke et al., 2013) but with improvements and refinements. The precipitation-induced landslide susceptibility map for the present climate classifies the terrain into five susceptibility classes by combining slope, vegetation, lithology and rainfall history information from global datasets.

Landslides are one of the biggest climate hazards facing Charagua. Increasing temperatures and rainfall patterns associated with climate change amplify the risk of landslides by altering soil moisture levels, weakening ground stability, and intensifying precipitation events. These changes in weathers are escalating the likelihood and severity of landslides, particularly in areas with steep slopes, unstable hilltops, poor vegetation cover, unpaved dirt roads and limited drainage systems such as areas like Charagua Pueblo and Barrio 1ro de Mayo. The terrain and infrastructure in these areas cannot effectively manage increased rainfall or soil erosion, thereby threatening both infrastructure and safety

As illustrated by the above map, Charagua Pueblo, particularly its western and southern areas, including Barrio 1ro de Mayo, are highly exposed and prone to landslides, which pose a significant threat to the existing infrastructure and housing stock. The poor-quality construction prevalent in these areas is especially vulnerable to destruction during extreme climate events, as evidenced by recent surveys indicating the loss of households near the river due to landslides. This risk extends along the entire river border, not only endangering residents but also compromising access to essential public services, such as clean water distribution, thereby amplifying the vulnerability of these communities to both immediate physical hazards and long-term environmental degradation.

The exposure of these areas to landslides is further heightened by their proximity to the river, which increases the likelihood of flooding and erosion, exacerbating the potential for catastrophic impacts on homes, livelihoods, and community well-being during extreme weather events.

Fig. 21: Landslides in Charagua
Source: UN-Habitat

Indicator 2 – Drought

This indicator shows the areas with precipitation anomaly values, based on a comparison of the total precipitation amounts observed for a given accumulation period, with the long-term historical precipitation record for that period.

This indicator uses the Standardized Precipitation Index (SPI), which is the most widely used indicator worldwide to detect and characterize meteorological droughts. The SPI data recording period is from 2000 to 2023.

Droughts pose a major threat due to their far-reaching and compounding impacts. Water scarcity caused by droughts affects not only access to drinking water supply and security, but also public health, agriculture, food security, ecosystems, economic activity, and resilience. Droughts can have profound impacts on people, infrastructure, and ecosystems, leading to increased health risks from waterborne diseases, damage to critical infrastructure such as water and energy systems, and significant ecological disruptions including wildfires, soil erosion, and biodiversity loss, which can have long-lasting effects on ecosystem services and community well-being.

Drought is of the biggest climate hazards facing the Charagua municipality.

As illustrated by the above picture, the Charagua Pueblo jurisdiction falls within a region frequently affected by droughts, which are regarded as the most severe climate extreme in the Chaco region. Although the impact of droughts in Barrio 1ro de Mayo is currently assessed as moderate in magnitude, this does not diminish the significant risks and challenges posed by droughts to local ecosystems, agriculture, and community resilience, particularly given the area's reliance on rain-fed agriculture and limited water resources.

Climate projections indicate that the Gran Chaco region, including Charagua, will experience more severe, frequent, and prolonged drought periods in the future. These droughts, often coinciding with La Niña events, are expected to intensify due to climate change, intensifying existing challenges such as water scarcity, economic hardship, agricultural instability, food security, and ecosystem degradation. Prolonged droughts can also lead to subsidence in areas with unstable soil, particularly in regions with clayey soils (like most of the terrain outside the urban core of Charagua Pueblo). As drought conditions dry out the soil, it shrinks and cracks, weakening ground stability and increasing the risk of soil erosion and landslides. This loss of stability can cause the land to sink or settle, especially in areas with previously saturated or poorly compacted soil, compounding landslide risk during heavy rainfall events.

If urgent action is not taken, these issues will only worsen, further threatening the livelihoods of communities reliant on agriculture and natural resources and increasing their vulnerability to climate-related stressors.

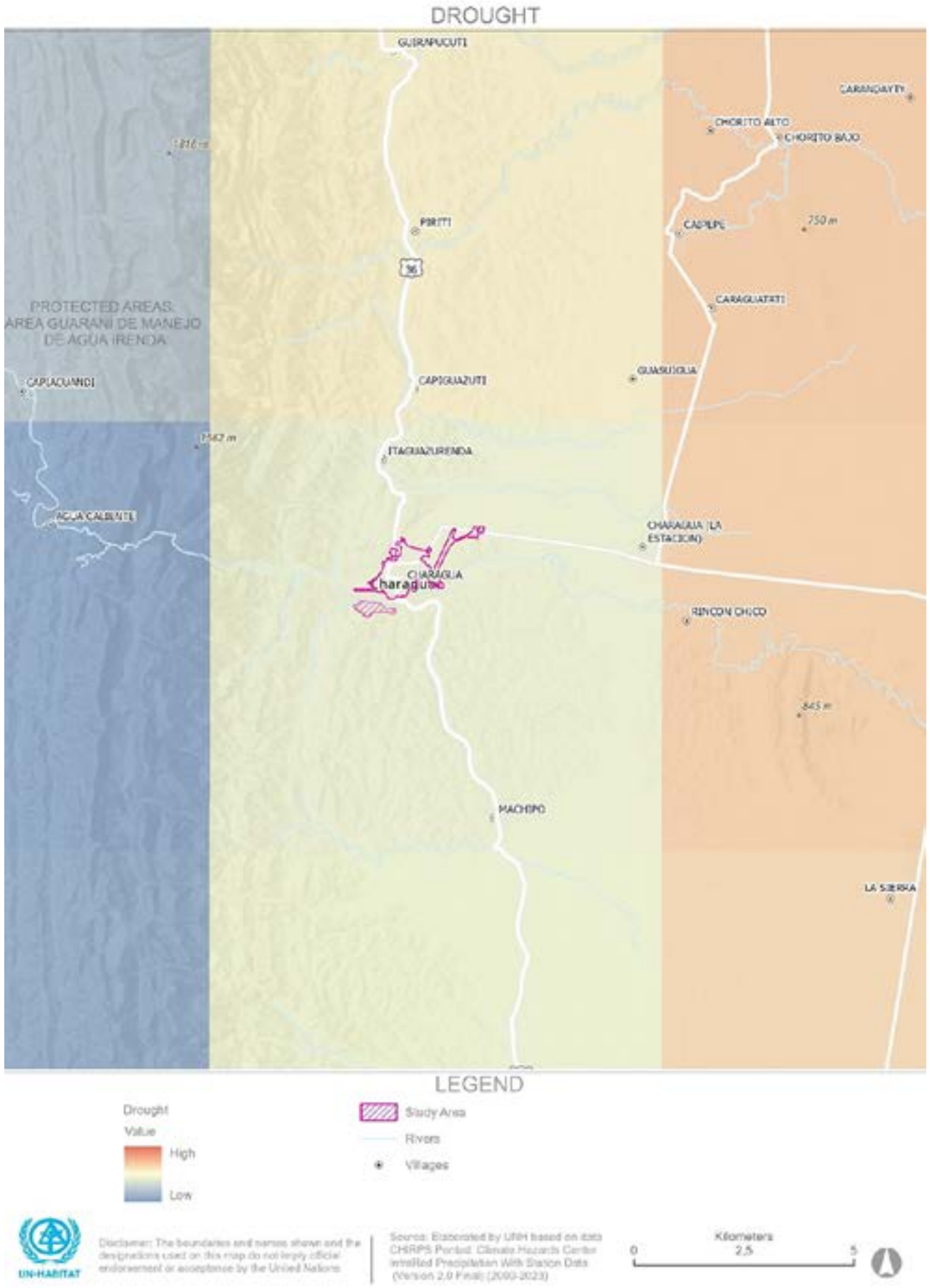


Fig. 22: Drought in Charagua
Source: UN-Habitat

Indicator 3 – Temperature Rise

Indicator 3. Temperature Rise. This indicator shows the areas with an increase in temperature values, based on temperature variations over time, taking as a reference the average annual temperature of a recent year compared to the historical annual average.

Rising temperatures can disrupt precipitation patterns and increase evaporation, negatively affecting the availability and quality of water resources. Higher temperatures can also be associated with an increase the frequency of heatwaves, which are understood as an unusually hot, dry or humid period, day or night, that begins and ends abruptly, lasting at least two to three days, with a discernible impact on humans and natural systems (World Health Organization and World Meteorological Organization), endangering human health and well-being. They can disrupt ecosystems, alter biodiversity patterns, and cause heat stress, which may damage critical infrastructure.

The indicator uses the global daily temperature dataset for the period 2003-2020 from A global 1 km resolution daily near-surface air temperature dataset (2003-2020) by Iowa State University.

As illustrated, Barrio 1ro de Mayo is experiencing a notable rise in temperatures, with its location situated near a zone of significant temperature increase. Climate projections suggest that this trend will continue, with temperatures in the area likely to rise further as climate change progresses, potentially exacerbating heat-related stress and other climate-related challenges for residents. The steep, hillside terrain with limited vegetation cover here can amplify the urban heat island effect, trapping more heat in the area. Additionally, the prevalence of poorly insulated housing materials like wood, along with inadequate infrastructure such as poorly ventilated homes and lack of green spaces, increases the likelihood heat-related stress for residents. These conditions reduce the community's ability to cope with higher temperatures, increasing the risk of health issues such as heatstroke and dehydration.

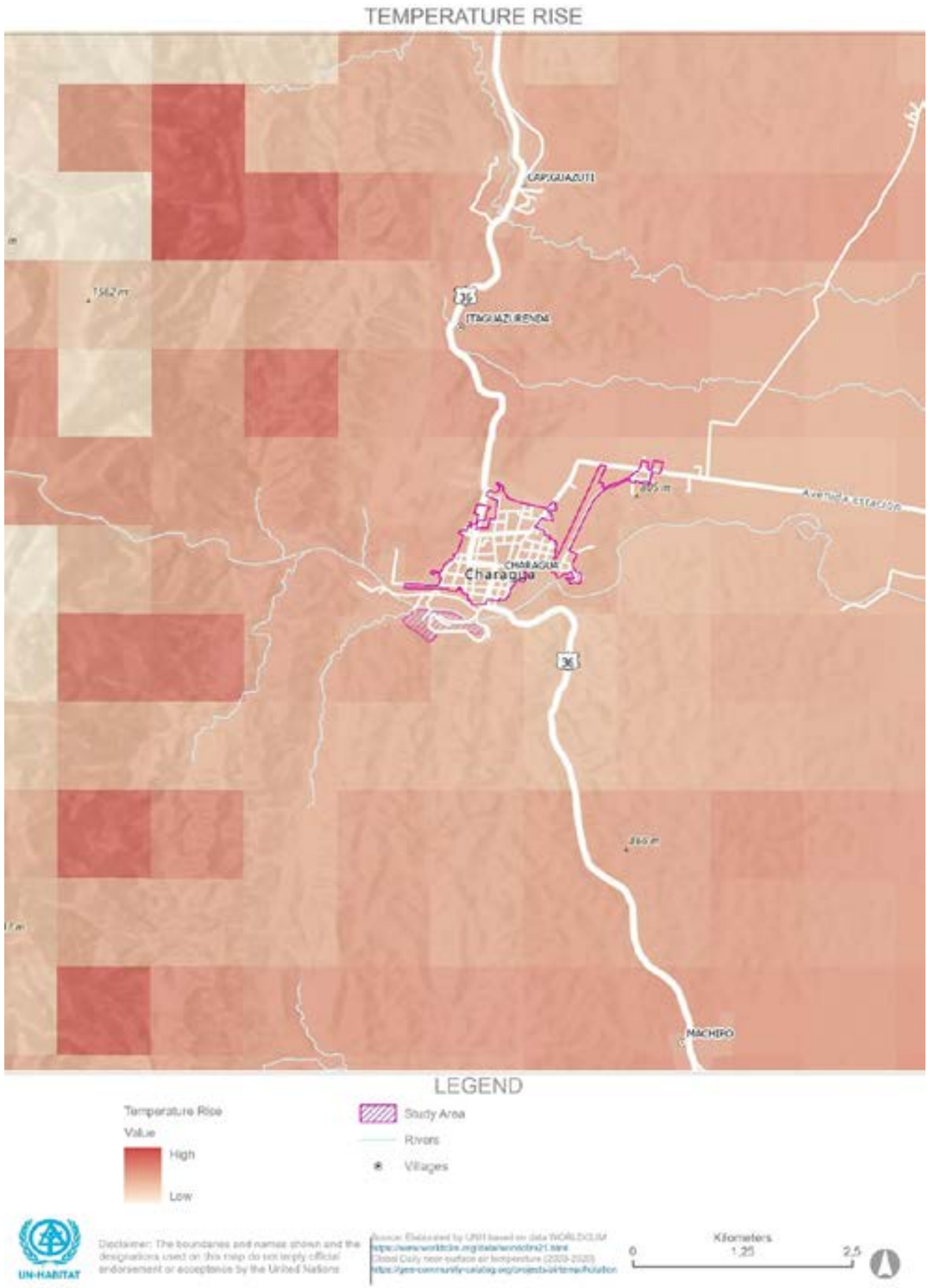


Fig. 23: Temperature in Charagua
Source: UN-Habitat

Climate Change Dimension Analysis

The following urban climate change analysis includes the 3 components of vulnerability: exposure, sensitivity and adaptive capacity.

Exposure

Intends the identification of how Charagua is exposed to changes in the climate today and how it could be in the future in the climate change dimension.

Description of current and future changes

Based on projections, Charagua Pueblo will experience changes to its climate that would negatively affect its resilience in the face of those changes.

The analysis showed that Barrio Primero de Mayo is severely exposed to landslides and drought. Within the study area, temperature has risen and is expected to continue to do so, putting its inhabitants at greater risk of health conditions associated with both acute and chronic heat exposure. The most vulnerable populations, e.g. the elderly, those who are pregnant, agricultural workers and children, will disproportionately feel the impacts of extreme heat.

Identification of people, places, institutions and sectors that are exposed to climate hazards

The following tables summarize several climate hazards in Charagua and their associated environmental and societal impacts.

Climate Change Hazard	Current Data	Climate Scenario Projections	Impacts	Exposed features and sectors
Drought	**Precipitation:** 560 mm to 1300 mm	**SENHAMI projections:** **Precipitations increase: 8%** **Temperature increase: 2,77%**	Displacement from households	Inhabitants of Barrio 1ro de Mayo
	Temperature: From 21 to 26ºC, which varies from east to west. The average temperature is 23ºC, the average maximum is 35ºC and the average minimum is 12ºC		Disruption of regular functioning of services and administrative tasks	Inhabitants of Barrio 1ro de Mayo
			Disruption of health services	Not applicable
			Disruption of education services	Not applicable
			Stop of supply of products and gastronomy	Stores, markets and restaurants

Table 7: Impacts associated with drought in Charagua
Source: Own elaboration

Climate Change Hazard	Current Data	Climate Scenario Projections	Impacts	Exposed features and sectors
Landslides	**Precipitation:** **560 mm to 1300 mm**	**SENHAMI projections:** **Precipitations increase: 8%** **Temperature increase: 2,77%**	Displacement from households	Inhabitants of Barrio 1ro de Mayo
	Temperature: From 21 to 26ºC, which varies from east to west. The average temperature is 23ºC, the average maximum is 35ºC and the average minimum is 12ºC		Disruption of regular functioning of services and administrative tasks	GAIOC
			Disruption of health services	Health service (in Charagua Pueblo´s hospital) and of the only health posts in Barrio 1ro de Mayo
			Disruption of education services	Negative impact on accessibility to the only school that is located at Charagua Pueblo
			Inhibition of supply of products and gastronomy	Stores, markets and restaurants

Table 8: Impacts associated with landslides in Charagua
Source: Own elaboration

Sensitivity

The objective is to identify the sensitivity of people, places, institutions and various sectors within Charagua to climate change and to identify the degree to which they could be impacted in the future. There are three considerations: demographic, housing and production and investment.

Demographic

Regarding demographic consideration, the data is nearly the same as that which is presented in the urbanization dimension. The difference is that in the climate change dimension, the information used for the analysis includes specific considerations of the climate change dimension.

Consideration	Variables	Sensitive Features (people, places, institutions) and sectors
Demographics	Gender	Women bear the brunt of household labor and, therefore, are more affected by climate change (e.g. food and water scarcity, temperature within the household, etc.).
		The places that are the most sensitive are Barrio 1ro de Mayo Alto and Bajo, since they are located closer to river Charagua.
	Proportion of children and elderly	In the dimension of climate change, these vulnerable groups (including people with disabilities) are especially affected by the loss of safe households and loss of accessible infrastructure.

Table 9: Socio-economic sensitivity variables (Demographics) in the climate change dimension
Source: Own elaboration

Housing

Regarding housing, the data is the same as that which is presented in the urbanization dimension, the only difference being that in the climate change dimension the information used for this analysis includes specific considerations of the climate change dimension.

Consideration	Variables	Sensitive Features (people, places, institutions) and sectors
Housing	Materials	In the dimension of climate change, houses with brick walls and calamine are more resistant and have better resilience to climate change hazards than those made of wood.
	Condition	In the dimension of climate change, households with no maintenance and with preexisting issues, such as cracks, holes and problems with the physical structure, are less resilient to climate change hazards
	Number of occupants	According to surveys, and despite the large risk in the area, there is no record of displacement. On the contrary, the population of Barrio 1ro de Mayo is increasing as a result of vegetative growth, not due to migration from agricultural or rural areas.

Table 10: Socio-economic sensitivity variables (Housing) in climate change dimension
Source: Own elaboration

Production and investment

Regarding the production and investment consideration, the data is the same as presented in the urbanization dimension, the difference being that the information for this analysis includes specific indicators of the climate change dimension.

Consideration	Variables	Sensitive Features (people, places, institutions) and sectors
Production and investment	Land-use areas residential, commercial, industrial, Infrastructure	Land-use is expected to change as climate change progresses and disasters occur. Agricultural land may become frequently inundated by floods or droughts, thus shifting to baren landscapes. Spaces within residential areas may be converted into sport or public spaces, thus taking away housing from residents.
	Land values	The value of land may diminish if that land is considered riskier under climate change projections.

Table 11: Socio-economic sensitivity variables (Production and investment) in climate change dimension
Source: Own elaboration

Coping capacity

At the local level, GAIOC's disaster response equipment is limited, consisting of only one bulldozer. GAIOCs protocol when disasters strike is to rent large equipment from Mennonites and other agricultural workers. The local government is thus dependent on these groups of people when inevitable climate extremes occur.

Determinant	Description	Relation to climate vulnerability	Status in Charagua
Economic wealth and financial capital	Municipal financial resources, incomes and wealth distribution, economic marginalization, fiscal incentives for climate risk management	Climate change adaptation with internal funding or external support	Charagua Pueblo is a little town with reduce economic and almost inexistent debt capacity. That situation makes it impossible to implement measures to make a town resilient to climate change hazards.
Access to information and technology	Communication networks, computing tools, freedom of expression, technology transfer and data exchange	Technical data, data modelling capability, sharing and distribution information to Climate change adaptation	Charagua has no higher education institution in its jurisdiction. However, its dwellers know pretty well their territory, since they live from agricultural activities. This knowledge is a good baseline but it needs to me upgraded with knowledge about resiliency to climate change. There is need that GAIOC´S civil servants learn GIS software so that they can monitor and understand better the measures to tackle hazards and risks.
Material resources and infrastructure	Transport, water infrastructure, buildings, sanitation, energy supply and management	Designed, constructed, located, and managed infrastructure and services to be more adaptable or easier to adapt to climate change impacts and risks	GAIOC has few material resources to deal with climate change hazards due to limited resources. However, the local government rents or borrows equipment from farmers and Mennonites.
Human resources and capacity	Knowledge (scientific, local, technical, political), education levels, labour.	Scientific understanding and knowledge, local knowledge, and human resources to undertake climate change planning work.	Environmental management is limited to one person, and no manager yet exists for risk management. There is not a map of risks in Charagua.
Organizational and social capital	State-civil society relations, non-governmental and community-based organizations, relationships between institutions.	Stakeholders (government, non-government, vulnerable groups, etc.) who work together.	One distinct feature is that the national government and international institutions, like AECID, are interested in working in Charagua, so new projects and programs will eventually arise. Climate change resilience is an increasing focus in projects undertaken in Charagua.
	Modes of governance, leadership, participation, decision and management capacity.	Functioning local government that is capable and willing to enforce municipal laws, plans and regulations.	There is a lack of cooperation between GAIOC and the association of neighbors so a partnership would require collaboration to improve Charagua Pueblo resiliency.

Table 12: Determinants of adaptive capacity and their relation to climate vulnerability in the climate change dimension
Source: Own elaboration

Climate Change Future Vulnerabilities

In terms of climate change, the future vulnerability of Charagua, particularly Barrio 1ro de Mayo hotspot would be more vulnerable to climate change hazards due to the intersection of lack of public service access and the lack of connectivity with the main town.

In Charagua there is not only one climate change hazard, but a variety of them. The following impacts could become a daily occurrence in Charagua.

Landslides: Because of poor soil carrying capacity, landslides have been occurring near the border next to the river. Currently less than 50 households have been affected. If new constructions fail to include climate resilience measures, inhabitants of the area would be increasingly vulnerable.

Drought: Every year, droughts have been more severe than in previous years. The consequence is less production of food and a potential increase in fires in various parts of the town. Human-ignited fires are common, particularly those used to clear land for agriculture, and negatively impact the health of community members. These fires cause dozens of deaths each year.

Temperature change: As pointed out earlier in this report, temperature rise has been noted by inhabitants and is increasingly affecting life in Charagua. The temperature is projected to increase by 2.77%. This is particularly harmful for vulnerable groups of society that do not have access to cooling systems. The risk to elderly people and children suffering from heat related illnesses will increase in the coming years (Andersen, 2014).

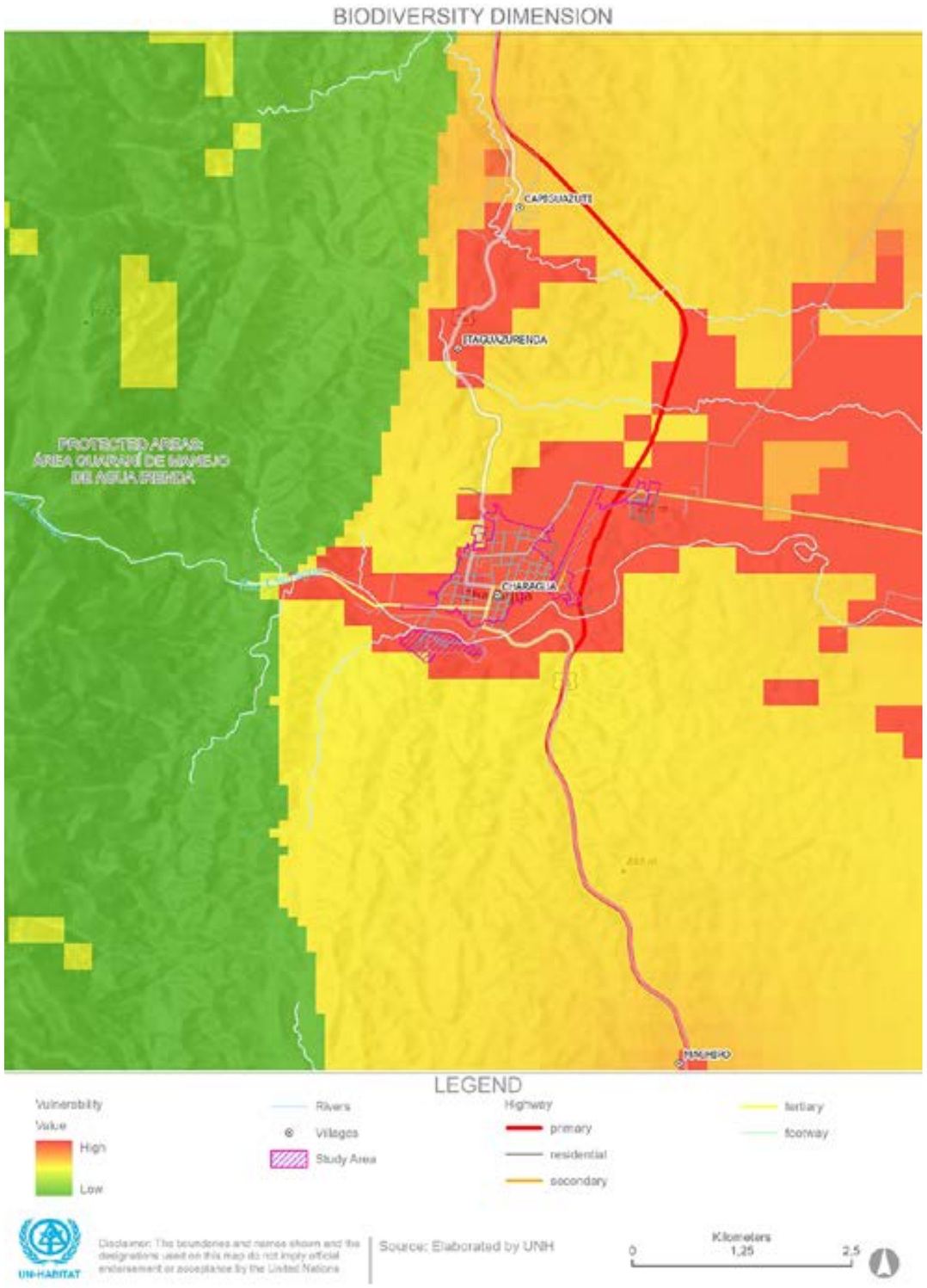
Biodiversity Dimension

Biodiversity dimension of the Multiayered Vulnerability Assessment (MVA) refers to the susceptibility of ecosystems, plant and animal species and biodiversity in general to the impacts of climate change, urbanization and other development pressures.

Bolivia represents 0.2% of the world's surface and is home to around 40% of the world's biological diversity. The complex topography and geographic location have allowed Bolivia to be one of the countries with the greatest diversity of ecoregions.

The Ministry of Environment and Water (MMAyA) manages environmental policies and climate change plans and programs, including biodiversity conservation plans. In this regard, MMAyA has an entity under tuition that is called the Authority for Inspection and Social Control of Forests and Land (ABT), which is an institution dedicated to contributing to comprehensive sustainable rural development through comprehensive sustainable management of forests, democratizing access, supervising and controlling the use of forest resources and land, guaranteeing benefits for users of the forest and land, contributing to economic growth. of the sector and the Plurinational State under the principles of transparency, effectiveness, efficiency, equity and social and environmental responsibility.

At the local level, the GAIOC understanding its context of being located in the Chaco Region, is putting an effort of biodiversity preservation through communication campaigns in favor of preserving Gran Chaco Kaa-Iya National Park. The main causes of biodiversity loss are: i) Degradation and loss of forests due to forest fires; ii) Soya production; iii) Intensive livestock; and iv) Illegal tree felling.



Indicators

Indicator 1 – Protected / Conservation Areas

This indicator shows the areas of the municipality declared for the protection and conservation of nature at national, regional and municipal levels. The protected and conservation areas reflect the surface area of natural spaces conducive to biodiversity development.

The location, characteristics, and conditions of protected and conservation areas within or near urban centres influence vulnerability to climate change and urbanization. These areas often contain diverse ecosystems—such as forests, wetlands, grasslands, and coastal habitats—that offer essential ecosystem services, enhancing climate resilience. They act as natural infrastructure for climate adaptation, providing crucial services like flood protection, water purification, cooling and erosion control.

This indicator was selected to assess the natural areas that are part of the main ecological structure, including rivers and riverbed, and forests within the city.

The picture shows the location of the reserve and natural park which is in the area of indirect influence towards Charagua Pueblo and Barrio 1ro de Mayo. Despite that distance it is important considering the influence of the town towards the biodiversity at the park, since urban growth would affect directly the natural environment and biodiversity.

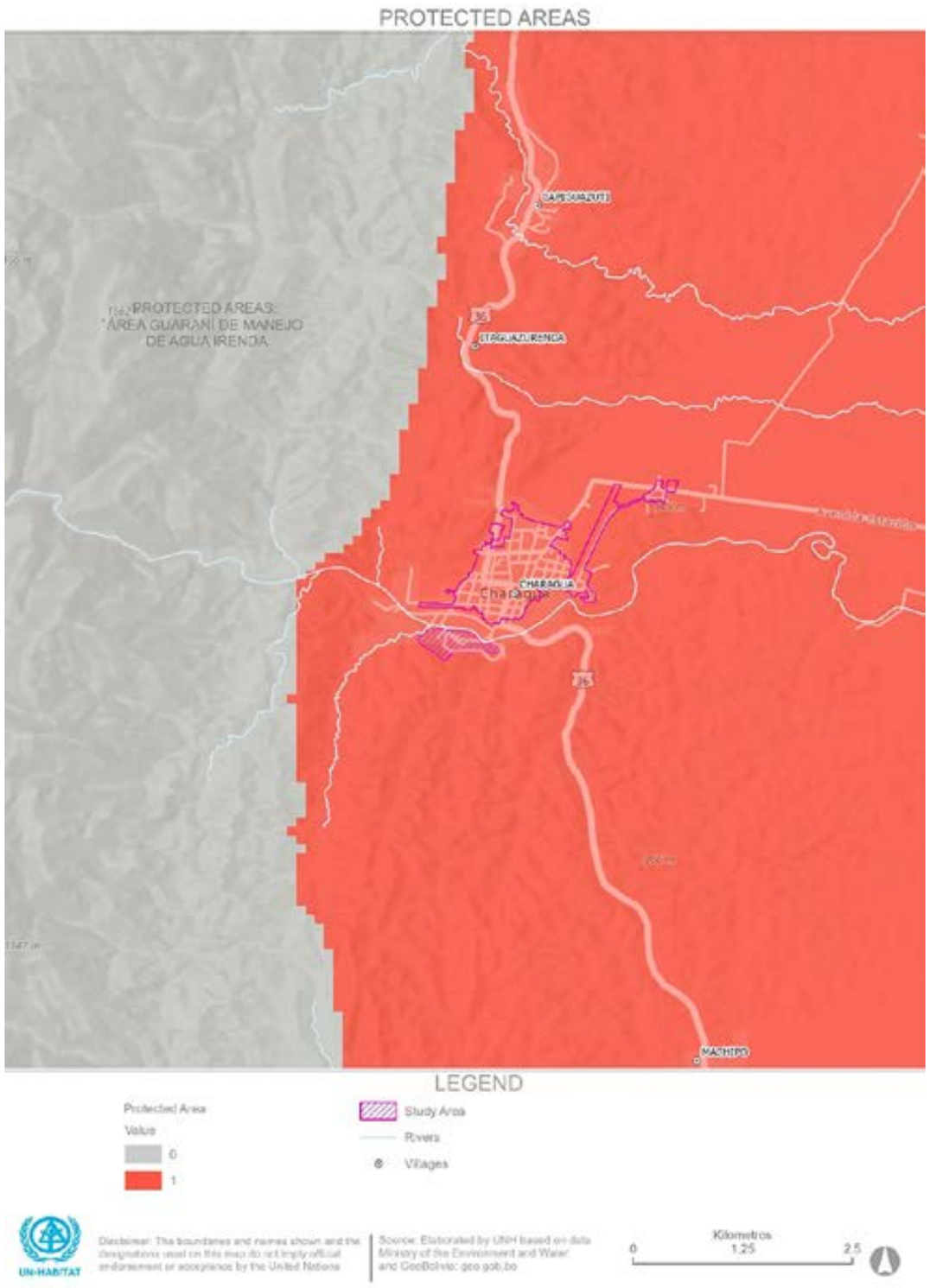


Fig. 24: Protected / Conservation areas in Charagua Source: UN-Habitat

Indicator 2 - Mean Species Abundance

This indicator shows areas of high biodiversity value where the mean species abundance serves as an indicator of the overall health, richness and integrity of biodiversity and ecosystems in and around urban areas. It is related to the mean species abundance (MSA) index, which measures the integrity of local biodiversity.

The indicator uses the GLOBIO4 model to produce spatial datasets with results for overall mean abundance (MSA) by Global biodiversity model for policy support

As illustrated in the map, Charagua Pueblo is located in an area of medium species abundance, largely influenced by its proximity to the Gran Chaco Kaa-Iya National Park, a vital biodiversity hotspot. Local surveys and observations indicate that bird species such as parrots and toucans are commonly sighted in the town, alongside a notable presence of rodent species and reptiles across various parts of Charagua. In Barrio 1ro de Mayo, bird species resembling Guinea fowl inhabit the surrounding areas, contributing to the ecological diversity of the region.

Regarding tree species, the most prevalent include red quebracho, mistol, pela pela, algarrobilla, and cupesí, with sporadic sightings of Tajibos in certain locations. However, despite the presence of these species, vegetation cover is notably sparse in both Charagua Pueblo and Barrio 1ro de Mayo. Tree density is significantly limited, with large trees primarily concentrated in the main square and along select areas near the Charagua River.

This reduced vegetation cover exacerbates biodiversity vulnerability by limiting habitat availability, increasing soil erosion risks, and reducing natural climate buffering capacity. The lack of tree canopy also contributes to higher surface temperatures and worsens local climate stressors, such as heatwaves and prolonged droughts. Moreover, ongoing urban expansion and land-use changes threaten to further degrade natural habitats, potentially leading to a decline in species diversity and ecosystem resilience. Without targeted conservation efforts and sustainable urban planning, the biodiversity of Charagua and its surrounding areas will face continued pressures, intensifying both environmental and climate-related vulnerabilities.

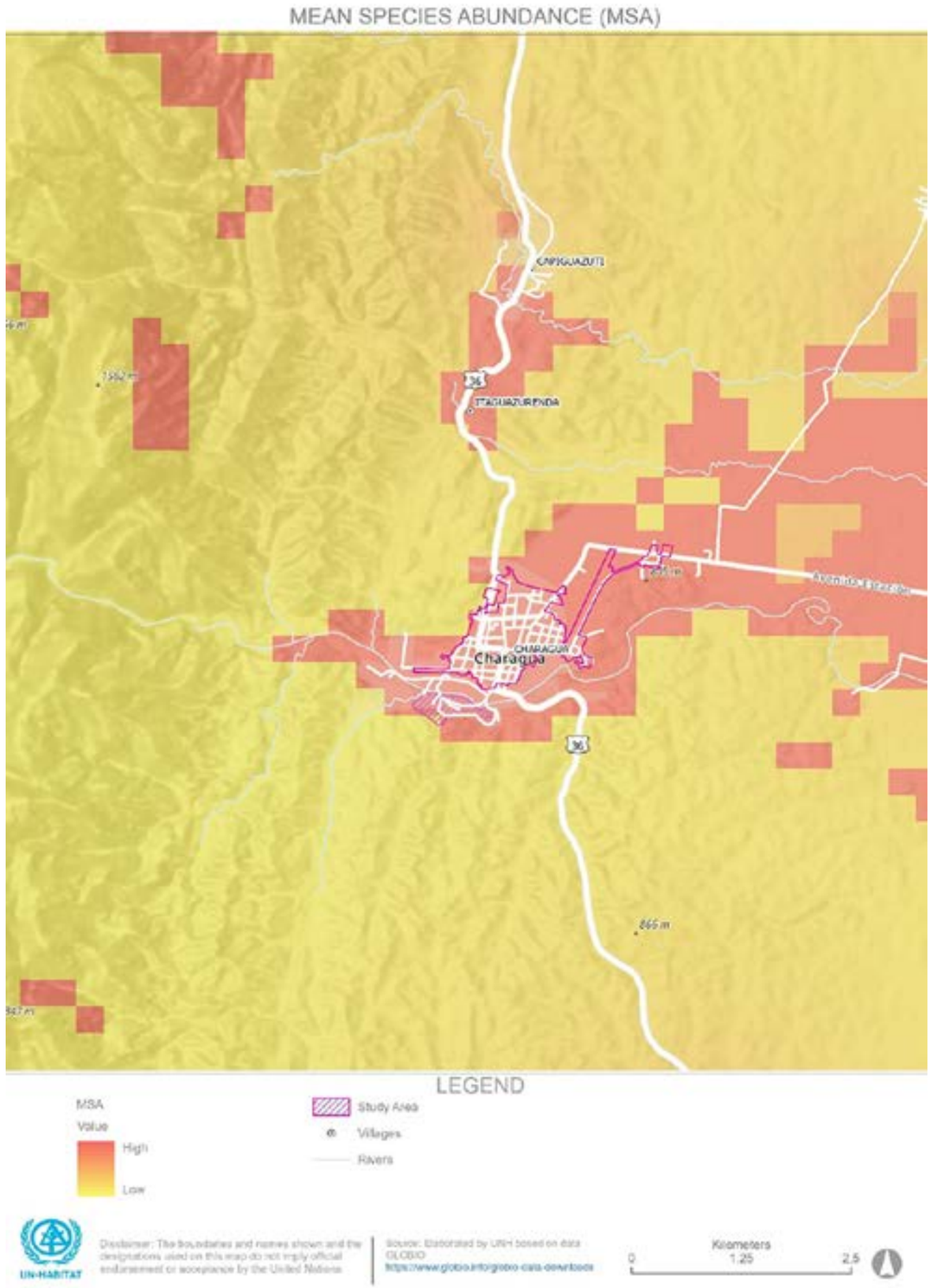


Fig. 25: Abundance in Charagua
Source: UN-Habitat

05

BIODIVERSITY DIMENSION ANALYSIS

Exposure

Intends the identification of how Charagua is exposed to changes in the climate today and how it could be in the future in the biodiversity dimension.

Description of current and future changes

Based in projections Charagua pueblo will experience changes in its climate that would affect the town in the dimension of biodiversity.

In the case of Barrio 1ro de Mayo, all of its territory is located in an area of high abundance of species, then the exposure of biodiversity towards urban growth is high.

In relation to the Gran Chaco Kaa-Iya natural reserve, the map show that even though there in not a direct impact in the long run with urban expansion, this reserve can be more exposed to human dwellings.

Identification of people, places, institutions and sectors that are exposed to climate hazards

The following table summarizes identification of climate hazards and exposed features and sectors.

Climate Change Hazard	Current Data	Climate Scenario Projections	Impacts	Exposed features and sectors
Drought/ Landslides/ temperature increase	**Precipitation:** 560 mm to 1300 mm **Temperature:** From 21 to 26ºC, which varies from east to west. The average temperature is 23ºC, the average maximum is 35ºC and the average minimum is 12ºC	**SENHAMI projections:** **Precipitations increase: 8%** **Temperature increase: 2.77%**	Loss of habitat	Charagua is located at Chaco, surrounded by biodiversity; therefore, the whole population would be affected if biodiversity is lost. Natural reserve: Gran Chaco Kaa-Iya National Park: Birds, rodents, mammals, reptiles, amphibians, etc. Tree species

Table 13: Identification of climate hazards and exposed features and sectors in biodiversity dimension
Source: Own elaboration

Sensitivity

The objective is to identify the manner that in Charagua (in the biodiversity dimension), exposed people, places, institutions and sectors are impacted currently and the degree to which they could be impacted in the future. There are 3 considerations: i) Demographic; ii) Housing; and iii) Production and investment.

Demographic

Regarding demographic consideration, the data is the same as presented in the urbanization and climate change dimensions, with the difference that in the biodiversity dimension the information that was used for this analysis includes specific considerations of the biodiversity dimension.

Other ideas regarding demographic and the intersection with biodiversity:

- Human activity affects biodiversity since land use to any human activity has caused loss of biodiversity because of the change of environment and consumption or resources with resultant pollution to the environment.
- Deforestation is a consequence of the growth of towns and neighborhoods and industrial and agricultural activities which reduces the size of reserve areas and change environments.

Consideration	Variables	Sensitive Features (people, places, institutions) and sectors
Demographics	Proportion of children and elderly	Children are sensitive to biodiversity because they have activities and practices related to the fauna and flora that are on the banks of the river.
	Household literacy	More literate population can be more sensitive towards biodiversity preservation than others.
	Proportion of economically active Household members	Human activity affects biodiversity since land use to any human activity has caused loss of biodiversity because of the change of environment and consumption or resources with resultant pollution to the environment.

Table 14: Socio-economic sensitivity variables (Demographics) in biodiversity dimension
Source: Own elaboration

Housing

Regarding housing consideration, the data is the same as presented in the urbanization and climate change dimensions, with the difference that in the biodiversity dimension, the information that was used for this analysis includes specific considerations of the biodiversity dimension.

Consideration	Variables	Sensitive Features (people, places, institutions) and sectors
Housing	Materials	In the biodiversity dimension, households´ construction materials are important in order to know the origin of those. For example, the wood household's construction (which are the majority in Barrio 1ro de Mayo) could be affecting the natural environment because of the loss of tree species.

Table 15: Socio-economic sensitivity variables (Housing) in biodiversity dimension
Source: Own elaboration

Production and investment

Regarding production and investment consideration, the data is the same as presented in the urbanization dimension, with the difference that in the climate change dimension the used information for this analysis include specific considerations of the biodiversity dimension.

Consideration	Variables	Sensitive Features (people, places, institutions) and sectors
Production and investment	Land use areas residential, commercial, industrial, Infrastructure	Regarding the biodiversity dimension, if those land uses change or host more dwellers that would put pressure into the surrounding environment, reducing presence of trees and animals.
	Land values	In the biodiversity dimension, low land values may cause that new activities would emerge, changing land use, thus; affecting environment and biodiversity in case of intensive of land, especially for agricultural purposes. Deforestation is the main risk for biodiversity in Charagua due to activities to dwellers and Mennonites.

Table 16: Socio-economic sensitivity variables (Production and investment) in biodiversity dimension
Source: Own elaboration

Coping capacity

After analysing the territory with the local government, it has been decided to include Gran Chaco Kaa-Iya National Park.as the main protected area near to the study area, since it is the natural reserve that is the closest to the Charagua Pueblo and present the following facts:

The Kaa-Iya was created by Supreme Decree No. 24122 of September 21, 1995, with two categories: National Park (PN) and Integrated Management Natural Area (ANMI), which in its 3,441,115 hectares, houses the "last opportunity to have a representative sample of the Chaco tropical dry forest in good state of conservation of the entire South American Gran Chaco ecoregion" (Management Plan 2013-2022).

Kaa-Iya, includes the Guaraní Charagua Iyambae Indigenous Autonomy and the municipalities of San José de Chiquitos and Pailón, is located in a transition zone of the Chaco region with the Cerrado or Chiquitano Forest, characterized by being the protected area with forests and wetlands with ecosystems that contribute significantly to the provision of environmental functions, habitat for fauna and flora, and mitigation of climate change. In hydrological and ecological conservation terms, one of the treasures of the protected area is the North basin, which is part of the Parapetí River basin, which is extremely important, receiving its waters and contributing flows to the Bañados de Isoso. from the upper part of the basin. This basin is responsible for recharging important aquifers in the region and provides water for wildlife and people.

The Kaa-Iya "Amo del Monte" protected area, due to its meaning in Guaraní mythology, represents the largest extension of the best-preserved tropical xerophytic forests in the world, and was created mainly with the vision of preserving the great biological and cultural diversity of the place; such as maintaining ecological processes and the conservation of fauna and flora populations.

Kaa-Iya of the Gran Chaco, is notable for its world-class conservation values, currently there is a recorded estimate that it houses a variety of vertebrate fauna species; among them 108 mammals, 226 birds, 72 reptiles, 43 amphibians and 105 fish species. It is home to threatened or endangered species such as the guanaco (Lama guanicoe), the solitary chancho (Parachoerus wagneri), the tropero (Tayassu. pecari), the pejichi (Priodontes maximus), the corechi (Tolypeutes matacus) , the jaguar (Panthera onca) and the anta (Tapirus terrestris).

Even though the importance of this wonderful national park, every time more, intensive agriculture is affecting its boundaries and generating pollution that is so dangerous to animals and plants.

Determinant	Description	Relation to climate vulnerability	Status in Charagua
Economic wealth and financial capital	Municipal financial resources, resident incomes and wealth distribution, economic marginalization, fiscal incentives for climate risk management.	Climate change adaptation with internal funding or external support	Charagua Pueblo is a little town with reduce economic and almost inexistent debt capacity. That situation makes it impossible to implement measures to make a town resilient to climate change hazards.
Access to information and technology	Communication networks, computing tools, freedom of expression, technology transfer and data exchange	Technical data, data modelling capability, sharing and distribution information to Climate change adaptation	Charagua has no higher education institution in its jurisdiction. However, its dwellers know pretty well their territory, since they live from agricultural activities. This knowledge is a good baseline but it needs to me upgraded with knowledge about resiliency to climate change and biodiversity preservation.
Material resources and infrastructure	Transport, water infrastructure, buildings, sanitation, energy supply and management	Designed, constructed, sited, and managed infrastructure and services to be more adaptable or easier to adapt to climate change impacts and risks	Because of lack of economic resources, GAIOC has few material resources to deal with climate change hazards (e.g. there is only one bulldozers). However, GAIOC rents or borrows equipment from farmers and Mennonites.
Human resources and capacity	Knowledge (scientific, "local", technical, political), education levels, labor.	Scientific understanding and knowledge, local knowledge, and human resources to undertake climate change planning work.	In the dimension of biodiversity preservation awareness, there are not research with people from Charagua. All the studies have been made by foreigners.
Organizational and social capital	State-civil society relations, non-governmental and community-based organizations, relationships between institutions.	Stakeholders (government, non-government, vulnerable groups, etc.) that work together.	One distinctive feature is that the national government and international institutions like AECID are interested in working in Charagua so that new projects and programs would eventually arise. Biodiversity is a topic every time more frequent in the programs and projects that are being undertaken.
	Modes of governance, leadership, participation, decision and management capacity.	Functioning local government that is capable and willing to enforce municipal laws, plans and regulations.	Regarding the biodiversity dimension there is no municipal law that is in place, but GAIOC might develop a draft for the year 2025.

Table 17: Determinants of adaptive capacity and their relation to climate vulnerability in biodiversity dimension
Source: Own elaboration

Biodiversity Future Vulnerabilities

In the case of biodiversity future vulnerabilities, Charagua is near to the natural reserve Gran Chaco Kaa-Iya, a place that is home of several bird species. Nevertheless, a current issue that is involving inhabitants and bird species is that some of them go to Charagua households and consume garden production of fruits and vegetables. So that in the most extreme cases, there has been bird poisoning, killing toucans and other species. With population hold that fact would exacerbate bird killing in Charagua Pueblo.

Regarding tree species, it is important to say that in general a reduced number of trees is present in Charagua pueblo streets, which is even less at Barrio 1ro de Mayo. So, the effect of heat island is present at the town. That would be increased if more households are built, reducing space for trees not only at town squares but also at the interior of the new households. Currently the majority of the buildings of Barrio 1ro de Mayo use wood as the main material. Those wood is extracted from the trees that surround the town.

As some authors argues (Andersen, 2014) there is a relevant aspect that needs to be highlighted. Climate change could even have positive effects in the case of Charagua. Despite the projected increase in precipitation variability would have a moderately positive effect on biodiversity across the country. In total, climate changes would have a positive effect in the department of Santa Cruz (due to the increase in precipitation in relatively dry areas). Then, in dry areas in Chaco region, even droughts would be less frequent and allow significant increases in biodiversity due to predicted increases in precipitations.

On the other hand, deforestation is a real menace for biodiversity in Charagua. It seems that extensive agriculture is seen as a good practice without considering its externalities towards pollution and loss of biodiversity.

06

OVERLAPPING VULNERABILITIES

Urban and Climate Change Vulnerabilities

The conflicting vulnerabilities between urban and climate dimensions have been identified using a map to determine the key hotspots in the study area.

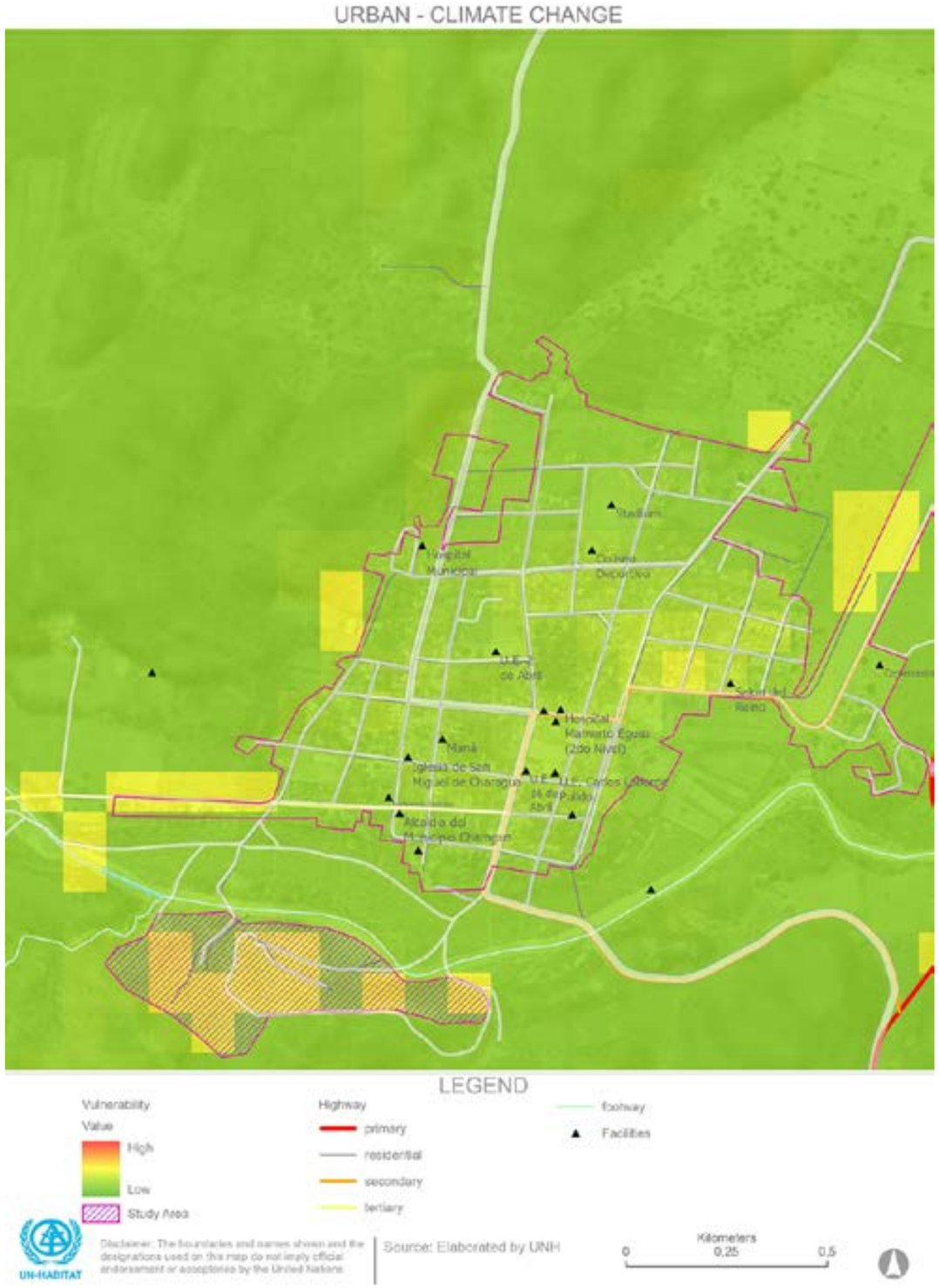
The identified hotspots indicate that Barrio 1ro de Mayo Alto and Centro are more vulnerable than Barrio 1ro de Mayo Bajo. Overall, the neighborhood's hotspots are predominantly of medium intensity

The health post, a critical piece of infrastructure in Barrio 1ro de Mayo Alto, is situated within one of the neighborhood's most vulnerable hotspots. This highlights the intersection of urban and climate change vulnerabilities, as essential services are directly exposed to heightened risks such as landslides, drought and extreme weather events. The precarious siting of this key facility not only threatens service continuity but also exacerbates the community's overall resilience challenges, particularly in times of crisis when access to healthcare is most urgent. Informal housing in this location are also at increased risk.

Regarding accessibility, the only road that connects Barrio 1ro de Mayo with Charagua Pueblo, it is located near to a medium-scale hotspot. Due to its location and condition, is significantly exposed to climate-related hazards such as flooding, landslides, drought- and heat-related erosion. This could significantly impact mobility, emergency response, and access to essential services, further isolating the already low-income, underserved and marginalized community during extreme weather events. Strengthening infrastructure resilience in this area is crucial to ensuring reliable connectivity, and community resilience.

The analysis of population density and climate vulnerability hotspots reveals that both the lowest-lying and hilltop parts of the neighborhood are situated within the most vulnerable area. This insight is crucial for urban planning, as it can guide authorities in steering future neighborhood expansion away from high-risk zones and toward areas with lower vulnerability, reducing exposure to climate-related hazards

It is important that these identified hotspots between the urban and climate change dimension would be used to better planning in term of the imminent growth of Barrio 1ro de Mayo, considering all the climate change hazards that would exacerbate this vulnerability.



Climate Change and Biodiversity Vulnerabilities

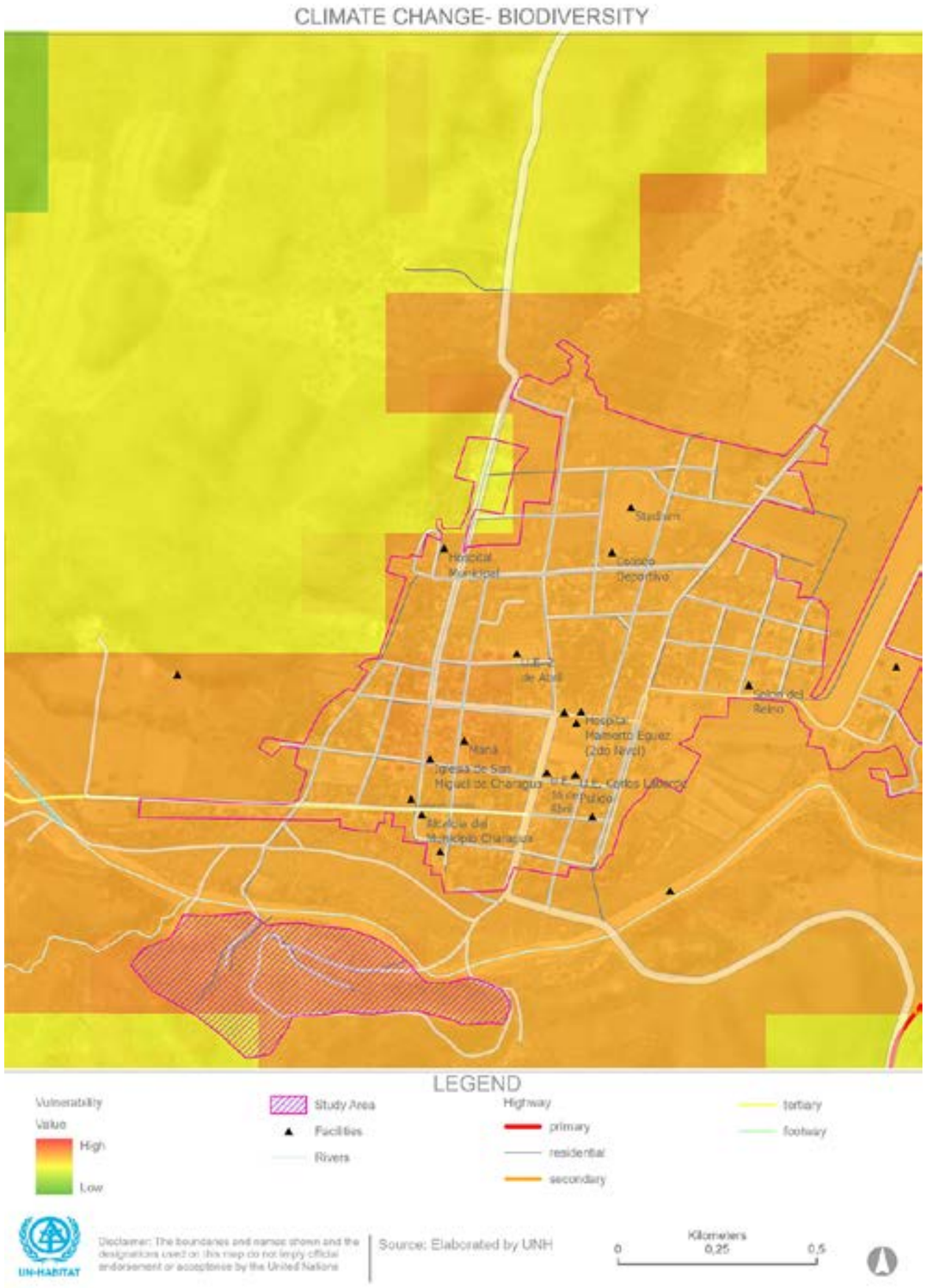
The conflicting vulnerabilities between climate and biodiversity dimensions have been identified using a map to determine the key hotspots in the study area.

Ecosystems operate at the broadest scale of biodiversity, with their services closely linked to climate conditions. The local climate determines temperature and humidity levels, shaping the viability of species within an ecosystem. In Charagua, the dry forests of the Gran Chaco depend on scarce rainfall, high temperatures, and low humidity, supporting low-lying vegetation and sustaining local fauna—both of which are critical for rural communities. However, climatic threats such as prolonged droughts and rising temperatures disrupt these delicate balances, impacting ecosystem services and threatening species stability

Barrio 1ro de Mayo – across its high, central, and low sections – is situated in an area of relatively high ecological value. However, if urban expansion continues into the lower part of the neighborhood, it risks encroaching upon nearby vulnerability hotspots. This uncontrolled growth could degrade the surrounding natural environment, intensifying biodiversity loss and further weakening the community's resilience to climate change

Another key finding is that the Gran Chaco Kaa-Iya Natural Reserve faces threats not only from human activity but also from climate change hazards. Rising temperatures, shifting rainfall patterns, and extreme weather events could disrupt local ecosystems, leading to habitat loss and biodiversity decline. Bird species, which are particularly sensitive to environmental changes, may face population reductions or displacement, while certain tree species could struggle to survive under altered climatic conditions, further destabilizing the region's ecological balance. As these ecosystems degrade, the essential services they provide – such as carbon sequestration, water regulation, and habitat provision –could be significantly weakened, further exacerbating environmental vulnerabilities for both wildlife and local communities.

The increasing impact of continuous hazards such as droughts and landslides could lead to significant loss of flora and fauna in the area. Prolonged droughts can weaken vegetation, reduce water availability, and disrupt food chains, making it difficult for many species to survive. Meanwhile, landslides can cause direct habitat destruction, uprooting trees and altering the landscape in ways that further threaten biodiversity. These combined effects not only reduce the region's ecological resilience but also diminish the critical ecosystem services that support both human and non-human populations

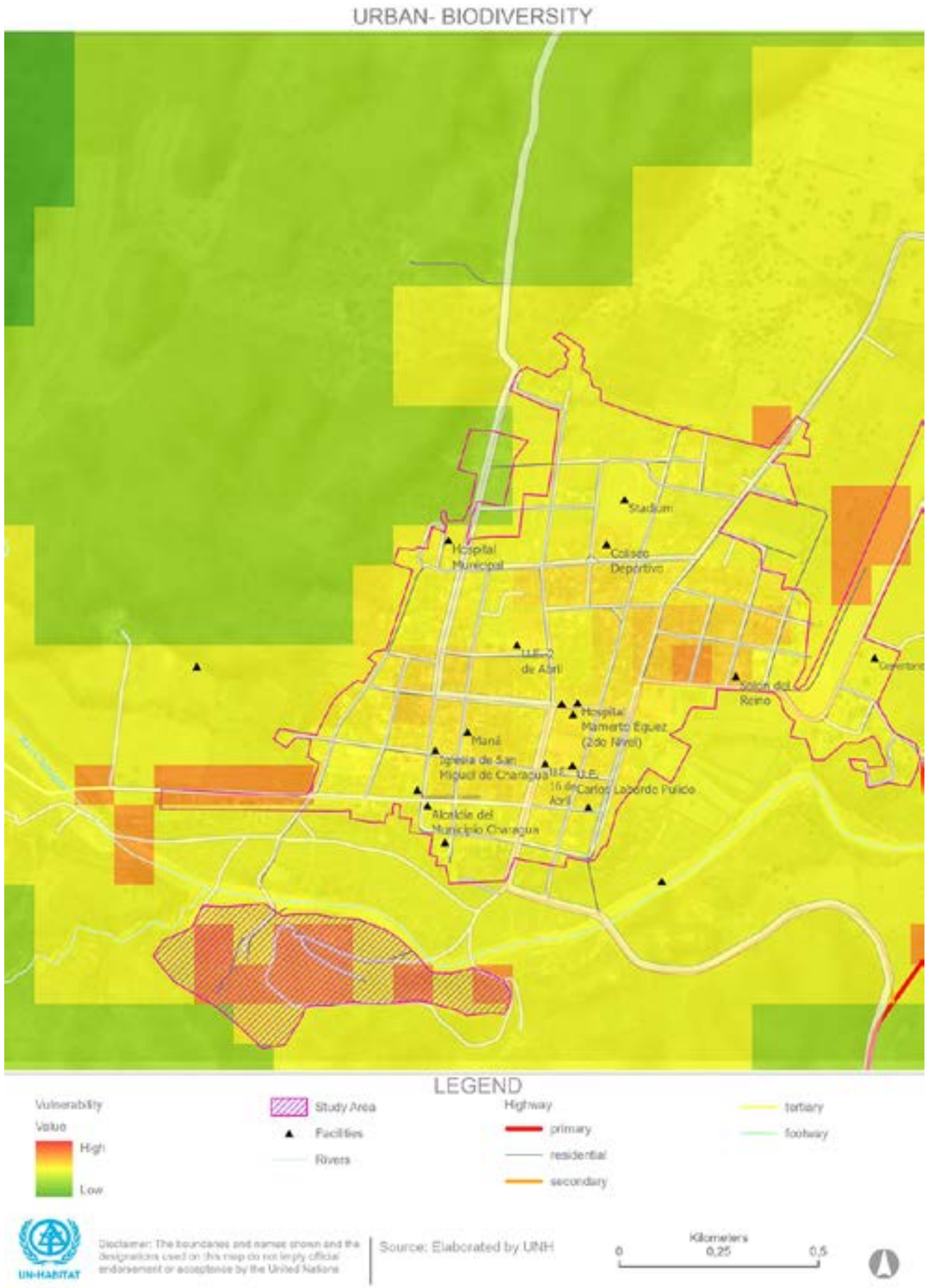


Biodiversity and Urban Vulnerabilities

The conflicting vulnerabilities between biodiversity and urban dimensions have been identified using a map to determine the key hotspots in the study area.

Barrio 1ro de Mayo Alto is situated within the highest intensity hotspot area, indicating that the neighborhood's expansion is likely to continue in an already vulnerable zone. This ongoing growth, coupled with harmful human behaviours and ecological practices, could further exacerbate environmental degradation, increasing pressure on natural resources and intensifying pollution of soil and water. Without sustainable planning measures, unregulated urban expansion may accelerate habitat loss, reduce ecosystem resilience, and heighten exposure to climate-related hazards such as flooding and landslides

The middle and upper sections of Barrio 1ro de Mayo are situated in hotspots with the highest values, indicating that further growth in these areas will have less impact on ecosystem resilience compared to the lower part of the study area. However, if the neighborhood continues to expand southward, the middle section may encounter more sensitive hotspots, potentially affecting the biodiversity of Charagua and the Gran Chaco Kaa-Iya National Park. The intersecting and concentrated vulnerabilities in this region underscore the complex dynamics between urban growth and biodiversity conservation, with potential risks of exacerbating ecosystem degradation, particularly in these sensitive areas.



Multilayered Vulnerability Hotspots

The three dimensions explored in this study – urban, climate change, and biodiversity, and there interconnectedness – highlight that Charagua, particularly Barrio 1ro de Mayo, is situated in an area highly vulnerable to climate change. As demonstrated, the overlap of these dimensions converges in "hot spots," where conflicts are most pronounced. These areas indicate where interventions must be prioritized to enhance community safety and resilience to climate change, while also preserving the biodiversity of the surrounding natural environment.

The ecosystem is the fulcrum that simultaneously connects biodiversity, climate impacts and urbanization. If we refer to the three contributions of vulnerability: exposure, sensitivity, and adaptive capacity, we have:

- The 1ro de Mayo neighborhood is highly exposed to climatic threats such as droughts and landslides, due to several factors including its precarious urbanization, limited accessibility, and spontaneous development on land with complex topography and poor soil capacity. As a result, residents of this area face greater vulnerability compared to other parts of Charagua. The neighborhood has experienced a range of issues, from droughts to landslides, which have negatively impacted its habitability. This situation is further compounded by institutional weaknesses and the lack of financial resources, which hinder the establishment of a comprehensive disaster risk prevention framework within the GAIOC

- In terms of sensitivity, the informal homes in the 1ro de Mayo neighbourhood are predominantly precarious constructions, with only basic water and electricity services. They lack sewage systems, storm drainage, and garbage collection, contributing to significant pollution. The only available service is a health post, which is located in the most vulnerable hotspot and is difficult to access. The neighbourhood is also isolated from Charagua town, as it is connected by a dirt road that crosses the Charagua River. This road becomes impassable during landslides or flooding, further isolating 1ro de Mayo in the event of disasters. As the poorest neighbourhood in Charagua Pueblo, the area faces significant socio-economic and infrastructural challenges.

- In terms of adaptive capacity, the residents of 1ro de Mayo, having faced previous disasters, have developed a pragmatic response strategy. They recognize that securing access to drinking water is paramount during emergencies, and as such, this becomes their primary focus. While online classes provide continuity in education, residents also take measures to protect their belongings by relocating furniture and valuables to the higher parts of their homes, demonstrating a practical approach to safeguarding property. The neighborhood has established an organizational structure, with a community president serving as the liaison to the GAIOC, coordinating disaster response efforts with municipal authorities and volunteers. However, despite these adaptive practices, the community's capacity remains reactive rather than proactive. Responses are predominantly initiated post-disaster, and there is a notable absence of preemptive measures or long-term preventive planning, indicating a gap in forward-thinking adaptation strategies that could mitigate future risks.

The vulnerabilities identified across social, economic, physical, and environmental dimensions in the Municipality of Charagua, and in Charagua Puebla and the 1ro de Mayo neighborhood, are deeply interconnected, amplifying one another in a vicious cycle of harmful practices that increase the community's vulnerability over time. These compounded challenges present an urgent need for Charagua Pueblo to better manage its territory. While Charagua is not a city, but rather a small town, strategic land use planning remains essential. A well-defined vision for the town's growth is crucial in determining priorities and identifying the necessary infrastructure for sustainable development. Development policies must be holistic, addressing key areas such as employment generation, social cohesion, environmental preservation, housing access, and the efficient provision of services, all while prioritizing resilience to climate change. This should not leave aside the planning of a Charagua resilient to the threats of climate change.

Governance remains a significant challenge in Charagua, aggravated by its indigenous autonomy. The municipality often faces issues of duplication and overlapping functions and differing views among local actors on governance approaches. Institutional weaknesses and a lack of resources further hinder the local government's ability to effectively meet its obligations.

Despite these critical challenges, they also present opportunities for transformation. Within the context of this analysis, priority areas for action have been identified. The 1ro de Mayo neighborhood, given its vulnerabilities, should be seen as a key focus for intervention. Targeted actions in this neighborhood could yield valuable, replicable outcomes that could extend to other areas of the municipality. Improving the availability of quality services and infrastructure that are resilient to climate change would significantly enhance the living conditions of the community, foster environmental stewardship, and reduce the pollution currently plaguing the area.

In light of these challenges, the critical issue lies in addressing the overlapping vulnerabilities in a holistic manner. A focused, integrated approach that bridges social, economic, physical, and environmental considerations will be essential for creating a resilient Charagua. Prioritizing neighborhoods like 1ro de Mayo offers a unique opportunity to implement pilot projects that can serve as models for broader municipal development. However, without a shift towards proactive, forward-thinking policies and a commitment to strengthening governance and institutional capacity, these vulnerabilities will continue to exacerbate. Therefore, fostering collaboration between local authorities, communities, and external stakeholders will be key to ensuring that Charagua not only survives but thrives in the face of climate challenges, setting a precedent for sustainable, climate-resilient development in the region

In conclusion, the multilayered vulnerabilities identified and assessed in this report – ranging from environmental risks to socio-economic and infrastructural challenges – demand urgent attention. The intersection of these vulnerabilities in hotspot areas requires strategic interventions that not only address immediate needs but also build long-term resilience. Moving forward, it is imperative to adopt an integrated approach that considers the complexities of urbanization, climate risks, and biodiversity preservation, ensuring that future development in Charagua is both sustainable and resilient

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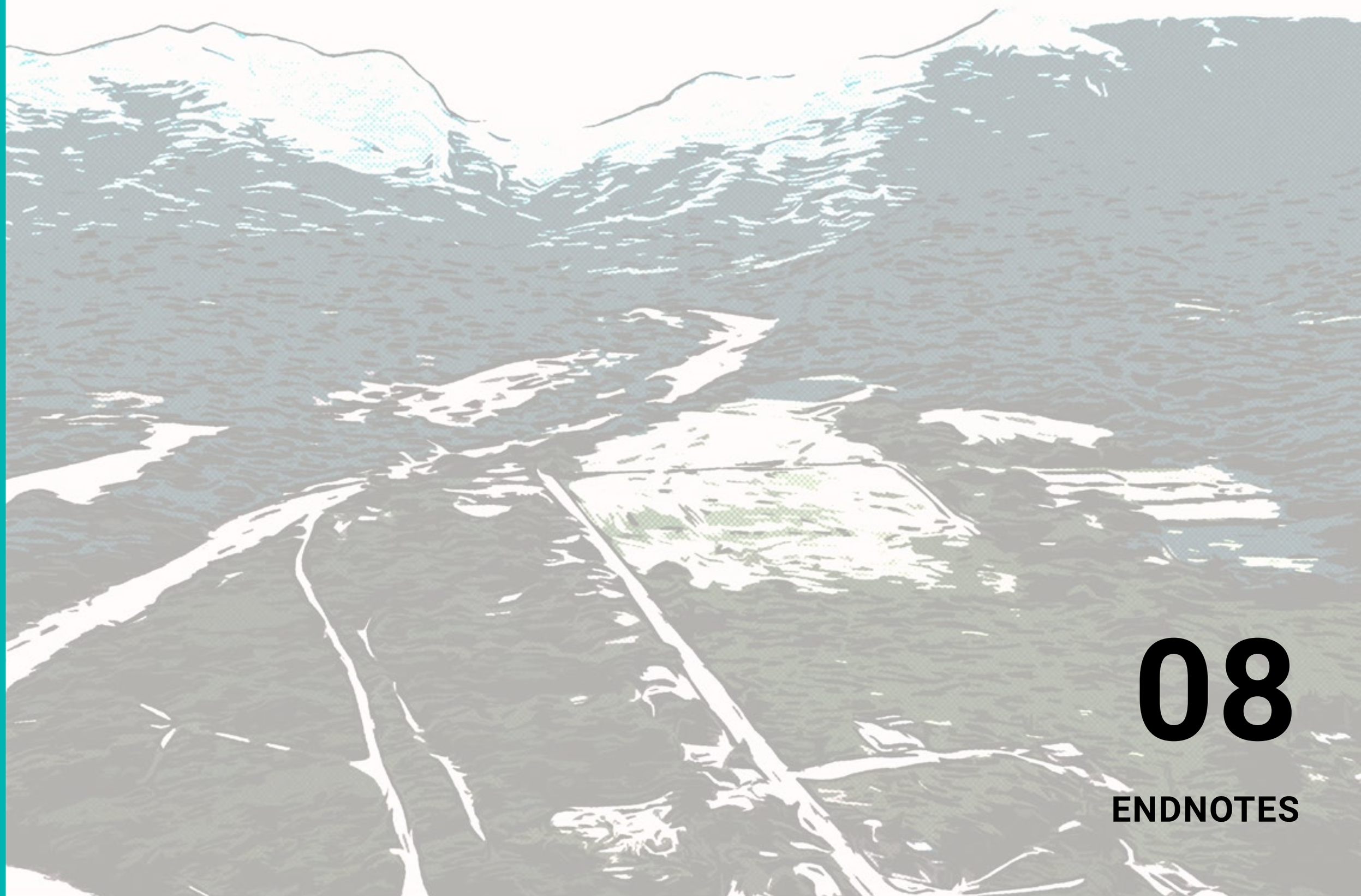

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ENDNOTES

[1]Is a method for determining ranges by targeting an object or a surface with a laser and measuring the time for the reflected light to return to the receiver. Lidar may operate in a fixed direction (e.g., vertical) or it may scan multiple directions, in which case it is known as lidar scanning or 3D laser scanning

[2] La economía del cambio climático en Bolivia - Impactos sobre la biodiversidad (BID, 2014)

[3] La economía del cambio climático en Bolivia - Impactos sobre la biodiversidad (BID, 2014)

[4] Infrastructure is a type of land use according to Charagua urban plan

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