

**A HIPPIE CLIMATE, A RIGID SYSTEM. CLIMATE ADAPTATION TO RIVERINE FLOODS
AND WATERLOGGING AT THE LOCAL LEVEL IN COLOMBIA**

by

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EXECUTIVE SUMMARY

Climate change intensifies extreme events, posing risks to ecosystems and human populations. In the near-term in a 1.5°C global warming scenario, more intense and frequent extreme rainfalls are expected, which is associated with flooding. Colombia is a highly vulnerable country to extreme weather, particularly flood risks. While the country has made progress identifying its climate vulnerabilities, and adopting policies to address them, the implementation of actions at the local level requires further assessment.

This Master Project seeks to understand if actions and institutional arrangements for flood risk adaptation at the local level in Colombia are commensurate with the challenges of climate change.

To answer this question, Chia, one of the most densely populated municipalities in the country that has suffered from flood impacts in the past, is used as a case study. Review of current literature and regulations, interviews to key stakeholders, and petitions to obtain information on government actions were used for the analysis, as well as estimations using geographic information systems.

From the analysis, it was found that current frameworks and literature analyzing flood risks focus on riverine floods and neglect other sources of floods, such as waterlogging, despite them being a significant hazard especially under climate change. Therefore, this brief presents a framework for local governments to analyze their current actions (if any) related to flood and waterlogging management, in order to identify gaps and overlaps that need to be addressed. The framework has ten components, including the following: area and climate change context, stakeholder analysis, regulatory analysis, current actions description and analysis, gaps description, problem definition, design of the alternatives, prioritization of alternatives, and monitoring and assessment actions.

Applying this framework to the case study, it was found that the municipality of Chia has reduced its flood risk as during the last decade dikes have been built along the river; however, it is estimated that 1,866 (0.9%) people in 2022 were living in areas of high flood risk. In addition, more than 80% of the population has a medium threat of riverine floods, which is concerning as even though total yearly precipitation is not expected to change considerably, precipitation is expected to increase in short periods of time (1 and 5 days), representing a threat to a municipality that has been highly urbanized.

The analysis of the actions deployed to tackle these risks reveals that they are fragmented both between the regional and local level, and within the local administration. Flood and waterlogging risks management face different challenges due to lack of information (outdated and limited public access to data), policy (lack of integrated plan with low consideration of climate change), administrative coordination (lack of clear responsibilities lead to overreliance on actors and actions), accountability (fragmented environmental management structure) and capacity (lack of specific expertise).

Flood and waterlogging actions need to be built upon existing initiatives. For flood management the most critical action is to guarantee the long-term quality of the dikes that were built by improving, among others, a better joint work between regional and local levels, as well as with the community. For waterlogging risks, it requires a better involvement of the local Environment Secretary to incorporate climate adaptation actions, fostering transversality and avoiding duplication. Infrastructure investments should focus on improving sustainable drainage systems, permeable surfaces and green spaces due to the complexity of increasing drainage systems.

Even though this policy brief considers a specific case study, it helps to identify barriers that municipal governments in Colombia are having to tackle climate change effects of floods and waterlogging.

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Section 1. Introduction

In the near-term in a 1.5°C global warming scenario, more intense and frequent extreme rainfalls are expected, which is associated with flooding,¹ which represents a risk to people, particularly the most vulnerable groups (IPCC, 2023), making it urgent to implement climate adaptation actions² focused on this type of event.³

Developing countries, particularly, face greater adaptation risks due to, among others, limited finance, difficult access to technology and lack of appropriate capacities (IPCC, 2023). This context has already led to numerous challenges in disaster risk up to date.

One developing country that has been particularly vulnerable to hazards up to date, and that also is vulnerable in the face of climate change is Colombia, in Latin America.

From 1914 to 2018 floods were the natural hazard with the largest impact on people indirectly (18.035.941 people) and directly (2.199.832 people). In the same period of time, floods have also been the cause with the largest contribution to houses destroyed and damaged (66%), and led to 2030 deaths, 4.106 people injured, 794 people missing, 89.689 houses destroyed, 1.224.726 houses damaged, 25.196 people relocated, and 368.902 people evacuated (UNDRR, na). According to The World Bank (2021), Colombia is the 10th country in terms of economic risk posed by three or more natural hazards, while it is the country with the highest recurrence of extreme events in South America.

Colombia's vulnerability to natural disasters, particularly floods, can further increase.

In 2023, Colombia was in the top 5 of countries of the World Risk Index, which assesses the disaster risk for 193 countries (RUB & IFHV, 2023). Furthermore, based on the assessment of 180 countries, which considers human deaths, losses in purchasing power parity, and the gross domestic product, in 2019 Colombia was the 28th country that suffered the most from extreme weather patterns; this means that is part of the top 16% of most vulnerable countries (Eckstein, Kunzel, Schafer. 2021). In addition, according to the Notre Dame Global Adaptation Initiative (ND-GAIN), which measures the countries' exposure, sensitivity, and capacity to adapt to climate change, from 185 countries, Colombia is in the 50% of most vulnerable countries in the 97th position. 22.9% of the population in Colombia is currently exposed to high flood risk, and 6.3% are exposed to floods and live in poverty (\$5.5 USD per day) (Rentschler et al., 2022).

Considering its vulnerability, Colombia has advanced in the identification of its risks at the national and local level,⁴ but little is known on how local levels are responding to such vulnerabilities.

¹ Floods play also a vital role for ecosystem function, including flora, agricultural crops, restoration, among others (World Meteorological Organization, 2017).

² It is important to differentiate between climate adaptation (i.e. measures to build resilience and develop the abilities to recover from climate change and natural hazards) and risk management (i.e. to minimize risks associated with unpredictable natural disasters).

³ Flood risk refers to the likelihood of damages and costs from flooding. Then, it is a function of hazard (i.e. physical factors that make certain areas more susceptible) and exposure (i.e. number of people and properties at risk) (Walls, Pesek, and Peterson, 2023).

⁴ For more information refer to the National Adaptation Plan of Colombia.

This policy brief fills this information gap by exploring how administrative and political authorities at the regional and local levels in Colombia are tackling the challenges posed by flood risks and analyzing whether they are commensurate with the need to adapt to climate change impacts. More specifically, the question to be answered is: ***Are the actions and the institutional arrangement for riverine flood and waterlogging risk adaptation and management on the local level in Colombia adequately addressing the impacts brought by climate change?***

The analysis focuses on the case study of Chia, a municipality that has suffered from riverine floods and waterlogging in the past. Fieldwork and qualitative semi-structured interviews made between May and August 2023 were key data collection methods, including 10 in-person interviews⁵ and visits to high-risk areas identified by the municipal flooding risk maps. Interviewees were contacted through their official professional channels by email, as well as some were referred or introduced by personal contacts. In addition, petitions for information disclosure regarding the implementation of actions related to flood management were sent to the local government in order to have more in-depth information. In addition, academic and gray literature on flood management adaptation was explored. The information collected was analyzed according to a framework developed to examine the actions on flood and waterlogging management at the local level.

The purpose of this policy brief is to inform the municipal government of Chía on how to integrate climate change adaptation into its current policies for flood prevention, as well as identify the gaps that need to be addressed in order to reduce future risks. In addition, this policy paper can also be used by regional and national authorities to improve the overall governance structure and actions to address flood risk in a climate change context in Colombia.

The brief is organized as follows. The document starts providing a background on riverine floods and waterlogging, examining its triggers and common actions to address the threats that they can represent are analyzed. In addition, an original framework to systematically assess and design flood and waterlogging policies is introduced. Later, the framework is used to analyze the current actions around flood and waterlogging in the municipality of Chía, Colombia, as well as the steps forward. Finally, the document provides some conclusions and reflections.

⁵ A member of the Environmental Regional Authority, Councilman of the Municipal Council of Chía, a former Environment Secretary of Chía, a businesswoman, a member of the Civil Defense, a group of workers of the municipal company of public services of Chía (aka EMSERCHIA), two local leaders, and a group of workers from the Environment Secretary.

Section 2. Background on riverine floods and waterlogging: from triggers to common policies

2.1. Flood and waterlogging risk triggers

The occurrence and damage from riverine floods and waterlogging events can be influenced by different factors. Regarding riverine **floods**, particularly, land-use changes play a key role as triggers. Land use changes affect run-off processes as well as river basins. Modern land-use changes and urbanization have accelerated runoff by reducing soils' infiltration capacity, as well as the obstruction of natural drainage systems, at the same time that sediment dynamics have been disturbed (World Meteorological Organization & Global Water Partnership, 2009; APFM, WMO, and Global Water Partnership, 2016). In addition, areas downhill or downstream burned areas are highly susceptible to flash flooding if the fire burned hot enough or long enough for the soil to develop a layer that repels water and, therefore, water is not absorbed (National Weather Service, na); then, there is a high importance of conservation and restoration of rivers and adjacent ecosystems to reduce flood vulnerability (APFM, WMO, and Global Water Partnership, 2012). In addition, changes in the retention capacity of rivers or the floodplains adjacent to them can influence flood risk (Bronstert, 2003; Jongman, 2018; Sharma et al., 2018).

Besides river overflow, waterlogging, which is the saturation of soil with water following heavy rainfall, may also lead to flooding. **Waterlogging risks are increased by poor drainage systems, which, in turn, are affected by** poor waste management, particularly solid waste when it obstructs drainage and natural water pathways. Poor disposal of waste can lead to blockages of drainages and watercourses, reducing the capacity of the systems to storage and, therefore, increasing flooding risks. Moreover, after flooding or waterlogging, waste can be a source of toxins and diseases (Lamond, Bhattacharya, and Bloch, 2012; Phonphoton, and Pharino, 2019). For instance, it is estimated that around 218 million people are at high risk of flooding worldwide due to plastic triggers (ResourceFutures, 2023). Therefore, the risk of waterlogging from municipal solid waste landfills must be assessed to prevent environmental and public health risks (Laner, Fellner, and Brunner, 2009; Neuhold, Nachtnebel, 2011),

In addition, the lack of appropriate infrastructure is another trigger. Efficient drainage infrastructure reduces waterlogging loss and damage (Sohn et al., 2020). Despite this, in developing countries urban development commonly advances without proper planned drainage, which can lead to, Depending on the type of system (separate or combined drainage disposal and rainfall drained networks) and drainage, as groundwater or surface water contamination, flood frequency, diseases, among others. (Tucci, 2001).

Finally, note that waterlogging can potentially escalate to floods if conditions get worse, such as continuous heavy rainfall, or saturated drainage systems.

2.2. Riverine Floods and Waterlogging Adaptation Actions

Human adaptation is defined as the process of "involving changes and choices that seek to protect individuals and societies from adverse effects of climate change, to allow them to function and attain wellbeing under changing climatic conditions" (Schipper, 2020).

There are two main categories of climate adaptation actions. On one hand, **hard (or grey) actions** refers to large scale engineering solutions, such as physical barriers, raising land around rivers (e.g., bunds, pump stations, dikes, levees), among others. On the other hand, **soft flood adaptation (or green)** refers to the prioritization of green infrastructure (e.g., ecosystem restoration, sustainable drainage, nature-based solutions,⁶ green roofs and facades). Overall, in practice gray infrastructure adaptation measures have prevailed over nature-based solutions due to lack of understanding of the protection level of the last one; even though a hybrid solution, that combines green and gray mechanisms, provides higher security (Jongman, 2018).

Even though gray infrastructures have been predominant since last century (ADB, 2019), green actions must increase as its potential over time can be higher, the costs can be lower and social impacts larger (IFRC & Flood Resilience Alliance, 2022).

In addition to hard and soft adaptation actions for waterlogging and/or flooding, the availability of accurate, reliable, and locally adapted risk assessments, early warning systems and emergency response plans (Kuller, Schoenholzer, and Lienert, 2021), as well as education and community engagement before, during and post disasters is key to reducing vulnerability and building resilience (Dufty, 2018; Torani et al., 2019; Scaini et al., 2021).

Overall, it is important to integrate river management (or riverine flood management) and urban drainage system sustainability, especially in cities that are close to rivers and have high urbanization rates. It is crucial to foster the interaction between flood risk management, ecological sustainability, as well as land and urban planning, recognizing the complementarity between structural and nonstructural methods (ADB, 2019; World Meteorological Organization, 2009).

The integrated flood management (IFM) framework can be considered to integrate the previously mentioned characteristics as it promotes the best mix of strategies, including short and long-term measures, managing water cycles as a whole and considering all types of floods (i.e., small, medium, extreme). Related to the environment, particularly, as part of IFM, ecosystems and biodiversity are preserved in order to foster resilience (World Meteorological Organization & Global Water Partnership, 2009). In addition, the framework promotes the recognition of the difference between current (e.g., according to current climate variability, the current water management system) and future (e.g., future climate conditions, considering more severe and frequent extreme events) vulnerability.

⁶ Nature-based solutions are "actions addressing key societal challenges through the protection, sustainable management and restoration of both natural and modified ecosystems, benefiting both biodiversity and human wellbeing" (IUCN, 2020)

Nevertheless, frameworks for flood management still need improvement as they have faced different challenges, including coordinating stakeholders and policies with divergent interests (Dordi et al., 2022), lack of appropriate institutions with clear mandates, as well as poor accountability and assessment (ADB, 2019).

To design actions that intends to reduce flood and waterlogging risk, it is recommended to keep in mind the following principles (Lim et al., 2005; Sayers, 2013; Hallegatte et al., 2020)

- Reduce risk and facilitate adaptation to people in the first place and assets (i.e., firms)
- Adapt land use plans to the risks in order to protect people, assets and services, while promoting ecosystems goods and services
- Adopt inclusive actions that promote social well-being
- Guarantee rapid, robust, and inclusive development is the first priority
- Manage residual risks
- Prioritize actions, implement them, and monitor their progress
- Realize that complete protection can't be guarantee and plan for failure of measures
- Take decision understanding dynamic changes in an environment of risk and uncertainty
- Integrate flood planning with other local priorities
- Deploy a portfolio of actions in order to avoid reliance on a single measure
- Set clear responsibilities in flood governance
- Communicate risk and uncertainty
- Adapt in the short term to reduce vulnerability in the long term

2.3. Designing an integrated riverine flood and waterlogging adaptation policy

Up to today, frameworks and literature analyzing floods have focused on riverine floods and overlooked other sources of floods, such as waterlogging, despite them being a great hazard, especially in urban environments (Xu et al., 2024). In addition, there is a lack of frameworks for local governments to analyze and evaluate their flood and waterlogging threats under climate change risks. This policy brief introduces a framework that local governments could use to analyze their current actions (if any) related to flood and waterlogging management, in order to identify gaps and overlaps that need to be addressed.

The proposed framework builds upon models of public policy analysis (Bardach and Patashnik, 2016), climate change adaptation policy analysis (Lim et al., 2005) and the characteristics of effective flood management (Sayers et al., 2013). The sections of each type of analysis and the proposed framework are available in Annex 1.

The framework shown in Figure 1, is made of 6 components whose main aim is to understand flood and waterlogging in the area of interest, and other six components to design the actions that will tackle the problems identified. The first group of components

should be updated when new information becomes available, while the design of the actions must have a periodical review and improvement.

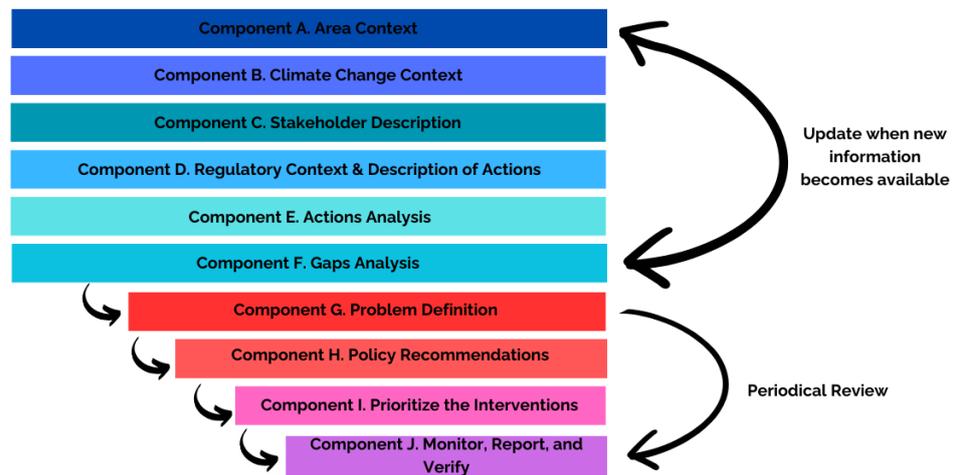


Figure 1. Flood and waterlogging adaptation policy-design cycle

Each of the components is described next.

Component A. Area context. Understand the area that you are interested in, particularly information related to its location and administrative division, its socioeconomic context, the environmental conditions, as well as a description, if any, of past flood events in the area.

Component B. Climate Change Context. Analyze, with available information, how climate change is expected to affect the area of interest, with emphasis on variables related to flood risk, such as precipitation. In addition, identify areas at risk, estimate possible economic losses, and which conditions minimize or exacerbate the possible impacts (C40 Cities Climate Leadership Group & C40 Knowledge Hub, 2021b; The World Bank Group, 2011). This can be made through different instruments, including mapping of past floods; mapping areas susceptible to floods based on their location; comprehensive flood risk assessments, which combines data on flood-prone areas and the location of vulnerable communities and key assets; and sophisticated flood modeling, which considers rainfall, waterways, drainage systems, and land use (C40 Cities Climate Leadership Group & C40 Knowledge Hub, 2021b).

Component C. Stakeholder Description. Identify and analyze the main stakeholders involved in flood management. This includes a description and nature of each actor, as well as an in-depth analysis of their role in flood management.

Component D. Regulatory Context. To understand the normative requirements that subnational governments need to comply with, it is important to identify the main national, regional, and local regulations that, directly or indirectly, provide guidelines or obligations for authorities to execute actions for the reduction of risks and the promotion of resilience to floods.

Component E. Current actions description & Analysis. Identify the current measures that have been deployed (if any) that are directly or indirectly related to flood management and/or waterlogging. This includes actions related to:

- Infrastructure Development and Maintenance (e.g., drainage)
- Early Warning Systems & Emergency Response Plans
- Waste Management
- Finance planning (e.g., insurance or savings).
- Risk assessment and knowledge building
- Ecosystem Preservation and Restoration
- Education and Community Engagement
- Land use planning and Zoning

In addition, analyze the actions with available information. For this process, the twelve OECD principles⁷ on Flood Governance provide a good resource to analyze the actions as a whole on their governance policy framework (what), the institutions (who), the instruments (how) and their impact. The Framework has over 100 questions that can be applied across all scales of water management (OECD, 2019).

Component F. Gaps Analysis. Based on the mapping of current actions related to flood management and waterlogging, identify the gaps. For this, the framework of the OECD's common gaps in flood governance can be used (OECD, 2019)

- **Policy gap.** Institutional and territorial fragmentation of flood policy across multiple actors and lack of effective policy coherence across sectors.
- **Administrative gap.** Mismatched administrative and hydrological boundaries for managing flood and water resources at the relevant scale.
- **Funding gap.** Questionable resource allocation and patchy financial management in undertaking flood-related responsibilities.
- **Capacity gap.** Gaps in scientific, human, technical and infrastructural capabilities for designing and implementing sustainable, efficient and effective flood policies and strategies.
- **Accountability gap.** Ineffective stakeholder engagement for inclusive and transparent flood-related decision making; insufficient or irregular monitoring, evaluation and enforcement.
- **Objective gap.** Divergent objectives that inhibit synergies and complementarities for managing floods at the appropriate scale.
- **Information gap.** Insufficient or incomplete flood-related data and information systems for assisting decision makers.

Component G. Problem Definition. Based on component F, clearly define and state your policy problem(s).

⁷ The principles are related to (1) the allocation of roles and responsibilities; (2) manage water at the appropriate scale; (3) foster policy coherence and cross-sectoral coordination; (4) improve the capacity level of responsible authorities; (5) the provision of updated information; (6) mobilization of financial sources; (7) effective regulatory frameworks; (8) promotion of innovative water governance; (9) mainstream integrity and transparency; (10) promote stakeholder engagement; (11) manage trade-offs; (12) promote regular monitoring and evaluation.

Component H. Policy Recommendations. Think and design the actions that can be taken to reduce the current and/or future vulnerability of the area of interest to floods or waterlogging in a climate change perspective. In the process, it is highly recommended to follow the FERM principles with a climate change adaptation perspective.

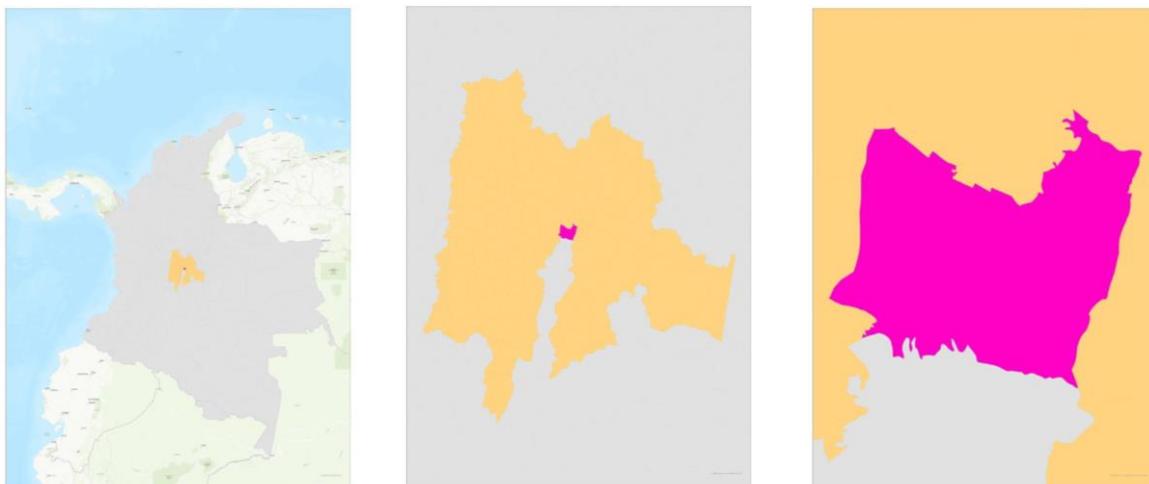
Component I. Prioritize the Interventions. Prioritize actions by assessing them according to projected costs and benefits, communities' priorities, among others. It is important to consider that although there is uncertainty on climate change impacts, adaptation actions can have indirect effects on climate change mitigation, public health, and economic development, among others (The World Bank Group, 2011).

Component J. Monitor, Report and Verify. Set performance indicators and evaluate the performance of the prioritized actions, giving space to adapt them, when new knowledge is available. The indicators do not necessarily need to be created from zero and must be connected with existing priorities (The World Bank Group, 2011).

Section 3. Designing a flood and waterlogging climate adaptation policy for Chía city by applying the framework

Component A. Area Context

Chía is a Colombian municipality located in the Department of Cundinamarca, in the savannah of Bogotá capital city, with an extension of 76 km². The municipality is divided into eight administrative units (Fonquetá, Fagua, Yerbabuena, Fusca, La Balsa, Cerca de Piedra, and Tiquiza).



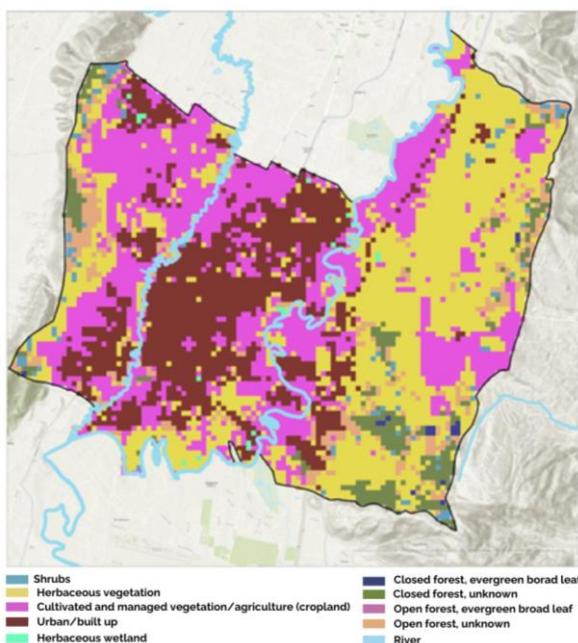
Map 1. From left to right: Colombia (country), Cundinamarca (Department), and Chía (Municipality)

Chía has a population of 164,995 people (48,5% men and 51,5% women), concentrated in urban areas (84,6%) over rural areas (15,4%) (DNP, na). Between 2005 and 2018, the census population increased by 35%. The population is mostly adults (42,8), followed by elderly (14,6%), adolescents (8,5%), and children (9,3%). In addition, 2,23% of the population is indigenous, 4,8% of the total suffers from multidimensional poverty, and 1,021 (~0,61%)

people have been identified as having a disability, although in this last one there can be an under-registration considering that people must register as disabled.

By 2035, the population is expected to grow to 206.626 inhabitants (PROBOGOTÁ & Cámara de Comercio de Bogotá, 2022).⁸ Due to the high urbanization rate, Chía put aside the development of spaces for social interaction (PROBOGOTÁ & Cámara de Comercio de Bogotá, 2022) which represents a challenge for participation spaces.

The municipality of Chía has 2.55 m²/inhabitant, well below the international standard of 10 m²/hab. Currently, the population density is 2.170,99 Hab/km², which puts Chía in the 16th/1102 position of the most highly dense municipalities in Colombia (DNP, na). Regarding key public services, 91% of the municipality has access to aqueduct, and 77.48% to sewerage.

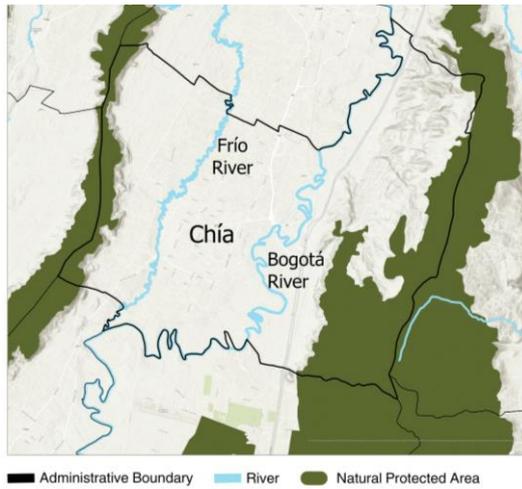


Map 2. Land Cover types and rivers in the municipality of Chía. Data from Copernicus.

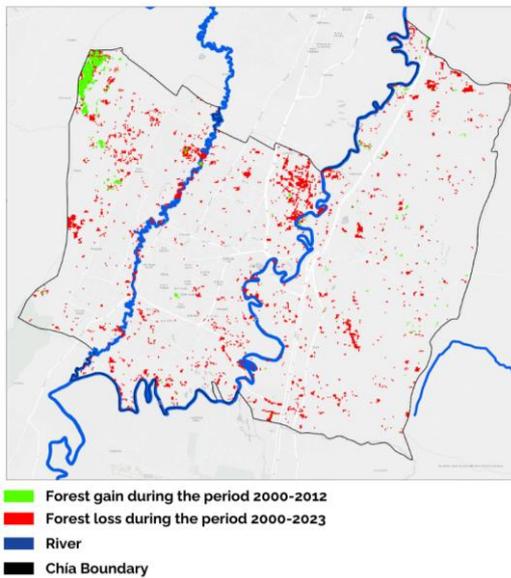
Land cover in the municipality is composed mainly of herbaceous and managed vegetation, as shown in Map 2. The most common land cover type in Chía is herbaceous and cultivated and managed vegetation (64%), followed by, Urban / built up (21.9%), open and closed forest (11.7%), shrubs (1.7%), and herbaceous wetland (0.2%).

The savannah of Bogotá is considered of national ecological interest, according to Law 99 of 1993 (Osorio Ardila et al., 2021). Chía, particularly, is characterized for having one of the most important ecological structures in the surroundings of Bogotá with two hills (Oriental and Majuy) and two rivers (frío and Bogotá), as it is shown in Map 3. On one part, the forests are protected by law through a forest reserve (*Reserva Forestal Protectora Productora- RFPP*

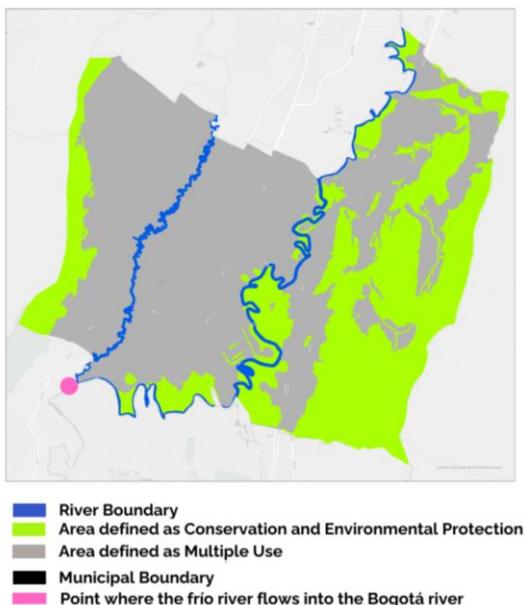
⁸ The density and socioeconomic dynamics in Chía didn't change until the decade of the 1990s (Mendoza-Jaramillo, 2016). However, since the end of the last decade, there is pressure from Bogotá, Colombia's Capital City, to metropolize nearby municipalities without proper planning. In the South with Soacha, and in the North with Chía. Nevertheless, the urbanization of the North took more time than the one in the South, and this was mainly because in the North the traditional farms resisted the advance of the city (Osorio Ardila et al., 2021). In the last decade of the twentieth century, the urban process started in the locality of Yerbabuena with the construction of the neighborhood of Santa Ana in 1994 and Hacienda El Fontanar in 2000. Later, the eastern hills started to be intensively occupied. The process of dispersed urbanization and subdivision of areas for the construction of high-income neighborhoods have affected areas of nature conservation, even though a large part of these areas is by law a Forest Reserve and have strategic value for water regulation (Mendoza-Jaramillo, 2016). In the end, the big neighborhoods are a synonym for the crisis of the municipality, where there are satellite semi-autonomous 'cities' disconnected from the traditional municipality (Mendoza-Jaramillo, 2016).



Map 3. Rivers and protected areas in the municipality of Chía



Map 4. Forest gain and loss in the municipality of Chía. Data from Hansen et al. (2023)

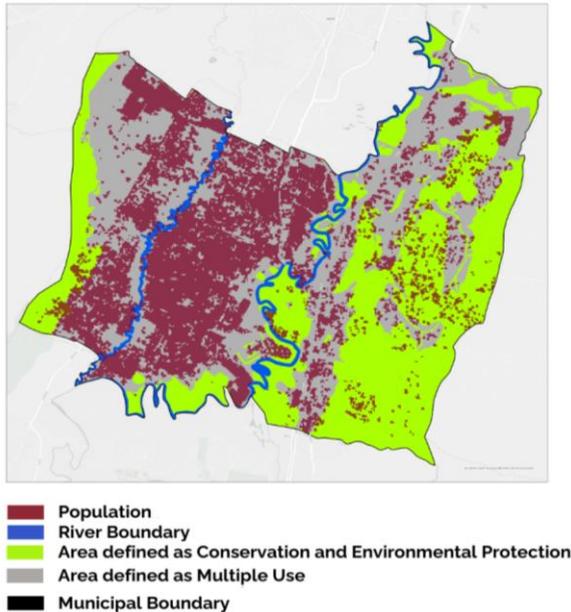


Cuenca Alta del Río Bogotá) legally established through the Agreement INDERENA 30 OF 1976, the Resolution 076 of 1977 from the Ministry of Agriculture, and the Resolutions 0138 and 0456 of 2014 from the Ministry of Environment. Overall, forests represent 22.42% of the total area of the municipality. Nevertheless, forest loss has been present in the municipality, even in areas close to the rivers, as shown in Map 4, despite the relationship between forest loss and high flood risk (Bradshaw et al., 2007).

On the other hand, the Bogotá River is part of the municipality of Chía. This is the most important river in the Department of Cundinamarca and has a longitude of 380 kilometers approximately. The river is divided in three sections: upper, middle and low river basin. The municipality of Chía is the part in which the upper and middle river basin join. The river has multiple tributaries, including the Frio river, that has a longitude of approximately 202 kilometers, flowing onto the Bogotá River in the municipality of Chía, as highlighted in Map 5. Despite areas of rivers confluence having higher flood risks (Benda et al., 2004; Geertsema et al., 2018; Wang et al., 2019), such area in the municipality of Chía is not prioritized for conservation, nor is it characterized currently as high flood risk (Map 8).

The protected areas described are protected by law and, therefore, should not have people living inside them. In addition, in areas that represent a threat due to natural hazards and whose risk can't be mitigable, should not have people inside them either.

Map 5. Land Cover types in the municipality of Chía. Data from the municipal government



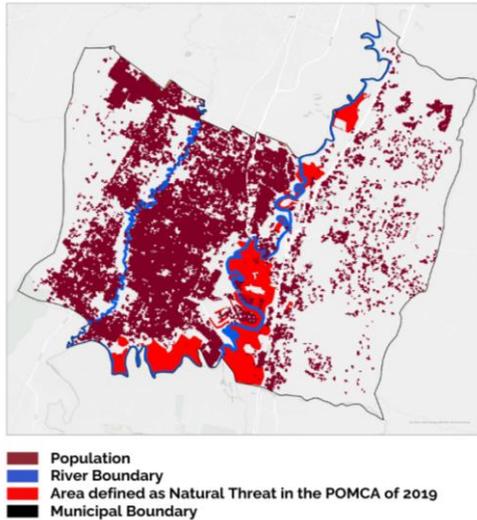
Map 6. Land Cover types, rivers and population density in the municipality of Chía. Data from Meta and the municipal government

According to classifications of Colombian regulation, in 2019 it was defined that 60.5% of the municipality area can be used for multiple uses (i.e., housing, industry, etc.), while 39% of the total area of Chía is defined as environmental conservation and protection due to its importance, or because it has a high natural threat, as it is shown in Map 5.

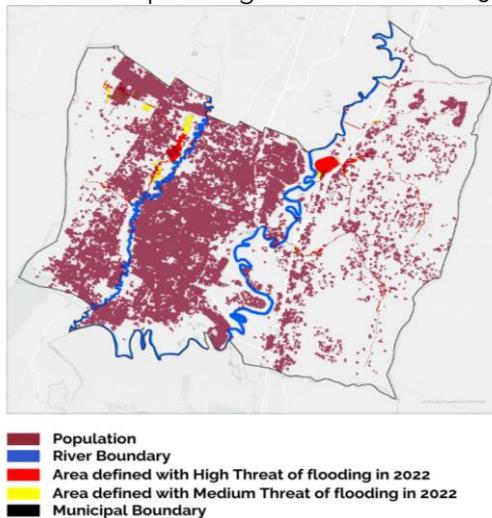
To have an estimate of the total population living in protected or high-risk areas, the population density data from Meta is used. Data from Colombia is for 2020. According to this data, 203,011 people were living in the municipality of Chía in 2020. This is above the estimations from the National Census of 2018. Nevertheless, this is the most precise georeferenced data in the world up-to-date. With this data, it was possible to estimate that approximately 22,190 people (~11%) live in areas categorized as high risk or of conservation and environmental protection, as shown in Map 6.

Precipitation, particularly, is considered the highest threat for the municipality. The largest flooding hazard in recent years happened in 2010 when Colombia suffered a fast transition between the phenomena of *El Niño* and *La Niña*, which brought severe climate oscillations (Cepal, 2012). Between September 2010 and May 2011, 55.6% of weather-related emergencies in Colombia were related to floods, which affected 2 million people, representing the costliest natural disaster in the country since the 1980s. Estimated losses and damages reached 6.5 billion USD losses and damages (Cepal, 2012). After this episode, the regional environmental autonomous authority (from now on referred to as CAR) implemented different measures, including the construction of dikes along the river.⁹

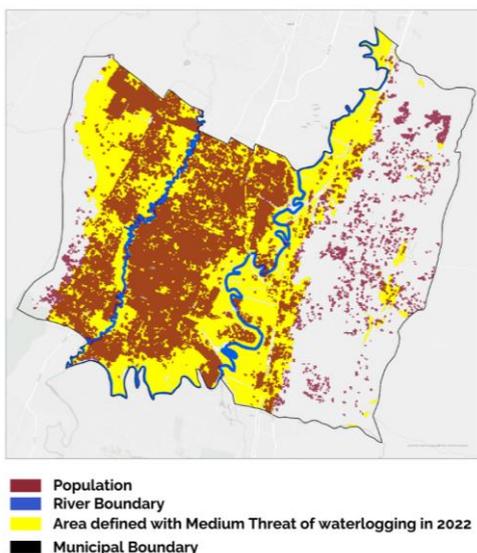
⁹ The construction of the dikes along the river have led to social conflict due to environmental concerns. In November 2020, inhabitants of municipalities surrounding Bogota, including Chia, gathered in the central offices of the CAR arguing that the work of the entity was removing riparian aquatic vegetation and disconnecting rivers from swamps and wetlands. Overall, the inhabitants mention that the river dikes have been made without the proper nature restoration plans (EL TIEMPO, 2020). The inhabitants also mention that local species, such as the *cangrejo sabanero* and the *pez capitán* are decreasing (Grupo Río Bogotá, 2020).



Map 7. Natural threat areas related to water according to the river planning instrument of 2019



Map 8. Areas with flood risk at the municipal level in 2022



Map 9. Areas with waterlogging risk at the municipal level in 2022

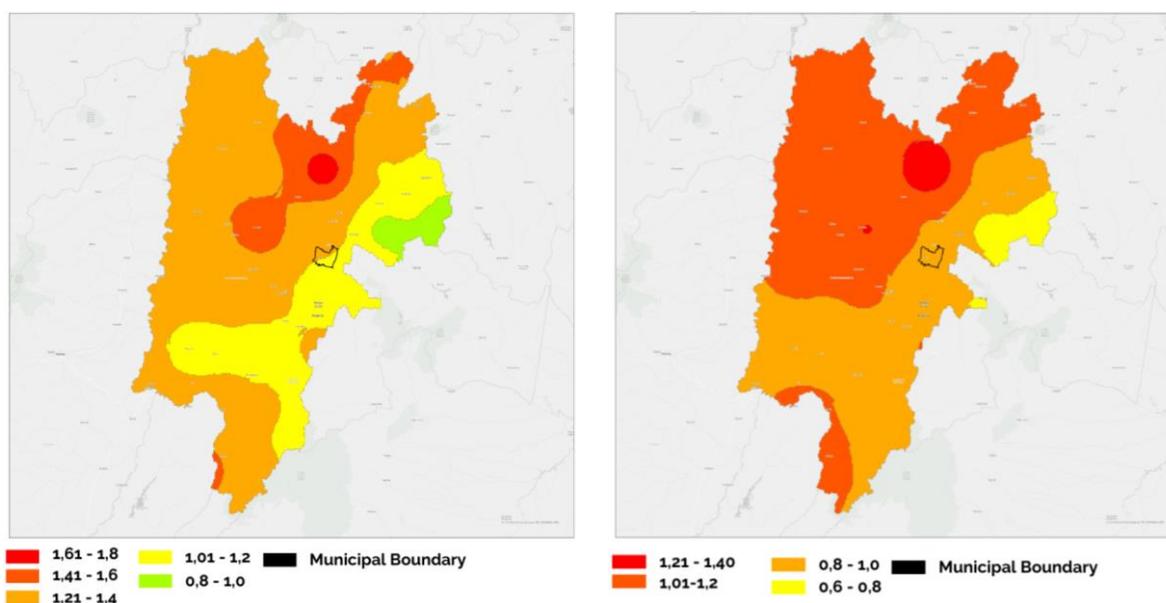
More recently, high precipitation rates have led to waterlogging, including in 2022 during *La Niña* season (Vargas, 2022). This is further supported by local information. According to the last risk maps assessments from 2022, 56.62% of the area of the municipality has a low threat for waterlogging, while 2.42% has a high threat of flooding, and 0.5% medium risk and 97.08% a low risk.

The number of people living in riverine flood and waterlogging risk areas is estimated using risk density data from Meta. Map 7 shows the areas identified as having a natural threat in 2019. It is identified that with the population of 2020, approximately 2348 (~1.2%) people were living areas of natural threat. It must be highlighted that the data is subject to overestimation, as the density data is one year older than the natural threat estimations.

After risk control measures in the areas of main threat, more specific risk maps were done in 2022. It is estimated, according to the population density maps of Meta for Colombia in 2020, that 631 (~0.3%) people were living in areas with a medium threat of flooding, while 1866 (0.9%) people were living in areas of high risk of flooding, as it is shown in Map 8. In addition, as can be seen in Map 9, it is estimated that 171,004 (84.2%) people were living in areas with medium risk of waterlogging. It must be highlighted that the data is subject to underestimation, as the density data is two years older than the flood and waterlogging risk maps.

Component B. Climate Change Context

For climate change analysis two variables will be considered: temperature and precipitation. The regional environmental authority did some estimations for its administrative area,¹⁰ and it found that in the period 2011-2040 the temperature of the municipality of Chía changes between 0,8 and 1,4 °C compared to the period between 1981 and 2010 depending on the climate change scenario,¹¹ as shown in Map 10.



Map 10. Difference of average annual temperature (°C) between the baseline (1981-2010) and the climate change scenario of RCP 4.5 (left) and RCP 8.5 (right) for the period 2011-2040 in the administrative region of the CAR

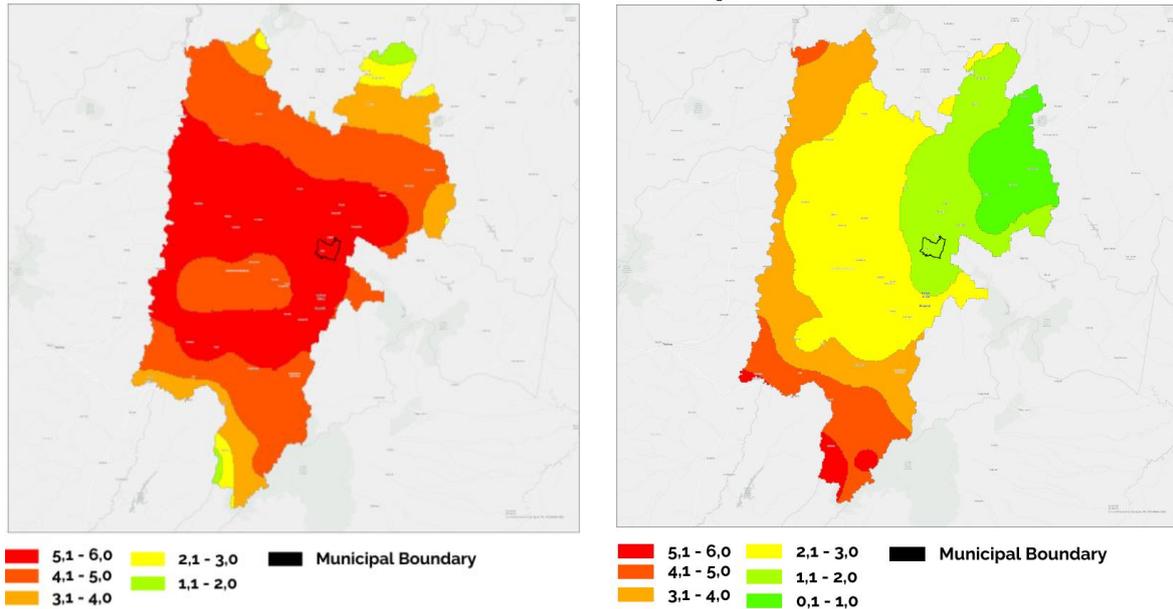
On the other hand, regarding precipitation regional analysis identify the center region of Colombia, where the municipality of Chía is located, as having a positive trend and a strong evidence that in the twentieth-century 100-year flood discharge will occur more often in the future (Merz et al., 2021); this is further confirmed by other complementary analysis of annual increase in precipitation by 2040-2059 is expected.¹² In addition, the departments in the Central region of the country are expected to be nearly twice as likely to experience extreme precipitation events with 100-year historical returns (The World Bank, 2023),

Furthermore, more specific estimates developed by the regional environmental authority shows that the total annual precipitation can change between 1,1 and 6% compared to the period between 1981 and 2010 depending on the climate change scenario, as shown in Map 11.

¹⁰ The administrative area of the CAR includes the following eleven municipalities: Cajicá, Chía, Cogua, Cota, Gachancipá, Nemocón, Sopó, Tabio, Tenjo, Tocancipá y Zipaquirá.

¹¹ For a scenario of RCP8.5 the difference between the baseline (1981-2010) and 2011-2040 is between 1,1-2% more, while in a scenario of RCP 4.5 would be between 5,1 and 6% more precipitation. The RCP8.5 means a worst-case scenario of continued increase in carbon emissions that would lead to a temperature increase above 3°C. On the other hand, in a RCP4.5 scenario temperatures increase between 2 and 3 °C.

¹² The estimation is according to a SSP3-7.0 scenario, which is associated with high emissions due to economic rivalry across countries.

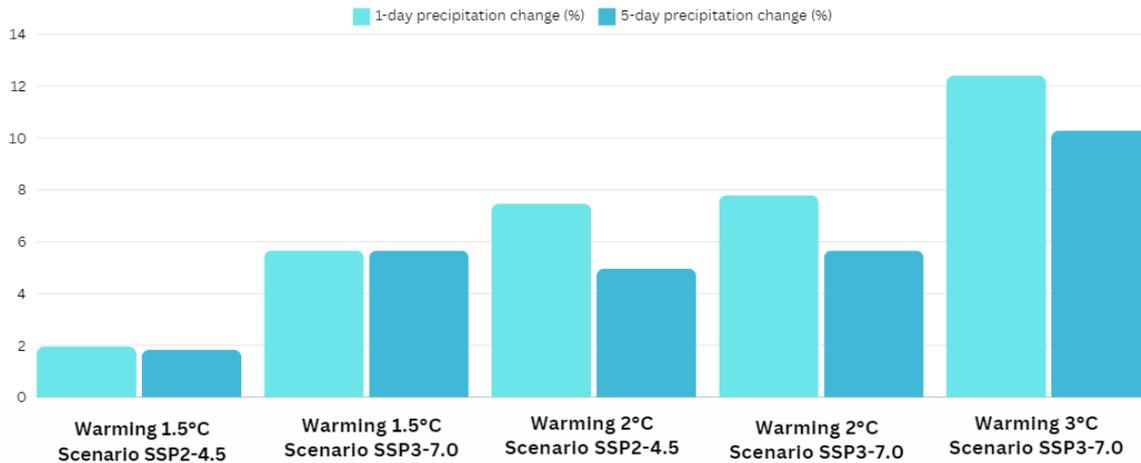


Map 11. Difference of total annual precipitation (%) between the baseline (1981-2010) and the climate change scenario of RCP 4.5 (left) and RCP 8.5 (right) for the period 2011-2040 in the administrative region of the CAR

Regional computations are for annual precipitation, however, based on global data it is able to make estimations in shorter periods of time.¹³ According to Graph 1 maximum precipitation levels for a 24-hour period increases as the world gets warmer, with a maximum precipitation change of 12,41%. Nevertheless, for precipitation levels in periods of 5 days, there is no linear relationship between higher precipitation and higher warming levels; however, it is estimated a maximum precipitation change of 10,29%.

It must be considered that the relationship between GHG emissions and precipitation is not linear and depends on local environmental and climatic conditions, as well as the geographic location.

¹³ For the computations, the climate change scenarios used are from the IPCC WGI Interactive Atlas. The methodology is as follows. First, three variables (total precipitation; maximum 1-day precipitation; maximum 5-day precipitation) and two climate change scenarios (SSP2-4.5 & SSP3-7.0) were considered for three different periods (Warming 1.5°C; Warming 2°C; and Warming 3°C). Second, each raster was resampled using a Bilinear methodology. Third, the information of the resampled raster was summarized per municipality in Colombia using Zonal Statistics and the maximum value per municipality. Fourth, the previous raster was converted to point using 'Raster to Point'. Finally, a Spatial Join was made to assign the value of the point to the municipality boundary.



Graph 1. Percentage change in Maximum 1-day precipitation (%) and Maximum 5-day precipitation (%) in Chia per warming scenario

This data shows that precipitation will increase during the year in climate change scenarios, but mostly it will be more intense in short periods of time.

Component C. Stakeholder Description

There are multiple actors that intervene in flood and waterlogging management in the local level, however there are seven key actors that have the largest influence according to the interviews, including two actors from the national level, one from the regional level and four in the local level.

National Stakeholders

- **Environmental Ministry.** According to Law 99 of 1993, the objective of the Environmental Ministry is to be the governing body of environmental and natural resources of the country, as well as it is the main entity in charge of climate change management.

Regional Stakeholders

- **Regional Autonomous Corporation of Cundinamarca (or CAR).** The Article 30 of 1993 defines the object of the CAR to execute policies, plans, programs and projects on environment and renewable natural resources, as well as comply with and timely apply the current legal provisions on its disposal, administration, management and use, in accordance with the regulations, guidelines and directives issued by the Ministry of the Environment. Nevertheless, its naturality as 'Autonomous' has prevented the effective coordination between the national Environmental Ministry and the CAR.

Local stakeholders

- **Environment Secretary of the municipality of Chia.** The municipal environmental secretary is in charge of defining and implementing environmental policies related to renewable natural resources. Nevertheless, its role is not defined in Law 99 of 1993, which is the Law of environmental management in Colombia. Therefore, the

Environment Secretary, unlike the Environmental Ministry or the CAR, is not an environmental authority. This, therefore, prevents effective coordination with the CAR and the national Environmental Ministry.

- **Civil Defense.** Is in charge of processes for disaster risk management, environmental management and education programs to contribute for human safety. The main duty of the Civil Defense is to reduce risk by, among others, verifying water bodies and fallen trees. In addition, they make environmental education activities, which includes climate change topics. Overall, the civil defense is part of risk control and prevention, but it is not an environmental authority.
- **Community Action Boards (or JACs).** The Article 7 of the Law 2166 of 2021 defines the JACs as community organizations with non-profit and voluntary nature composed by people living in its area.
- **Public Services Company of Chía (or EMSERCHIA).** EMSERCHIA is in charge of providing household public services of water, drainage, sanitation and complementary services in the municipality of Chía.

Component D. Regulatory Context

In order to understand the legal framework in which the local governments are working with and responding to, this section makes an analysis of most recently adopted norms related to disaster risk and climate adaptation in Colombia, with a focus on riverine floods and waterlogging.

The figure 2 represents a summary timeline of the adoption of laws and regulations related to climate change adaptation and disaster risk management in Colombia starting in 1993, that created the Environment Ministry.

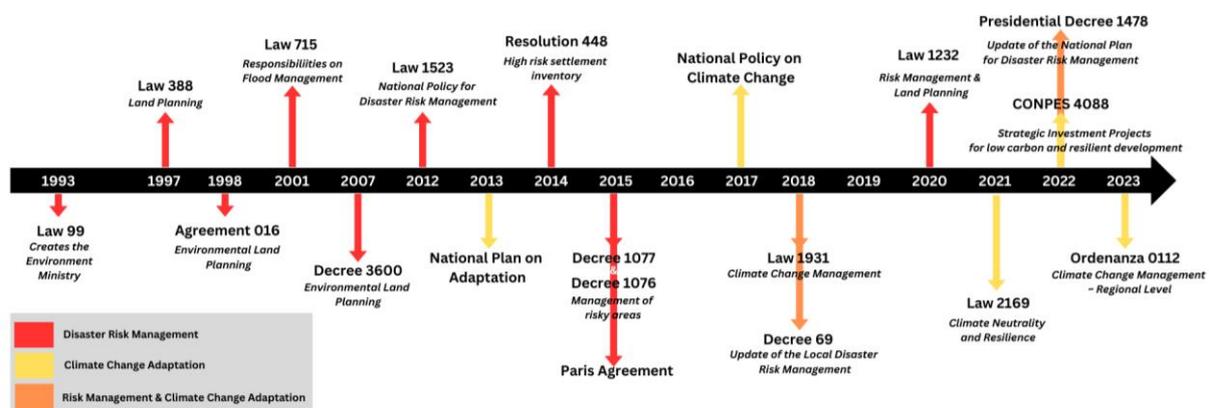


Figure 2. Timeline of climate change and disaster risk management in Colombia

Until 2013, the year in which the National Plan of Adaptation was published, all regulations were focused on disaster risk management. However, it is not until 2018 that climate change adaptation and disaster risk management started to be tackled together. This finding is in line with the fact that until 2018, judges in Colombia used to consider risk management and natural disasters as unpredictable events for local entities, for which it

did not configure a responsibility (Quevedo, 2018). In addition, even though climate change management has been promoted from the national level since 2017, it was not until 2023 that the regional governments developed their own guidelines that must be further implemented at the local level. Local governments and regional authorities have deployed separated actions to reduce risks, but without climate change considerations. Therefore, it took five years to translate a national law that promotes climate change adaptation and disaster risk management intersection into a regional regulation.

D.1. Disaster Risk Management Regulation

Disaster risk management is a requirement for land planning decisions in Colombia. Since 2012, risk management must be incorporated in territorial planning¹⁴ as risk of disasters is a determining factor to organize the territory;¹⁵ for floods and water-related disasters, local governments must promote cofinance and execute the necessary defense actions.¹⁶

To improve territorial planning with a water basin perspective, municipalities must consider, among others, the hydrographic basin planning and management plan, or POMCA. The POMCA helps to identify and characterize present threats, particularly those related with flooding and torrential avenues, among others.¹⁷ Later, human settlements in risk areas must be identified, and analyze if the risk is mitigable or, otherwise, advance in actions for resettling.¹⁸ Therefore, municipalities shall identify and limit the areas of protection and restriction,¹⁹ and establish their use,²⁰ considering environmental characteristics.²¹

Overall, disaster risk management is the responsibility of local authorities.²² Therefore, local governments must develop their Municipal Plan of Risk Management and execute them accordingly, including through the Municipal Councils for Disaster Risk Management.

D.2. Climate Change Adaptation Regulation

Colombia has defined climate adaptation targets for 2030 by law.²³ Furthermore, the Environmental Minister in coordination with environmental authorities and territorial competent entities to incorporate in mitigation actions the massification of nature-based solutions in degraded ecosystems and forest areas.

¹⁴ Article 41, Law 1523 of 2012 ~ *Disaster Risk Management Policy*, Law 1232 of 2020 ~ *Modifications to land planning guidelines*, and Decree 1077 of 2015 ~ *Normativity associated with housing, city and territory*

¹⁵ Article 10, Law 388 of 1997 ~ *Modifies rules for municipal development plans*

¹⁶ Article 74, Law 715 of 2001 ~ *Public Services guidelines*

¹⁷ Article 2.2.2.1.3.2.2.3, Decree 1077 of 2015

¹⁸ Law 388 of 1997 ~ *Land use guidelines*

¹⁹ Law 388 of 1997 ~ *Land use guidelines*

²⁰ Subsection 1, Decree 1077 of 2015

²¹ Article 1, Agreement 016 of 1998 ~ *Environmental guidelines for land planning*

²² Article 40, Law 1523 of 2012

²³ Article 6, Law 2169 of 2021 ~ *Low Carbon Development Law*

The country promotes the adoption of climate change adaptation measures at the local level. Such actions must be identified, evaluated, and prioritized in the Integral Territorial Plans for Managing Climate Change that are developed at the regional level.²⁴ All adaptation actions must be local, participative, and based on territorial needs in order to guarantee long-term efficiency of actions.²⁵

Actions for climate change adaptation can be funded, among others, through a special fund that the national government manages. The National Fund for Adaptation, which is attached to the Finance Ministry, was created after the riverine floods of 2010-2011.

Adaptation actions with higher benefits and the lowest cost shall be prioritized. Actions with higher benefits to reduce impacts on the population with the lowest cost and higher social, economic, and environmental co-benefits will be prioritized.²⁶

At the regional level, the Department has advanced in the identification of adaptation actions.²⁷ The Department of Cundinamarca defines two strategic lines for its climate change management plan. The first one is to implement restoration and conservation actions for ecosystem connectivity (Strategic Line 4). The second one promotes a program for water risk management for climate change adaptation in susceptible municipalities in seasons of low or high precipitation (Strategic Line 5).

D.3. Disaster Risk Management and Climate Adaptation Joint Regulation

In 2018 Colombia started to connect climate change adaptation and risk management in the law,²⁸ defining as one of its principles the prioritization of adaptation actions with the highest risk reduction.

Colombia updated its National Plan for Disaster Risk Management 2015-2030.²⁹ **under the logic of adaptation to climate change to reduce risk of disasters, including measures for floods.**³⁰ Two specific objectives related with floods are to reduce existing disaster risk conditions (objective 3) by resettling people in high risk non mitigable areas and providing guidelines for climate adaptation of houses located in high risk mitigable

²⁴ National Policy on Climate Change of 2017

²⁵ National Plan on Adaptation of 2013, and National Policy on Climate Change of 2017. In addition, working in this direction, in the updated NDC of Colombia from 2021 the country highlights that it has developed maps of climate change risk and vulnerability as well as local vulnerability assessments.

²⁶ Article 2, Law 1931 of 2018 ~ Guidelines for climate change management

²⁷ Ordenanza No. 0112 of 2023 ~ *Regional climate change policy*

²⁸ Article 11, Law 1931 of 2018 ~ *Climate change management guidelines*

²⁹ Related with flooding events, the Environment sector is in charge of making a map of strategic ecosystems for floods risk reduction (program 1.1.2); The Mining and Energy sector must develop a methodology to assess the threat of torrential avenues (program 1.2.2); the National Unit of Management of Disaster Risk is in charge of developing infrastructure to mitigate and protect from floods and torrential avenues (program 3.3.1); finally, the Housing sector must update the resettlement due to disaster risk inventory and support municipalities in the process of at least one resettlement located in a high risk area (program 1.6.10), as well as developing the guideline of climate adaptation for settlements located in high mitigable risk (program 3.2.5)

³⁰ Presidential Decree 1478 of 2022 ~ *Update of the National Disaster Risk Management Plan*

areas; as well as guarantee a prompt, effective and adequate management of disasters (objective 4) by implementing self-protection programs for emergencies, especially in high risk areas.

Local governments in Colombia must incorporate climate change issues in their development and land planning tools taking as reference the PIGCCTs.³¹

At the municipal level, the municipality of Chía updated its disaster risk management plan, which mentions climate change impacts.³² The Municipal Plan on disaster risk management of Chia, which mentions the need to develop municipal studies on the risk associated with climate variability, and risk scenarios for different topics, including long-impact sunshine, excessive rainfall, high and low temperatures, prolonged droughts, and GHG.

D.4. Description of the policies promoted at the regional and municipal level pertaining related to riverine flood and waterlogging risk in Chia

Currently the municipality has neither a public policy or guideline for climate change adaptation, nor one specifically for flooding adaptation. Nevertheless, there are different actions that the local government or the regional authorities have been deploying that directly or indirectly are related to flood prevention. The main key policies are explained next.

Regional Policies

- **River Planning Instrument (or POMCA).** According to the Decree 2811 of 1974, the planning of hydrographic basins is the coordinated management of the soil, water, flora and fauna. The CAR is in charge of this land planning tool. The POMCA of the Bogotá River had a first version in 2006, and was updated in 2019 through the Resolution 957 of 2019. The POMCA considers the Bogotá River and its tributaries, including the Frío river. According to law, the POMCA is the hierarchical superior to the local land planning policy, or POT. The POMCA of the Bogotá River includes actions such as the developing action for the socio-environmental resilience of the river basin, the creation of information systems and early warnings, the management of water supply basins, the strengthening of the governance of the Bogotá River, and the protection and restoration of the ecological structure. Even though this land planning instrument should be aligned with the POT, this has not formally happened as the POT of Chía is from the year 2000 and hasn't been able to be updated.
- **Ruling of the Bogotá River.** In 2004 the Superior Court of Cundinamarca, and an *Auto* issued by the State Council in March 2014, demanded the need to establish real and coordinated actions for the decontamination and sanitation policy for the Bogotá River. The ruling mandates different actions to regional and local governments in order to improve the conservation and risk management in the

³¹ Article 9, Law 1931 ~ Guidelines for climate change management

³² Municipal Decree 69 of 2018

Bogotá River and its tributaries, including the Frío river. The most critical action is the necessity to reduce the flooding risk of municipalities near the river. The action prioritized to comply with this requirement was the construction of dikes. The CAR started to work in 2009 to get funding from The World Bank to advance in the Bogotá River Hydraulic Adaptation and Environmental Recovery Project. The Nation supported this process by issuing the CONPES 3631 of 2009. Throughout the last decade, the CAR has built dikes along the Bogotá River, including in the municipality of Chía.

Municipal Policies

- **Municipal Development Plan (or PDM)**. According to Law 152 of 1994, the territorial entities, including municipalities, must establish their development plans with an investment plan for the mid and long-term. Territorial entities have autonomy for economic development, social and environmental management planning according to their competencies. The PDM has to be updated when a new mayor starts its government period. The PDM that was considered was the one of the periods 2020 to 2023, as the PDM for 2024-2027 is still under elaboration. The PDM includes actions for land planning around the Bogotá and Frío rivers, on environmental education, on the conservation of ecosystems and improving the sustainable drainage system.
- **Territorial Management Plan (or POT)**. The POT is the main land use and planning policy in Colombia, regulated through the Law 388 of 1977 and further specified in the Decree 1232 of 2020. It defines, among others, the areas of ecological protection due to their importance, or because the risk of disasters (e.g., floods) is too high. The POT of the municipality of Chía that is currently in effect is outdated. It was adopted in 2000, when the urbanization, socioeconomic, and demographic situation of the municipality was different from now.³³ Although there have been several attempts to update the POT, it is currently undergoing judicial proceedings following accusations of lack of due process. Therefore, it remains in effect until the case is resolved.
- **Comprehensive Solid Waste Management Plan (or PGIRS)**. According to Decree 1077 of 2015, the PGIRS is the planning policy developed by one or more territorial entities for solid waste management over a certain period of time. The PGIRS is further regulated by Resolution 754 of 2015. The PGIRS includes actions of waste management education with schools and households, specific work with recyclers and large generators, the collection of specific wastes such as warehouses, as well

³³ While in 2005 the population of Chía was 97,444 people, in 2018 it reached 132,181 according to censuses. More specifically, while in 2005 young people between 15 and 19 years old represented 38.7%, in 2018 it represented just 28.6%; similarly, in 2005 kids between 0 and 4 years represented 9.4% of the population, in 2018 it represented just 6.1%. In addition, people in labor age, between 20 and 59 years old, increased from 51.9% to 58.4% (Alcaldía Municipal de Chía, 2020a). The economy of the municipality has also changed. Its participation in the value added of the Department of Cundinamarca increased from around 4.2% in 2011 to 5.37% in 2021. Such increase was promoted due to the increase of the tertiary sector (i.e., services, commerce, transport and communication) that has increased from around 1000 billion COP in 2011 to 3150 billion COP in 2021; on the contrary, between 2011 and 2021 the added value of primary (i.e., agriculture, livestock, mining) and secondary (i.e., industry and construction) economic activities have remained relatively stable around 29.34 billion COP and 345.05 billion COP, respectively (DNP, na). This panorama implies changes in socioeconomic conditions that have different demands on public services and infrastructure, increasing pressure on natural resources by developing actions in new areas that can have disaster risks, such as flooding.

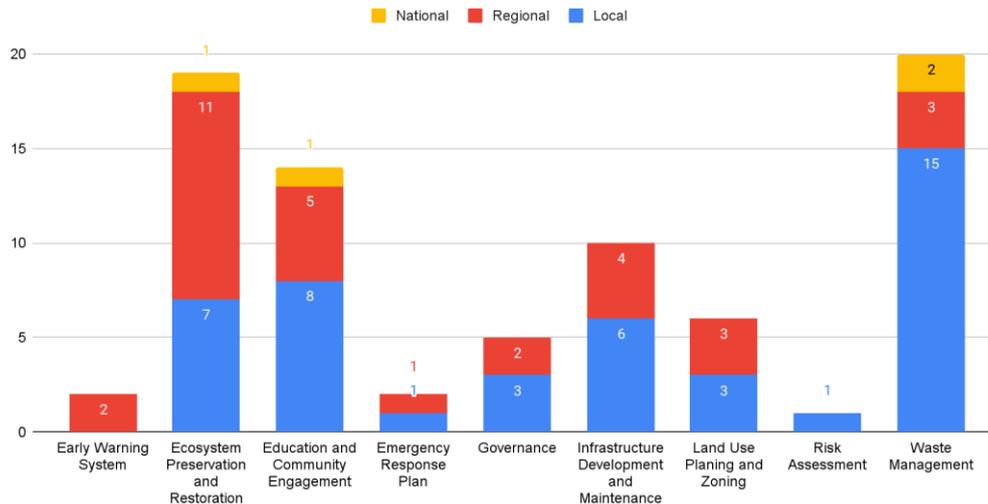
as strengthening the tree pruning. Chía, particularly, has its own PGIRS which is mainly in charge of the company of public services, or EMSERCHIA

- **Municipal Disaster Risk Management Plan.** The municipality of Chía has its own disaster risk plan, issued in 2018; although currently it is being updated through Decree 199 of 2023. Actions related to flood management include studies for risk identification, strengthening of monitoring systems, the adequation of river basins, the identification of assets in critical threat points, the cleaning of river sediments, and the deployment of education campaigns.
- **Drainage and Sewage Master Plan.** The Municipal Decree 26 of 2017 defines this plan and specifies that the actions contained in this plan are transverse to all planning instruments of the municipality.
- **Municipal Environmental Management Plan.** Adopted through the municipal Decree 73 of 2018, it seeks to protect the main ecological structure of the municipality. This plan includes actions such as controlling urban expansion, the development of co-management actions for environmental planning, the execution of environmental education processes, the management of underground water systems, the recovery and conservation of the ecological structure, as well as of protected areas.
- **Community Development Plans.** The JACs must develop their own Community Development Plans according to Law 2166 of 2021. However, up to date none of the JAC has developed its plan.
- **Sustainable Drainage System Plan.** The municipality of Chia has a network of drainage systems above ground. However, these are normally obstructed and have not been maintained. The municipal government developed a strategy to improve the system in an area of the municipality, which includes actions for the reconfiguration of 100% of the total length of the drainage channel, the construction of 100% of the drainage crossing structures, and the construction of 100% of the length of pipes for water management.

Component E. Description & Analysis of Current actions adopted by Chia municipality

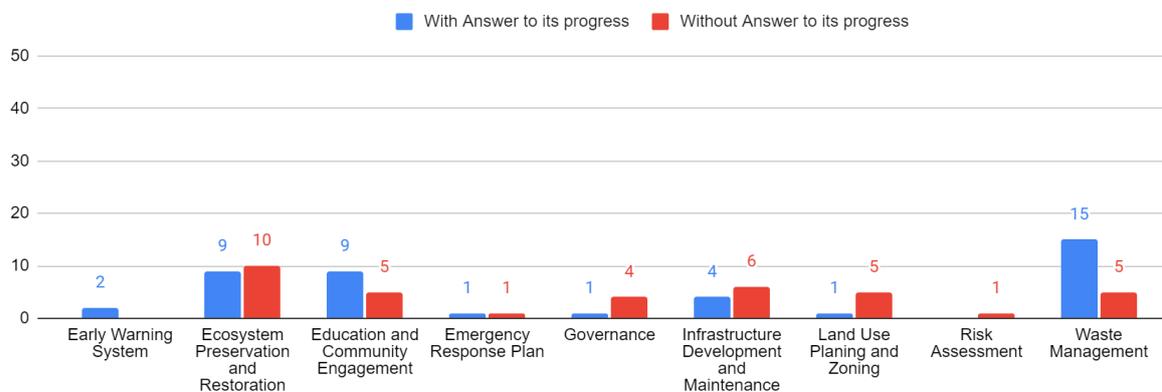
A total of 79 actions in the different policies cited above were found to be related to flood management. Each of these actions were categorized according to their geographical scope (e.g., National, Regional, or Local), the type of instrument in which it is established (e.g., Regulation, Guideline, or Legal requirement), and its topic (e.g., Risk Assessment and Management, Land Use Planning and Zoning, Infrastructure Development and Maintenance, Education and Community Engagement, Ecosystem Preservation and Restoration, Waste Management, and Governance).

The majority of the actions are focused on waste management (20), followed by ecosystem preservation and restoration (19), and education and community engagement (14), as shown in graph 3. In addition, the majority of the actions come from the local level (56%), followed by the regional level (39%), and the national level (5%).



Graph 3. Geographic coverage of the actions and their topic

It highlights that the actions for which there is a response to their progress are concentrated in waste management, while those related to ecosystem preservation and restoration are the only ones in which there is less response; as shown in graph 7.



Graph 7. Topic of the actions and response to their progress

E.1. Assessment of the actions

To assess the actions, petitions were sent to the local government to identify the level of progress of their implementation. In addition, the OECD framework for flood management assessment was used. The actions will be divided by those related with riverine floods, those related with waterlogging, and those that are for both such as education and participation.

E.1.1. Actions to prevent riverine overflow

There are four types of actions related to riverine floods management: land use planning, emergency response plans, ecosystem conservation and restoration, and dikes building.

First, **the main action related to land use is the update of the territorial development plan and its homogenization with other land planning tools, including the POMCA and**

the community development plans. Land-planning remains disordered until the court³⁴ defines what can be done and which territorial planning plan comes into effect. Despite this, the local government has decided to make some progress for updating the POT again and homogenize it with the POMCA; this process [Target 50 of the MDP] has a progress of 68.75%, as the local government recognizes the uncertainty surrounding its update due to judicial constraints. Despite this, the municipality has advanced in mapping flood risks, studies that were already approved by the CAR³⁵ The process to identify high-risk flood areas, considering all river flows in the area of the municipality, is defined by law and although it considers maximum return periods, it does not consider climate change scenarios. According to one of the interviewees, Colombian law is not designed to respond to the uncertainty of climate change. It is too difficult to design a system based on projections, including land planning. Nevertheless, the findings are useful to guide the policies: in rural areas, 2.43% of the territory has a high threat, while 97.08% has a low threat and 0.5% a medium threat (Alcaldía Municipal de Chia, 2022c).

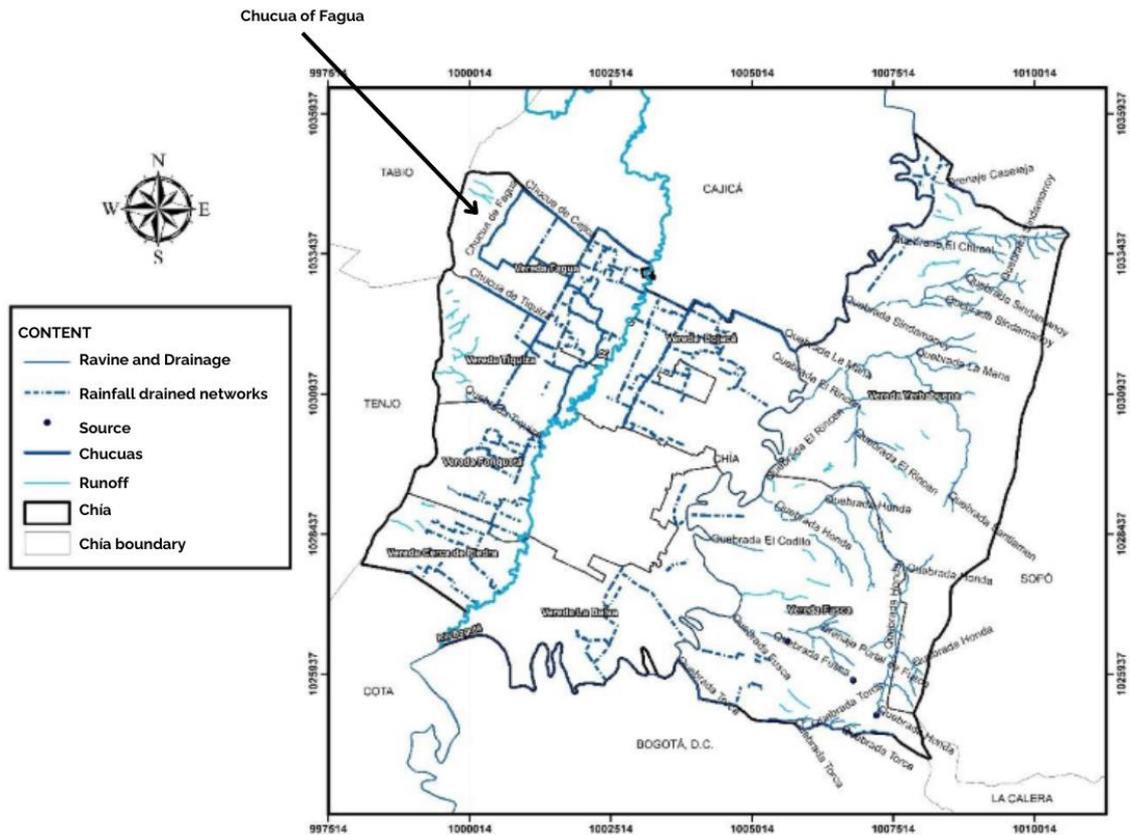
Second, on **emergency response plans and early warning systems** the local government mentions that it provides training on risk management, and it updated in 2022 the municipal risk management plan, and emergency response strategy, for which the socialization is on implementation. When there are floods, the Civil Defense is in charge of putting motor pumps, according to one of their workers. In addition, the fact that the most in-risk areas are highly expensive neighborhoods, make things more complicated. As one of the people formerly involved in evaluating flood risk situations, there are socioeconomic differences that don't allow everyone to get into those spaces, even if you are from a public authority. In addition, to promote socio environmental early warnings [Target GB 122 of the POMCA], as well as in the process of creating an information system for disaster risk management and climate change for the Bogotá River basin [Target GIRB413 of the POMCA] the municipality just provides support when required by the CAR.

Third, **the actions related to ecosystem conservation and restoration are mostly concentrated in two: reforest and restore water sources by cleaning the sources, as well as protect the ecological structure of the Bogotá River basin and its tributaries such as the Frio river.** On the first measure, actions to conserve land and water sources [Target 57 of the MDP] have had a progress of 64% from 2020 to June 2023. In addition, local governments must work to restore key ecological areas [Target EE211 of the POMCA], as well as restore fragmented areas [Target EE214 of the POMCA] where there are reforestation and maintenance activities projected for areas prioritized by the CAR, for which a landscape management tool project is being formulated. The *chucua de fagua*, a wetland, specifically, was repeatedly mentioned by the community and the authorities as a key point to prevent floods in the municipality; the location of this water body is shown in Map 12. The community mentioned that it was plugged, so if it rains heavily one day, a flood is created. In addition, this water body has been taken for waste waters of nearby neighborhoods, so its level increases faster. The mayor's office has been looking at this topic and they did their own study to analyze this. However, the environmental

³⁴ The court is part of this process as the last POT developed was sued for inconsistencies in its design and lack of citizen participation.

³⁵ The municipality considered information related to hydrographic basins, precipitation per day and area, spatial variation of precipitation, maximum flows, as well as past flooding episodes.

autonomous authority didn't recognize such study and they are doing their own. The community mentions similar problems with other Chucuas in the municipality.

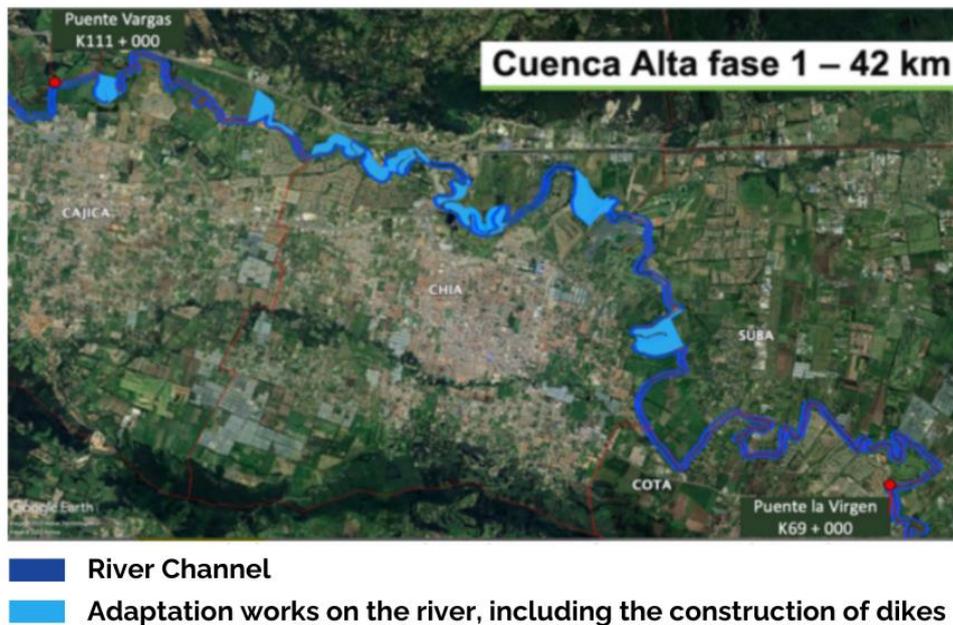


Map 12. Water network of the municipality of Chía. Taken from Alcaldía Municipal de Chía (2020)

On the second measure, to protect the main ecological structure of the Bogotá River basin and its tributaries [Target EE222 of the POMCA], an analysis for implementing payments for ecosystem services is being carried out by the local municipality. In addition, at the basin level an improvement in the integrated management of water basins [Target GB114 of the POMCA] by reforestation and maintenance activities, as well as awareness campaigns on environmental protection and waste management was reported. In addition, the eco-development of the basin [Target GB115 of the POMCA] is promoted by granting to properties that allocate an area of their land for protection a differential tax rate. Nevertheless, according to a worker from the Civil Defense and a member from a local JAC, the Environment Secretary nor the CAR or the Police actually protect the surroundings of the rivers. The worker from the local Civil Defense highlighted that even though there haven't been problems with humans when water levels increase, often they need to rescue animals, mostly cattle.

Related to protecting the ecological structure of the Bogotá River, the CAR has built dikes along the Bogotá River, including in the area of the municipality of Chía, as shown in Map 13. They argue in favor of this measure as there are high density areas in which the risk

was too high and, therefore, had to be mitigated.³⁶ Therefore, the dikes started to be made in the middle basin, as the flood risk was higher and there was more population.³⁷ Overall, the aim, according to the employee from the CAR, is not to ensure that the river does not flood, but rather that it floods in a controlled manner. It highlights that the actions were made only in the Bogotá River, and not in the Frio river or their confluence.



Map 13. Location of Hydraulic Adaptation Works in the Upper Basin of the Bogotá River. Information provided by the CAR.

During interviews the lack of knowledge sharing on the status of the dike's development from the CAR to the local government was clear. Workers and former workers of the municipality mentioned that the mayor's office and the environmental authority do not talk to each other and the relationship is limited to the case in which the environmental authority is going to do something in the area. Therefore, the articulation is absent. On this, the interviewee of the environmental authority mentioned: "Neither the municipality is the authority of the river, nor does the CAR give planning guidelines." Despite this, the CAR mentions that they have made public participation spaces, once the projects are ready to go.

It is not just the local government that is unaware of the level of progress on the measures, but also the local communities, that, according to representatives of the JACs, mentions that commitments made by the CAR have not been met regarding nature restoration processes, the construction of the lineal park,³⁸ and there are also concerns on the long-

³⁶ The community mentioned that although the dikes were in fact necessary to protect residential sectors, that risk was created by the same environmental authority that in the past allowed high-expensive neighborhoods to be built

³⁷ According to an employee from the CAR, this was the first time that dikes were built as a coordinated strategy, as historically the river has been modified by landowners that modified the ecosystem by cutting the curves of rivers, for instance.

³⁸ Regarding the lineal park, it was declared as a passive restoration. The community mentions that during the participation period the environmental authority promised a park along the river, which has not happened until now. In addition, the community mentions that the problem with the lineal park is about planning. This, as in the municipality of Chía, unlike other areas closer to Bogotá where the lineal park has been built, the people

term efficacy of the dikes. Regarding the nature restoration processes, the CAR recognized in the interview the possible impacts of dikes on the ecosystem and stressed that restoration actions must happen after the adjustments in order for the soil to settle, otherwise the trees, for instance, won't prosper, as well as sometimes they have to cut trees as the roots can damage the dikes. Nevertheless, as the community understands that the CAR is not doing the restoration, they mentioned in the interviews that they are doing some reforestation activities. The lack of communication can lead, then, to problems in the quality of the dikes in the future.

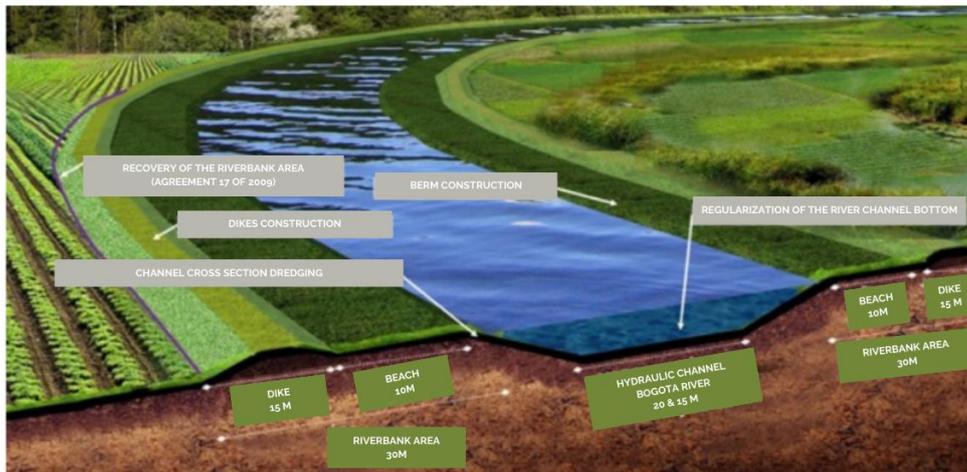


Figure 4. Main characteristics of the dikes built in the upper basin of the Bogotá River. Illustration made by the CAR

Figure 4 presents the main characteristics of the Bogotá River after the adjustments made by the CAR, such as the beach and the dikes. This includes the hydraulic channel of the Bogotá River (~15-20 m), throughout which there is a riverbank that has a width of approximately 30 meters and is composed by a dike (~15m), that prevents the river to overflow, and the beach (~10m), that slow the velocity of water or redirects it to areas less susceptible to erosion or in which flood is controlled better.

Regarding the long-term efficacy of the dikes, the community see it, according to the interviews, as a palliative action that will work for a while, but not in the context of climate change as the capacity and characteristics of the river would change. Representatives of the JACs mentioned that some dikes were made over the wetlands, blocking natural water flows, which would affect ecosystems' functioning (Schipper, 2020). In addition, a Councilman highlighted that the dikes do not have maintenance protocols and their construction were made without studies. Former workers of the Environment Secretary mention that the adjustments to the river make no sense; dredging makes no sense, because one of the river's functions is to move sediment.

Even though dikes are a cost-effective measure in highly populated areas, having positive effects such as protection from direct risk of injuries or damaging key infrastructures, or address existing inequalities, this infrastructure require high investments for construction

that are around the river are high-expensive houses, not poor people. There is a forced displacement of rich people that do not like cow smell, to poor people.

and maintenance, as well as can give a false sense of complete security in flood-prone areas (Jongman, 2018). In a case of failure, there can be larger impacts as commonly these structures create a feeling of safety. Then, it is important to monitor and maintain it constantly (World Meteorological Organization, 2017). Therefore, the effectiveness of dikes depends on the functioning of the system as a whole, as there are different design conditions that can lead to failures (World Meteorological Organization, 2017).

Overall, local entities mention that the environmental authority must have a stronger say and increased participation in the management of the dikes and the river adjustments. In addition, the community mentions that the Environment Secretary always takes the CAR as an 'excuse' not to act. According to the Environment Secretary, their work with the CAR is limited to submit complaints when it is the case, as well as support environmental education activities.

E.1.2. Actions to prevent waterlogging

Actions for waterlogging risk control can be grouped in two: waste management improvement and drainage network development.

First, regarding actions on waste management for waterlogging prevention, there are four actions on waste collection, and five on improving management from the source.

On waste management collection, entities are required to update the PGIRS, for which the contractual process is open in the local municipality. This includes the improvement of the work with the local collectors, and the promotion of young environmental leaders [Project 24 of the PGIRS], which has a compliance of 100% in 2022]. During 2022, the municipality worked with professional recovery personnel by updating their census [Project 17 of the PGIRS], as well as promoting their recognition and visibility [Project 18- PGIRS] and their participation in an interinstitutional table [Project 19 of the PGIRS]. These activities had a compliance of 100% in 2022. Nevertheless, there is no available public assessment of the role of the local police to avoid people throwing waste into water bodies, among others [Article 100 and 111 of the Police Code], as well as to the drainage system [Article 280 of the Police Code].

On improving waste management from the source, from 2020 to June 2023, the control of polluting sources [Target 59 of the MDP] had a progress of 57% by having technical visits, and campaigns. In addition, the management of special waste [Project 22 - PGIRS], including construction waste [Project 23 of the PGIRS], large generators of solid waste [Project 6 of the PGIRS], and solid organic waste [Project 8 of the PGIRS] had a compliance of 100% in 2022. For all of this, the regulation on warehouses and collection centers has been improved [Project 16 of the PGIRS]. In addition, waste management is in charge of improving the process of tree pruning, including a tree registry and inventory [Project 4 of the PGIRS] to avoid blockages; this had a compliance of 100% in 2022. Overall, the improvement in the quality in the provision of recollection and transport of waste [Project 2 of the PGIRS] reports a compliance of 100% in 2022; EMSERCHIA, specifically, identifies key areas and times for waste disposal. Nevertheless, an employee from the CAR highlighted that the blockage of water bodies it is still a high problem in the rivers of the

region and stressed that it is a problem of citizens' habits as people need to stop throwing away condoms, wet towels, cooking oils, wheel's' cars, etc., in spaces that are not for this purpose.

Second, regarding the drainage network development, the community denounces that uncontrolled construction licenses lead to flood risk. For instance, the community mentions that some neighborhoods use certain ecosystems as a repository for drainage water, which in the end increases the water level of ecosystems that have not been fully recognized, as mentioned before, but that are similar to swamps. Therefore, as it rains harder, the volume of water is harder to manage. In addition, the storm sewer is interrupted and mixed with the sanitary sewer. Then the wastewater treatment plants are not going to work. Moreover, the municipality has the duty to maintain 100% of the ditch network [Target 58 of the MDP] from 2020 to June 2023 the target had a progress of 62.38%, and highlights the formulation of the plan for the fences in the western sector of the municipality.

E.1.3. Broader societal actions to reduce riverine flood and waterlogging risks

Besides the targeted technical actions reviewed above, we should also consider four types of broader societal actions that can further reduce riverine flood and waterlogging risks: environmental education, knowledge sharing, community engagement and communication, and better collaboration among actors.

First, on environmental education there are four types of actions: campaigns to the general public, targeted campaigns, improvement of public servant's knowledge, and knowledge sharing and creation. On campaigns to the general public, these are mandated to be focused on ecology, responsible consumption practices, sustainable lifestyle, organic route, reduction of single-use materials, fauna protection, circular economy, separation at the source and conservation of the eastern and western hills, among others. For this, the municipality has an interinstitutional committee for environmental education. To raise awareness on environmental issues [Target 60 of the MDP] from 2020 to June 2023 the local government has had a progress of 82%. Regarding targeted campaigns, there have been efforts to work with the industry, although no actions on this was reported, and with households on solid waste management [Project 15- PGIRS], with a compliance of 100% in 2022. In addition, for improving public servant's knowledge, there are provisions to educate municipal administrators on waste management [Project 12 of the PGIRS], which is reported with a compliance of 100% in 2022. Finally, the municipality assists to trainings and meetings scheduled by the CAR, provides support to community and school environmental projects, also known as PRAES and the PROCEDAS.

Second, in knowledge sharing, there are efforts to monitor environmental school projects (or PRAES). From 2020 to June 2023, an advance of 82% was registered. [Target 60 of the MDP], while the support to PRAES related to waste [Project 13- PGIRS] reports a

compliance of 100% in 2022. In addition, the environmental regional autonomous authority is required to consider local municipalities to build technical-scientific knowledge for socio environmental resilience [Target GBB132 of the POMCA]. Finally, local governments must work with rangers to prevent fires and provide environmental education [Target GB116 of the POMCA], for which a forest ranger team is hired annually; as well as promote knowledge sharing for the management of the basin's water sources [Target GB131 of the POMCA], for which an alliance with the Governor office for science and innovation is being in works.

Third, on actions related to community engagement it includes improving the participation of the community on flood prevention and ecosystem conservation. To provide integral participation with the Bogotá River [Target GBB121 of the POMCA] the municipality just provides support when required by the CAR. However, according to a member of a local JAC the participation spaces that the CAR opens are poorly managed. For instance, the entity developed dialogue workshops on the dikes building but the information provided was poor. In addition, the local government has the duty to help in the development of the Citizens projects of environmental education (or PROCEDAS), which registered a progress of 82% from 2020 to June 2023. However, it was not possible to access the topics of such projects in order to analyze their relationship, or not, with flood management actions.

Finally, **on collaboration among actors**, as a former environment secretary of the municipality and members of the community mention, there is a complete disconnection between the mayor as local authority and the CAR as environmental authority. According to a councilman and a former environment secretary, the articulation between the CAR and the environment secretary is practically just in the political arena, and not in the technical one which leads to a disarticulation of competencies. According to workers of the Environment Secretary, the relationship between both entities is restricted to complaints resolution but about information sharing, or related. The disarticulation between both environmental actors is evident to local communities, according to the interviews conducted with the members of the local JAC. In addition, the community mentions that the environmental secretary always uses the CAR as an excuse to not do anything.

Component F. Gaps Description

To identify the gaps, the actions will be divided into those related with riverine floods, those related with waterlogging, and those that are for both such as education and participation.

F.1. Gaps in Riverine Flood Adaptation

Main gaps found related to riverine floods include policy gaps, information gaps, and accountability gaps,

First, two main policy gaps were found. On one hand, as exposed in the introduction of this policy brief, one of the principles of climate change adaptation is not to rely on just one action. However, from the interviews it was clear that all actors are depending on just one action to guarantee the risk reduction from riverine floods: the construction of dikes. Even though this action has reduced the number of people exposed to high flood risk, their long-term quality is a concern of the community and former employees of the local environmental secretary.

On the other hand, the delay in the update of the local territorial planning tool, or POT, represents a risk for the efficient interaction with the river planning tool, or POMCA. This represents a high vulnerability to the municipality in order to adapt to climate change, as it limits the possibilities of the local government to define the use of certain areas, as well as guarantee the conservation of others. According to an employee from the CAR, land planning and risk control is a constant trade off that limits municipalities from developing and, as the land planning tools have not been updated in more than two decades, risk was not correctly measured and has not been completely integrated in the zoning of the municipality. The lack of update of the land planning, according to a Councilman and a member from a local JAC, also was the reason for the construction of the dikes, as highly expensive neighborhoods were granted permission for construction in the surrounding of rivers and, therefore, the dikes were necessary for their protection.

Second, on information gaps it was found that it is difficult for people to access information related to the construction of the dikes. Although it was highlighted that the information is shared in participation spaces, up-to-date information and manipulable data is hard to find and, therefore, must be requested. The lack of access to proper information can be leading to problems for the long-term efficacy of the measures as local representative bodies are developing bottom-up initiatives on ecosystem restoration that can affect the long-term quality of the dikes. In addition, information related to river management with climate change considerations is still lacking. Nevertheless, the Universidad Nacional is doing research on climate change impacts on floods and its governance; however, although the CAR is helping, it is not clear so far how such exercise will be used.

Third, on accountability gaps, although there are many widespread reforms and changes that can affect the allocation of responsibilities for flood management, the characteristic that affects the most is the environmental management structure in the country. The Law 99 of 1993 creates the Regional Autonomous Environmental Authorities that has limited the coordination of the national, regional and local levels on environmental affairs. As they operate in an autonomous way, according to the interviews, the responsibilities of actors are not clear and not commonly known. In addition, there are no mechanisms to assess performance/effectiveness, gaps and overlaps in the regulatory framework. The only space for stakeholders to meet is in some meetings part of the ruling of the Bogota River, required by the court; however, its scope is much broader, and, therefore, flood management can be overlooked. Even though no conflicts among stakeholders were found, it is possible that these arise as part of conflicting/overlapping policies, most of all considering that there are no mechanisms to mitigate conflicts around flood-related policies. To the best of my knowledge, there are no instruments in place (e.g., Cost-benefit analysis) that are being used to improve stakeholder engagement.

F.2. Gaps in Waterlogging Adaptation

Main gaps found related to waterlogging include policy gaps, accountability gaps, and information gaps.

First, on policy gaps, even though the municipality has actions related to sewage infrastructure needs and the development of sustainable drainage systems, its implementation has been slow and focused in certain specific areas of the municipality. In addition, even though waste management actions are easier to track, its interaction with other areas such as environmental education is critical, but there are duplications in actions across actors, which implies a gap in the accountability.

Second, on information gaps, as the municipality does not have a cohesive policy to deploy actions intended to reduce riverine floods and/or waterlogging risks, the information is widely spread, which makes its tracking highly complicated. This also leads to uncertainties from the community, as was identified during the interviews.

F.3. Gaps in Broader Societal Riverine Flood and Waterlogging Management

Main gaps found related to waterlogging and floods include administrative gaps, capacity gaps, and policy gaps.

First, **on administrative gaps** even though the roles and responsibilities of the different stakeholders are defined across laws and decrees, there are uncoordinated and ineffective actions due to lack of communication, which translates in the lack of collaboration among actors, as mentioned before. From the interviews, it is possible to analyze that the biggest blockage to innovative governance is the fragmentation of institutions and responsibilities that prevent real action from the local government. In environmental education, for instance, is where most actors converge. However, the coordination between different authorities is lacking and, therefore, there is a juxtaposition of actions between the PGIRS, the MDP, and the environmental management plan which efficiency can be amplified with better coordination,

Second, **on capacity gaps, even though as it was described there are different actions related to environmental education to the general public**, it was evident during the interviews the lack of knowledge from the local government on topics related with ecosystem management and climate change, which can further translate to un updated information shared with the community in the knowledge sharing spaces. This was further recognized by different people in the local government. Nevertheless, all showed their willingness to learn more about it and how to integrate it in the local policies.

Third, **on policy gaps** it highlights that during the assessment of the actions, the consideration of climate change is lacking on environmental education, knowledge sharing and during the coordination among actors. None of the policies analyzed explicitly mention climate change as a key variable to consider when designing specific actions.

This is in line with the information provided by the workers of the Environment Secretary who mentioned that they do not have any action in the moment that considers climate change. Furthermore, according to representatives from the JACs, climate change is being considered in the local government just to comply with the Sustainable Development Goals (SDGs), but not from a technical perspective.

In addition, it is necessary to identify the people that are still living in areas of high risk of floods, as initial estimations confirm the presence in 2020 of people within them. Their social and economic conditions must be analyzed, to deploy actions for their protection based on their needs.

Component G. Problem Definition

The municipality of Chía, and the environmental authority to which it is subscribed have deployed numerous actions to address flood risks from riverine overflow and waterlogging, both the highest threats according to historical events and current estimations.

Nevertheless, the lack of a comprehensive and integrative policy for adaptation to riverine floods and waterlogging with a climate change consideration has led to an overreliance on single actions such as dikes, a lack of integration between planning tools that can exacerbate vulnerabilities, and a fragmented environmental management structure that hinders effective coordination and accountability.

Component H. Policy Recommendations

The necessary actions to reduce flood vulnerabilities in the municipality of Chía do not have to start from zero and, therefore, must be leveraged by current efforts taken by different directions and authorities, and from national to local actors.

The actions proposed are divided into those related to riverine floods, those related to waterlogging, and those in which the national and local stakeholders must work together.

H.1. Actions required regarding the adaptation to riverine floods

In the first place, the construction of the dikes is already the main action to reduce flood risk. Therefore, from now on the main task is to guarantee their long-term maintenance. For this, it is necessary to foster the articulation across territorial entities and local communities to identify on time places where the dikes need to be reinforced, as well as improve the collaboration in the restoration process. In addition, municipalities must guarantee a session of up-to-date information on strategic projects related to the environmental authority.

Secondly, the municipal government must advance on improving knowledge on climate change affairs in its staff, particularly the Secretary of Environment. Climate change must

start to be considered as an integrative risk and opportunity for the coming years. This action also improves waterlogging adaptation.

H.2. Actions required regarding the adaptation to waterlogging

Firstly, the municipality of Chía must increase infrastructure investments to grow and separate the drainage network, while also taking advantage of interventions that do not require making holes in the streets to introduce sewage, since in the interviews it was a great concern of the government. Recognizing the complexity of changing drainage systems, adaptive measures at the ground level are easier and cheaper than infrastructure changes, which includes sustainable drainage systems,³⁹ and the introduction of permeable surface infrastructure. On ground level infrastructure, it has been found that the adoption of blending green infrastructure, combined with gray infrastructure, such as the expansion of formal drainage, has a higher net benefit; examples include New York City and Copenhagen. Therefore, it is key to incentivize or require permeability in properties by adapting permeable asphalt on the city's streets, parking lots, and driveways, as well as the incorporation of award points (e.g., Malmö, London, Seattle) (C40 Cities Climate Leadership Group & C40 Knowledge Hub, 2021a; C40 Cities Climate Leadership Group & C40 Knowledge Hub, 2022). The municipality can also advance with a climate risk assessment that identifies needs and opportunities to upgrade green space and infrastructures. Examples of such analysis include Rotterdam, Melbourne, Paris, Buenos Aires and Austin (C40 Cities Climate Leadership Group & C40 Knowledge Hub, 2021b). In addition, on sustainable drainage systems, a member of the local JAC highlighted the importance of promoting the 'Care Crews' (*Cuadrillas de Cuidado*) can be promoted together with the JACs, with clear schedules to keep the sustainable drainage clean, as well as trees well pruned so that there is no risk of them falling.

Secondly, the municipality of Chía needs to locate better and above the ground the disposal sites, as well as timely identifying any blockages to water canals (C40 Cities Climate Leadership Group, 2020). For this, technology can be used to improve efficiency. In Cameroon, for instance, drones have been used to identify blockage to drainage and rivers (UNDRR, 2023).

In third place, the municipality needs to integrate waterlogging risk reduction with other priorities such as the lack of public green space and roads. For instance, in London the Sustainable Drainage Action Plan is intersected with the Transport Strategy to adapt impermeable surface to drain (C40 Cities Climate Leadership Group & C40 Knowledge Hub, 2022). In addition, in China the concept of sponge cities has gained traction. This refers to the consideration of natural forces to drain water when upgrading urban drainage systems, to promote natural accumulation, penetration, and purification. The promotion of this type of urban planning has also led to other indirect effects, such as an increase in the houses where urban water management improves (i.e., sponge city program) because its

³⁹ Sustainable Drainage Systems are actions to manage rainwater and reduce risk of flooding and water pollution, reducing pressures on sewerage networks, improving ecosystem services and biodiversity conservation (Graham et al., 2012).

risk for waterlogging decreases (Xu et al., 2024).

In fourth place, the municipal government must work together with the judicial system to reach an agreement on how to proceed with the update of the land planning tool, or POT, as it is critical for the municipality to define land uses according to current and future priorities and vulnerabilities.

Finally, the municipality needs to advance in the formulation of a climate adaptation plan according to climate variations. The municipality must prioritize actions with a twofold objective: advance in adaptation to floods and address current socio-economic problems. This can include actions to bring people closer to the main ecological structure to generate environmental awareness; the use of rivers' buffers as public spaces and mobility axes to generate an ecological corridor between the Majuy hill with the western hill through the Bogotá River; the development of recreational parks;⁴⁰ among others (PROBOGOTÁ & Cámara de Comercio de Bogotá, 2022).

H.3. Actions that require national and regional efforts

Starting with the national level, it is necessary to improve overall performance through effective articulation. Colombia needs to modify the Law 99 of 1993 in order to i) clearly define the role of local Mayors on environmental affairs, as highlighted by a former environment secretary; ii) foster a real articulation between the environmental authorities and the municipal environmental secretaries, starting with a required meeting when the local mayors change to make a review of the processes and projects that the local mayor has with the CAR. In the regional level from the municipality of Chía, this can be fostered through the recently updated (*Ordenanza* No. 0112 of 2023) Integral Territorial Management Plans for Climate Change (or PIGCCT).⁴¹ One of the objectives of this plan is to incorporate climate change in municipal land planning, as well as coordinate and evaluate climate change actions; to keep track of this, there will be an information system for the integral management of climate change at the department level.

On the other side, the environment secretary must be defined as the entity in charge of articulating climate change adaptation actions, including for floods, as recommended by a Councilman. Such space is necessary to guarantee an efficient transversality of actions, avoiding doubling efforts and preventing gaps of action. This can help to further improve the articulation between the regional environmental authority, CAR, and the Environmental Secretary of the municipal government.

⁴⁰ Parks can also be incorporated to improve overall wellbeing. PROBOGOTÁ & Cámara de Comercio de Bogotá (2022) did a study to understand the main areas in which these spaces can be developed, prioritizing two within Chía: Parque de la Sabana (18,79 ha), and Parque de los Andes (49,85 ha); these spaces can develop nodes of cultural, sport and recreational interest, as well as improve tourism.

⁴¹ These are an instrument for territorial entities and environmental authorities to identify, evaluate, prioritize and define climate change adaptation and mitigation actions.

Component I & J. Prioritize and Monitor the Interventions

The actions prioritized are those over which the municipality of Chía has more control, as these do not depend largely on third actors or law updates. The following table presents the time horizon of the action, its topic, its description and the indicator to assess its progress.

Execution Horizon	Topic	Action Description	Following Indicator
Immediate execution	Responsibility change	Modify the responsibilities of the Environment Secretary of the municipality of Chía to articulate actions related to climate change, particularly related to precipitation increase; track the actions and ask information to the CAR about all the actions that they have implemented or are implementing in the municipality territory.	Add the tasks described as responsibilities of the Environment Secretary in the update of the PDM.
Immediate execution	Land planning and use	The municipality of Chía must update as soon as possible its POT that was designed more than twenty years ago with a population of less than half what it currently is. Land planning and use definition is crucial for ecosystem conservation and risk control. It is recommended to work closely with the judicial system to reach a decision as soon as possible.	POT updated
Immediate execution	Stakeholder Articulation	Set a session of up-to-date information on strategic projects related to the environmental authority at the beginning of each change of administration	Update the government change guidelines
Immediate execution & Long-term permanence	Capacity-building & knowledge sharing	Develop capacity building spaces for the local government staff on climate change and its impacts.	Number of capacity building spaces to local government staff on climate change affairs
Immediate execution & Long-term permanence	Environmental education aligned with Climate Change	Strengthen the climate change adaptation and risk control on environmental education campaigns and programs	Number of environmental education programs that include climate change as an integrative factor
Medium term execution	Waste management improvement	Deploy centralized infrastructure to locate garbage disposal sites above the ground, while	A georeferenced map identifying the best spots to deploy above-the-ground infrastructure for

		identifying blockages to the drainage network using drones.	waste disposal.
Medium term execution	Risk Control	As risk reduction of riverine floods is hardly focused on dikes' quality, it is recommended that the municipality of Chia develop a study to understand critical points in which the dikes can fail, its reason, as well as design a plan for dikes' failure.	Study on the vulnerability of the dikes in the long term is developed.
Medium term execution	Drainage Infrastructure improvement	Identify critical areas of high urban density and poor drainage to amplify and strengthen it.	A georeferenced map identifying areas with high urban density and poor drainage system.
Medium term execution	Risk Reduction	Identify and characterize people living in high flood risk areas and design actions for their protection.	Database of people living in areas of high flood risk with a description of their needs.
Medium term execution & Long-term permanence	Climate change adaptation plan	The municipality of Chía must develop its climate change adaptation plan, which includes considering climate change scenarios and precipitation changes.	The municipality of Chía has a climate change adaptation plan with clear actions.
Medium term execution & Long-term permanence	Drainage Infrastructure improvement	Develop a study on the quality of the sustainable drainage system in the whole municipality, and not just in certain areas. Later, execute a program with the JACs and neighborhood associations promoting the Care Crews to keep the drainage functioning throughout the years.	<ul style="list-style-type: none"> • Study on the sustainable drainage system in the complete area of the municipality is updated. • Care crews program framework is designed.
Medium term execution & Long-term permanence	Urban Infrastructure recovery	Promote the incorporation of permeable construction inputs and green spaces in urban development, particularly in streets and parking lots, as well as in new and already established neighborhoods. The use of incentives for the adoption of green spaces and permeable inputs in private spaces is recommended.	<ul style="list-style-type: none"> • A decree modifying the requirements of new constructions in the municipality is published, defining the requirement to use permeable inputs. • Urban resilience to flood program is designed to promote benefits for current infrastructure to adopt green spaces and permeable inputs.
Medium term execution & Long-term	Ecosystem conservation	The municipality must advance in the establishment, in a joint effort with the CAR, of a lineal park along the rivers; for this, the	Make a joint agreement with the CAR to identify the most suitable areas to design parks along the

permanence		studies from Probogotá can be used as an input.	rivers.
Medium term execution & Long-term permanence	Ecosystem conservation	Deploy actions to include local communities, through neighborhood associations or the JACs, in the conservation of the main ecological structure, particularly the surroundings of rivers. The adoption of a program of care crews according to areas is recommended. In this process, restoration processes in the dikes must be incorporated.	Design a program of community-based nature restoration and conservation.

Section 4. Conclusion

The municipality of Chia does not have a comprehensive policy for climate change adaptation, nor for flood or waterlogging management. Nevertheless, the municipality has different policies with actions that directly or indirectly are related to flood management. Despite this, none of the policies' actions consider climate change impacts.

The policy brief can be used by regional and national authorities to improve the overall governance structure and actions to address flood risk in a climate change context in Colombia. More specifically, the document can inform the municipal government of Chia on how to integrate climate change adaptation into its current policies for flood prevention, as well as identify the gaps that need to be addressed in order to reduce future risks.

The policy brief further strengthens the knowledge on flood adaptation and governance in developing countries, as evidence is lacking. Overall, flood management and governance literature is highly focused on Europe, and more research is needed on developing countries, and although there are already different tools to manage flood risks, there is less work on the implementation part (Dordi et al., 2022).

The government needs to understand that climate change effects will occur at different time scales and levels of impact, so there is no one definitive set of measures but a range of measures that need to be developed (United Nations. Economic Commission for Europe, 2009). In addition, the combination of structural and non-structural measures has reduced loss of lives (medium confidence) and has the potential to reduce adaptation costs (medium confidence) (IPCC, 2023).

Even though there is uncertainty on climate change impacts, adaptation actions can have indirect effects on climate change mitigation, public health, and economic development, among others (The World Bank Group, 2011). This can lead to the promotion of actions that can have positive impacts on the municipality's wellbeing while at the same time fostering climate adaptation, particularly to floods.

However, the urgency to act cannot lead to mistakes. If designed poorly, adaptation actions to manage floods can lead to negative social and environmental impacts, also known as maladaptation (IPCC, 2023), which refers to measures where climate change impacts are increased due to certain actions taken (Schipper, 2020) without the intention to cause harm (Reckien et al., 2023). Maladaptation is different from 'failed' or 'unsuccessful' adaptation as it refers to actions that result in increasing vulnerability instead of decreasing it (Schipper, 2020).

For instance, some hard adaptation actions can negatively alter ecosystems and habitats, with repercussions on populations that depend on rivers' resources (e.g., fishing), as well as can have negative effects on spaces that are meaningful to communities due to recreation, nature connection, wellbeing, among others (Quinn et al., 2023). In addition, a large part of current adaptation actions is not correctly addressing future climate variations by prioritizing immediate responses. They can also reinforce inequalities by protecting elite places and excluding marginalized groups (United Nations Environment Programme, 2022: IPCC, 2022).

Overall, the municipality of Chía must act under the principle of prevention, caution on climate change uncertainty and not reliance on single measures. In addition, as it has been stressed, the deployment of flood management and waterlogging actions can lead to higher citizen wellbeing by creating more inclusive infrastructure through the sustainable drainage system, that foster recreation activities with the ecosystem conservation actions, and that reduces risks to people and assets through land planning actions.

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Annex 1. Comparison of public policy, climate change adaptation, and flood management analysis frameworks

Component Type	Climate change adaptation framework for riverine floods and waterlogging	Public Policy Analysis	Adaptation Policy Framework	Flood Management Actions - Characteristics of good flood risk management
Component A. Area context	Understand the area where the analysis will focus on, particularly on: <ul style="list-style-type: none"> ➤ Location and administrative division ➤ Socioeconomic context ➤ Environmental context ➤ Description of past flood events, if any 	Component 2. Assemble evidence		Component 1. Understand the system behavior and societal goals by, among others, identifying short-term needs and long-term goals
Component B. Climate Change Context	Understand how climate change will affect the area of interest, with emphasis in variables related to flood risk, such as precipitation	Component 2. Assemble evidence	Component 2. Assessing current vulnerability. Particularly answering the following questions: <ul style="list-style-type: none"> ➤ Where does a society stand today with respect to vulnerability to climate risks? ➤ What factors determine a society's current vulnerability? ➤ How successful are the efforts to adapt to current climate risks? Component 3. Assessing future climate risks	
Component C. Stakeholder Description	Analysis and description of the main stakeholders involved in flood management			
Component D. Regulatory Context	Analysis of the regulation surrounding climate change adaptation, disaster risk management and flood management		Component 1. Guarantee that adaptation actions are well integrated in policy planning and development processes	
Component E. Current Actions Description & Analysis	Identify and analyze the current measures that have been deployed (if any) that are directly or indirectly related to flood management and/or waterlogging. This includes actions related to: <ul style="list-style-type: none"> ➤ Infrastructure Development and Maintenance (e.g., drainage) 			Component 5. Delivery of good flood risk management relies upon: <ul style="list-style-type: none"> ➤ Appropriate risk and uncertainty analysis ➤ Spatial planning ➤ Infrastructure management (e.g., flood defense assets) ➤ Maintain, repair, improve or replace ➤ Emergency planning and

	<ul style="list-style-type: none"> ➤ Early Warning Systems & Emergency Response Plans ➤ Waste Management ➤ Finance planning (e.g., insurance or savings). ➤ Risk assessment and knowledge building ➤ Ecosystem Preservation and Restoration ➤ Education and Community Engagement ➤ Land use planning and Zoning 			<p>management</p> <ul style="list-style-type: none"> ➤ Flood hazard and risk mapping ➤ Early warning system ➤ Effective land control and building codes ➤ Insurance
Component F. Gaps Analysis	Based on component E, identify the needs that current actions are not addressing. For this, you can take the framework of the OECD (2019) of types of gaps related to flood management: policy, administrative, funding, capacity, accountability, objective, and/or information gap.			
Component G. Problem Definition	Based on component F, clearly define your policy problem or problems	Component 1. Define the problem		
Component H. Policy Recommendations	Design actions that can address the problem (s) identified in component G	Component 3. Construct the alternatives	Component 4. Formulate the adaptation strategy in response to current vulnerability and future risks	Component 3. Implement a portfolio of measures and instruments to deliver multi-objectives, such as to <ul style="list-style-type: none"> ➤ Reduce flood hazard and associated consequences (both exposure and/or vulnerability) ➤ Pre, during and post event measures ➤ Solutions delivering multiple objectives
Component I. Prioritize the interventions	Set decision criteria, assess and prioritize among the alternatives identified in component H. In this process, you should try to project the outcomes of each of the alternatives, as well as their trade-offs	Component 4. Select the criteria Component 5. Project the outcomes Component 6. Confront the trade-offs Component 7. Focus, narrow, deepen, decide		Component 2. Use knowledge of risk and uncertainty to inform decisions
Component J. Monitor, Report, and Verification	Set performance indicators and evaluate the performance of the prioritized actions, giving space to adapt the actions, when necessary, when new knowledge is available		Component 5. Implement, monitor, evaluate, improve and sustain the initiatives	Component 4. Monitor, review and adapt the actions based on new knowledge