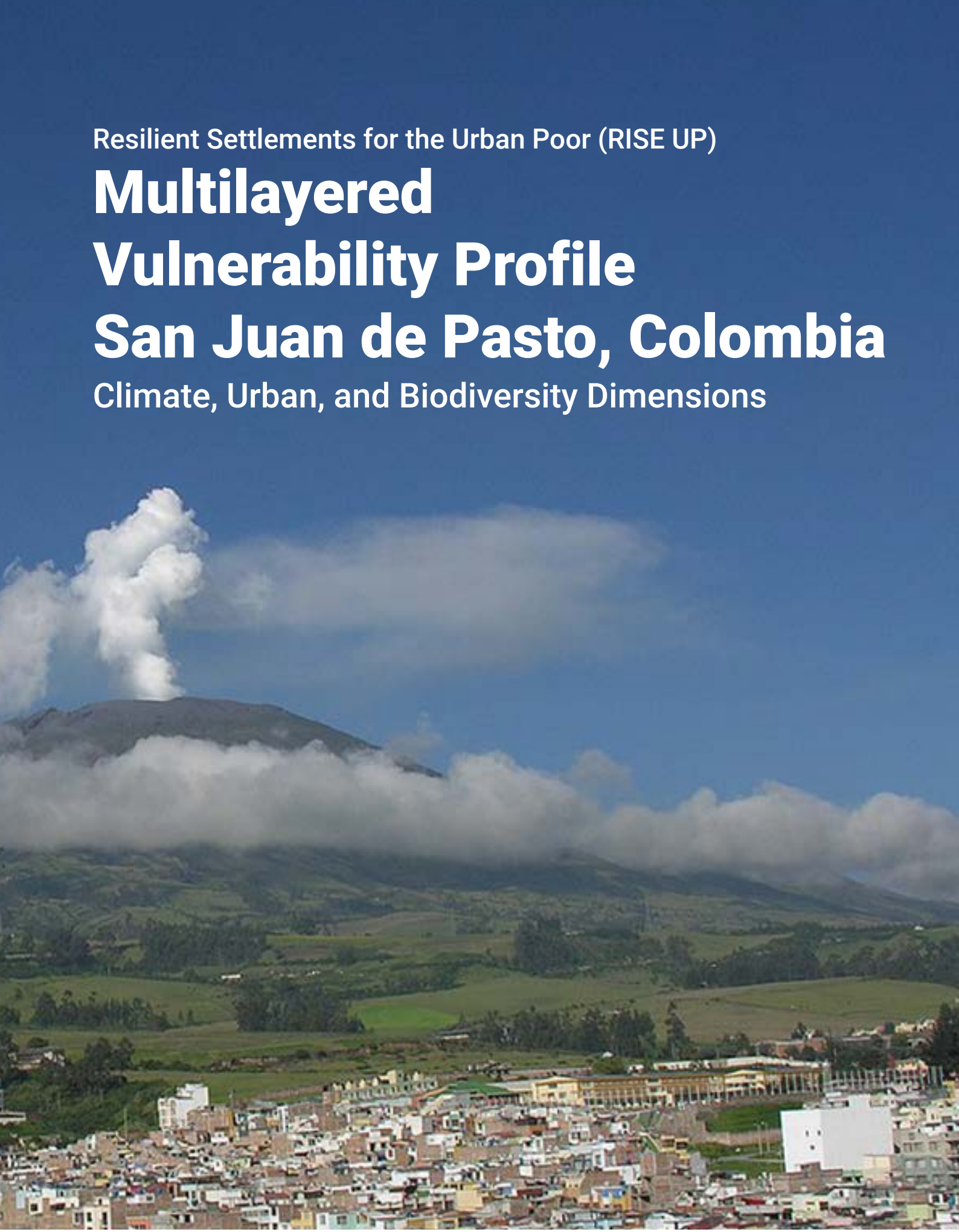
Resilient Settlements for the Urban Poor (RISE UP)

Multilayered Vulnerability Profile San Juan de Pasto, Colombia

Climate, Urban, and Biodiversity Dimensions



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Cover photo Aerial View of Pasto, Colombia

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Abbreviations

CAF	Development Bank of Latin America and the Caribbean
CBO	Community-Based Organization
CORPONARIÑO	Autonomous Regional Corporation of Nariño
CO2	Carbon dioxide
DANE	National Administrative Department of Statistics
DRR	Disaster Risk Reduction
EMPOPASTO	Pasto Sanitary Works Company
FINDETER	Financial Fund for Territorial Development
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse gas emissions
GIS	Geographic Information System
IIED	International Institute for Environment and Development
IDB	Inter-American Development Bank
ILO	International Labour Organisation
IADB	Inter-American Development Bank
MPI	Multidimensional Poverty Index
NGO	Non-Governmental Organisation
NUA	New Urban Agenda
PMD	Municipal Development Plan
POT	Land Use Plan
ROM	Romani population
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHO	World Health Organization

Glossary

Corregimiento: A rural administrative subdivision within a municipality. This category facilitates the organization and management of territory more effectively, particularly in areas with specific characteristics, such as being less urbanized or having more dispersed communities.

Comuna: territorial division corresponding to the urban area of municipalities. Each Comuna encompasses several neighborhoods and is considered a unit of urban planning and management. They facilitate the organization of public services and citizen participation in the management of local public affairs.

Departamento: a territorial entity that functions as an administrative subdivision of the country. Each department has its own government, led by a governor, and a departmental assembly responsible for local legislation and administration. Departments are responsible for managing matters such as education, health, infrastructure, and economic development within their territory.

Frailejón: type of plant belonging to the genus *Espeletia*, which is native to the high-altitude paramo ecosystems of the Andes in South America, particularly in Colombia and Venezuela. Frailejones play a crucial role in their ecosystem, helping to retain water and prevent soil erosion.

Gini coefficient: the statistical measure used to represent the distribution of income or wealth within a population. It ranges from 0 to 1, where: 0 represents perfect equality and 1 represents perfect inequality.

Municipality: is the territorial unit, politically and administratively organized, in the jurisdiction and with the inhabitants of the Department Section, the basis of the territorial organization of the unitary and democratic Colombia State.

Neighbourhood: urban organizational unit of municipalities, composed of a group of residences and community spaces. Generally, they are characterized by having a distinct identity, based on aspects such as culture, history, and the coexistence of their inhabitants.

Pacific Biogeographic Region: refers to a major ecological region that includes the coastal and marine environments of the Pacific Ocean and its surrounding landmasses. It is part of a broader classification used to understand biodiversity patterns across the world. The term “biogeographic region” refers to a geographic area that has a distinct combination of flora and fauna, shaped by its climate, geography, and evolutionary history. The Pacific Biogeographic Region encompasses several distinct ecosystems and includes both land and oceanic components.

Paramo: unique type of high-altitude ecosystem found in the Andes mountains of South America, particularly in Colombia, Ecuador, and Venezuela. Characterized by a harsh climate with cold temperatures, high winds, and significant daily temperature fluctuations, páramos are typically located above the tree line, at elevations of around 3,000 to 5,000 meters (9,800 to 16,400 feet). These ecosystems play a vital role in water regulation, serving as important watersheds that capture and store rainfall and meltwater, which is crucial for the surrounding regions. Additionally, páramos are significant for biodiversity and provide habitat for various endemic species.

Watershed (Hydrographic Basin): This refers to the area of surface or groundwater that drains into a natural network with one or more natural channels, with continuous or intermittent flow, that converge into a larger watercourse. This watercourse may in turn flow into a main river, a natural water reservoir, a swamp, or directly into the sea. A watershed is defined by the watershed divide, which is the highest elevation or contour line that separates two adjacent basins.

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 San Juan de Pasto. 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.

Pasto is located at 1° 12' 52.48" North latitude and 77° 16' 41.22" West longitude, in the southwestern region of Colombia. The city is situated in the mountainous massif of the Nudo de los Pastos (Andes mountain range), over the Atriz Valley, at the foot of the Galeras volcano, with its municipal seat at an altitude of 2,527 meters above sea level. The average temperature is 12.8°C, with maximums of 17°C and minimums of 9.5°C. The relative humidity fluctuates between 71.4 per cent and 87 per cent throughout the year, and the average total annual rainfall is 796 millimeters.

Pasto covers an area of 1,100.31 square kilometers, of which 23.88 square kilometers correspond to the urban area, accounting for 2.17 per cent of the total. The municipality has a population of 413,484 people (2024), with 22.2 per cent residing in rural areas and 77.8 per cent in urban areas. The average population density in the urban area is 13,477 inhabitants per square kilometer, making it a dense and compact city. Women represent 53.2 per cent of the population, and 3.22 per cent of the total population identifies as ethnic minorities (2.26 per cent are indigenous, and 0.92 per cent are Afro-Colombian, Black, or Mulatto).

Administratively, Pasto is the capital of the Department of Nariño, and its political division includes 12 comunas, 414 neighborhoods, and 17 rural districts. The highest municipal authority is the mayor, who works with the municipal council, the main deliberative and oversight body, and who issues agreements and regulations that govern the functioning of the municipality. On average, the municipality's annual revenues for the period 2020–2023 were 906 billion pesos (approximately 213 million USD), of which 19.8 per cent came from taxes, 15.7 per cent from capital, 62.7 per cent from transfers, and 1.7 per cent from non-tax sources. In terms of expenditures, for the 2023 fiscal year, 8.8 per cent was allocated to operations, 81 per cent to investment, and 2.3 per cent to debt servicing. By the end of 2023, the municipality had accumulated a financial liability of 80.42 billion pesos, equivalent to 7.9 per cent of its revenues.

Urban Dimension

The city of Pasto features a vertical profile dominated by apartment buildings, comprising nearly 40 per cent of housing units. At the same time, the city has been expanding toward the rural edge of the municipality, with particular pressure on areas with a rural tradition that are now exhibiting conurbation dynamics, such as Jongovito, Obonuco, Jamundino, and Catambuco. Although the Land Use Plan designates the sectors of Aranda (northeastern area), Jamundino (southern area), Mijitayo and Altamira (southwestern area) as urban expansion zones—and the criteria of the Partial Development Plans define general burdens applicable to this type of urban development—the lack of monitoring and control, low generation of developable land, and violations of regulations have resulted in a complex urban morphology. This includes a significant deficit in public space (the municipal capital of Pasto has an effective public space index of only 2.08 square meters per inhabitant), in addition to pressure on public service provision and environmental and landscape imbalances in the urban area.

Poverty and extreme poverty further exacerbate the vulnerability of Pasto's population. Approximately 25.3 per cent of the population lives on less than $1.97 per day, 31,134 households in the city face qualitative housing deficits, and a shortfall of 4,477 homes unable to find affordable and formal housing solutions.

The recent construction of a perimeter road offers both opportunities for growth and challenges, particularly related to infrastructure strain. Vulnerability is particularly pronounced among marginalized groups, including elderly women engaged in commerce. Strengthening the social fabric through community action and effective public-private collaboration is essential to enhance coping capacities and improve living conditions.

Updating the Municipality's Land Use Plan should go hand-in-hand with reinforcing the social fabric through community action and effective collaboration between public and private sectors to support sustainable urban development.

Climate Change Dimension

Climate change poses a substantial threat to Pasto, heightening disasters risks such as landslides and flooding, especially in vulnerable areas near water bodies and steep slopes. The municipality has initiated a Disaster Risk Management Plan aimed at increasing resilience; however, threats from climate variability necessitate further action. Projections indicate significant increases in rainfall by 2100, amplifying risks to food security and potable water supply.

The main climate risks affecting the city are floods and Landslides events. Floods have caused damage to people, food security, biodiversity, infrastructure, and human habitats, and are mainly associated with the city's topographic and geomorphological features, land use in floodplains of water bodies, mainly the Pasto River and its tributaries, blocked sewage systems, and deforested slopes. Landslides are caused by increased water erosion, deforestation, land use changes (mainly for agriculture), and the presence of informal settlements in sloped areas.

Regarding greenhouse gas (GHG) emissions, the per capita emission was an average of 1.58 tons of CO2 equivalent per year (the national average is 1.6 tCO2eq/year), and 186 tCO2eq/Km2-year were generated (Period 2019-2021), which suggests that in a carbon neutrality scenario, absorption processes would need to cover around 9 per cent of the territory (IDB, 2021). The net GHG emissions in the municipality are generated by the transportation sector, which represents 50.91 per cent (of which 45.53 per cent corresponds to gasoline used mainly for private land transportation), the stationary energy sector (residential buildings, commercial and institutional facilities, and industries, among others) with 31 per cent, and the waste sector with 16 per cent (of which 68.15 per cent corresponds to the disposal of solid waste in landfills and 13.59 per cent to domestic wastewater). The responsibility for the GHG inventory falls 93.82 per cent on activities carried out by the local population, making it feasible to develop effective actions through municipal management and administration tools.

Biodiversity Dimension

Located between two biogeographical zones, the Norandina and the Amazonian, the municipality of Pasto lies in the Pastos knot, where the Andes mountain range splits into the Western and Central mountain ranges, creating landscapes of high plains, mountains, and foothills. Hydrologically, 45.3% of the municipality belongs to the Pacific region, while the remaining 54.7% is part of the Amazonian region (Pasto City Hall, 2024). 76.65% of the total municipal territory is designated as protected land, consisting of areas within the municipal ecological structure and land considered under the system of threats and risks. Notable protected areas include the Galeras Flora and Fauna Sanctuary, which serves as a buffer zone, and the Ramsar Wetland Laguna de la Cocha, covering 390 square kilometers, of which 42 square kilometers correspond to the lake's surface, making it the largest water body in Colombia that drains into the Amazon.

In the urban area, 9.17 square kilometers are protected, representing 38.7% of the total surface. However, only 5.26% of the urban area consists of green spaces larger than two hectares (0.02 km²), impacting the continuity of ecological corridors and the perception of public space as a collective landscape. The Pasto River basin is the main environmental structuring element of the urban area. With a linear course of 13.64 kilometers (POT, 2015), it flows through seven Comunasand, by 2013, had 17.12% illegal occupation along its riverbank. The immense potential for biodiversity conservation presented by water bodies is challenged by the lack of a wastewater treatment plant in the urban area of Pasto, as well as the channeling of 21.29% of streams and rivers within the urban perimeter (POT, 2015).

The expansion of agricultural and urban frontiers places additional pressure on key ecosystems, particularly the high-altitude páramos and the Ramsar wetland. Strategic measures are needed to balance development with conservation to safeguard biodiversity and the ecosystem services critical to the community's well-being.

Overlapping Vulnerabilities

The interconnections between urban vulnerabilities, climate change, and biodiversity create multifaceted challenges that the city must address in a coordinated manner. Floods and Landslides (landslides and torrential flows) are the primary climate risks the city faces in its urban area, affecting the general provision of public services, mobility, and strategically important assets, particularly trade and supply centers. The communities' sensitivity is linked to high population density, expansion without compliance with municipal regulations, and the socioeconomic conditions of the population. The multi-dimensional vulnerability analysis reveals that specific areas in comunas 10, 8, and 5 are especially sensitive and require the development of immediate action plans to mitigate the effects of climate change on their communities. However, adaptive capacity stands out, which is related to the strong existing community processes as well as territorial roots that are evident. Local organizational dynamics, associated with Community Action Boards, Youth Councils, water committees, and the organizational processes led by educational institutions, form part of the assets that strengthen the adaptive capacity of these communities.

The vulnerability analysis highlights the influence area of the Guachucal stream and the community around the El Potrerillo Market Square in Comuna 5. This is a territory exposed to extreme climate phenomena, such as floods and torrential flows, which have put the market's operation at risk. The sensitivity of the communities there is related to their weak economic conditions, below average, high permanent and floating population density, and subsistence economic dynamics involving displaced and migrant populations. This area is a priority because it is a source of food provision and a base for food security in the municipality and the region, establishing it as a significant area for the future and stability of Pasto and its inhabitants.

In order to reaffirm the New Urban Agenda to address the world's greatest challenge—the eradication of poverty in all its forms and dimensions—and its necessary approach for sustainable development, RISE – UP will focus its efforts on establishing a financially feasible action plan in this area. This will promote equitable opportunities and shared benefits that urbanization can offer while ensuring the impacts of climate change are faced with a differential approach.

01

INTRODUCTION

Background and Context

Climate Change, Urbanization and Biodiversity

The climate emergency is also an urban crisis, affecting every aspect of city life. With over 55 per cent of the global population living in cities—expected to exceed 67 per cent 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 per cent of cities are located within the world's 36 global biodiversity hotspots, where urban expansion threatens both biodiversity and climate resilience. As human settlements grow, natural habitats are rapidly lost, a process exacerbated by climate hazards. Recognising this challenge, cities are increasingly prioritizing spatial planning and urban land management to safeguarde ecosystems and natural assets. These strategies not only protect biodiversity but also enhance climate resilience, delivering co-benefits for both people and nature. Effective spatial planning is crucial to prevent the degradation of urban areas that rely on the ecosystem services provided by biodiversity. Targeted pro-biodiversity interventions are urgently needed, both within and beyond urban areas, backed by robust tools and strategies.

UN-Habitat highlights the urgent need for multidimensional, multidisciplinary approaches to address the interconnected challenges facing cities, with a focus on building resilience for the one billion urban poor living in informal settlements. These marginalized communities are particularly vulnerable to climate hazards and disasters, often residing in fragile areas where unplanned urban growth encroaches on natural habitats. Informal urbanization not only exacerbates their vulnerabilities but also intensifies the interconnected 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, UN-Habitat's flagship programme, is 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:

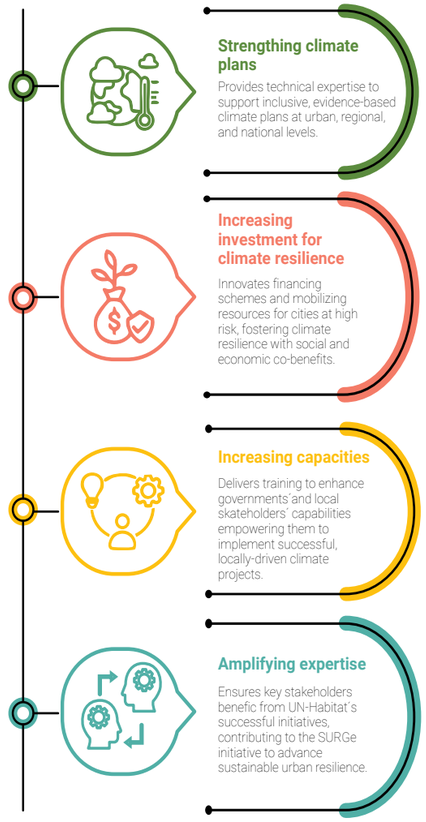


Fig. 1: RISE UP objectives
Source: UN-Habitat, 2024.

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

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 geographic 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 are 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, which is intended to help communities, cities, and local leaders 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 inhabitants. This enables decision-makers to make informed choices about urban expansion and adapt to urgent climate-related challenges.

Implementation of the 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 (AECID). It presents the vulnerability profiles of the selected project cities, detailing the outcomes of Stages 1 and 2 of the MVA, including preparation, 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 Islands 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, Colombia, Ethiopia, Jordan, and Tunisia 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 San Juan de Pasto, Colombia

The territory where San Juan de Pasto (official name of the city, hereinafter referred to as Pasto) is located must be understood within the context of a historical and natural process that extends far beyond human presence. Its defining features – the mountain ranges, the Galeras Volcano, the Atriz Valley, and the Laguna de la Cocha, along with other biotic and ecologic al elements – have been shaped over millions of years through geological cycles, climatic changes, erosion, and the evolution of life.

Pasto's distinct geographic heterogeneity, situated at the convergence of the biogeographic Pacific and the Andean region, and its role as a tributary to the Amazon, provided the perfect environment for the indigenous Quillasinga people. They were the first to establish spatial relationships between humans and nature in what is now the Municipality of Pasto.

This socially constructed space, developed by indigenous communities with their own cultural, political, social, and administrative systems, encountered a new paradigm with the arrival of the Spanish and the onset of colonization. With colonization came a different relationship with the land, biodiversity, and climatic conditions. As an autarkic city, Pasto served as an important intermediary between the Viceroyalty of New Granada and the Viceroyalty of Peru, becoming a key trade route and connection point across the emerging regions of what would later form Gran Colombia.

With the advent of the Republic, however, Pasto was relegated to the periphery of the national economy. Its reliance on agricultural trade and exports encountered major challenges due to the lack of infrastructure, communication routes, and accessible ports—constraints that continue to hinder the region's development today.

Pasto's identity is thus shaped by overlapping historical layers, ranging from pre-Hispanic practices and traditions, still present in the territory, to the Spanish colonial urban layout visible in its historic center. These elements coexist with the political-administrative framework established during the Republic's formation and are further entangled with contemporary processes of modernization. Today, the city finds itself at a crossroads, as market-driven logics conflict with the need to organize the territory in a way that ensures sustainable growth and leaves no one behind.

In recent years, the city has experienced significant changes, including increasing densification, urban sprawl, and the loss of agricultural land, all of which have made it more vulnerable to the impacts of climate change. This growing risk highlights the need for effective urban planning that promotes orderly development and addresses the challenges of human settlements. In the absence of adequate opportunities, many communities have settled in high-risk areas, further increasing their exposure to environmental threats.

The loss of food security, driven by droughts, floods, and other extreme weather events, has become a critical concern for Pasto. Addressing these vulnerabilities requires an urgent and strategic response, as the city must navigate the challenges posed by climate change to secure a sustainable future for its inhabitants.

Context Analysis

Location and Geography

Pasto is located in the Northern Hemisphere, on the South American continent, at 1° 12′ 52.48″ north latitude and 77° 16′ 41.22″ west longitude from Greenwich. It is a municipality in Colombia, covering an area of 1,118 km², with an urban area of 26.4 km² and a rural area of 1,104.6 km² (Figure 2).

Its administrative center is situated at an altitude of 2,527 meters above sea level, in the midst of the Andes Mountain range, within the mountainous region known as the "Nudo de los Pastos." The city is in the Atriz Valley, at the base of the Galeras Volcano, and lies at the convergence of the Pacific Biogeographic region, the Amazon area, and the Andes, which serves as a natural border with the country of Ecuador.

Administratively, the municipality is the capital of the Department of Nariño, Colombia, and is organized into 12 comunas, 414 neighborhoods, and 17 rural districts or corregimientos, as illustrated in Figure 3. The municipality shares borders with La Florida, Chachagüí, and Buesaco to the north; the municipality of Funes and the Department of Putumayo to the south; the municipality of Buesaco and the Department of Putumayo to the east; and the municipalities of Tangua, Consacá, Nariño, and La Florida to the west.

Fig. 2: Location of the Municipality of Pasto in the Department of Nariño, Colombia
Source: UN-Habitat, 2024.

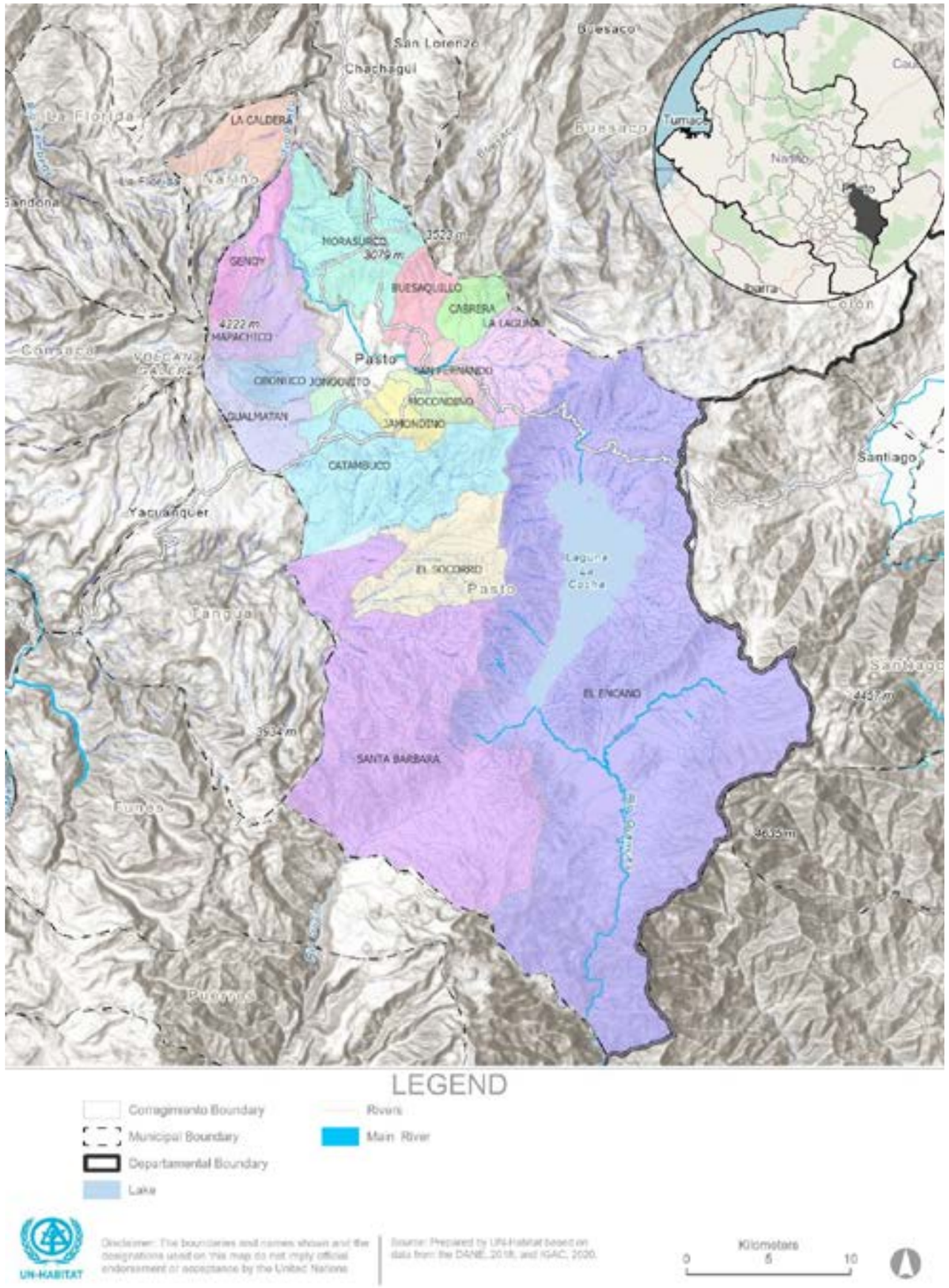


Fig. 3: Map of San Juan de Pasto, Colombia
Source: UN-Habitat, 2024

History of City Development and Growth

The city of Pasto was founded in 1537 by the Spanish conquistador Sebastián de Belalcázar, following the urban planning guidelines set by the Royal Audiencia for the Americas. These guidelines included territorial divisions of 80 m² per block, attention to public health, the promotion of Catholic culture, and the establishment of administrative structures characteristic of the viceroyalty (Bastidas Urresty, 2000).

Before the Spanish arrival, the area where Pasto now stands was inhabited by the Quillacinga[1] people. These Indigenous communities contributed a lasting heritage of knowledge and traditions that continue to shape the city. Their influence is reflected in the preservation of native languages, diverse cuisine, cultural practices, and a profound relationship with the land, exemplified by community processes such as "La Minga"[2].

During the colonial period, Pasto emerged as a significant administrative, military, cultural, and religious center in the Andean region, gaining prominence during the Viceroyalty era. After Colombia's independence, and with the formation of the Granadine Confederation and the subsequent creation of the Department of Nariño[3] in the early 20th century, Pasto embarked on a path of modernization.

In 1904, the University of Nariño was founded with five initial faculties, catalyzing progress in science, arts, education, and culture. Despite being geographically isolated due to limited communication routes, the city's determined population advanced industrial manufacturing and improved its infrastructure.

By the 1930s, after nearly fifty years of conservative dominance, Pasto began to undergo urban transformations typical of a modern city. The construction of a highway connecting it to the country's center significantly improved its links with other parts of Colombia.

At this time, Pasto had access to electricity, though its water service and telecommunication services remained limited. A census recorded around 45,162 inhabitants, with the city covering an area of 140 hectares. The local economy was supported by a variety of industries, including cigarette production, leather tanning, textile manufacturing, brewing, and brick-making. The city also had a strong tradition of cabinetmaking and carpentry, gaining artistic recognition for the "Barniz de Pasto," now listed as an Intangible Cultural Heritage of Humanity by UNESCO.

In the 1950s, Pasto entered a new phase of development and modernization, marked by major public infrastructure projects. These included the construction of the airport, several public administration buildings, the departmental stadium, the coliseum, and key avenues, alongside an expansion of urban construction.

By the 1990s, the city's population had grown to approximately 312,000 inhabitants, with an economically active population of 184,000. However, unemployment reached 13 per cent, and informal employment was on the rise, reflecting limited economic opportunities. Despite these challenges, the city's commercial sector began to flourish, contributing significantly to the local economy. During this period, economic activities were dominated by small industries, with over 50 per cent of employment in commerce and 28 per cent in the service sector.

In recent years, Pasto has positioned itself as a leader in citizen participation through the collaborative development of public policies and development plans. In 2000, the city introduced participatory budgeting in its urban areas, building on earlier efforts in rural sectors. This period marked the beginning of discussions on sustainable human development, with a focus on improving quality of life while considering environmental conservation and the broader regional context.

Finally, the municipality was recognized as a Creative City of Crafts and Folk Art by UNESCO in 2021. This recognition places it on the global stage for its outstanding Andean cultural heritage, which is further complemented by the 2009 recognition of the Blacks and Whites Carnival as an Intangible Cultural Heritage of Humanity by UNESCO.

Demographics

According to DANE projections from the 2018 cencus, Pasto has a population of 413,484, with a density of 365.59 individuals per square kilometer. The most densely populated comunas are 3, 4, 5, and 6, and collectively account for 48.4 per cent of the urban population (Figure 4). In rural areas, the corregimientos with the highest population density include Jongovito, Jamondino, Mocondino, San Fernando, Buesaquillo, and La Laguna, representing 29.5 per cent of the rural population.

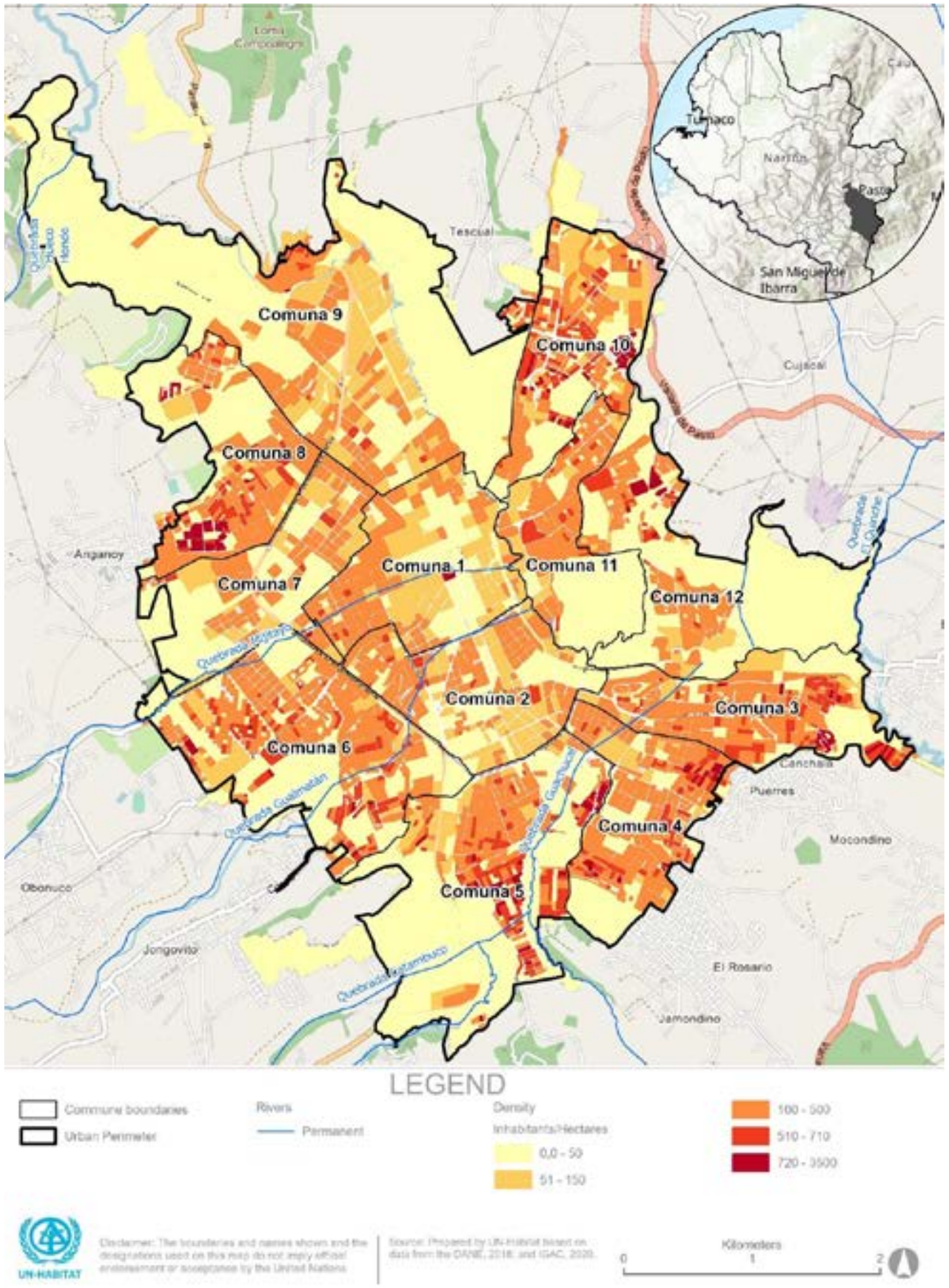


Fig. 4: Population density of Pasto, Colombia
Source: UN-Habitat, 2024.

Of the total population, 53.2 per cent (220,090 individuals) are female, and 46.8 per cent (193,394) are male. In terms of spatial distribution, 77.8 per cent (321,833 people) live in the urban area, while 22.2 per cent reside in rural areas. The city's population pyramid reveals a concentration of both men and women in the middle-age ranges (see Figure 5 below).

When grouping the population according to the age ranges defined by public policies for population care in Colombia (Figure 6), the presence of a still-active demographic dividend stands out. This allows for the projection of a sustained labor force in the coming decades and highlights the need for both guaranteed access to education and the creation of employment opportunities.

Furthermore, it underscores the importance of directing medium-term attention toward the elderly population (over 60 years old), who will increasingly demand care and health services, thereby exerting pressure on the Municipality's public resources in the coming years. Finally, the country's declining birth rate is reflected in the low percentage of the population under the age of four, raising concerns about the long-term demographic sustainability of the Municipality.

The ethnic minority population totals 13,295 individuals, or 3.22 per cent of the overall population. This group is predominantly composed of indigenous people (9,354), followed by Afro-Colombian, Black, and mixed-race populations (3,809). Smaller groups include the Romani or Rom population (100), Raizal (20), and Palenquera (12).

Migration is an important factor, particularly due to the Municipality's proximity to the border area. Since 2018, the department of Nariño has hosted a significant number of migrants, primarily of Venezuelan nationality. According to data from Migración Colombia (UAEMC), as of September 2024, the Venezuelan population in Nariño totals 41,629, of which 38.45 per cent (16,010) are located in Pasto. Among the Venezuelan migrant population in Pasto, 51.57 per cent are women, of whom 71.98 per cent are between the ages of 5 and 39. Within this demographic, there are likely to be pregnant women and mothers with children who are likely to be more vulnerable to the impacts of climate change.

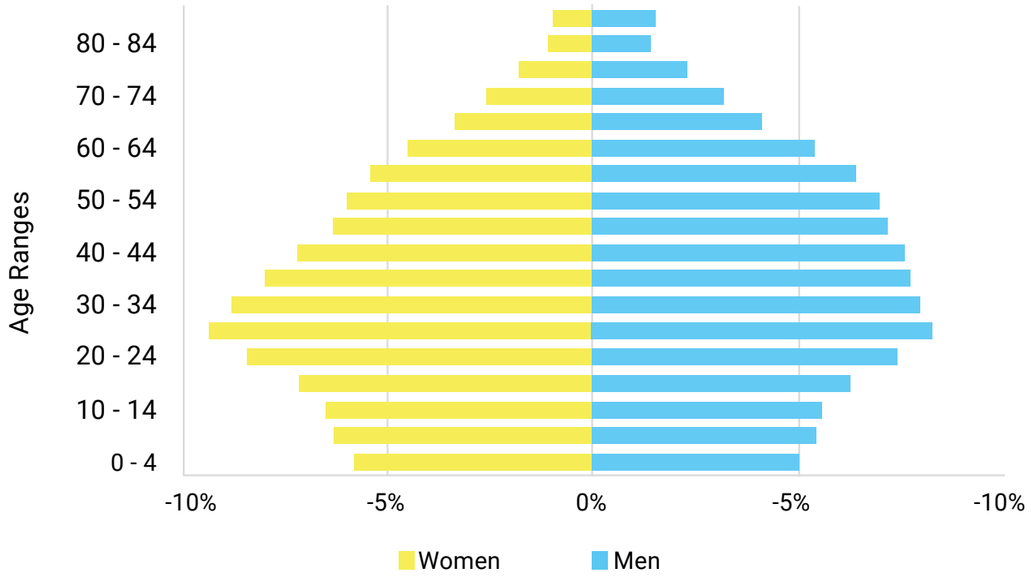


Fig. 5: Population Pyramid of Pasto, Colombia (2018)
Source: DANE – Population projection based on the 2018 Census.

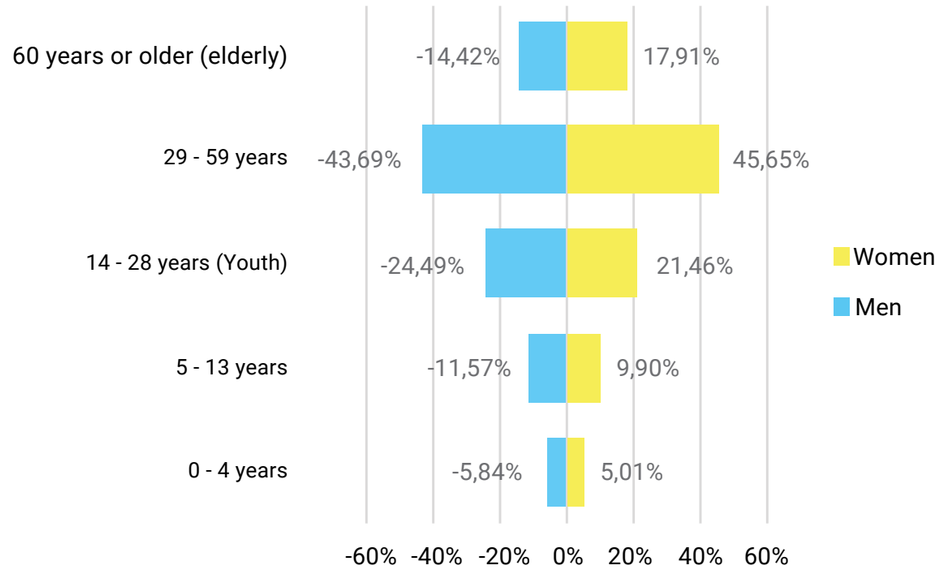


Fig. 6: Age groups of the population of Pasto, Colombia (2024)
Source: UN-Habitat, 2024 - population projection based on the 2018 Census

In addition to the Venezuelan migration, there are families from Haiti, Ecuador, China, Vietnam, India, Bangladesh, Nepal, Africa, Afghanistan, and other countries, entering Colombia with the aim of reaching the Darién Gap on their journey to the United States. According to reports from Migración Colombia, the irregular migration flow in Nariño from 2020 to September 2024 amounts to 156,946 people from various nationalities.

Furthermore, the city serves as a destination for victims of the armed conflict, hosting 53,796 victims, of which 74.30 per cent (39,973) have been forcibly displaced, 8.12 per cent (4,369) have been threatened, 7 per cent (3,769) have been victims of homicide, and 2.16 per cent (1,167) have suffered forced dispossession of property. These figures are based on data from the National Information Network of the Victims' Unit as of September 30, 2024.

In economic terms, 25.3 per cent of the population—approximately 104,620 individuals—lived below the poverty line in 2022, earning less than USD 1.97 per day. The Gini coefficient, measuring income inequality, was recorded at 0.505 (PMD, 2024). For the January-March quarter of 2024, DANE reported an employment rate of 60.2 per cent, though more than half of those employed work in informal sectors. The unemployment rate for the same period was 12.9 per cent .

The primary economic activities in Pasto are trade and vehicle repair, followed by public administration, defense, education, and health services. Arts, entertainment, recreation, and other service-related activities are also significant contributors to the local economy.

Key Economic Sectors

Economic activities in Pasto are predominantly concentrated in the tertiary sector, which accounts for 84.65 per cent of the total (PMD, 2024). This sector includes trade, public services, transportation, communications, finance, tourism, hospitality, recreation, and public administration. In 2023, the distribution of companies by sector in the municipality was as follows: commerce (51.55 per cent), accommodation and food services (13.0 per cent), and manufacturing industries (9.1 per cent).

The primary sector by area is agriculture which covers 8,862 hectares of temporary crops and 3,128 hectares of permanent crops, contributing 2.45 per cent to the local economy. In contrast, the secondary sector, which represents 12.9 per cent of economic activities, occupies less than 1 per cent of the city's territory. Key industrial activities linked to the municipality's socioeconomic structure include:

- Apparel manufacturing
- Household furniture
- Cork, wicker, and shoemaking articles
- Wooden doors, windows, and frames
- Saddlery and leather goods
- Bakery products
- Dairy products
- Flours, semolina, oats, corn, rice

As shown in Figure 7, 97.01 per cent of businesses in the city are micro-enterprises (fewer than 10 employees), followed by small enterprises, which make up 1.79 per cent (Chamber of Commerce of Pasto, 2023). This indicates a significant limitation in job creation and wealth generation, with the municipality achieving only 65 per cent of the national average in per capita value added (Ministry of Finance, 2019).

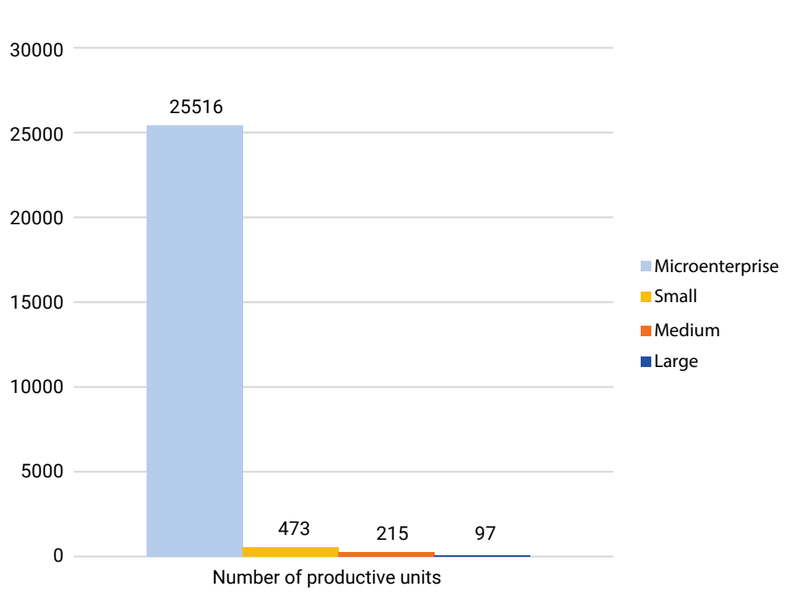


Fig. 7: Stock of companies in Pasto by size , Colombia
Source: Cámara de Comercio de Pasto, 2023.

Environment, Biodiversity and Climate

The city of Pasto features a municipal ecological structure that is significant both environmentally and anthropogenically. The hydrographic system of Nariño is situated within two major river basins: the Pacific and the Amazon. The Pacific basin covers 49,616.3 hectares, or 45.3 per cent of the total municipal area, while the Amazon basin spans 59,993.3 hectares, making up 54.7 per cent of the municipal area, as shown in Figure 8.

The region includes a natural Andean-Amazonian zone formed by the basin of Lake Guamuez, the Alisales River, the El Estero River, direct streams, and the Upper Guamuez River. It exhibits geomorphological, climatic, and ecological characteristics typical of a volcanic mountainous landscape, including páramo ecosystems, high mountains, and hills. This area has gained national environmental recognition as part of the Andean-Amazonian corridor Bordoncillo-Patascoy-La Cocha and international recognition through the Ramsar Wetland of International Importance, Laguna de la Cocha.

Another natural area, the Andean-Pacific zone, encompasses the basins of the Bobo and Pasto rivers. This area is characterized by volcanic landforms, high mountain zones, and lava flows. It includes the Galeras Volcano, which is part of the Galeras Flora and Fauna Sanctuary. This protected area, located in the northwestern sector of the city, covers 8,215.4 hectares, with 1,460.7 hectares falling within the municipality's jurisdiction.

Pasto's total water supply is 28.59 cubic meters per second, distributed as follows: 6.3 cubic meters per second in the Pasto River basin, 8.67 cubic meters per second in the Bobo River basin, and 13.62 cubic meters per second in the Guamuez area.

The municipality's strategic ecosystems are located in high mountain zones, super páramos, páramos, and sub-páramos, all at elevations of 3,000 meters above sea level or higher, which is considered a critical conservation threshold. These ecosystems play a significant role in carbon storage, cooling capacity, habitat quality, and climate regulation (NaBa, 2023).

In terms of climate, the city of Pasto, situated at an altitude of between 2,000 and 3,000 metres above sea level and experiences an average annual temperature of 13°C. During July and August, temperatures drop slightly to 12.6–12.7°C. Precipitation varies across the municipality, with moderate rainfall (approximately 800 mm) in the capital, which lies within the Andean region, and average levels (1300 mm), near Lake Guamuez (Laguna de la Cocha), an area with strong connections to the Amazon region. Visibility in the region averages 10 km, while humidity ranges from 60 per cent to 80 per cent.

According to inventories conducted by Corponariño, the natural forests within the Pasto, Bobo, and Guamuez basins contain an average of 22 families, 28 genera, and 37 species. However, forest biodiversity and volume have been declining due to agricultural expansion and the extraction of resources for charcoal production and other uses.

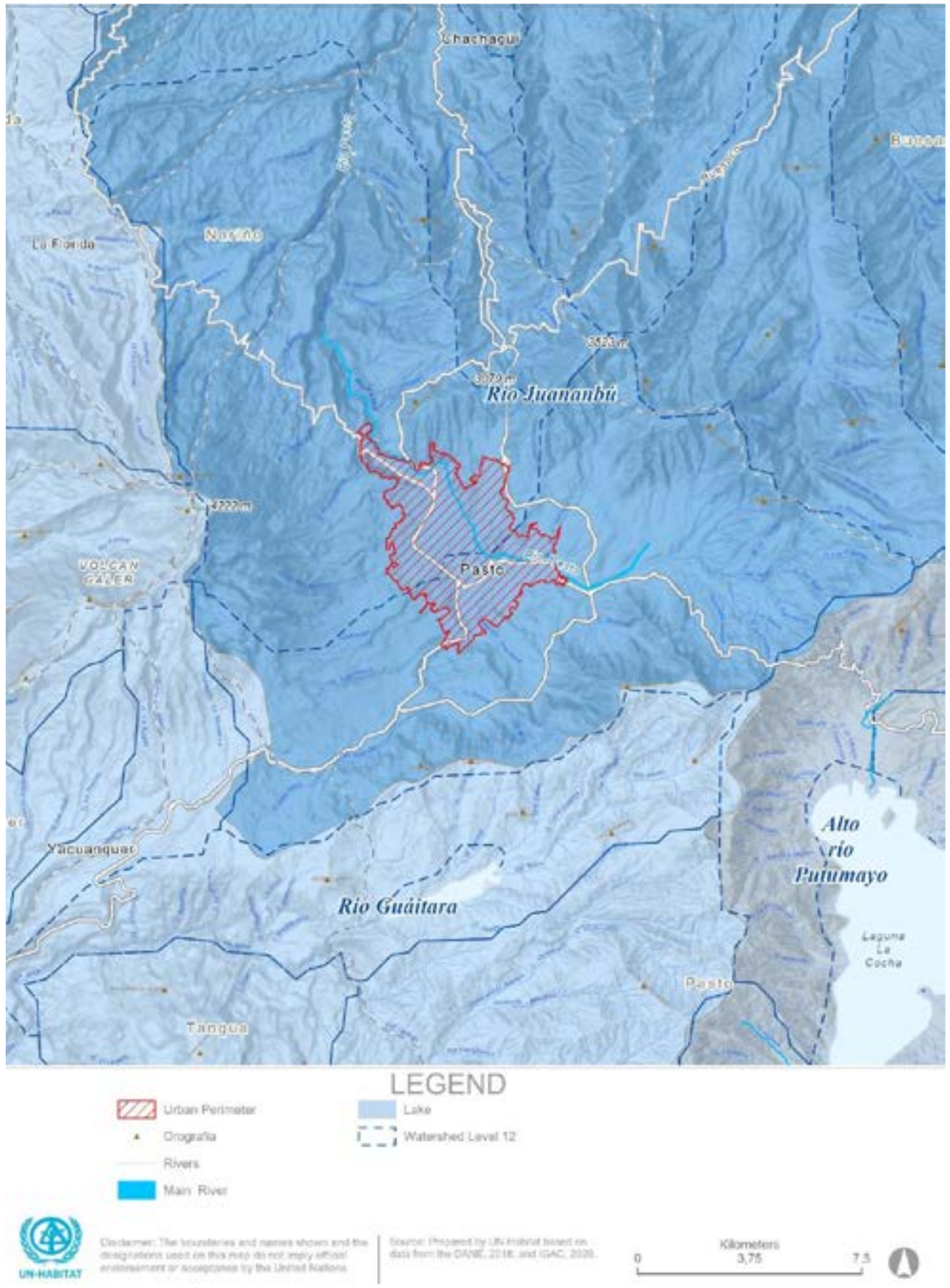


Fig. 8: Hydrology and river basins in Pasto, Colombia
Source: UN-Habitat, 2024.

In terms of biodiversity across the municipality, there are reports of 2,550 observed species, of which 117 are endemic. These include 571 animal species, comprising 76 invertebrates and 495 vertebrates, along with 1,838 plant species and 130 fungal species (Alcaldía de Pasto, 2024).

Finally, the net GHG emissions in Pasto amounted to 1,861,175 tCO_2eq for the years 2019, 2020, and 2021 (ICLEI, 2023b), with carbon sequestration of -193,804 tCO_2eq, representing a -9.43 per cent reduction of the municipality's total emissions, which sum to 2,054,978 tCO_2eq. This equates to 1.58 tCO_2eq per capita per year.

In pursuit of carbon neutrality, the city of Pasto would need to allocate approximately 120 square kilometers of land for carbon absorption, in order to offset its annual emissions of 186 tCO_2eq per square kilometer. The potential of forest cover and public space for this purpose is constrained by the lack of connectivity and its limited extent of forested areas within the city. This weakness is related to the absence of continuous environmental structures and the inadequate maintenance of watercourses that traverse the city, most of which have been channeled, thus negating their environmental and conservation potential (Figure 9).

The study conducted by ICLEI on the greenhouse gas index finds that 93.82 per cent of the emissions are directly linked to local population activities, highlighting the need for municipal management and administrative action to address them. The sectors that have the greatest impact on GHG emissions are:

- **Transport sector:** This sector accounts for 50.91 per cent of the municipality's net GHG emissions. Of this, 45.53 per cent corresponds to gasoline use, primarily used in private land transportation, while 55.43 per cent corresponds to diesel oil, mainly used for freight transport.

- **Stationary energy sector:** Contributes 31 per cent of the GHG emissions, primarily from energy used in residential units for cooking (Liquefied Petroleum Gas, LPG) and electricity. The manufacturing and construction industries account for only 5 per cent of the sector's emissions.

- **Waste Sector:** This sector accounts for 16 per cent of the municipality's greenhouse gas (GHG) emissions, with solid waste disposal in landfills representing the largest share at 68.15 per cent. Domestic wastewater follows, contributing 13.59 per cent of emissions, a figure closely linked to the absence of a wastewater treatment plant in the city. The analysis underscores the need to prioritize this sector in public policy development, as it showed the greatest increase in emissions during the study period. Furthermore, there is significant economic potential in the recovery and utilization of waste generated in the city. This potential is already being tapped through initiatives such as the valorization of recyclable waste, the management of construction and demolition debris, and controlled burning practices aimed at reducing GHG emissions—all framed within a circular economy approach.

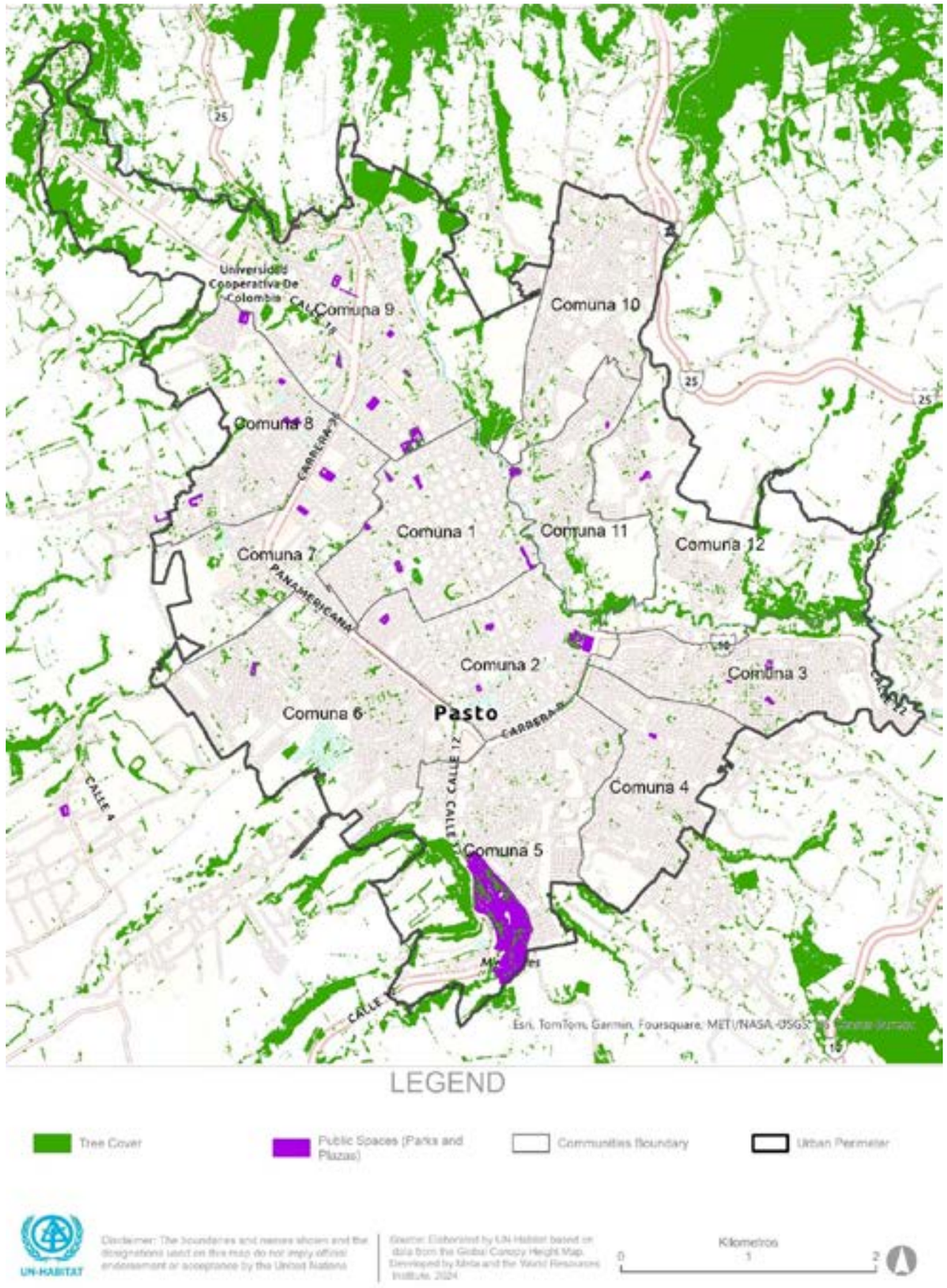


Fig. 9: Forest cover and public space in the urban area of Pasto, Colombia
Source: UN-Habitat, 2024

Urbanization Trends

Historically, the city of Pasto has experienced dense and continuous growth of its urban footprint, which is estimated to cover 23.88 square kilometers. This historical trend is now at a turning point due to the increasing demand for new developable land for future residents, as well as the need to address the current housing deficit.

Urban densification is constrained by high land costs and the minimal restrictions on unplanned development in rural areas (corregimientos), making low-density urban expansion likely. As such, the urban footprint is projected to grow by 175 per cent by 2050 (Findeter, 2014), corresponding with the growth the city has experienced over the last two decades, as illustrated in Figure 10. This figure visually supports the trend of spatial expansion and highlights the transformation of the city's territory over time. The typology of neighborhoods, traditionally consisting of single-family homes, is shifting toward high-rise gated communities and condominiums, altering the urban fabric and the social value placed on public spaces. This trend is further compounded by the lack of investment in infrastructure and effective public space.

The proposed land use vision for the city, as outlined in the POT 2015-2027, presents a model based on the sustainability of the territory. This model aims for the consolidation of the city as a provider of goods and services to surrounding areas, urban-rural integration through an ecological structure, regulation of growth in sectors identified as high risk, and leveraging environmental assets as the municipality's main offering within its physical and spatial context.

According to the 2015-2027 Land Use Plan (Plan de Ordenamiento Territorial), the new development areas in the city of Pasto include the northeastern expansion zone, known as Aranda, which spans 2.27 square kilometers and is located between elevations of 2,660 meters and 2,700 meters above sea level. Meanwhile, the southern expansion zone corresponds to the Jamondino sector, which covers 1.14 square kilometers and is situated between elevations of 2,670 meters and 2,710 meters above sea level.

As part of the Emerging and Sustainable Cities Initiative led by the Inter-American Development Bank (IDB), the city of Pasto has developed the "2038 Action Plan for a Sustainable and Competitive City," which serves as a roadmap to promote the sustainable development of the city with a long-term vision. The plan focuses on sustainability, climate change adaptation, urban resilience, and good governance.

Physical and Social Infrastructure Assets

The public facilities located in the municipality of Pasto, both basic and collective, total 414, with the majority in the following sectors: public education (152), public administration (55), security and coexistence (52), culture (38), social welfare (33), recreation and sports (24), health (23), public services infrastructure (15), cemeteries and parks (11), road and transportation infrastructure (6), and food supply (5). Additionally, Pasto has 16 rural parks and 101 urban parks, providing 2.32 square meters of green space per inhabitant (compared to the WHO recommendation of at least 9 square meters per inhabitant, within a 300-meter radius) (Alcaldía de Pasto, 2015).

Regarding household public services, the city has infrastructure for potable water supply. The main provider is the Empresa de Obras Sanitarias de Pasto, EMPOPASTO S.A. E.S.P., which serves the urban sector. In addition, there are operators from Rural Aqueduct Administration Boards, responsible for small neighborhood aqueduct systems. According to EMPOPASTO data, the coverage of the water supply service in the urban sector of Pasto is 96%. Water is supplied by six (6) surface water sources, as follows:

Main Sources:

- Upper Pasto River Basin
- El Quinche Micro-basin
- Mijitayo Micro-basin
- Miraflores Micro-basin

Backup sources for drought and/or emergencies:

- Upper Bobo River Basin (reservoir)
- Las Piedras Micro-basin

This supply system enables the city to meet its water demand and ensures coverage even during drought periods such as those caused by the El Niño phenomenon.

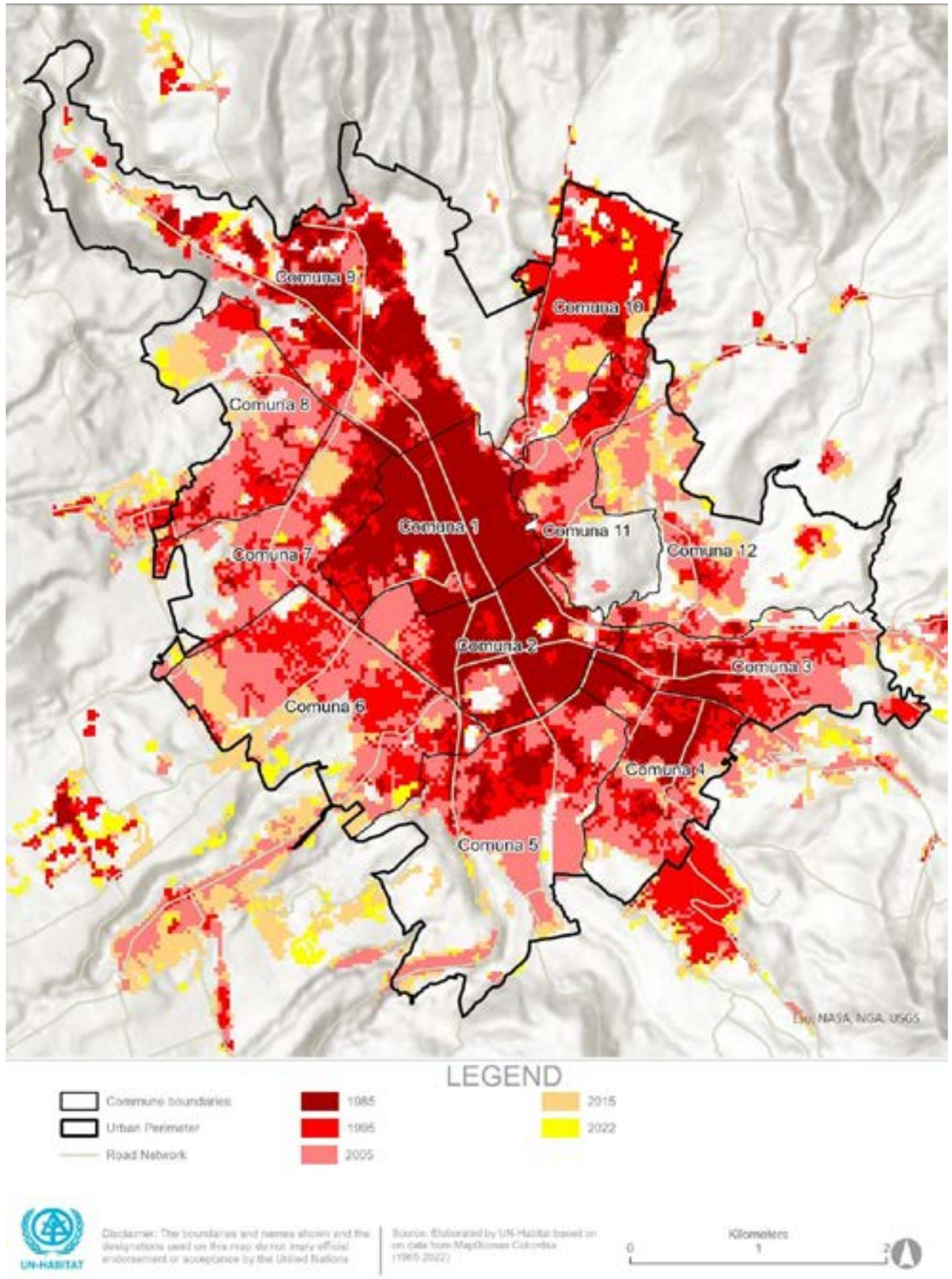


Fig. 10: Urban growth of Pasto, Colombia
Source: UN-Habitat, 2024

Regarding sewer system coverage, this service is provided in the urban core of the city by EMPOPASTO, while the rest of the city relies on final disposal systems such as septic tanks, latrines, and discharge into surface waters. EMPOPASTO reported that the sewer system coverage in the urban sector of the Municipality of Pasto was 95.5%.

On the other hand, the 2018 national population and housing census provides the following data on households with access to public services (DANE, 2018), which serves as the baseline for analyzing living conditions in the municipality:

- Electricity: 99.7 per cent
- Water supply: 98.4 per cent
- Sewerage: 89.8 per cent
- Natural gas: 24.4 per cent
- Waste collection: 90.1 per cent
- Internet: 49.0 per cent

An important social and infrastructure asset is the municipality's markets, which are the backbone of regional food security. The Potrerillo Market Square serves as the main supply and storage center for agricultural products from the southwestern region of the country. This market square has more than 2,600 formal trading stalls, over 1,000 informal stalls, and nearly 12,000 daily users.

Between March and April 2024, Pasto faced torrential rains which, combined with the incapacity of the drainage infrastructure and blockages in the sewer systems from solid waste, temporary evacuation was necessary to mitigate the risk to the community, affecting the lives of vendors and users, as well as the food supply to the municipality. This emergency (also experienced in 2011) highlights the need for actions in the area, particularly those related to waste management and water and wastewater management.

Institutional and Policy Frameworks

Colombia has a stable institutional framework, normatively established to ensure that urban development adheres to planning criteria, environmental management, and, more recently, climate change management.

The 1991 Political Constitution of Colombia defines the general agreements for the functioning of the state. Based on this foundation, the most relevant laws for the definition and organisation of the territory, as well as the activities carried out within it, are as follows:

- **Law 1454 of 2011:** This is the Organic Law of Territorial Organisation, which establishes the organic norms for the political-administrative organisation of the territory. It sets forth the guiding principles of organisation and defines the competencies and instruments for territorial development.

- **Law 388 of 1997:** This law serves as the foundation for the development of the technical and regulatory instruments for planning and managing the territory in the country, known as the territorial organisation plan or scheme (depending on the population of the municipality). As an instrument for integrating territorial and environmental organisation, it establishes a set of actions and policies—both administrative and physical planning—that guide the development of municipal territory in the short, medium, and long term, regulating the use, occupation, and transformation of urban and rural physical space.

- **Law 152 of 1994:** This law defines the criteria for the formulation, approval, execution, monitoring, evaluation, and control of development plans, as well as community participation in these processes, serving as the main instrument of administrative management for a period of four years.

- **Law 136 of 1994:** This law establishes the general criteria for the organisation and functioning of municipalities as fundamental territorial entities within the political-administrative division of the state, granting them political, fiscal, and administrative autonomy. mRegarding biodiversity, Law 165 of 1994 approves the "Convention on Biological Diversity" from Rio de Janeiro and serves as the foundation for subsequent developments in this field, including the National Biodiversity Policy.

Concerning climate change, in 2018, Law 1931 was approved, establishing guidelines for climate change management. This law mandates, among other criteria, the inclusion of climate risk management criteria in development plans and territorial organization plans by municipal authorities.

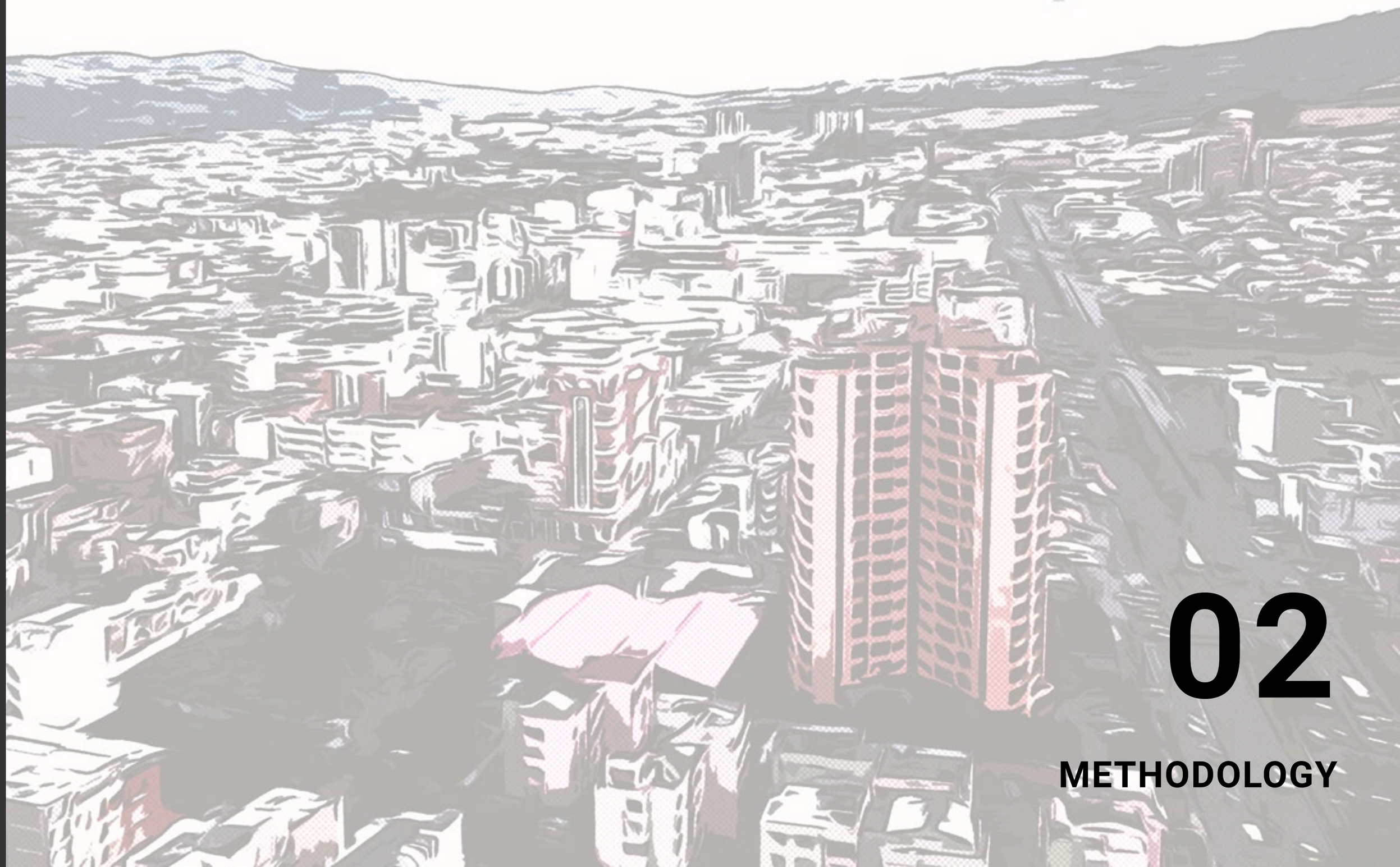
Within this regulatory framework, the municipality of Pasto has implemented the Municipal Development Plan 2024-2027: "Competitive, Sustainable, and Secure Pasto," which was approved in the last week of May 2024, and the Territorial Organization Plan 2015-2027: "Pasto Territory with Sense," approved in 2015.

Administratively, Pasto is organized into 15 secretariats, three administrative directorates, one administrative department, and five offices, supported by eight decentralized institutions. Political control is exercised by the Municipal Council of Pasto, which consists of 19 councillors and includes the following consultative and participatory bodies:

- Women's Citizen Council
- Citizen Participation Council
- Territorial Planning Council
- Technical Table of the Care Economy
- Effective Victims' Participation Table
- Rural and Campesino Women's Table

Finally, within the institutional framework, the Autonomous Regional Corporation of Nariño, known as Corponariño, is the public entity legally responsible for environmental management and renewable natural resources. It operates with a focus on sustainable development in the municipality and the surrounding geographical area, characterised by similar ecosystem, geopolitical, biogeographic, or hydrogeographic unit features.

Building on this broad diagnosis of the city, focussing on its urban area, the analysis of vulnerability across multiple dimensions serves as a methodological approach to identify key urban priorites. This framework aligns with the commitment to "leave no one behind" while strengthening the city's capacity to adapt to climate change. It emphasizes the interconnectedness of urban dynamics, extreme climate events, and biodiversity, promoting a holistic perspective that balances social needs with the conservation and protection of the environmental cornerstone of the territory.



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 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 indicators 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 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 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.

Tailoring to Local Context

The methodological process was adapted to the conditions of the municipality of Pasto and the availability of information, incorporating existing inputs and planning processes undertaken by the administration in previous terms. This adaptation process included three interrelated major components:

1. **Knowledge and Recognition of Municipal Administration:** Recognizing the municipal administration as a fundamental actor in territorial planning and its relationship with climate change and the conservation and protection of the municipality's biodiversity.

2. **Territorial Construction with Local Actors:** Acknowledging that territory is constructed by the actors who inhabit it, and that the collaboration between the community, academia, non-governmental organizations, private actors, and municipal, departmental, and national administrations is crucial for accurately identifying the vulnerabilities and needs of the territory.

3. **Dialogue with International Actors:** Engaging with international stakeholders, particularly incorporating inputs generated by international cooperation initiatives that have deepened the analysis of the territory. Additionally, processes of knowledge and experience exchange with actors facing similar realities, particularly those in Spain, help identify relationships and build strategies that are not developed from scratch but rather stem from historical accumulations.

Due to the lack of local information for the development of some indicators and the construction of maps, it was necessary to use downscaled information from global databases.

Finally, recognizing that quantitative information must be contrasted and validated by the actors, efforts have been made to complement it with qualitative information collection mechanisms through structured dialogues, interviews, social mapping, and other methods.

Geographic Scope

The analysis conducted in Stage One of the MVA led to the identification of the influence area of the Guachucal Stream and the Potrerillo Market. This area, shown in Figure 12, was validated as a priority zone for climate action and required an action plan, following the MVA presented in the following sections.

Fig. 11: three-stage methodology
Source: UN-Habitat, 2023

Through this MVA, the Guachucal Stream Influence Zone and Potrerillo Market were selected as the priority areas based on three key considerationa identified during the project implementation process:

1. **Landslide threat:** The area faces a significant threat of landslides, impacting productive activities, public services, and infrastructure. This risk became evident with the closure of the Potrerillo Market at the end of March 2024, as landslide hazards were detected within the influence zone of the Guachucal Stream (Figure12).

2. **Municipal prioritization:** The municipal administration has prioritized the area surrounding the El Potrerillo Market in order to improve its infrastructure and address issues, such as landslide risks, improper waste disposal, informal housing, among others.

3. **Diversity of actors and activities:** The area is a hub for a wide range of actors involved in commercial and productive activities. The presence of migrant populations seeking economic opportunities near Potrerillo is particularly relevant. Additionally, a significant number of women are engaged in productive activities, which opens up opportunities for adopting a gender-focused approach to strengthen ongoing initiatives in the area.

The focus communities are located around the El Potrerillo market square, situated in Comuna 5 of the city, at coordinates 1°11'46"N, 77°16'14"W. This market square serves as a hub of attraction not only for the surrounding population but also for residents from other parts of the municipality and the region in general, underscoring its strategic importance. It exerts a significant influence on the urban structure, functioning as an anthropogenic factor that has helped shape the southeastern neighborhoods of the city, bounded by Avenida Chile, Calle 18A, and Carrera 21B–Calle 4A. In addition to being a key point for food supply in Pasto and the southwestern region of the country, the market facilitates the trade of livestock and agricultural products, as well as the wholesale distribution of machinery, inputs, and supplies for food production in the department.

The characterization carried out by De la Rosa indicates that the population faces an educational deficit, as only

Fig. 12: Landslide emergency in Guachucal Stream
Source: Majority of Pasto, 2024

53 per cent have completed primary education and just 32 per cent have reached secondary education or high school level. The area serves as a magnet for unskilled labor, which aligns with the needs of the migrant population, leading to a 15 per cent increase in the area's population, thus heightening vulnerability to emergencies, including those related to extreme weather events. Additionally, it is estimated that approximately 12,000 people and around 400 vehicles converge in the area daily, along with more than 1,000 temporary vendor stalls located on the sidewalks and public spaces surrounding the market square, making it a significant urban node for the municipality.

Women, represent the majority (64 per cent) of the population involved in the commercialisation of organic products in the market. These women belong to generations that have built their livelihoods in the area. The market square attracts and concentrates a population of rural origin residing in the municipality and surrounding areas. These families engage in the entire production chain—covering the production, transportation, and commercialization of agricultural products. The area's exposure to flooding, landslides, and sanitation issues related to wastewater and greywater, combined with the heightened vulnerability of the population, makes the area significantly at risk, as confirmed by the multi-layered vulnerability analysis presented below.

Urban Dimension

The Urban Dimension of the Multidimensional Vulnerability Assessment (MVA) for the City of Pasto includes indicators that reveal the city's vulnerability to the challenges of urbanization, population growth, and socioeconomic pressures. This dimension, graphically represented in the following figure, reflects the interaction between population density, urban growth, multidimensional poverty, and the urban inclusion marker, all of which influence the Municipality of Pasto's ability to adapt to urban growth in a planned manner and with clear criteria for social integration.

In the raster-type representation shown in Figure 14, four indicators are integrated into square grids representing areas of 100 by 100 meters, with a color scale ranging from green to red, red representing the highest level of vulnerability in the analyzed urban dimension.

The indicators included in this dimension are presented below:

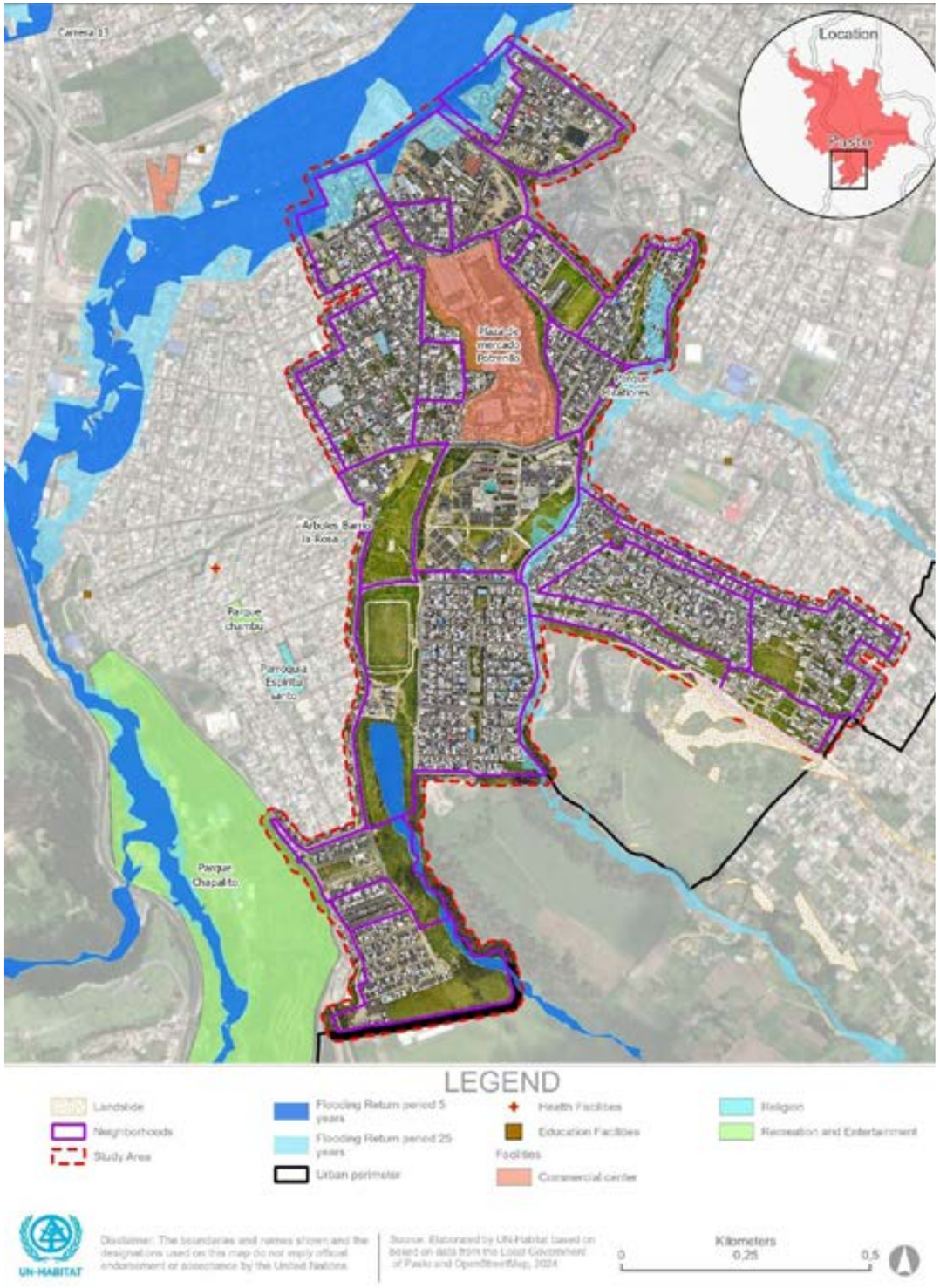


Fig. 13: Geographic scope
Source: UN-Habitat, 2024

03

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 the city of Pasto.

Urban Dimension

The urban dimension of the Multilayered Vulnerability Assessment (MVA) for the city of Pasto 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, urban growth, and poverty, which influence the ability of the Municipality of Pasto to respond to the pressures of urban growth. This dimension is summarized in Figure 14.

Indicator 1: Population Density. This 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, high concentrations of marginalised communities, and competition for basic services.

The population density indicator shows the population within a specific area, to the indicator the observation unit is called a block, and covers 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.

Indicator 2. Urban Growth. This indicator reflects changes in land cover and urban growth. Urbanization and urban growth are fundamental to understand how the municipality of Pasto has expanded and transformed and to make observations on future spatial growth. A comparison of satellite images from 2005 and 2023 was made revealing increasing changes in size of urban coverage.

The spatial expansion of cities and the concentration of built-up infrastructure further exacerbate urban vulnerability. Rapid and extensive urbanization increases exposure to natural hazards, leading to the loss and fragmentation of natural ecosystems and biodiversity, and reduces the capacity of infrastructure to accommodate growing populations or withstand the impacts of climate change. Unsustainable urban growth may also exacerbate the exposure of populations to the urban heat island effect, air pollution, and geophysical hazards.

Indicator 3. Socioeconomic Vulnerability. This indicator captures the degree of exposure of the population to economic and social risks. It assesses disparities in income, employment and access to services, which are essential to understand how vulnerable populations can cope with different urban development scenarios.

Socioeconomic vulnerability also infers the sensitivity and adaptive capacity of a population to climate-induced shocks and stresses. These are influenced by an individual's social and economic characteristics. Socioeconomic vulnerability is made up of various factors, including income level, poverty rate, employment, education level, access to healthcare, race/ethnicity, age, disability, and housing tenure.

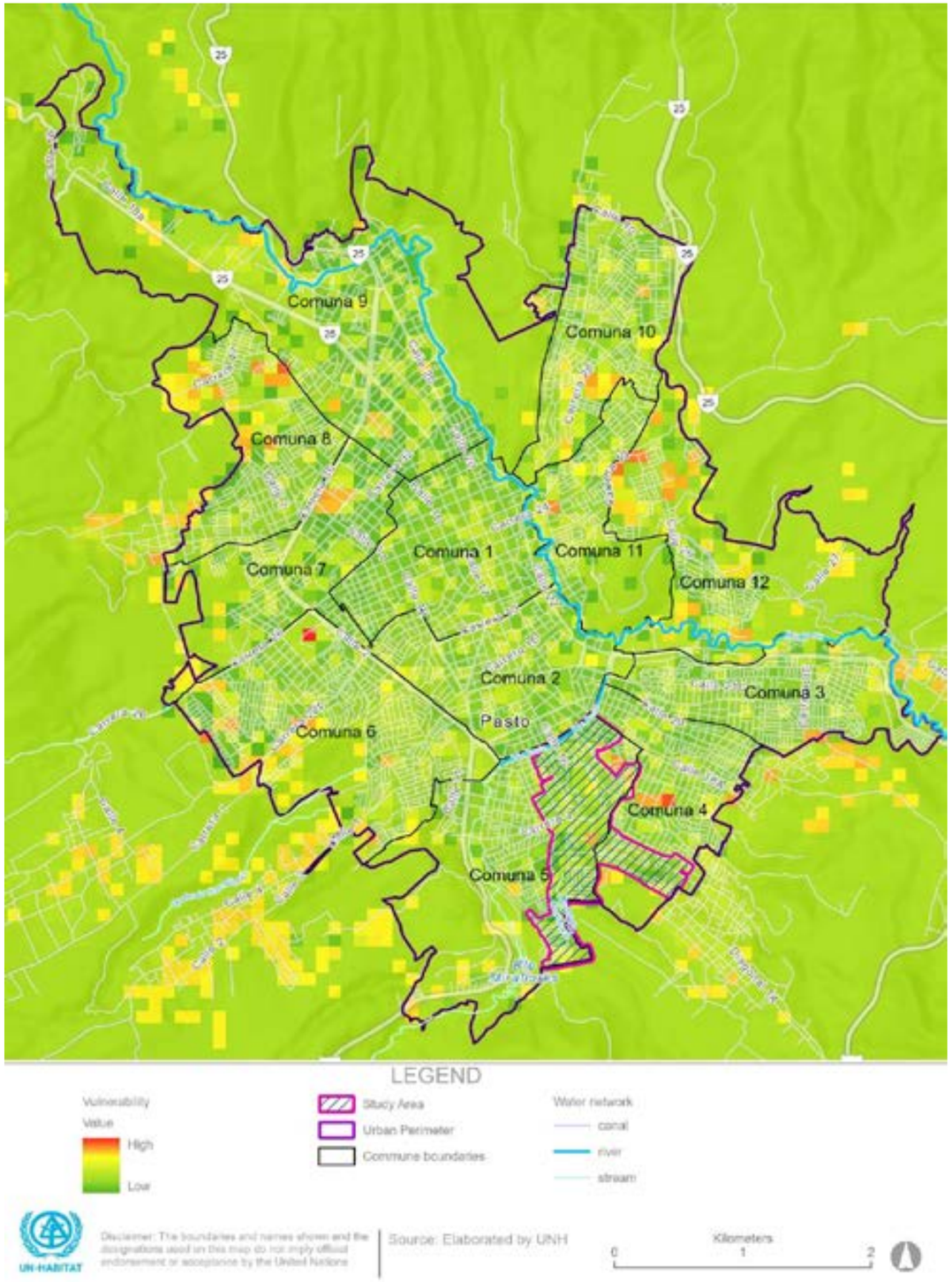


Fig. 14: Urban dimension map
Source: UN-Habitat, 2024

In Colombia, socioeconomic vulnerability is measured using the Multidimensional Poverty Index (MPI). This index, developed following the frameworks proposed by Alkire and Foster (2007, 2011), defines the household as the unit of analysis and evaluates it across five key dimensions:

a) educational conditions;

b) conditions of childhood and youth;

c) employment;

d) health; and

e) housing conditions and public utility services.

These dimensions are further divided into 15 variables. A household is considered to be in a state of multidimensional poverty if it suffers from deprivations in at least five of these variables, representing 33 per cent of the total deprivations. Each variable carries equal weight within the index. The data comprised in the indicator of this MVA are from the year 2018.

Indicator 4. Basic Urban Inclusion Marker. This indicator uses a georeferenced composite index that measures the aggregate level of inclusion of a city and its potential contribution to the spatial, social, economic and cultural integration of its inhabitants. It includes the following variables; affordable housing, quality of services, employment and economic opportunities, health and well-being, education, diversity and culture, and public space, safety and vitality of the urban environment. The data comprised in the indicator of this MVA are from the year 2023.

The Basic Urban Inclusion Marker was built on the guidelines and monitoring frameworks of the New Urban Agenda and the 17 Sustainable Development Goals, and based on the lessons learned from the City Prosperity Initiative.

The analysis of the urban dimension reflects the ongoing trend of unplanned growth within the city. Despite this challenge, the municipality possesses tools that can guide and correct the city's planning. At the national level, the Land Use Planning Law and its implementation at the municipal scale are particularly significant.

Key planning instruments include the Development Plan (valid until 2027) and the Municipal Land Use Plan (Agreement 004 of 2015), which defines urban expansion zones such as Aranda, Jamondino, Mijitayo, Chapal and Altamira. These instruments, currently under revision, serve as essential legal and regulatory frameworks for directing the city's urban development (further information can be found in the Context Analysis).

For the urban dimension, based on four indicators, the MVA has revealed specific vulnerable areas (shown in Figure 14 above) including within Comuna 4, 8 and 12 in particular. The vulnerability associated with this dimension highlights the ongoing expansion process the city is experiencing, as well as the emergence of new urban hubs along the urban–rural fringe of already existing Comunas in Pasto. Although Comuna 5 does not stand out in the aggregate of the indicators—given that it is a historic and consolidated area not currently undergoing urbanization—the indicators related to multidimensional poverty and population density are noteworthy in this area, as shown in the following figures.

Indicators

Indicator 1 – Population density

As shown on the Figure 15, the comunas and neighborhoods with the highest population density are located in areas that are already consolidated within the city, meaning they have a history and urban tradition in Pasto. In Comuna 4, the most densely populated neighborhoods include Lorenzo de Aldana, El Tejar, and Miraflores Etapa I. These neighborhoods are notable for their size and have significant economic and community activity. They feature sports spaces such as football fields, a coliseum, and a market square, reflecting their social dynamism. Comuna 5, which consists of 34 neighborhoods, has the highest population density in areas such as Altos de Chapalito, Antonio Nariño, Cantarana, Chambú, and El Progreso. Finally, the high population density observed in comunas 2, 6, 8, and 11 is the result of the proliferation of residential units and apartment towers—both private and public initiatives—developed over the past two decades in an effort to reduce the city's housing deficit and accommodate population growth. This trend contrasts

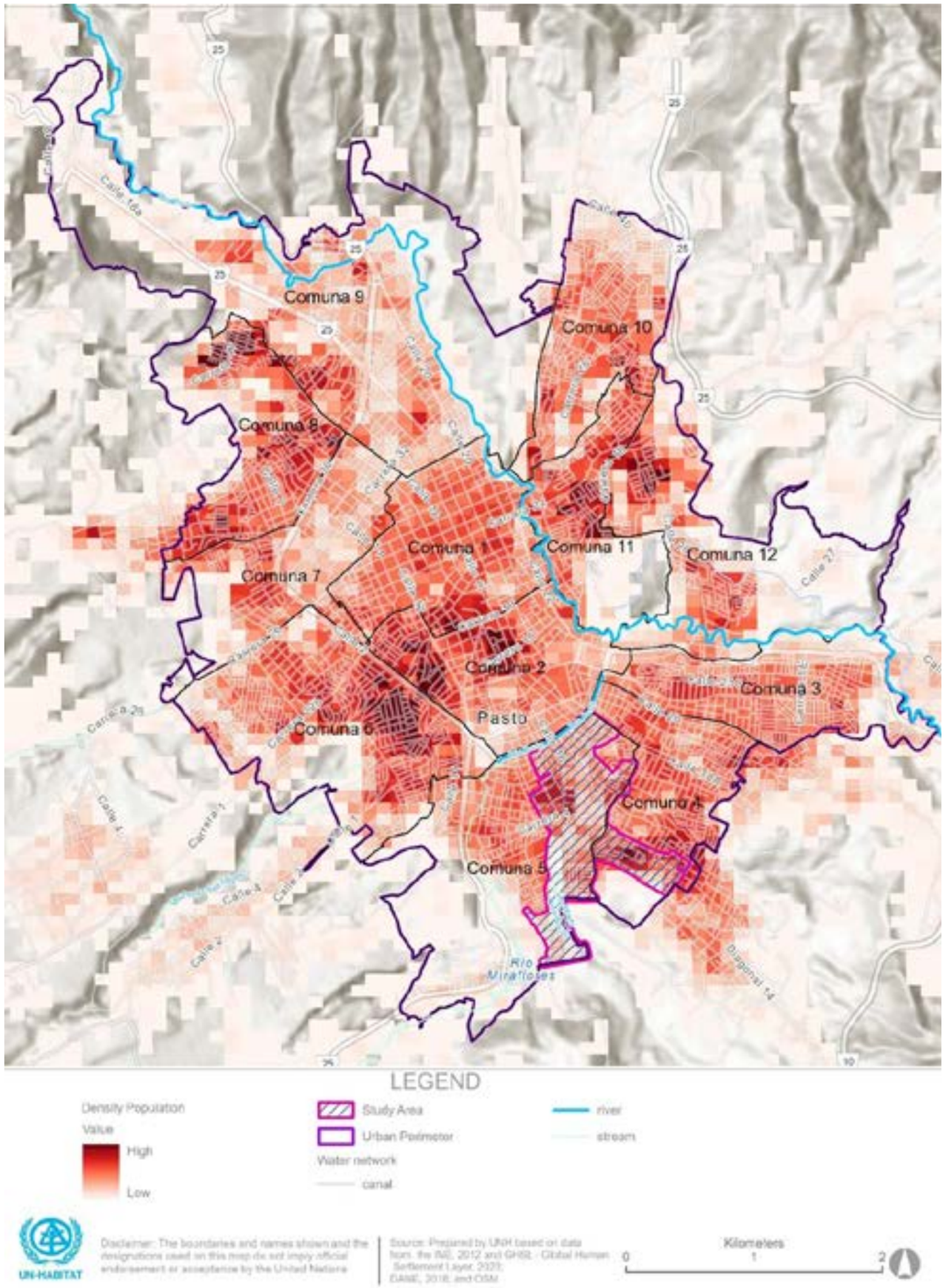


Fig. 15: Population density map
Source: UN-Habitat, 2024

with the limited availability of formally designated developable land.

Although the UAF (Family Agricultural Unit) in the municipality of Pasto establishes a range of 10 to 14 hectares per housing unit, in practice, there are rural areas where this regulation is not being followed, with densities reaching one housing unit per 3 to 4 hectares. This occurs even in areas formally designated as rural or for expansion, revealing an urban footprint that is growing in ways that do not comply with current planning regulations—an issue that requires urgent attention.

Indicator 2 - Urban growth

The map shown in Figure 16 illustrates urban expansion and the growth of the urban footprint between 1985 and 2022, reflecting the general trends of urbanization identified by UN-Habitat. Currently, this growth is occurring at a pace that exceeds updates to regulatory frameworks. Ideally, the regulatory process should be proactive rather than reactive, with the construction and expansion of the urban footprint being a consequence of the city's urban planning criteria.

The map highlights comunas 5, 6, 7, and 8, which show significant urban expansion and a movement of urban growth towards the West. This expansion includes growth in hillside areas, thereby increasing the risk of landslides during the rainy seasons. It is important to note that the Eastern By-pass road, built in the last ten years, exerts significant pressure on this corridor, which is already evident in comunas 4, 5, and 10. This unplanned growth threatens the functionality of infrastructure, in addition to putting pressure on public resources and rural or conservation areas that are at risk due to this expansion.

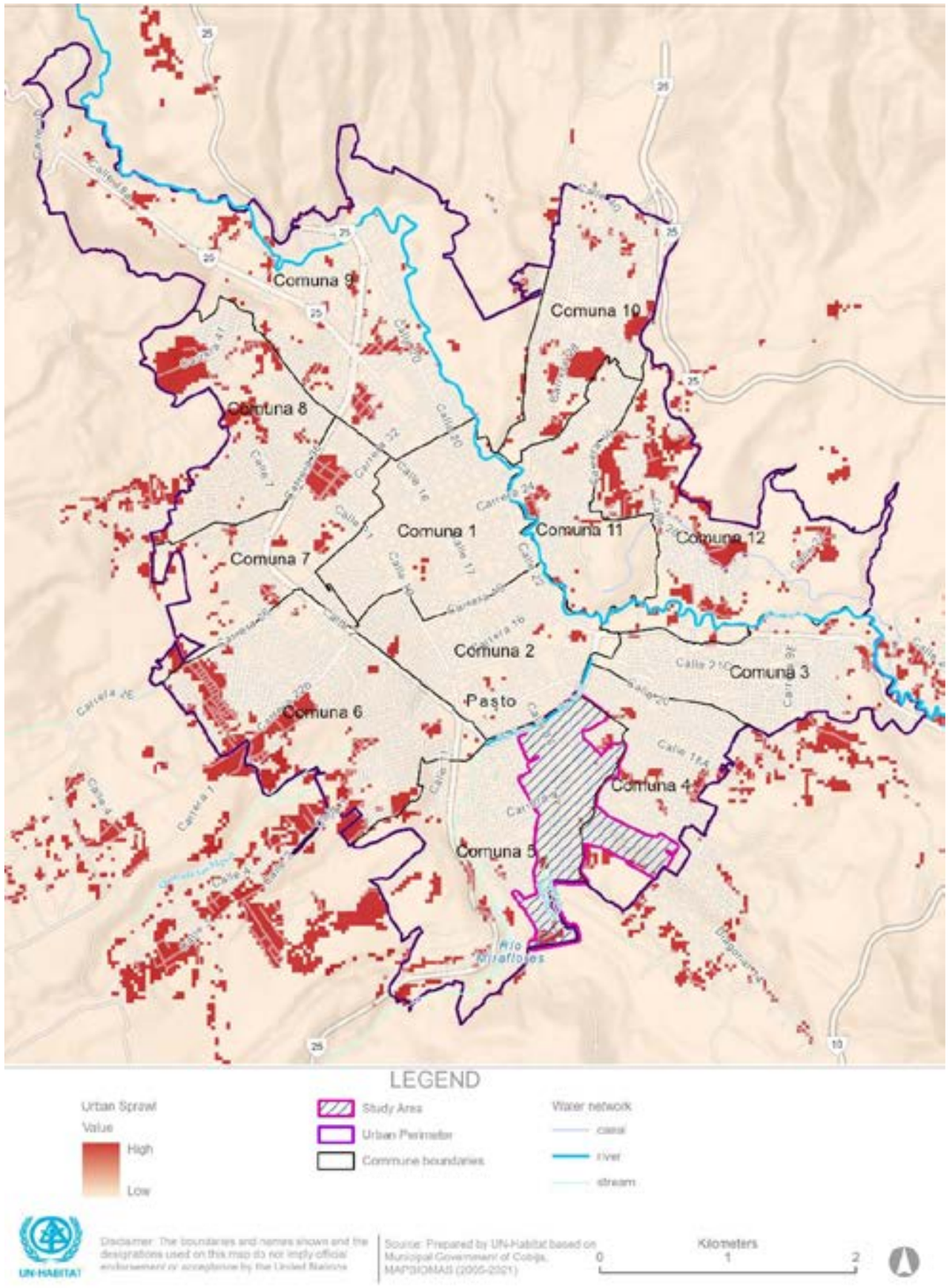


Fig. 16: Urban growth map
Source: UN-Habitat, 2024

Indicator 3 – Socioeconomic Vulnerability

Figure 17 spatially reflects the multidimensional poverty indicator. Areas with an MPI above the municipal average are shown in the darkest shades, highlighting the neighborhoods of Aranda, Cementerio, Loma del Carmen (Marquetalia), San Albano, and their surroundings. These areas are characterized by limited access to basic services such as drinking water, inadequate sanitation, and poor housing quality. Other areas that have historically been part of the city's urban area are also highlighted, such as those influenced by the El Potrerillo Market and the bus terminal, where paid sexual activities and other informal activities involving migrant populations, primarily women, take place.

In general terms, multidimensional poverty is concentrated in the southern corridors (comunas 4 and 5) and the northern and eastern corridors (comunas 10 and 12). This is a clear example of the concentration of poverty in the city's peripheries, where lower-income residents face the growing demand for urban land and the rise in land value, which prevents them from accessing decent housing in the central areas of the city. Public and private actions must align with the principle of leaving no one behind, as proposed by the UN through the New Urban Agenda.

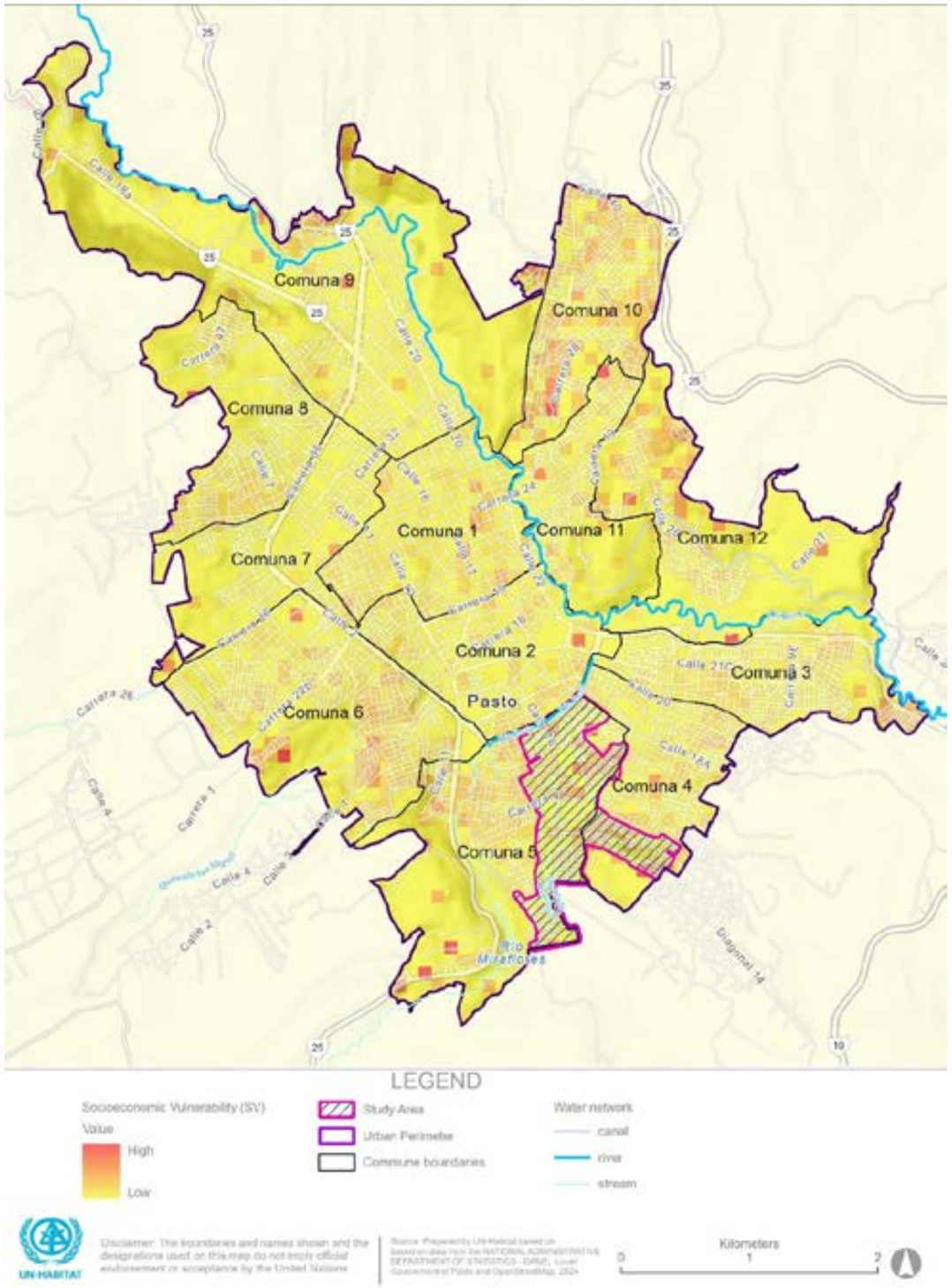


Fig. 17: Multidimensional poverty index map
Source: UN-Habitat, 2024

Indicator 4 – Basic Urban Inclusion Marker

The composite index used aims to measure the overall level of urban inclusion, as well as the city's potential to promote spatial, social, economic, and cultural integration among its inhabitants. It is built upon five key dimensions: (i) affordable, quality housing with access to services; (ii) health and well-being; (iii) education, diversity, and culture; (iv) public space, safety, and urban vitality; and (v) employment and economic opportunities. By combining these factors, the index enables the identification of areas with higher and lower levels of inclusion across the urban territory.

The results of this index reflect a city that has managed to concentrate a range of services which, in terms of proximity, allow access to the urban core of Pasto. However, certain areas exhibit very low levels of inclusion, particularly on the city's periphery and in historically marginalized zones that have not received adequate government attention. In Comuna 6, the area influenced by the Jardín de las Mercedes Cemetery, as well as in Comunas 4 and 5, particularly the surroundings of the El Potrerillo Market, emerge as areas of interest due to their low inclusion levels and potential for improvement.

Moreover, the city's unplanned expansion towards the eastern, northern, and southern zones is a matter of concern. The limited provision of services and the distance from consolidated urban centers hinder the integration of the population and the fulfillment of their rights. The map associated with the index reveals a clear spatial concentration of these indicators, highlighting both the territories with higher inclusion levels and those that require urgent action to close existing gaps and move toward a more equitable and integrated city.

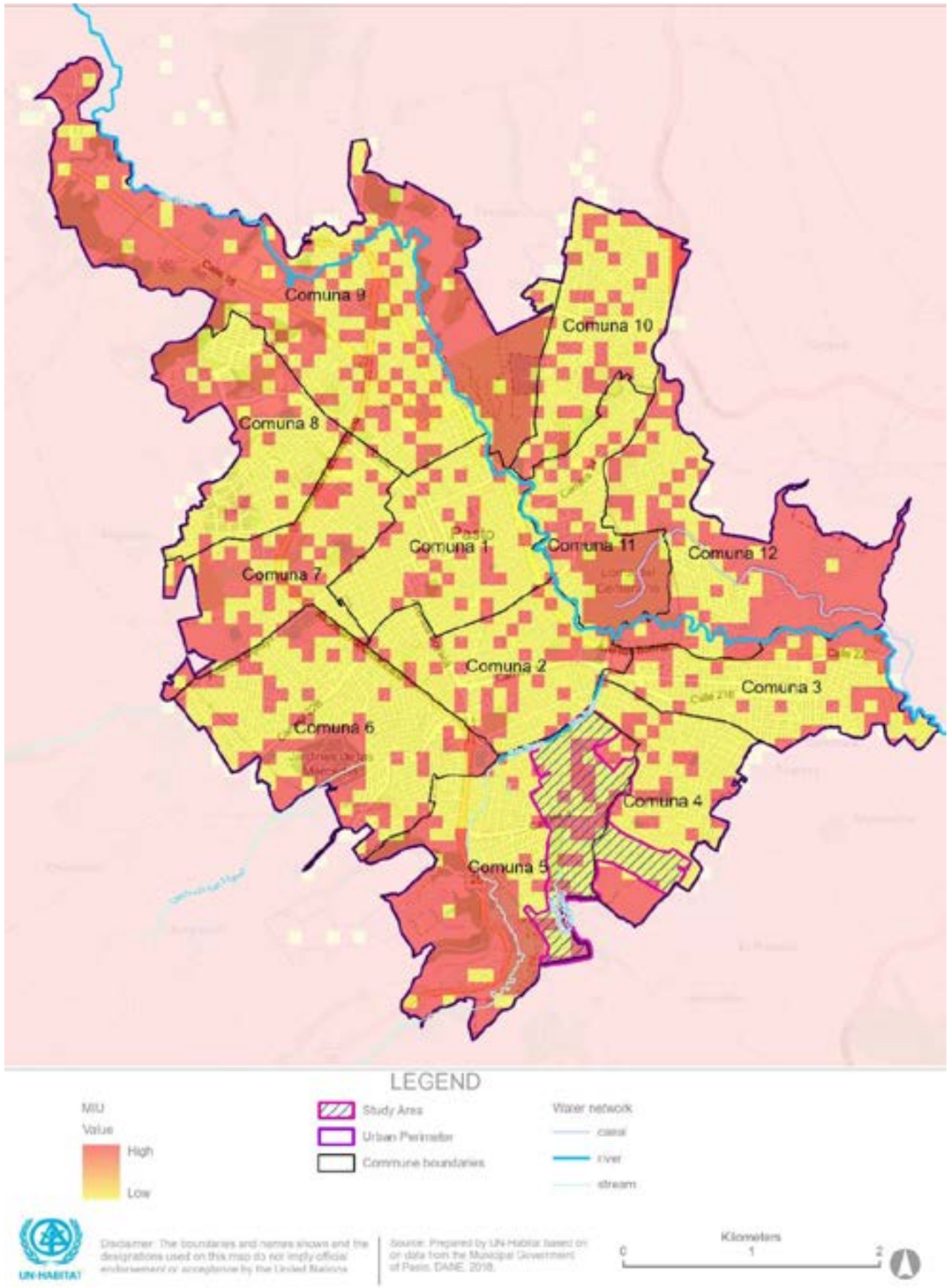


Fig. 18: Urban Inclusion Marker map
Source: UN-Habitat, 2024

Urban Dimension Analysis

The city's expansion has resulted in increased densification at the urban-rural edge and the creation of settlements with higher MPI. This urban growth has led to the transformation of historically rural communities, such as Jongovito, Obonuco, Jamundino, and Catambuco, which are now adopting urban characteristics. However, these changes have not been accompanied by the necessary infrastructure, such as adequate roads and green spaces, heightening the vulnerability of these populations.

The construction of apartment buildings has driven much of the city's growth, exerting pressure on land use, public services, and quality of life. According to data from the 2012 Land Use Plan (POT), compiled by DANE, the city had 24,586 apartments, representing 26.63 per cent of the total housing. By 2018, this number had increased to 52,832 apartments, accounting for 40.43 per cent of the municipality's housing (Figure 19).

This housing growth has not been accompanied by an improvement in housing quality. Over 8 per cent of the total housing stock continues to consist of rooms and other types of accommodation lacking essential sanitation and kitchen facilities. Furthermore, the number of housing units with qualitative deficits - defined as lacking essential attributes such as structural integrity, adequate space, and access to domestic public services - rose from 12,184 in 2005 to 31,134 in 2018. These units accounted for 13.2 per cent of the total housing in 2005 but grew to 23.8 per cent by 2018, as shown by DANE and the Municipality and summarized in Figure 20.

Housing units with greater qualitative deficits tend to be concentrated on the periphery of the city, creating suburban areas with lower quality of life. The neighbourhoods most affected include Emilio Botero, Santa Matilde, Ojo de Agua, San Antonio Padua, Rosal de Oriente, Polvorín, Pejendino Reyes, Marquetalia, Juanoy Alto, and Figueroa. These areas face compounded challenges, including poverty, extreme poverty, and exposure to both natural and anthropogenic risks, increasing the vulnerability of urban communities in the municipality.

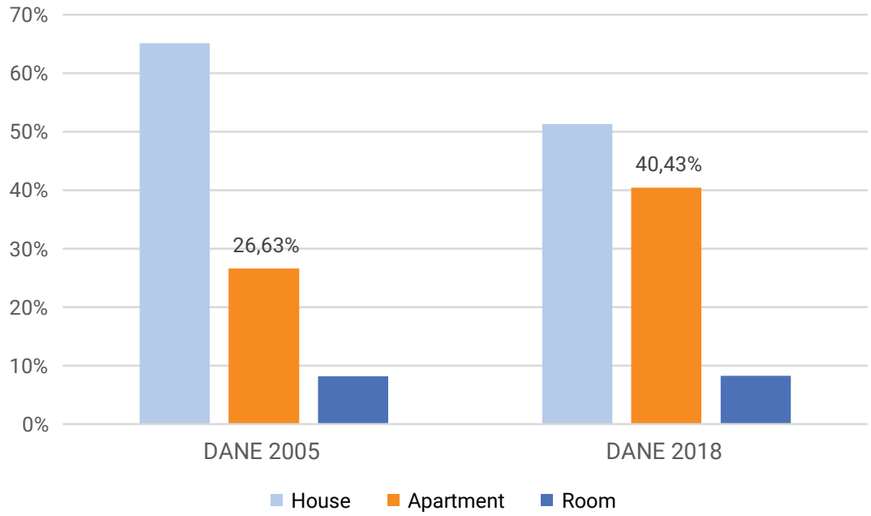


Fig. 19: Percentage of Housing types in Pasto 2005-2018
Source: UN-Habitat, 2024

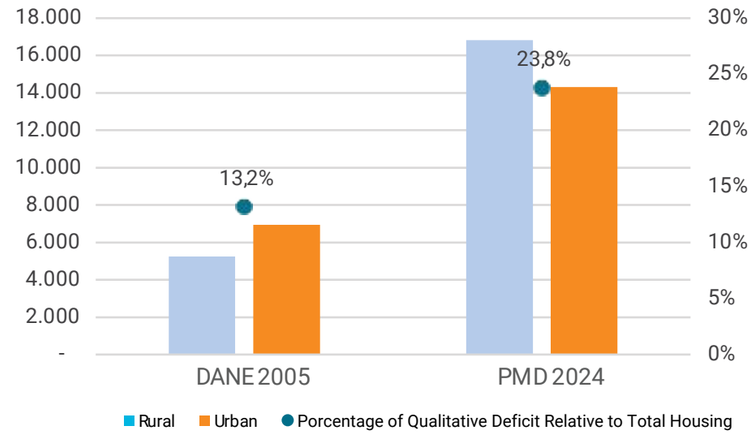


Fig. 20: Number of Housing Units with poor quality and their per centage relation to total housing 2005-2024
Source: UN-Habitat, 2024

The assessment is supported by the perceptions of community leaders regarding urban growth (Figure 21). While nearly half believe that overcrowding exists in their territory (46,9 %), there is a widespread perception of new informal settlements in the city (81,3 %), with women being the most likely to report this (85,7 %).

The recent opening of the perimeter road connecting to the Pan-American Highway presents both opportunities and challenges. While it may facilitate expansion and densification in the northeastern and southwestern sectors, it also poses a risk to the road's intended functionality. An uncontrolled pattern of urban expansion is already unfolding in these areas, driven in part by the accessibility offered by the new infrastructure. This unplanned growth threatens to absorb the road into the urban fabric, gradually transforming it into an internal transit route rather than preserving its original role as a bypass for regional connectivity and urban decongestion. The prevalence of informality and precarious living conditions in these zones underscores the urgent need for both public and private sectors to focus on generating employment and wealth. This is essential for stabilizing the territory and improving residents' quality of life.

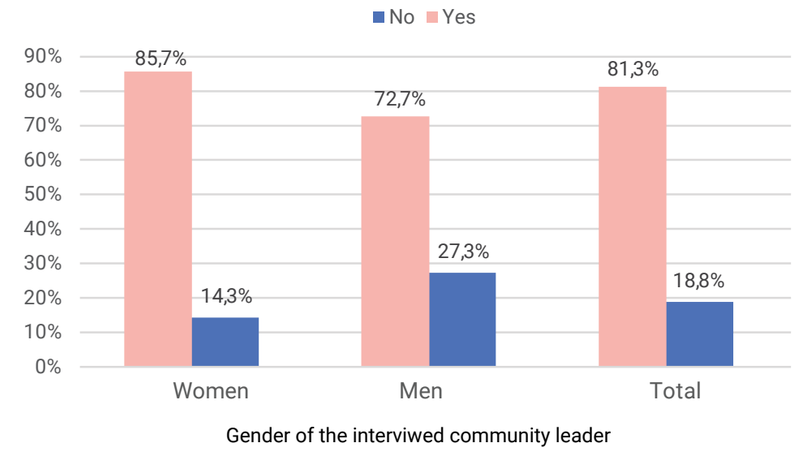


Fig. 21: Community leader perception regarding the emergence of new informal settlements
Source: UN-Habitat, 2024

This phenomenon of informal settlements is also evident in the prioritised area (comunas 4 and 5). Originally organised in 1975 as a temporary space for product commercialisation, it now extends over more than 4.5 hectares, with semi-permanent infrastructure made of brick, cement, concrete roofs, or tiles, alongside remaining wooden and temporary structures. These structures are consistent with informality and, as such, they are highly vulnerable to climate-related hazards.

Urban growth without adequate land management, sufficient public spaces, and transportation corridors increases exposure to risks. Additionally, the living conditions of the population in this area, combined with increased densification heighten vulnerability, particularly for elderly women engaged in commercial activities. Notably, residents of the area have coping capacities through their linkages to the strong social fabric and the presence of some community and social mechanisms, especially those involving Community Action Boards, merchant organisations, and neighbourhood and labour unions which provides some social protection.

It is crucial to implement comprehensive urban policies grounded in sustainable development to ensure that urban expansion occurs in an orderly manner with adequate services and infrastructure. Furthermore, efforts must align with the Sustainable Development Goals (SDGs), particularly Goals 5 and 11, to promote safe cities and public spaces for women and girls. Addressing these goals will help overcome gender gaps, reduce institutional tolerance, and challenge the normalisation of violence against women and girls in both public and private spaces.

Urban Future Vulnerabilities

The disorganized and unplanned growth of the city—particularly the occupation of rural and expansion land with condominiums, residential units, and built-up areas exceeding permitted limits—creates vulnerabilities for the municipality. This situation demands addressing the uncontrolled demand for goods and services, as well as allocating resources to ensure both access and quality. Unplanned expansion disrupts the colonial planning tradition that once shaped the city. Over the past 50 years, institutional breakdowns have hindered the development of green spaces, sustainable mobility options, pedestrian infrastructure, and the potential to create a compact, walkable city with a low carbon footprint.

If current trends of disorderly urban growth and subsistence-level economic conditions for most of the population persist, the city risks losing its potential for proximity and walkability. Urban planning must account for the ongoing realities of expansion, formalizing them to ensure compliance with regulations. Progress is necessary to guarantee that new developments align with concessions, public space projects, and other factors consistent with established construction standards.

In this context, territorial planning tools hold great potential to redirect the course of urban development. The upcoming update of the Land Use Plan (POT), scheduled for 2027, represents a key opportunity to integrate criteria of sustainability, resilience, and urban equity. Likewise, partial plans, as established in Article 19 of Law 388 of 1997, serve as instruments through which the provisions of land use plans are developed and complemented. These apply to specific areas of urban land and urban expansion zones, as well as to those that must be developed through urban action units, macro-projects, or other special urban operations, according to the authorizations established by general urban planning regulations. Their effective implementation could be decisive in ensuring more orderly, balanced development that is compatible with environmental protection.

Finally, demographic changes—particularly the significant increase in the elderly population—require focused efforts on mobility infrastructure that supports the movement of people with reduced mobility for caregiving, recreational, and medical activities. The city must improve its walkability infrastructure, including sidewalks, public transportation, and related services, which are currently insufficient and will have a direct impact on the quality of life of an aging population.

04

CLIMATE CHANGE DIMENSION

The climate change dimension of this 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 floods, landslides, and temperature change. These insights will help guide targeted interventions to improve the city's resilience to future localized climate challenges. This dimension is represented in Figure 22.

Pasto faces a number of climate hazards and a complex situation, given Colombia's extreme vulnerability to future climate changes. At the national level, this vulnerability is primarily due to its geographic location, the unequal distribution of water resources across the territory, and the sensitivity of its agricultural systems, which could be highly impacted by fluctuations in temperature and precipitation.

Climate change presents one of the greatest challenges facing sustainable urban development and disaster risk management. The impacts of natural and environmental hazards are likely to intensify due to changes in climate variables such as temperature and precipitation. Colombia has established guidelines for climate change management aimed at reducing the vulnerability of both the population and ecosystems to hazards, while promoting the transition towards a competitive, sustainable economy and low-carbon development (Law 1931 of 2018).

Although Pasto has developed a Disaster Risk Management Plan, climate-related hazards are still expected to cause significant risk. For example, there are specific threats to areas in close proximity to bodies of water and with slopes greater than 7 per cent, which could affect a large part of the city.

Indicator 1. Riverine flooding. This indicator shows the occupation by water of areas that are normally dry, as a result of the unusual or sudden contribution of a quantity of water greater than the riverbed itself can drain.

Riverine flooding was selected as a key indicator in the climate change dimension of Pasto's MVA due to its widespread and unpredictable impacts on communities located near rivers. This risk has been evidenced by events such as the 2011 flood in the area influenced by the Guachucal creek, which occurred again in 2024, significantly affecting the local population and infrastructure. Flooding has the potential to inundate large areas, cause loss of life and injury, disrupt property and infrastructure systems, and damage urban services, economies, and agricultural land. It can also displace people, resulting in significant social and economic consequences and threatening public health.

For this indicator, the 10-year Flood Risk: Existing Climate map from the Coalition for Disaster Resilient Infrastructure was used, which employs the Continuum model (Silvestro, et al. 2013 and 2015). It is a continuous, distributed, physically-based hydrological model capable of reproducing the spatiotemporal evolution of soil moisture, energy fluxes, soil surface temperature, evapotranspiration, and streamflow. In order to generate flood hazard maps, resulting discharge estimates are input to a hydraulic model based on the Manning equation that compute channel uniform flow depth. This simplified approach fits to determine flood maps on large areas.

Indicator 2. 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 to analyze the indicator. 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, often causing injury, loss of life, and severe damage to properties and assets. Critical infrastructure - such as roads, bridges, utilities, health care facilities 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 modifications 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.

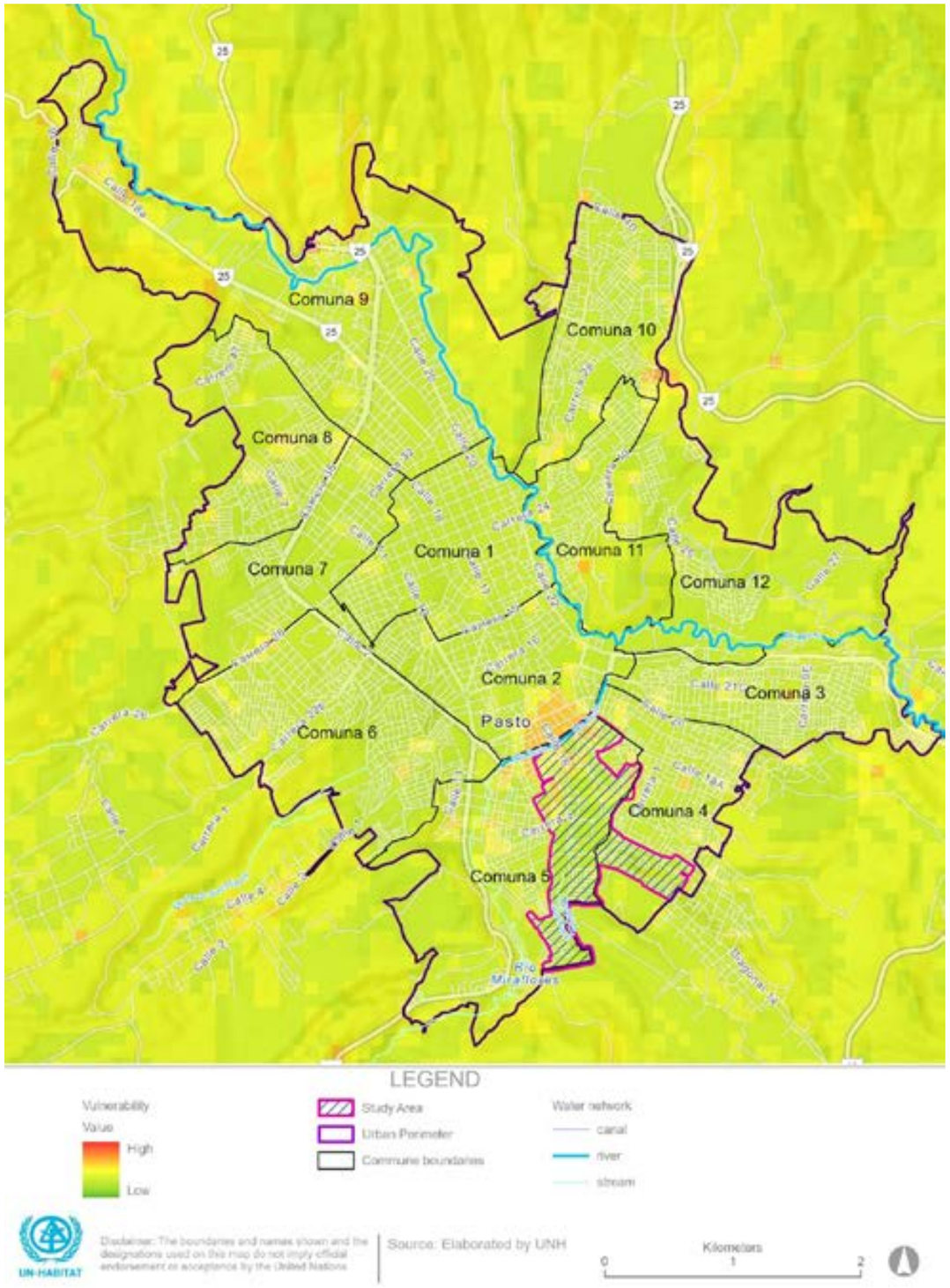


Fig. 22: Climate Change Vulnerability Hotspot Map
Source: UN-Habitat, 2024

Indicator 3. Temperature Change. This indicator shows areas which have experienced an increase in temperature, based on temperature variations over time, taking a baseline from 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, 2019), endangering human health and well-being. Heatwaves can also disrupt ecosystems, alter biodiversity patterns, and cause heat stress. There could also be damage critical infrastructure, such as melting tarmac, damage to electricity lines etc.

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.

Indicator 1 – Riverine flooding

This indicator represented in Figure 23 highlights the importance of the prioritized study area, as it concentrates regions of high vulnerability to riverine flooding. Comunas 2 and 5 present clear critical points, particularly in the neighborhoods of Cantarana, Madrigal, Potrerillo, El Progreso, El Triunfo, Chile, Chapal, and El Pilar with extremely high vulnerability to fluvial flooding. The flood-prone areas can be directly linked to areas where the natural watercourse structure of the city has been modified through intense urban development.

The water bodies Mijitayo, Miraflores, Guachucal, San Miguel, and Pasto have been altered from their natural courses, or urban development has encroached upon natural floodplains and protected zones, exacerbating flood risk after periods of extreme precipitation. There are also pockets of high vulnerability in Comunas 8, 9, and 10, where the causes may include, among other factors, the lack of protection of riparian buffer zones and the presence of slopes greater than 15%, which significantly increase flood hazard. Moreover, the traditional system of watercourse channelling—used over the past two centuries as a common strategy for managing the city's hydrological system—now contributes to increased risk in these areas, as highlighted in the map.

The high vulnerability observed on the edges of Comunas 2 and 5 can be explained by the historical presence of a wetland-type drainage system in this area, which functioned as a buffer zone for the hydrological flows descending from the high mountain region in the south of the city. Today, this ecosystem has been fully built over, putting vital infrastructure at risk, such as the El Potrerillo Market, the Departmental Hospital, and the southeastern interconnection with the rest of Pasto's urban area.

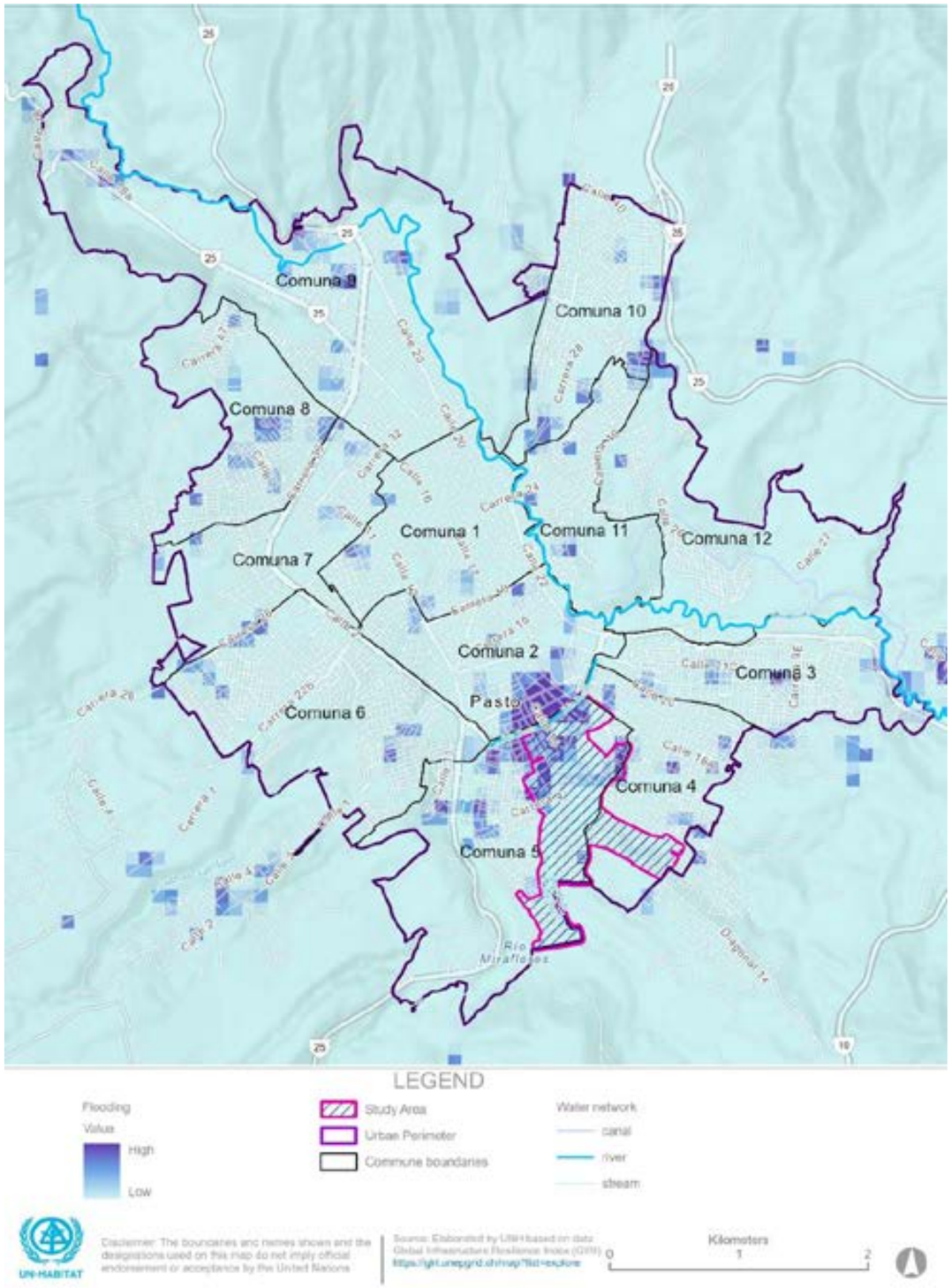


Fig. 23: Riverine flooding map
Source: UN-Habitat, 2024

Indicator 2 - Landslides

The assessment of landslides shows low vulnerability across much of Pasto, particularly in the core urban areas. However, there are areas with considerable vulnerability to landslides, particularly on the periphery of Pasto, for example in the northwest of the city, in Comunas 8 and 9 (Juanoy, Quintas de San Pedro, Altos de la Colina, La Colina). These areas are characterized by irregular topography and steep slopes which, combined with intense rainfall and a lack of control over construction activities, significantly increase the risk of landslides. Furthermore, the city's ongoing expansion will increase encounters will landslides at the urban-rural boundary. In these sites of expansion, significant land conversion is taking place including the removal of natural vegetation and ecosystems to make way for housing and urban infrastructure. Natural vegetation serves a vital purpose in securing slopes and soils to prevent erosion and landslides, the removal of deep-rooted vegetation will likely escalate landslides. Restricting unplanned expansion processes is crucial in order to prevent future exposure of vulnerable populations in landslide-prone areas. Necessary and legal expansion must also follow strict guidelines to protect communities and assets.

The city's urban expansion over the past two decades into comunas 11 and 12 is significantly constrained by the high landslide vulnerability evident in the spatial analysis. Although areas such as the well-known Loma del Centenario serve as a critical component of the city's potable water supply system, the construction of high-rise buildings above this elevation compromises slope stability, posing immediate and long-term risks to the city's infrastructure and safety. The landslide vulnerability is particularly acute in the vicinity of the neighborhoods Torres del Cielo and María Paz, where the terrain's sensitivity is exacerbated by urban development pressures. This situation underscores the urgent need for geotechnical evaluations and the implementation of land-use regulations that prevent further construction in geologically unstable zones.

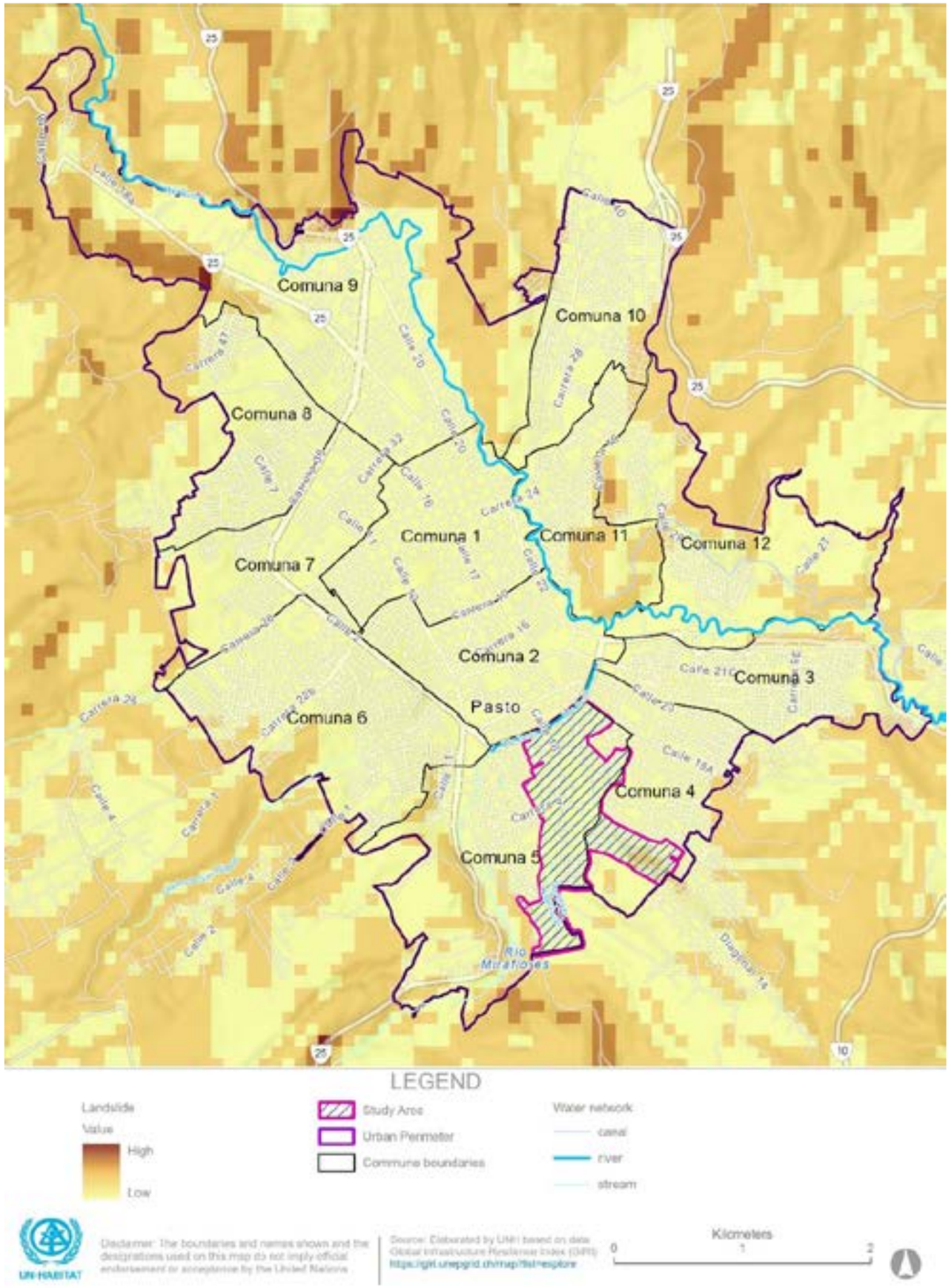


Fig. 24: Landslides map
Fuente: ONU-Hábitat, 2024

Indicator 3 - Temperature Rise

The Temperature Change Indicator required a normalization exercise, producing a grid with a lower granularity than other indicators, due to the data availability. However, the graphical representation aligns with previous studies (ICLEI, 2023) that have raised concerns about an increase of approximately two per cent in the city's average temperature (The average temperature in Pasto ranges from 13 to 15 °C throughout the year). The northern area of the city, as well as those areas associated with the ecosystems of the Galeras Flora and Fauna Reserve, show much higher changes, which may be linked to the loss of vegetation cover (vegetation provides a cooling affect) and land use changes (urban areas are often higher temperatures as materials such as concrete and asphalt absorb and store heat). A deeper analysis for this indicator requires identifying these changes and conducting a more detailed urban analysis, including infrastructure and green areas designated for conservation and/or recreational purposes within the municipality. However, from the data which is available, there appears to be higher changes in Comuna 6 and Comuna 9 in particular.

The central Comunas, including Comunas 1 and 2, exhibit limited temperature variation, which may be attributed to minimal changes in urban morphology over recent decades. Although there has been a gradual replacement of single-family homes with apartment buildings, there is no evidence to suggest that this transformation has significantly impacted temperature patterns within these areas.

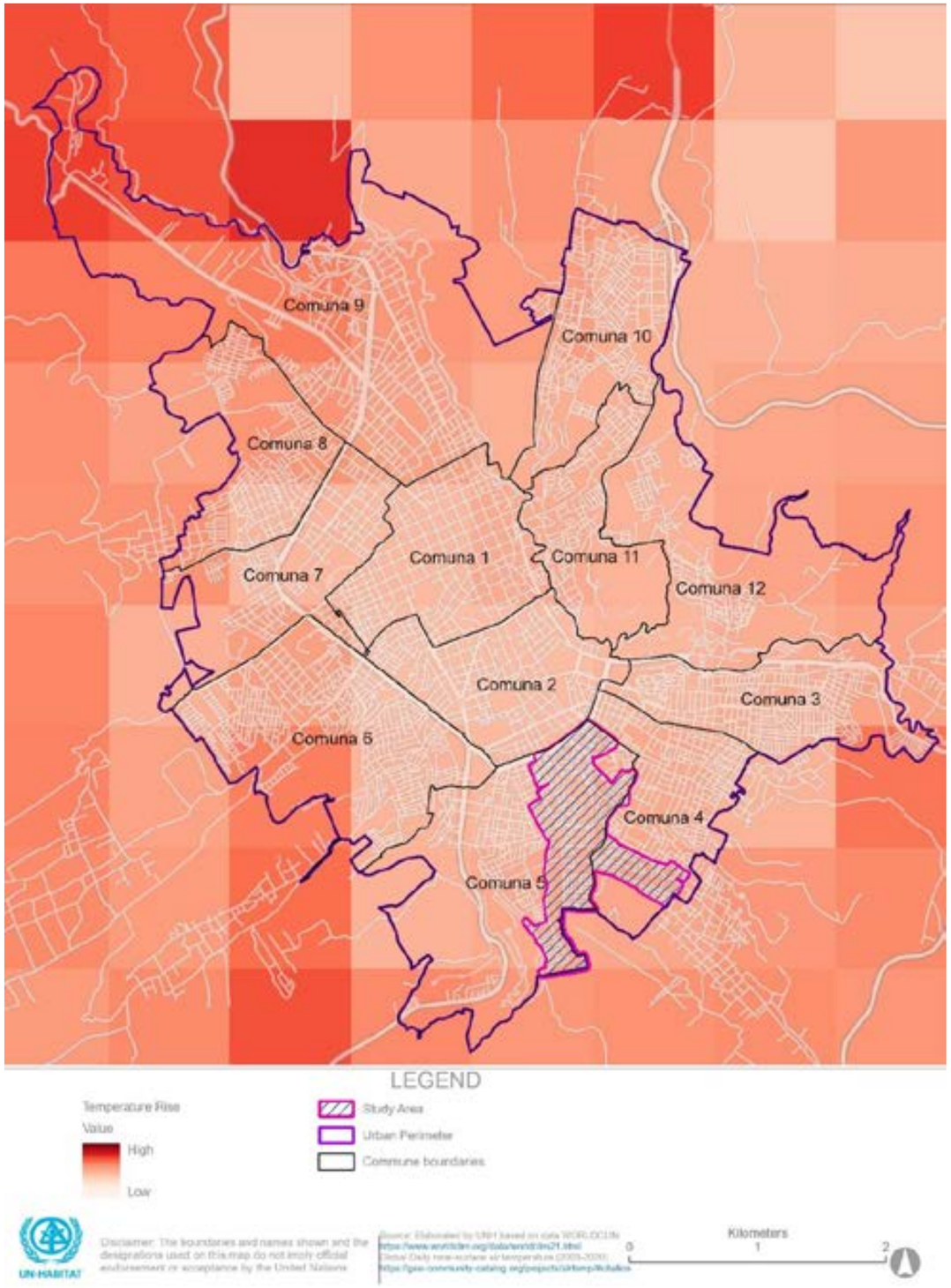


Fig. 25: Temperature Change map (rise)
Source: UN-Habitat, 2024

Climate Change Dimension Analysis

The Climate Change Dimension validates the need to concentrate efforts on addressing the influence area of the El Potrerillo Market and the Guachucal Stream (Figure 22). This area is located in a "V"-shaped valley, with terrain ranging from gently rolling, with slopes of less than seven per cent, to steep slopes reaching up to 80 per cent, as evidenced in the neighborhoods of La Minga, Chambú, and Altos de Chapalito, which are adjacent to the study area.

The high exposure to landslides and flooding historically experienced in the area of influence of the Guachucal Stream is largely due to urban development encroaching upon this water body. The channeling of the stream removed its natural meanders, which would normally slow down and dissipate floodwaters at the confluence with the Chapal River (which runs beneath the El Potrerillo Market Square), thereby contributing to the vulnerabilities identified both in cartographic analyses and in the city's past experiences.

Furthermore, it is important to note that the existence of a Illegal dumping site in the upper area of Zarcillejo Park, between the neighborhoods of La Minga and Chambú, has led to the obstruction of the current sewage system, keeping the risk of future flooding a persistent concern. The El Potrerillo Market Square was constructed over the channelled Guachucal Stream. This has increased the exposure of the market to floods and has been compounded by flat topography with slopes of less than seven per cent. This situation leads to the sedimentation of materials transported from upstream and the formation of an alluvial fan, which, combined with the accumulation of solid waste, sediments, and debris, causes water overflow and collapse of the sewage system—phenomena that have repeatedly occurred in the analysis area.

It is important to note that responses to climate-related hazards in Colombia are regulated by the administration, aiming to reduce vulnerability for both the population and ecosystems, while promoting the transition to a competitive, sustainable, and low-carbon economy (Law 1931 of 2018). To address this issue at the municipal level, Pasto has developed a Disaster Risk Management Plan, which prioritizes, formulates, programs, and monitors the specific actions necessary for risk awareness, monitoring, reduction of present and future risks, risk transfer, as well as preparedness for emergency response and recovery planning.

Climate Change Future Vulnerabilities

Climate variability in the municipality is marked by prolonged and more intense rainfall events, further impacting the living conditions of residents, the survival of biodiversity and ecosystems and the condition of critical infrastructure. Projections for Pasto under the RCP 4.5 scenario for the year 2100, suggest an increase in precipitation, ranging from 161 to 237 mm, which will likely intensify the frequency and severity of flooding and landslides across both urban and rural areas. The number of consecutive days without rain will also be reduced throughout the municipality (suggesting a lower prevalence of drought conditions). However, a considerable decrease in the frequency of intense precipitation events and in the amount of precipitation associated with extreme events is expected in most of the territory (ICLEI, 2023a).

This analysis led to the development of a risk model for the city of Pasto, in which climate change scenarios were integrated through an update of the threat indicators. The update focused particularly on shifts in precipitation patterns, as this climatic variable is the main driver of the identified risks (ICLEI, 2023a).

According to the climate change scenarios detailed in Colombia's Third National Communication on Climate Change (2015), the department of Nariño could experience temperature increases of up to 2.06 °C above current levels by the end of the century (2011–2100), based on the multi-model scenario. This scenario represents the projection with the highest degree of climate variability, highlighting the potential severity of future climate impacts in the region.

The risks extend beyond infrastructure to food security, as climate impacts threaten agricultural production. Water resources are also under pressure, jeopardising the provision of potable water and energy supply, the latter of which relies heavily on hydroelectric systems.

Finally, informal settlements, along with urban buildings and developments constructed over various periods, remain a significant concern. The presence of multiple water bodies flowing through the city further compounds the risks to urban safety and resilience in the coming years. In addition, climate variability and the loss of strategic ecosystems—particularly in and around riparian buffer zones—pose serious threats to biodiversity and ecological integrity. These combined factors underscore the urgent need for integrated urban and environmental planning to safeguard both human and natural systems.

Biodiversity Dimension

The Biodiversity Dimension examines the vulnerability of ecosystems, flora and fauna species, and overall biodiversity to the adverse effects of climate change, urban expansion, and various developmental pressures. This analytical perspective is visually represented in Figure 26.

Although Colombia is the second most megadiverse country on the planet, the municipality of Pasto faces the loss of species and the destruction and degradation of ecosystems in its territory.

Colombia has been transitioning from understanding biodiversity as only a natural attribute towards perceiving nature as the ecosystem services which offer supporting, regulating, provisioning, and cultural services to society. These services are vital and strategic for ensuring the viability and vitality of societal processes related to growth, development, and well-being.

The Biodiversity Action Plan 2016–2030 has provided a framework for implementing concrete and coordinated actions, both intersectorally and regionally, to reduce direct and indirect pressures on biodiversity and its ecosystem services. Within this context, a focus on these dimensions becomes crucial for the analysis conducted.

The vulnerability analysis proposed for the biodiversity dimension is composed of the following indicators:

Indicator 1. Protected / Conservation Areas. This indicator shows the areas of the municipality that have been declared for the protection and conservation of nature at national, regional and/ or municipal level. The protected and safeguarding areas reflect the surface area of natural spaces conducive to biodiversity conservation.

The location, characteristics, and conditions of protected and conservation areas within or near urban centers influence the vulnerability of people and places 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.

It highlights areas that are part of the city's primary ecological structure, including rivers, wetlands, forests, volcano and others natural spaces.

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.

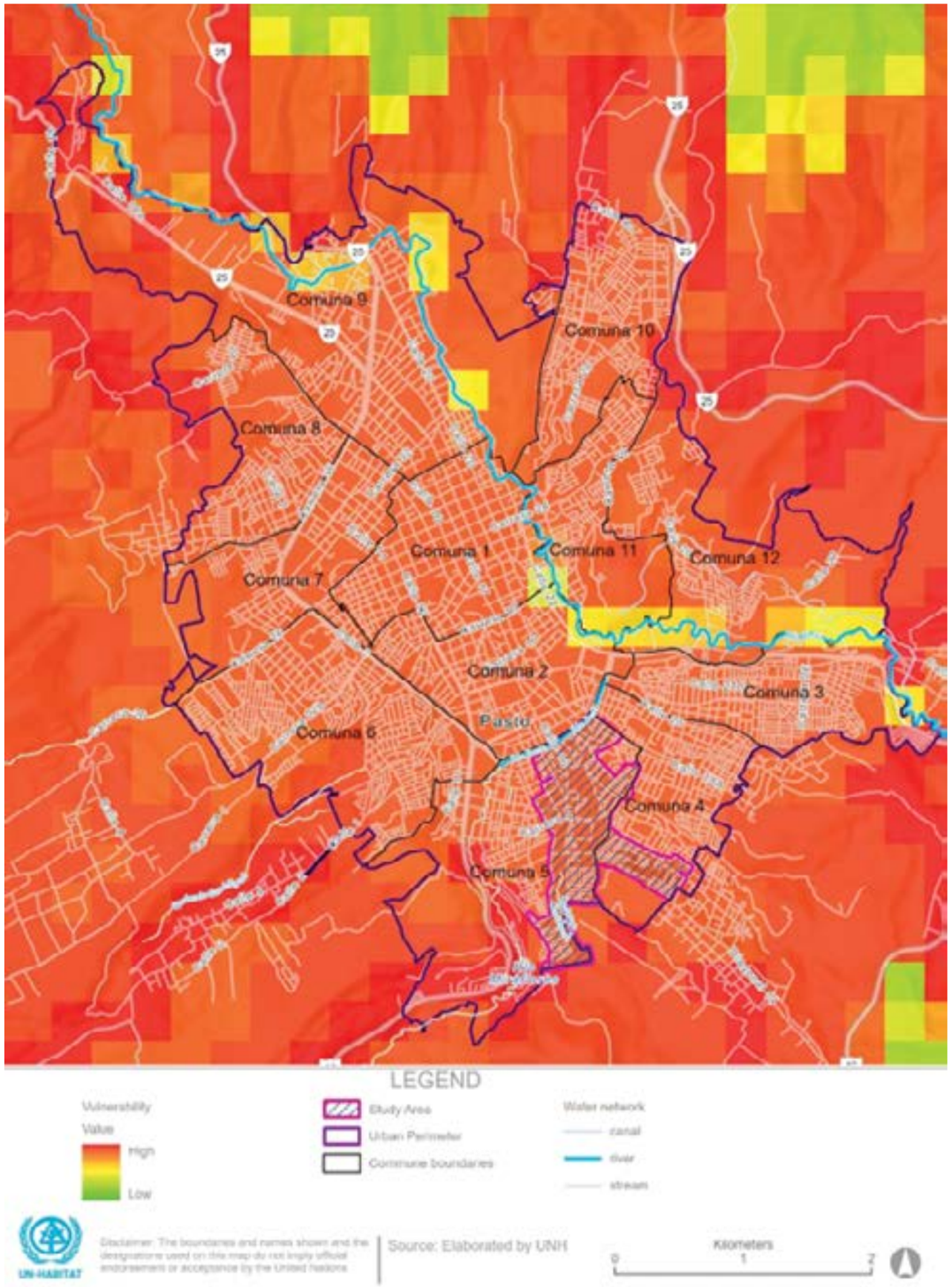


Fig. 26: Biodiversity Vulnerability Hotspot Map
Source: UN-Habitat, 2024

Indicators

Indicator 1 – Protected / Conservation Areas

Here is evident pressure from urban expansion, as certain protected areas directly border developed zones—particularly along the Pasto River, which flows through the city's urban area from east to north. While the river presents important opportunities for promoting and conserving biodiversity, it is also affected by previously discussed issues such as pollution, encroachment on riparian buffers, and channel modifications. These factors have degraded the river's ecological integrity, further challenging its role as a natural asset within the urban landscape.There are very limited protections in place surrounding the Pasto River except the immediate buffer areas, as such it is expected that contaminants and pollutants from the urban areas (captured and transported by surface run-off) will affect the water quality and the ecosystem health of the river. The indicator shows the river's potential for supporting biodiversity and demonstrates the imperitive for a planning process that recognizes the importance of these environments.

The protected areas surrounding the municipality of Pasto are primarily located in the peripheral zones of the city, especially along the northern, eastern, and southwestern edges. Key areas include the Municipal Protected Area of Cerro Morasurco, the Galeras Flora and Fauna Sanctuary — declared under Resolution 020 of 1984 by INDERENA and currently managed by CORPONARIÑO as a natural reserve — and the ecosystems associated with the Pasto River, which flows through the city from east to north. These areas are protected under national and local environmental regulations, including the National System of Protected Areas (SINAP) and the city's land-use planning instruments (POT). In several locations, protected zones are fragmented by urban development, particularly in the north and east, where patches of high Andean forest and páramo ecosystems persist between urbanized sectors. This fragmentation illustrates the growing urban pressure on these zones, posing risks to their ecological integrity and their role as biodiversity corridors.

Moreover, although the city has other tributaries and bodies of water, their channelization and, in some cases, the imposition of infrastructure over them undermine the underlying capacity of this environmental and biotic resource that the city possesses and that requires attention.

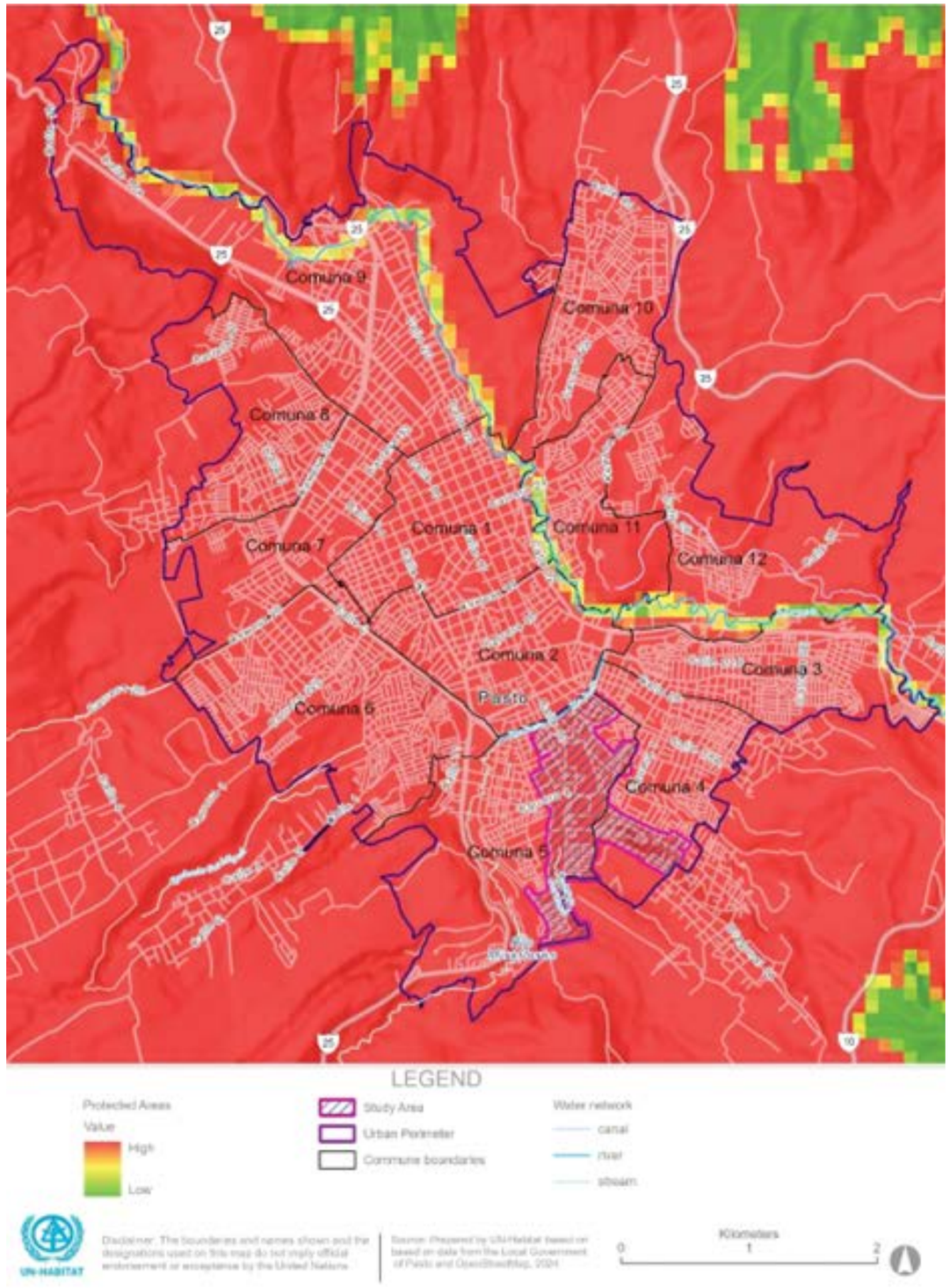


Fig. 27: Protected areas map
Source: UN-Habitat, 2024

Indicator 2 - Mean Species Abundance

The city center and surrounding urbanized Comunas (e.g., Comuna 1, 2, 3, 5, and 6) exhibit predominantly low MSA values (shown in yellow and orange). This pattern suggests that urban expansion has led to significant biodiversity loss, driven by deforestation, habitat destruction, pollution, and other anthropogenic activities. The transformation of natural landscapes into dense urban areas has reduced suitable habitats for many native species, which could result in a shrinking gene pool and declining population resilience.

The MSA values across the municipality highlight extensive environmental degradation, particularly within the urban perimeter, where species abundance is notably lower than the regional average. The urban matrix has fragmented what were once continuous habitats, isolating populations and limiting their ability to migrate, reproduce, and adapt to environmental changes (impacting the health of ecosystems).

Even the water corridors, and particularly the main watercourse, the Pasto River, show similarly low MSA values suggesting that proximity to urban zones negatively impacts aquatic and riparian ecosystems. Typically, rivers act as natural corridors for species movement, supporting biodiversity by connecting different habitats. However, in Pasto the intensification of human activities near water bodies - such as infrastructure development, waste disposal, and water pollution - has likely disrupted these ecological functions. The degradation of riparian zones, combined with urban runoff and sedimentation, further reduces water quality and negatively affects aquatic life.

The southwestern and northeastern areas exhibit larger patches of degraded biodiversity, signaling intensified habitat fragmentation. Fragmented habitats pose a major challenge for wildlife by disrupting migration routes and restricting gene flow between populations. This isolation increases the risk of inbreeding, genetic bottlenecks, and local extinctions, ultimately threatening the stability of entire ecosystems. Each of these will affect the ability of ecosystems to support the population of Pasto, potentially affecting air and water quality, provision of food and regulation of the climate including temperature.

The potential of conservation areas, as well as the large water reservoirs of the Bobo River and La Cocha, and the bodies of water that flow through the city, are of special importance in the perspective of strengthening and recognizing the biodiversity that underlies the territory of the city of Pasto.

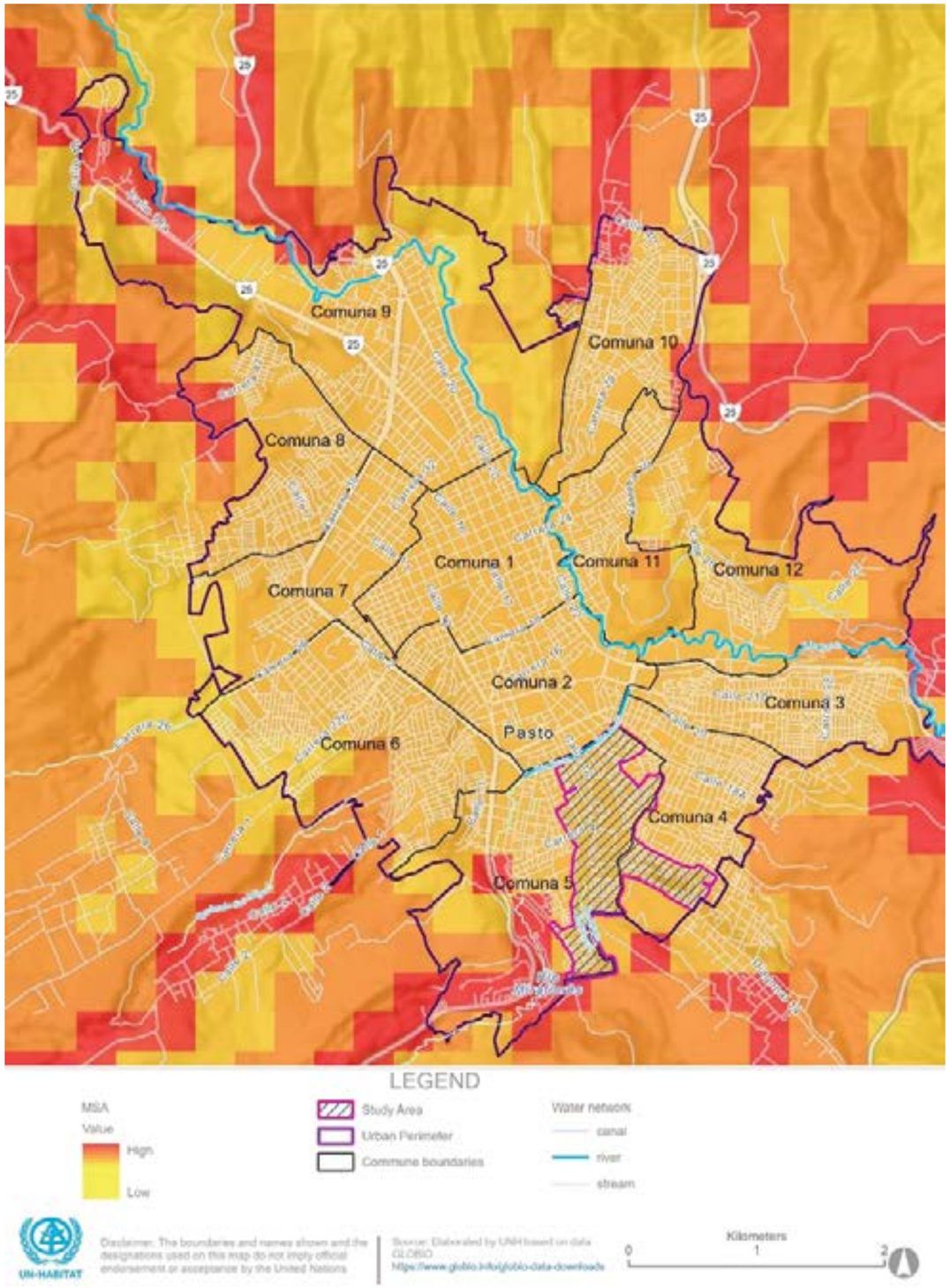


Fig. 28: Mean species abundance map
Source: UN-Habitat, 2024

05

BIODIVERSITY DIMENSION ANALYSIS

It is imperative to enhance the interconnection of protected areas, urban spaces, hydrological systems, and recreational facilities to foster ecological resilience. The fragmentation of natural landscapes and the lack of conservation efforts in urban strategic ecosystems heighten environmental vulnerability. This challenge is exacerbated by limited knowledge of the plant and animal species present in the urban territory, making effective conservation more complex.

The municipality's protected area system includes nationally designated protected areas, national protective forest reserves, municipally designated protected areas, and private conservation initiatives. However, true ecological functionality cannot rely solely on legally protected spaces. Unprotected yet ecologically critical areas must also be recognized for their role in providing essential ecosystem goods and services, such as air and water purification, carbon sequestration, soil stabilization, and climate regulation.

The hydrological system of Pasto, particularly where it intersects urban areas, should serve as a structural axis for biodiversity conservation. Water bodies are natural corridors for species movement, helping to maintain gene flow and ecosystem health. However, as observed in the MSA map, these waterways are severely degraded. Comprehensive decontamination and restoration efforts for the Pasto River and other municipal watercourses must be prioritized to revitalize these aquatic and riparian ecosystems.

Beyond the urban area, fragile high-altitude ecosystems above 3,000 meters - such as paramos and sub-paramos - demand urgent protection. These zones regulate water cycles, support unique biodiversity and provide essential ecosystem services to communities downstream. Conservation actions must focus on buffering zones, riparian restoration, and the preservation of water sources. Critical components that require immediate attention include:

- Water springs, aquifers and recharge zones;
- Rivers, streams, riparian zones, wetlands (both formally protected and unprotected);
- Paramo and sub-paramo ecosystems;
- Lagoons, reservoirs, sustainable stormwater drainage systems;
- Remnants of humid forests and forestry-protection zones; and
- Areas supplying aqueducts, which ensure water security for the Municipality .
- Biodiversity conservation in Pasto is directly threatened by deforestation, which currently results in the annual loss of 1,000 hectares of forest (POT, 2015). The drastic reduction in vegetation cover is driven by multiple anthropogenic factors, including:
- Conversion of primary forests for agriculture and pastureland
- High demand for firewood and charcoal as energy sources
- Selective logging of commercially valuable species
- Infrastructure expansion, including road construction
- Encroachment of human settlements into environmentally sensitive areas.

Together, these factors reflect a systemic undervaluation of environmental assets, which must be urgently addressed through local policy and land-use planning reforms. Urban expansion must integrate biodiversity-sensitive strategies, preventing further encroachment into key ecological zones while promoting nature-based solutions in existing urban infrastructure.

The selected hotspot area lies within the life zone of Low Montane Dry Forest (bs-MB), which spans 15,208 hectares (13.5 % of the total municipal area) and is a biodiversity hotspot that requires targeted conservation efforts. The life zone stretches from the corregimiento of La Laguna to the corregimiento of Genoy.

Additionally, an important environmental determinant is the Guachucal stream, which serves as a natural link between 1,382 hectares of biodiversity in the paramo ecosystem of El Tábano, (at 3,600 metres above sea level) and the upper basin of the Pasto River. However, this interconnected system faces intense human pressure, ranging from agricultural expansion to urban development, increasing its vulnerability to degradation.

To enhance Pasto's ecological resilience, it is essential to foster local capacity and community engagement in conservation initiatives. Public awareness and education must be prioritized to ensure that local communities recognize the value of strategic ecosystems and actively participate in their protection. This includes:

- Developing environmental education programs to raise awareness about the role of biodiversity in urban sustainability.
- Encouraging community-led conservation initiatives to restore degraded areas.
- Strengthening local governance structures to integrate ecological considerations into municipal planning.
- Incentivizing sustainable land-use practices to balance economic development with ecosystem health.

Biodiversity Future Vulnerabilities

The expansion of the agricultural frontier in the municipality, along with the sprawl of urban areas, exerts considerable pressure on formerly rural and natural zones dedicated to environmental conservation and ecosystem preservation, threatening the stability of the territory and its biodiversity. Real estate development and the increased use of land for rural housing and other purposes jeopardize key ecosystems, especially those associated with high-altitude páramos, the Ramsar Wetland La Cocha, and even the National Natural Park, which houses the Galeras Volcano.

Of particular concern is the growing urban footprint encroaching upon protected areas, which poses a direct risk to biodiversity and undermines critical environmental conditions. Although there is a national framework for the protection of strategic ecosystems—such as the National Policy for the Integral Management of Biodiversity and Ecosystem Services and the Strategic Ecosystems Protection Strategy—these mandates often clash with the limited enforcement capacity at the municipal level. Local authorities struggle to uphold environmental regulations, which weakens the effectiveness of conservation efforts and facilitates ongoing degradation.

The need for urgent action to curb this unregulated urban expansion and balance the interests of the community with those of private stakeholders in the construction sector is increasingly clear. While the ecosystems of Pasto display an overall trend toward stability in their contributions, it is critical to develop more specific management and planning tools that address biodiversity and key ecosystems within the municipality. These efforts must go beyond the páramos, which make the most significant contributions across various aspects. Furthermore, a biodiversity action plan is required for the urban area, including a comprehensive diagnostic assessment, the projection of ecological corridors, and strategies for their conservation (ICLEI, 2023b).

06

OVERLAPPING VULNERABILITIES

The previous sections presented individual dimension analyses, with methodologies designed to incorporate new indicators that enhance each dimension and deepen the understanding of the interactions between phenomena affecting territorial development, particularly in urban areas. Additionally, the proposed analysis facilitates the intergration of these dimensions, providing a comprehensive framework to guide both public and private sector management in addressing urban, environmental, and climate change needs. This section builds on that foundation by synthesizing the dimensions to conduct a more in-depth analysis, aiming to identify critical points in the urban landscape of Pasto that require targeted interventions.

Urban and Climate Change Vulnerabilities

In this representation (Figure 29), the urban and climate change dimensions are integrated. Using a color gradient, the map illustrates critical points associated with these two dimensions across the city. The raster-type representation normalizes areas of 100 by 100 meters, with colors shifting toward red to indicate higher degrees of vulnerability.

The city of Pasto is undergoing growth and densification towards its urban peripheries, with expansion reaching areas that traditionally have rural characteristics. Unplanned growth intensifies the risks of landslides and flooding, as land value determines access to property, forcing the most vulnerable populations—those with low incomes—into areas with the highest exposure.

Urban areas are becoming increasingly vulnerable to extreme weather events, such as heavy rainfall and prolonged droughts. The city's urban infrastructure, particularly its drainage systems, transportation networks, and buildings, are highly susceptible to these events, which adversely impact the productivity and sustainability of the urban environment.

Community leaders in the city affirm these concerns, with the vast majority (93.8 per cent) reporting that the overall economic situation has been negatively affected by extreme climatic events. These insights were gathered during consultations conducted in August 2024, where local leaders emphasized the increasing impacts of climate variability on livelihoods, infrastructure, and ecosystem services (Figure 30). Their testimonies highlight the

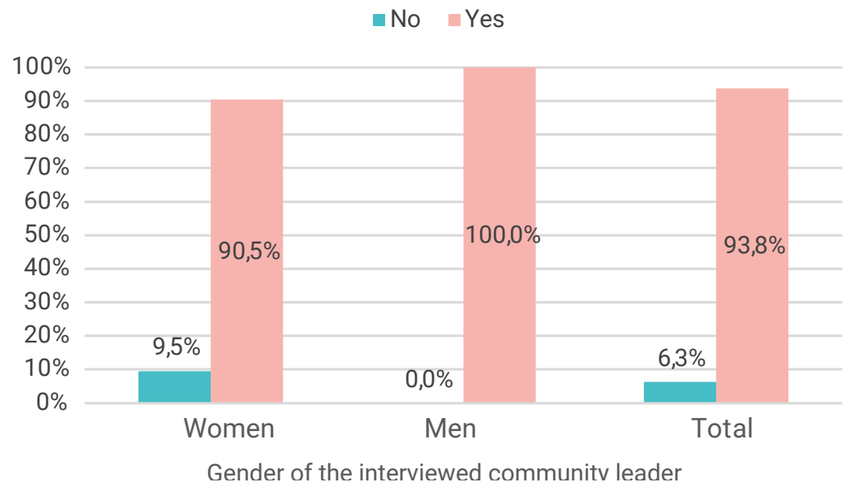


Fig. 29: Economic situation affected by extreme climatic events
Source: UN-Habitat, 2024

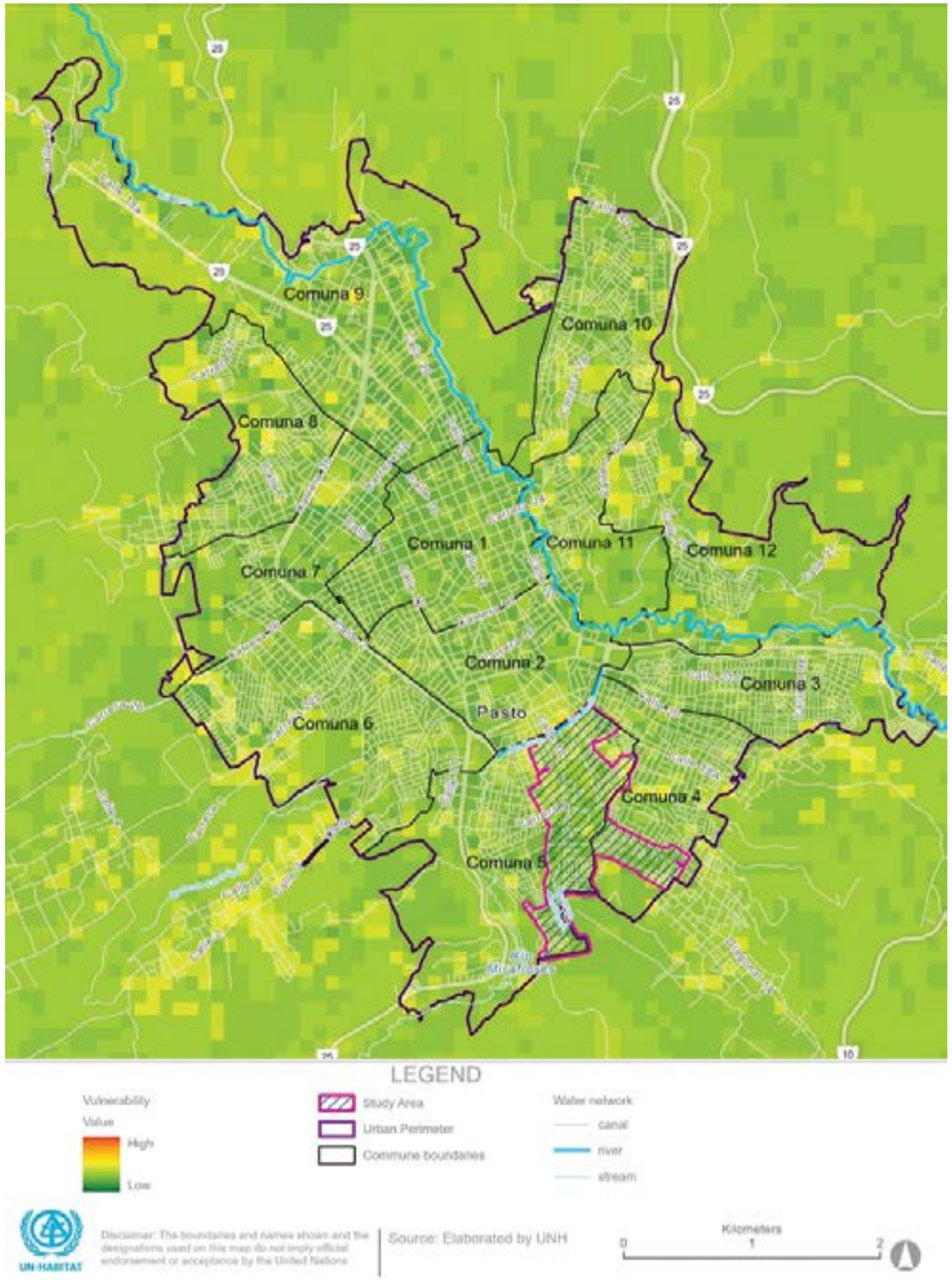


Fig. 30: Urban x Climate Vulnerability Hotspot map
Source: UN-Habitat, 2024

urgent need for coordinated action and enhanced institutional support to address these growing challenges.

The exposure to climate-related hazards, combined with poverty, high population density, and precarious housing, converges in specific areas that should be prioritized for intervention. These include:

- Comuna 3: the neighbourhoods of Barrio Popular, Rosal de Oriente, and Arnulfo Guerrero.
- Comuna 4: the neighbourhoods of the lower sector of the Corregimiento de Jamondino and Villa Olímpica.
- Comuna 6: the neighbourhoods of Caicedo, Niza II, and the Cyrgo sector.
- Comuna 10: the neighbourhoods of Bella Vista de Aranda, Marquetalia, El Carmen, Río Blanco, and Centenario.
- Comuna 11: the neighbourhoods of Ciudad Real, Calvario, Rincón del Paraíso, Aquine Alto, Alameda, and the Sector of Loma Centenario.
- Comuna 5: the neighbourhoods of Prados del Sur, Chapal II, Parque Chapalito, and Plaza de Mercado Potrerillo. The latter area requires particular attention due to the nearby sectors of Cantarana and Madrigal, where the low hydraulic capacity of the Quebrada Membrillo Guayco stream causes flooding in adjacent flat areas with slopes of less than 10 per cent.

Disorganized growth often coincides with the emergence of informal settlements, typically located in highly exposed areas such as low-lying zones, floodplains, or steep slopes prone to landslides. High population density, inadequate housing, limited sanitation facilities, poorly developed sewage and drainage systems, and insufficient access to green spaces, healthcare, and essential emergency services further exacerbate the vulnerability of these areas. These conditions make them critical targets for immediate intervention.

Climate Change and Biodiversity Vulnerabilities

In the visualization of Figure 31, the dimensions of biodiversity and climate change are overlaid to understand the hotspots where climate hazards and biodiversity vulnerabilities intersect. Using a raster-type standardization, 100 by 100 meter areas are normalized, and with the use of a color gradient ranging from green to red (indicating higher levels of vulnerability), the critical vulnerability points associated with these two dimensions in the city can be spatially visualized.

Understanding that ecosystems represent the broadest scale of biodiversity, the services they provide are inextricably linked with climate change. Consequently, climatic threats and alterations in climate variability—such as changes in rainfall and temperature—affect ecosystem services and disrupt species stability while conversely biodiversity loss, habitat fragmentation and poor ecosystem health exacerbate localized and global climate change.

The most vulnerable areas within biodiversity x climate are found in the urban-rural transition zones of Pasto, where ecosystems are more sensitive compared to highly urbanized areas that have lost their natural spaces. However, some urbanized areas remain susceptible to biodiversity decline, particularly in natural floodplains and landslide-prone zones along streams, such as the Guachucal stream (for example in Comuna 2, 4 and 5).

Vegetation cover, particularly the high Andean forest and azonal páramo ecosystems, is negatively affected by extreme weather events such as changes in precipitation and rising temperatures. Species such as frailejones, fruit and medicinal trees, as well as wildlife, suffer from these extreme variations, endangering the stability of the systems they belong to.

Furthermore, the ability of ecosystems to provide essential services for human well-being, such as clean air, fresh water, food security, and climate regulation, is at risk. Ecosystem degradation and biodiversity loss reduce the resilience of natural systems, thereby increasing society's vulnerability to climate impacts.

The most relevant ecosystems in the city are the Andean forest, the páramo, the Laguna de la Cocha, the Galeras volcano, and the forest areas near water bodies or present in peri-urban areas (ICLEI, 2024a). The majority of Pasto exhibits medium levels of vulnerability in the climate x biodiversity nexus, this is indicative of the low coverage of vegetation and green space, combined with consistent increases in termperature across the city.

Although the Laguna de la Cocha in the rural area of the municipality is of enormous importance in terms of biodiversity, it is under significant threat due to the expansion of agricultural and livestock activities, as well as the high levels of unregulated tourism taking place in its surroundings. The enormous ecotourism and nature tourism potential of the area is threatened if this trend continues.

Since the risks associated with flooding and landslides are the most significant in the municipality, and precipitation projections for 2100 predict increases between 161 and 237 mm (ICLEI, 2024a), the probability of these phenomena occurring increases, thereby increasing the vulnerability of the territory. Increasing the integrity and resilience of the biodiversity dimension involves recognizing these threats and implementing actions in the watercourses, such as creating an environmental corridor along the Pasto River and protected areas to ensure the conservation and key ecosystem functions for the city.

Special attention must be given to ecosystems related to the supply and maintenance of water resources. In general, these areas and ecosystems must be considered strategic and designed as connection corridors between the established reserve zones, particularly those corresponding to the Galeras Volcano and the Ramsar Wetland of La Cocha.

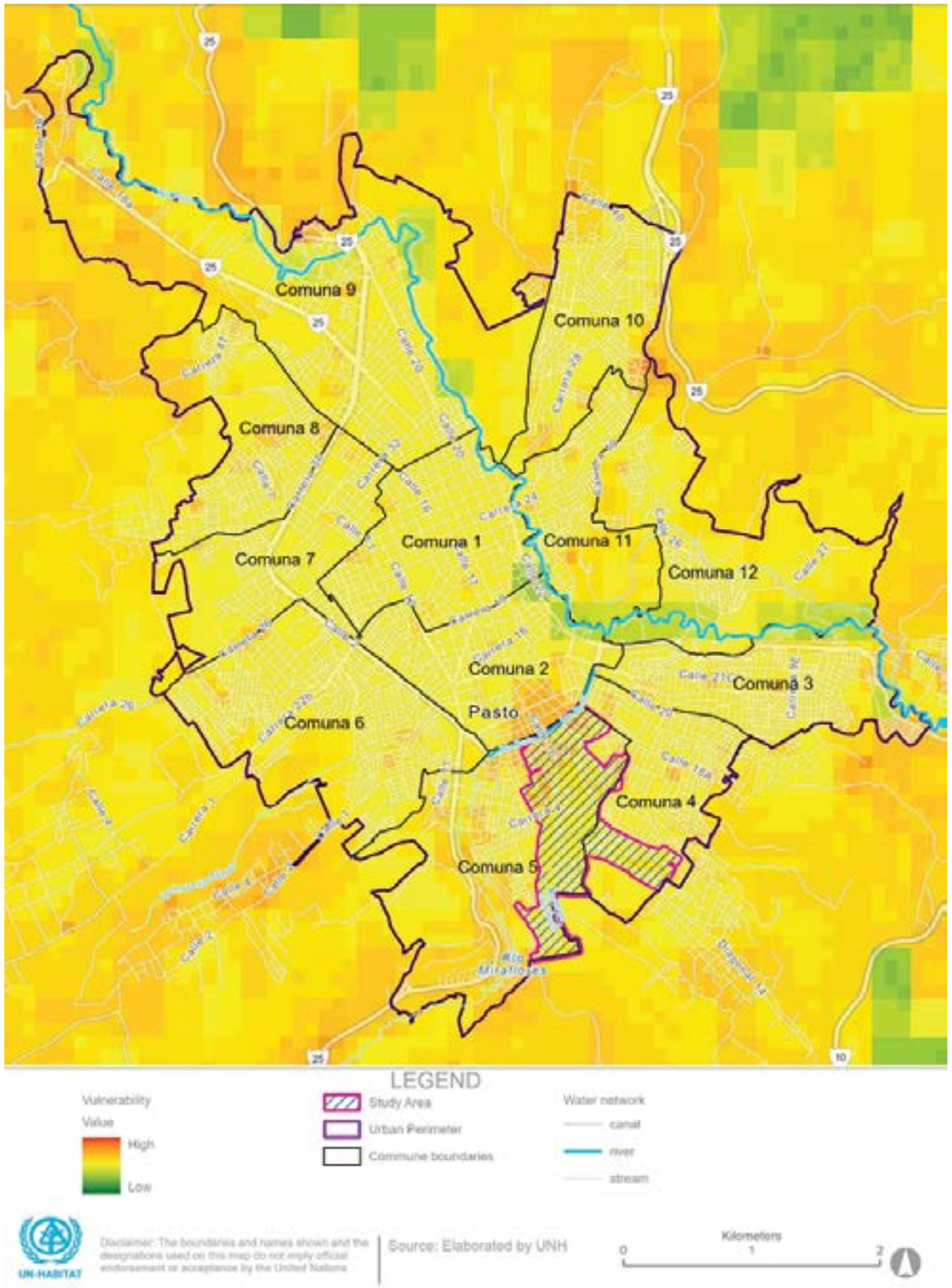


Fig. 31: Climate Change x Biodiversity Vulnerability Hotspot Map
Source: UN-Habitat, 2024

Biodiversity and Urban Vulnerabilities

In this integration of the biodiversity and urban dimensions, the indicators and overlaid to visualize sites of vulnerability. The raster-type representation normalizes areas of 100 by 100 meters, and through a color gradient, where the colors towards red represent higher degrees of vulnerability, the critical points associated with these two dimensions in the city are identified.

Like most cities, Pasto has been replicating an urban model characterised by low to medium density, with a voracious appetite for land and a segregated approach to land use. This model reflects the region's characteristics and those of the twentieth century. The relationship between land-use change and biodiversity is complex. The strategic natural ecosystems of the city, linked to peripheral bodies of water such as Laguna de la Cocha, as well as streams and the river itself, have undergone significant biophysical alterations. These changes include the elimination of forest cover, alterations in water courses, and the burial of waterways due to infrastructure and building development. Consequently, protected areas have become isolated relics of biodiversity and ecosystem services, severing their continuous connection to the inhabited areas of the municipality.

A continuum of hot spots between these two dimensions corresponds to the city's access roads and river courses, which can be spatially represented as zigzag lines. These mobility and transport routes connect Pasto to other locations, but they have been transformed into areas where the conditions necessary for biodiversity have been compromised. Ecological corridors are nearly imperceptible at the municipal scale, particularly in the most urbanized areas, with the exception of certain points to the north of the city along the Pasto River.

The change in land use for human settlements represents the most significant direct environmental pressure at the interface between Pasto and its natural systems. In addition to converting extensive natural and rural areas into urban environments, urban expansion has often occurred without integrating natural assets, which undermines the city's sustainability.

Land-use changes associated with urban expansion are the primary drivers of biodiversity loss in Pasto. This unplanned growth, often manifesting through informal or illegally developed settlements, leads to habitat degradation and fragmentation, diminishing the availability of suitable habitats for native species. Such conditions interrupt migration corridors and isolate populations, resulting in genetic isolation and decreased species diversity.

In this context, the phenomenon of expansion along the southern corridor adjacent to the city's perimeter road is particularly noteworthy. The urban areas of Aranda, Potrerillo, and Chapalito require close monitoring. Furthermore, the growth towards the Galeras Volcano influence zone, along with the rising population and rural housing developments in the La Cocha area, necessitates special attention to mitigate the strategic loss of ecosystems within the municipality.

Unplanned urbanization disrupts the provision of essential ecosystem services, such as carbon capture, water purification, and air quality, which are vital for maintaining biodiversity and supporting human well-being. The loss or degradation of these services heightens community vulnerability to environmental stressors and negatively impacts local cultural services that the city has promoted as sources of employment and wealth, particularly those associated with religion and tourism, which depend on ecosystems and biodiversity.

It is imperative to address the alteration of land-use patterns, which affects vegetation cover, soil composition, and hydrological cycles. Habitat degradation, soil erosion, and biodiversity loss necessitate the restoration of ecosystems and a focus on planning criteria related to the city's water resources. Urban sprawl and rural development must consider these ecosystems and ensure that planning incorporates effective water management, particularly in the corregimientos of La Laguna, Cabrera, and Buesaquillo. These areas are crucial for capturing water for human consumption in Pasto's urban sector and also serve as a strategic corridor within the Andean-Amazonian cycle.

Addressing the flow of wastewater into the Pasto River and the increasing pollutant load is essential for effectively responding to biodiversity conservation efforts through the protection of water resources. This requires controlling the expansion of agricultural and urban frontiers by establishing reserve areas, acquiring land in recharge zones, and protecting riparian zones. Implementation of reforestation programmes and restoration

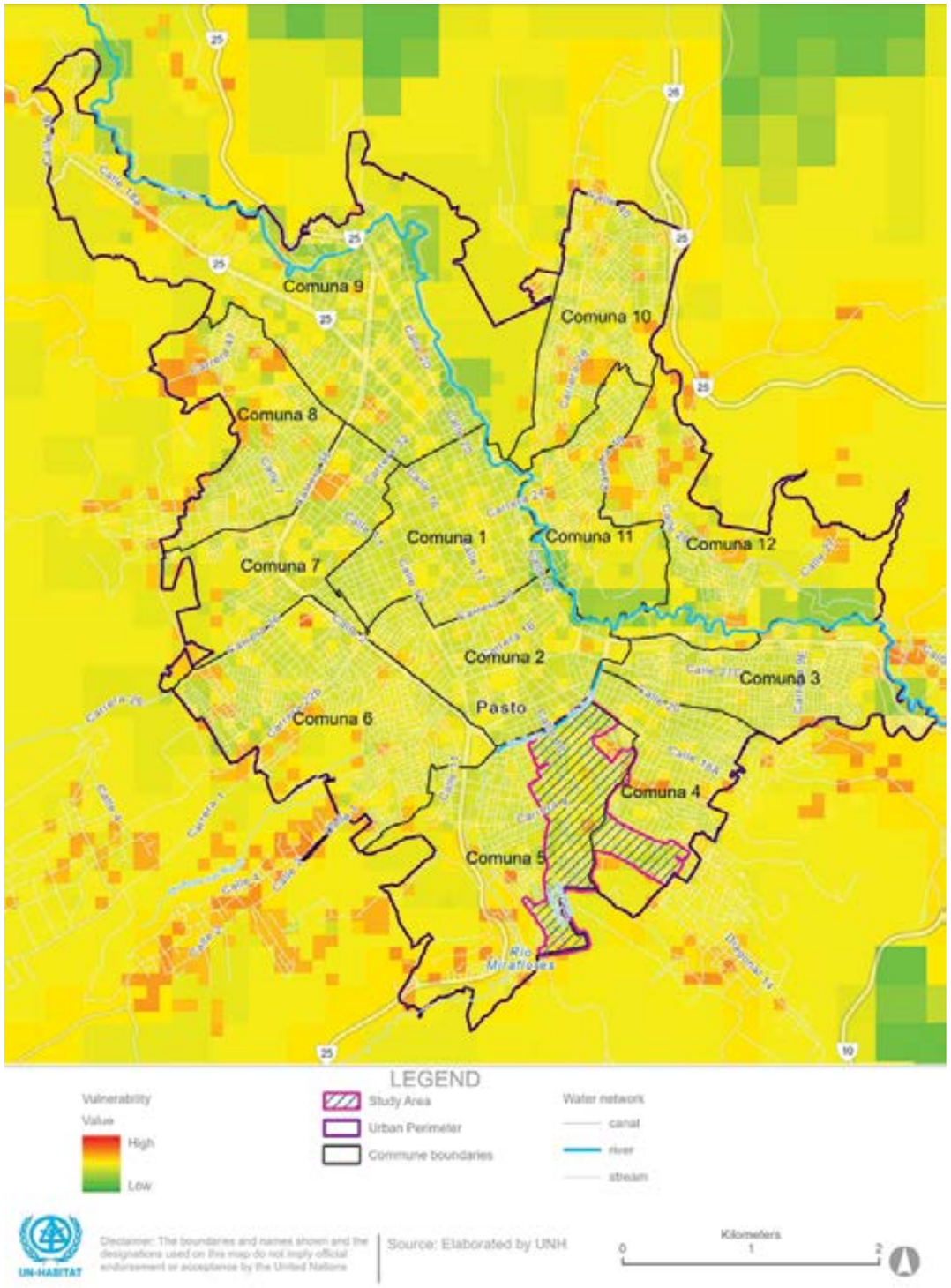


Fig. 32: Biodiversity x Urban Vulnerability Hotspot Map
Source: UN-Habitat, 2024

of protective plantations, along with activities focused on soil conservation practices, particularly in the strategic ecosystems of Bordoncillo páramo, El Tábano ridge, Las Ovejas páramo, Tábano - Divina Pastora páramo, and Bordoncillo páramo, will be vital.

Finally, delineating the municipality's Main Ecological Structure and ensuring the interconnection of the Pacific, Andes, and Amazon regions within the city should inform criteria for intra- and interurban ecosystem connectivity. This approach is crucial for ensuring long-term environmental conservation and protecting resources threatened by the growth of informal settlements lacking adequate infrastructure.

Multilayered Vulnerability Hotspots

To integrate the three dimensions and the indicators involved, the multilayered vulnerability analysis proposes a graphical representation where these dimensions are overlapped, generating a single graphical output that summarizes the vulnerabilities in the urban area of the municipality. The raster-type representation in the Figure 33, normalizes areas of 100 by 100 meters, and through a color gradient ranging from green to red, with red colors representing higher degrees of vulnerability, the critical points associated with the urban, climate change, and biodiversity dimensions in the city are identified.

The critical points of urban vulnerability in the city of Pasto reflect growth in urbanization, density, and population expansion. The concentration of socioeconomic deprivation, combined with the prevalence of marginalized and informal communities, increases susceptibility to the adverse effects of climate change, along with the growing degradation of biodiversity and habitat loss.

Low-income neighborhoods, characterized by high population density and the presence of informal settlements, are particularly vulnerable to the cascading effects of climate impacts, including pressure on emergency services, healthcare, and housing. In Pasto, the urban area, particularly in Comunas 4, 5, 6, 7, 8, and 10, encompasses most of the high-vulnerability points currently found in the urban perimeter.

When organizing the spatial information by quintiles and assessing vulnerability on a scale from very low to very high, it is evident that no values fall within the highest or lowest ranges. The spatial analysis shows that all the comunas in the urban area are at a medium (average) level of vulnerability, with high-vulnerability areas present in all comunas, except for Comuna 1. This is likely because the urban and climate indicators display consistent levels of vulnerability across Pasto. The highest vulnerability points are located in Comuna 5, Comuna 8, and the prioritized area, while the areas with the lowest vulnerability correspond to low vulnerability in Comunas 1, 2, 3, 9, 11, and 12. The Figure 34 shows the maximum vulnerability value found for each comuna and the study area, as well as the average vulnerability value for each political division within the urban area of the municipality.

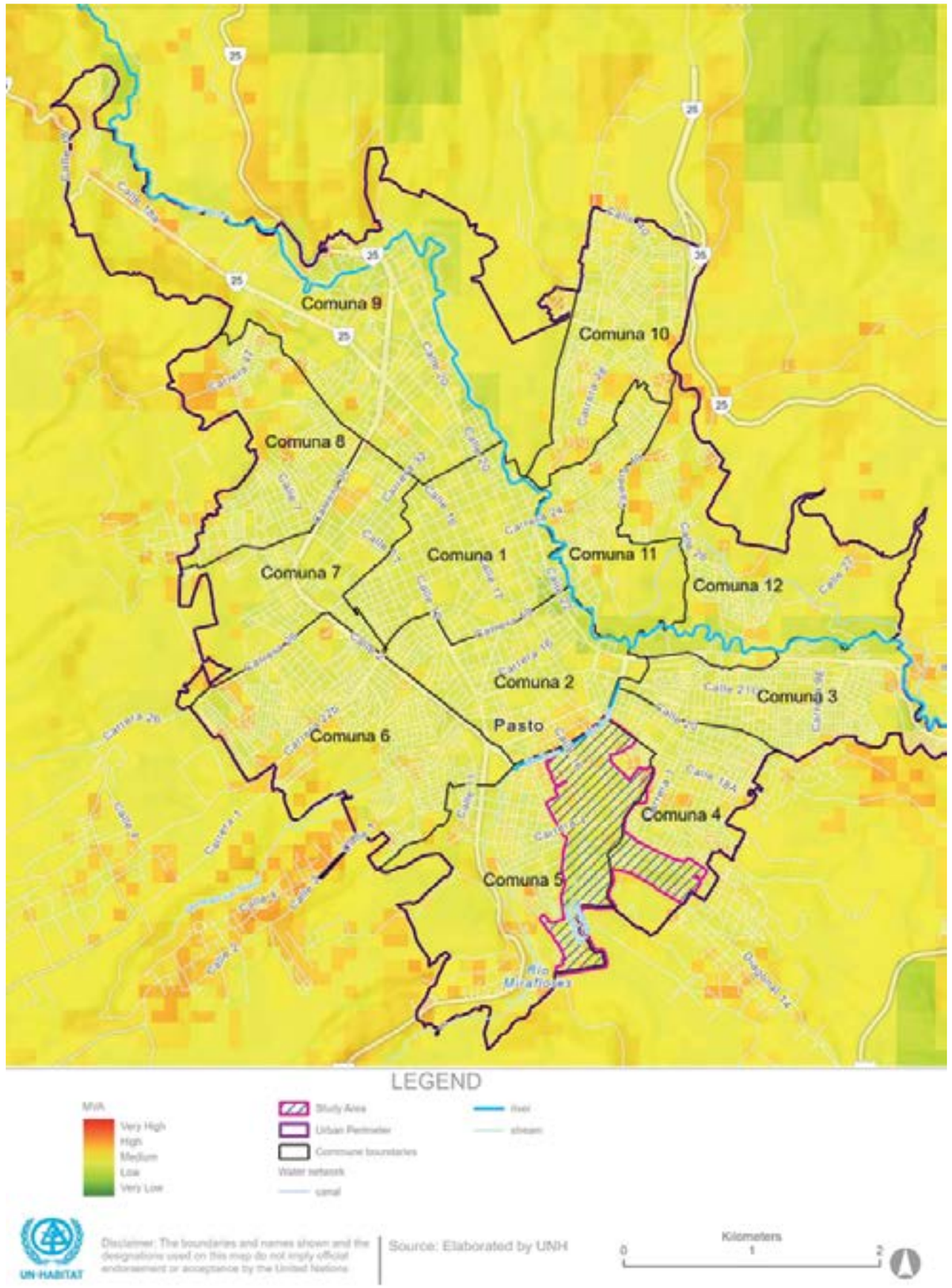


Fig. 33: Vulnerability Hotspot Map
Source: UN-Habitat, 2024

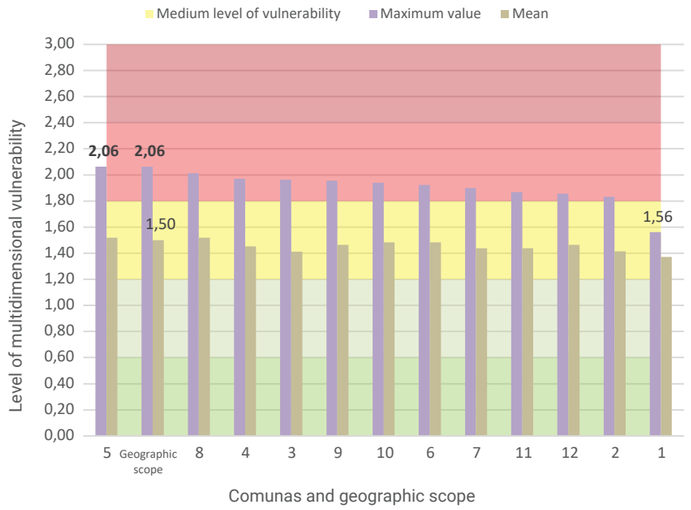


Fig. 34: Maximum and average multilayered vulnerability level for each comuna and the prioritized area
Source: UN-Habitat, 2024

According to the applied methodology, it is found that 94.9 per cent of the urban area of the Municipality of Pasto is in medium vulnerability, 2.5 per cent in high vulnerability, and 2.6 per cent in low vulnerability. The Figure 35 represents the per centage of area in each comuna at each vulnerability level, highlighting Comunas 8 and 5, as they have the highest per centages of territory in high vulnerability, in contrast to Comunas 1, 7, and 11, which have the smallest areas in this category.

As illustrated in Figure 36, the multidimensional vulnerability analysis confirms that the area surrounding the Guachucal Stream and the community near the Potrerillo Market—primarily located within Comuna 5—concentrates critical points of urban vulnerability. This spatial concentration highlights the area as a potential site for targeted, multidimensional interventions aimed at reducing exposure and enhancing resilience. This action would leverage the existing infrastructure and community processes to contribute to improving the living conditions of the inhabitants in harmonious relation to the ecosystem. Additionally, the land use planning around the water provided by the stream allows for coordinating the response to extreme climate threats, with the protection of the ecosystem and the care of the vulnerable population settled in the study area.

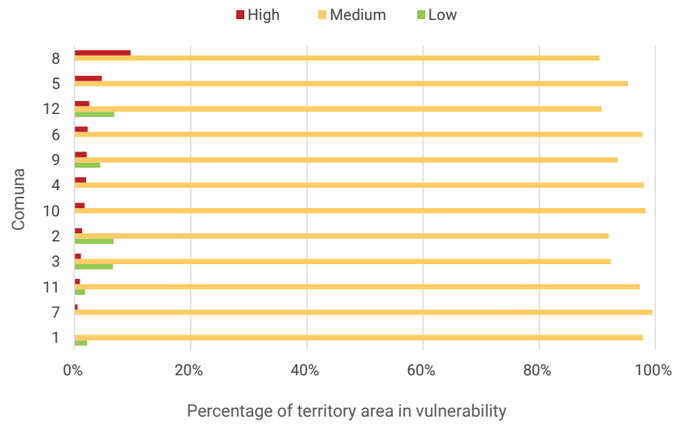


Fig. 35: Percentage of the area of each comuna by multilayered vulnerability level
Source: UN-Habitat, 2024

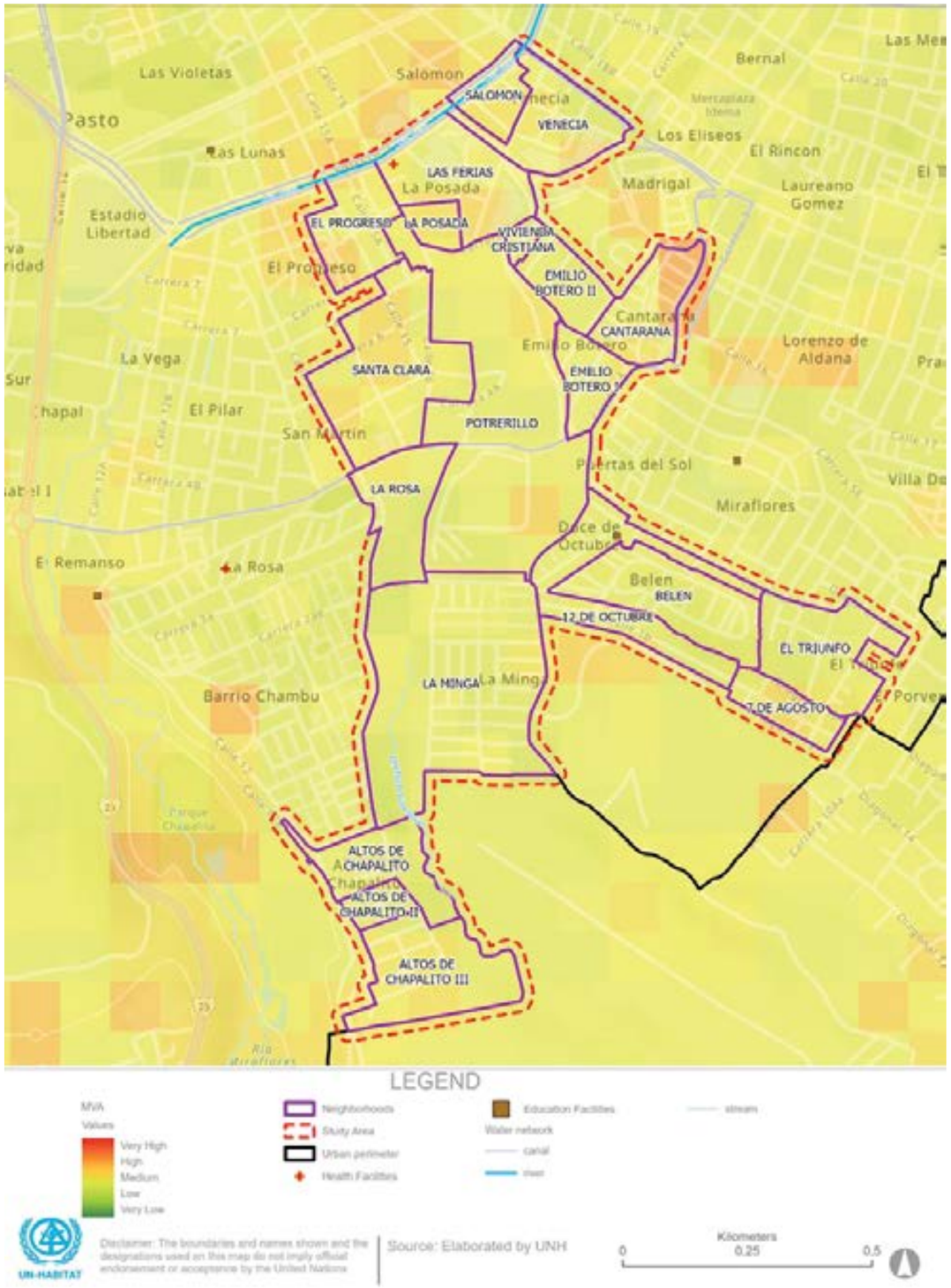


Fig. 36: Map of multidimensional vulnerability of the focused area – Potrerillo Market and Guachucal steam
Source: UN-Habitat, 2024

The adaptability of communities is closely linked to their social cohesion and the networks they possess to respond and recover effectively from climate-related phenomena. Furthermore, food security and sovereignty are critical to the function and sustainability of the city. With evaluating and increasing the adaptive capacity of residents, consideration should be made to food supply, as well as the consolidated urban areas that provide landscaping and historical conservation services, maintaining their purpose and strengthening their connections.

It is essential to broaden community knowledge in order to respond effectively and efficeintly to emergencies caused by extreme climate events, as community leaders have pointed out that there is a lack of clarity on how to act in such situations. As shown in next figure, 72.7 per cent of men report not knowing how to react to an extreme climate event, while 85.7 per cent of women find themselves in the same situation. The gender component is particularly relevant, as women generally take on caregiving roles and replicate practices and experiences within their immediate and community environments, especially among vulnerable populations such as older adults, children, and youth.

To deepen the multilayered vulnerability analysis, an assessment of exposure, sensitivity, and adaptive capacity was conducted to identify the structural components of the vulnerability process faced by the territory from an urban, biodiversity, and climate change perspective.

Exposure Analysis

The document collection process conducted for this study revealed that landslides and flooding are the primary threats to which the urban area of Pasto is exposed. These threats are exacerbated by the projected rise in temperature for the city, as mentioned in previous sections (ICLEI, 2023a).

These threats impact both urban components associated with public infrastructure, housing, and productive activities in the city, as well as environmental corridors and ecosystems, which form the basis of the city's biodiversity.

The following table summarizes the urban and biodiversity components at risk from extreme climate events, which trigger the aforementioned threats. These components have been analyzed in the Municipal Development Plan, the Land Use Plan, and other studies on the city's vulnerability to climate change.

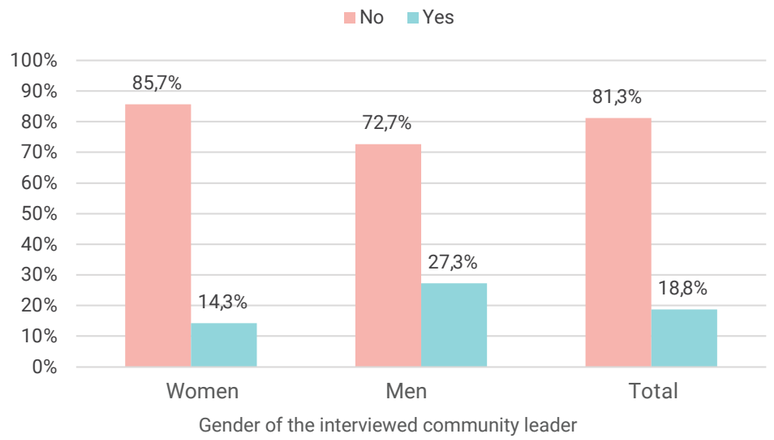


Fig. 37: Percentage of community leaders who believe they know how to react to an extreme climate event
Source: UN-Habitat, 2024

Sensitivity Analysis

The sensitivity of the city is reflected in its demographic conditions, housing, human development, and produc-

Climate Hazard	Projected Climate Variations	Exposed Urban Area	Exposed Ecosystems
Flooding (River Floods)	5% increase in precipitation in the urban area and ecosystems feeding the Pasto River. 2% average temperature increase (IDEAM)	**Morasurco Sector:** This area is exposed to flooding due to the low hydraulic capacity of its cross-section and the accumulation of sediments from the tributaries of the Pasto River, which inundate the surrounding flat areas. **Cantarana and Madrigal Sectors:** These sectors, which are part of the prioritized area, are exposed to flooding due to the low hydraulic capacity of the Membrillo-Guaico stream, which floods the adjacent flat areas with slopes of less than 10% (POT, 2015). The **581 kilometers of sewer networks** in the city are vulnerable to increased rainfall because they lack sufficient drainage capacity, which can lead to flooding and infrastructure damage throughout the urban area.	The Pasto River Watershed has been identified as high-risk in 6% of its area and medium-risk in 49%. The natural covers and associated ecosystems within this watershed are exposed to the threat of flooding (ICLEI, 2023). These following areas are highly vulnerable to the impacts of flooding and other climate-related hazards, which can significantly affect the local biodiversity and ecosystem services: • **Influence area of the Guachucal stream.** • **Influence area of the Mijitayo stream.** • **Influence area of the Membrillo-Guaico stream.** • **Buffer zone of Laguna de la Cocha.**
Landslides	5% increase in precipitation in the urban area and ecosystems feeding the Pasto River. 2% average temperature increase (IDEAM)	• **Loma del Carmen** (including the neighborhoods of Marquetalia, El Carmen, and Rio Blanco) • **Loma del Centenario** (including the neighborhoods of Aquine Alto I and II, Centenario, and Alameda) • **El Calvario sector, Carrera 24** • **Caicedo sector, Cyrgo area** • **Potrerillo Market Plaza** • **Madrigal-Cantarana sector** • **El Egido slope** • **Figueroa neighborhood sector** • **Chapal-Prados del Sur sector** • **Villa Flor II sector** • **Nuevo Amanecer neighborhood sector** (POT, 2015) According to official data, **333 properties, one educational institution,** and **674 buildings** are exposed to the risk of landslides (POT, 2015). Additionally, the **Centenario water canal,** which supplies **62% of the city's water,** has undergone interventions on its slopes, increasing the risk of landslides and compromising both the water supply and surrounding infrastructure (PMD, 2024). These areas are particularly vulnerable due to their steep topography and ongoing changes in land use and climate conditions, highlighting the need for risk mitigation and urban planning strategies.	The **Galeras Flora and Fauna Sanctuary, Andean forests,** and **paramo ecosystems** are highly exposed to the risks of landslides and other environmental threats due to their **geomorphological characteristics** and **steep slopes.** These areas, which are vital for biodiversity conservation, face significant vulnerability as they are located in mountainous regions with fragile ecosystems. In addition, areas with **ecosystem services by land-use vocation** in rural zones such as **La Laguna, Mocondino, Jamondino,** and **Catambuco** are also exposed. These areas play a key role in providing important ecological services, including water regulation, soil stabilization, and carbon storage, and are vulnerable to the effects of climate change, land degradation, and extreme weather events. The preservation of these areas is crucial for maintaining the ecological balance and resilience of the region.

Fig. 38: Exposure to Threats and Their Relationship with Urban Area and Biodiversity
Source: UN-Habitat, 2024

tion. The general assessment presented indicates an increase in vulnerability among low-income communities with unmet needs. Among the conditions that heighten sensitivity to hazards, the following are significant:

1. According to the report from the National Administrative Department of Statistics (DANE, 2018), the coverage of public services is still insufficient, affecting the quality of life and amplifying the vulnerability of the population. The per centage of households with access to public services are:

   a. Electricity: 99.7 per cent

   b. Water supply: 98.4 per cent

   c. Sewage system: 89.8 per cent

   d. Natural gas: 24.4 per cent

   e. Waste collection: 90.1 per cent

   f. Internet: 49.0 per cent

2. The elderly population consists of 65,583 people, representing 16.0 per cent of the total municipal population. Of this total, 58.5 per cent are women and 41.5 per cent are men. Among this group, the illiteracy rate is higher than the average, especially among women. While 8.3 per cent of elderly men are illiterate, the per centage of elderly women reaches16.1 per cent.

3. There is a resident ethnic population which have a variety of cultural and worldview considerations which may make them more susceptible to hazards. 3.22 per cent of the total population belongs to these groups, with 2.26 per cent being Indigenous and 0.92 per cent Black, Mulatto, or Afro-Colombian.

4. Several poverty indicators highlight the need to leave no one behind. According to the results of the 2018 National Census of Population and Housing (CNPV), 16.3 per cent of the city's population has a multidimensional poverty index (IPM). By 2022, 104,620 people were living in monetary poverty, and 31,051 in extreme poverty, which spatially coincides with comunas 10 and 5, the latter being where the prioritized study area is located.

5. The productive sector faces significant challenges in infrastructure and equipment, particularly in transport and connectivity with the rest of the country. The general weakening of the national production system has led to subsistence economies, reflected in the size of businesses (mostly microenterprises), which form the productive base of the city.

These sensitivity components require special attention to address the high and medium vulnerability levels identified in the urban area of the municipality. They constitute key elements for strengthening urban resilience and climate change adaptation in the city.

Adaptive Capacity Analysis

The municipality's adaptive capacities, in individual, collective, and institutional components, are essential to address the identified vulnerabilities. Among these components, the following are significant:

- **Individual Capacity:** The sources of this capacity include access to education and, in general, the high level of education of the population, which is above the national average. This is reflected in the city's competitiveness indices, where the municipality ranks first.

- **Collective Capacity:** The city is compact and heavily urbanized, aligning with models promoted by UN-Habitat for strengthening urban potential worldwide. The concept of "Inclusive, Sustainable, and Smart Cities," "15-Minute Cities (Proximity Cities)," and "City-Region," which have been promoted to transform urban dynamics, find a solid foundation for development in the configuration of the city of Pasto.

- **Institutional Capacity:** The municipality has recognized institutions, along with planning instruments that have guided public management and private action in recent years. In particular, the Municipal Development Plan (which has a four-year term), the ongoing update of the Land Use Plan, and risk management plans, as well as environmental management plans related to existing watersheds, stand out. Finally, there are solid public service institutions, such as those providing water and sewage services, which can improve responses to vulnerabilities and ensure an integrated short-term response.

The recognized adaptive capacity elements to address exposures and sensitivities, and provide a comprehensive response to the critical points identified in this multi-layered vulnerability analysis are summarized in the following table:

The multidimensional vulnerability analysis conducted validates the importance of focusing efforts on reducing the critical points identified in the area surrounding the Quebrada Guachucal and Mercado el Potrerillo. This is due to the potential derived from the existing community and social processes, as well as the urban dynamics associated with production and economic activity in the area, where the most vulnerable populations—particularly migrants and female heads of household—find means of subsistence.

While it is essential to concentrate efforts in the Quebrada Guachucal area, the vulnerability analysis also highlights the need to address Comuna 8, located in the northwestern part of the city, in future processes aimed at tackling vulnerabilities. This would contribute to building more resilient communities across the territory.

Determinant	Description	Relationship with Multilayered Vulnerability
Economic. Municipal Financial Capacity	Municipal finances are sound, with an emergency response approach in public management that allows resources to be directed toward the most vulnerable population.	Interest in climate change adaptation and the potential to enhance local actions with financing or external support.
Access to Information and Technology	Access to robust geographic information systems and institutional repositories at the local, regional, and national levels that facilitate the exchange and use of open data.	Technical data, data modeling capacity, and the exchange and distribution of information to provide an integrated institutional response.
Human. Resources and Capacity	High professional level, with technical, scientific, and political knowledge, with a local emphasis.	Understanding and local scientific knowledge that enables the projection of actions to address the identified vulnerabilities, including the knowledge of the population living in the territory.
Organizational and Social Capital	A robust structure of state-civil society relations that enables the creation of spaces for dialogue and community-based consensus-building, with the presence of international or external catalysts. Governance modes are in place that allow the development of leadership and participatory engagement without the risk of harm or physical elimination of opponents.	Actors (governmental, non-governmental, vulnerable groups, etc.) with the potential for coordination and common goals. A functional local government with institutional capacity to formulate and implement planning criteria in accordance with the current regulatory framework.

Fig. 39: Figurative Elements of the Adaptive Capacity of the Municipality of Pasto
Source: UN-Habitat, 2024

Harmonizing the environmental, ecosystemic, and urban components requires territorial organization processes around the hydrological structures present in the city, recognizing their potential for spatial planning. Combined with the municipality's productive and commercial-cultural focuses, these elements should guide the spatial management of San Juan de Pasto. This approach will enable the city to progress in building a more inclusive, resilient, and sustainable city, with an adaptive response to the impacts of climate change, as demanded by Sustainable Development Goals 11 and 13.

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08

ENDNOTES

[1] An indigenous people originating from the central and northeastern areas of the Andes Mountain range, in the department of Nariño. They settled in the municipalities of Pasto, La Florida, Tangua, and La Cruz, as well as in some suburban settlements of the city of Pasto (López, 2000).

[2] A community practice for constructing infrastructure or providing services where members and stakeholders collectively define and undertake communal work to develop activities that benefit all its members.

[3] Colombia is divided into 32 departments, in addition to the Capital District of Bogotá, which has a special status. Each department can contain several municipalities, which are the smallest administrative units. The departmental structure aims to promote regional development and the decentralization of administrative power within the country.


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