Building Water Resilience in Bogota and the Region

ANNEX 2
FEASIBILITY STUDY

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CONSERVATION INTERNATIONAL

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Acronyms and abbreviations

AR6	Sixth Assessment Report of the Intergovernmental Panel on Climate Change
CAR	Corporación Autónoma Regional/ Regional Environmental Authority
CCVA	Climate Change Vulnerability Assessment
CI	Conservation International
CMIP6	Coupled Model Intercomparison Project Phase 6
CRA	Comisión de Regulación de Agua Potable y Saneamiento Básico
DANE	Departamento Administrativo Nacional de Estadística
DNP	Departamento Nacional de Planeación
EAAB	Empresa de Acueducto y Alcantarillado de Bogotá
EFA	Economic and Financial Analysis
ENSO	El Niño– Southern Oscillation
ET-SCI	Expert Team on Sector-specific Climate Indices
GCF	Green Climate Fund
GIS	Geographic Information System
IAvH	Instituto de Investigación de Recursos Biológicos Alexander von Humboldt
IDEAM	Instituto de Hidrología, Meteorología y Estudios Ambientales
IPCC	Intergovernmental Panel on Climate Change
MCDA	Multi-Criteria Decision Analysis
MRV	Monitoring, Reporting and Verification
NbS	Nature-based Solutions
NRW	Non-Revenue Water
PES	Payment for Ecosystem Services
POMCA	Plan de Ordenación y Manejo de Cuencas Hidrográficas
POT	Plan de Ordenamiento Territorial
RNSC	Reserva Natural de la Sociedad Civil
SDA	Secretaría Distrital de Ambiente
SINAP	Sistema Nacional de Áreas Protegidas
SSP	Shared Socioeconimic Pathway
SSP2-4.5	Intermediate emissions scenario used for climate projections
SSP5-8.5	High-emissions scenario used for climate projections
SSPD	Superintendencia de Servicios públicos Domiciliarios
SWAT	Soil and Water Assesment Tool
TNC	The Nature Conservancy
VWB	Volumetric Water Benefit
WMO	World Meterorological Organization
WRI	World Resources Institute

Introduction

Water security in the Bogotá Region is shaped by the interaction between climate change, ecosystem degradation, increasing demand, and uneven institutional capacity across territories. The region depends on a complex socio-ecological system that integrates high-mountain ecosystems, productive landscapes, and urban water infrastructure, where upstream land-use decisions directly affect downstream water availability, quality, and reliability. In this context, climate change does not operate in isolation, but amplifies existing structural vulnerabilities, intensifying hydroclimatic variability, increasing the frequency of extreme events, and reducing the capacity of ecosystems to regulate water flows.

Against this backdrop, this annex presents the Feasibility Study, which aims to demonstrate that a watershed-based, nature-positive intervention model can effectively address the underlying drivers of water insecurity while generating measurable adaptation outcomes. The study is designed to provide a comprehensive analytical foundation for the project feasibility and design by linking climate evidence, territorial dynamics, intervention logic, and financial sustainability. The structure of the Feasibility Study is as follows:

Part I. Climate problem definition

Chapter 1. Base line conditions and non-climate drivers of water vulnerability in the Bogotá Region. This chapter focuses on providing and analyzing key geographical, biodiversity, economic, social and institutional information of the Bogotá Region to define and explain the current situation. It includes an explanation of existing water supply systems and their dependency on high-mountain ecosystems. The chapter presents the most relevant non-climate drivers or stressors, with an emphasis on those that exacerbate climate challenges. The analysis enables the contextualization of climate drivers and supports the definition of the climate problem.

Chapter 2. Climate rationale: Observed and projected impacts on water security in the Bogotá Region follows the IPCC Sixth Assessment Report to present the methodological approach, data sources, analysis, and results of the Climate Change Vulnerability Assessment (CCVA), as well as the characterization of climate risk, which comprises climate hazard, exposure, and vulnerability (IPCC, 2022). The CCVA integrates historical trends and downscaled climate projections of climate hazards from the Instituto de Hidrología, Meteorología y Estudios Ambientales (IDEAM) with an analysis of socioeconomic and institutional indicators to characterize the region's vulnerability to climate change impacts on water security, populations, and ecosystem services (IDEAM, 2024). The analysis emphasizes climate impacts on vulnerable populations.

The analysis includes a description of risk impact chains, potential solutions, and integrated climate risk mapping, and explains how it informed the selection of intervention sites (Chapter 4). It also describes the most likely scenario, whether prevailing conditions or alternative pathways, that would persist in the absence of the proposed interventions. The chapter concludes with a definition of the climate problem and the climate rationale for intervention in the Bogotá Region, as well as the identification of key adaptation needs.

Part II. Project Design

Chapter 3 Analysis of Gaps and Barriers to Address the Climate Problem defines and assesses the key gaps and barriers that hinder the effective response to the climate problem. It describes the financial, regulatory, institutional, and technical barriers present in the Bogotá Region and explains why these gaps have not yet been addressed. The analysis is directly linked to the climate problem, CCVA, and risk

assessment presented in Chapter 2. Chapter 7 further explains how the proposed activities are designed to address these gaps and remove barriers.

Chapter 4. Prioritization of intervention landscapes and watersheds presents how the analysis of the climate problem, baseline, non-climate drivers, gaps, and barriers informed the selection of the intervention landscapes. It demonstrates that the selection of intervention landscapes is based on climate risk and vulnerability findings, complemented by additional criteria, including strategic hydrological relevance for water regulation functions and the water supply system of Bogotá City and the Region. The chapter also presents the methodologies and analyses used to identify priority watersheds within each landscape, as well as territories to be intervened within each watershed.

Chapter 5 Option Analysis: selecting the highest-impact interventions for water resilience presents the methodological approach and results of assessing alternative intervention options. It justifies the use of GCF resources by demonstrating alignment with the most effective and efficient alternatives, leading to the adoption of a two-component structure. The analysis compares solutions to Bogotá's water security challenges based on their economic, social, and environmental performance, while also responding to fiduciary requirements for concessional climate finance. It demonstrates that the selected activities offer the highest impact potential to address the climate problem and contribute to a paradigm shift. The chapter concludes by clearly explaining how and why the proposed activities have been selected.

Chapter 6. Design selection and theory of change: builds on the previous analyses and presents the rationale for the selected project design. It outlines the proposed activities, expected outcomes and impacts. The chapter explains the logic for grouping activities into two complementary components and highlights their synergies. It also introduces the "watershed transformation model" concept, including the role of each activity within it, the underlying proof of concept, and the approach to mobilizing long-term finance.

Chapter 7. Feasibility assessment of interventions to achieve the highest impact presents the methodology, analysis, and results used to evaluate the feasibility of each component and activity in achieving the intended outcomes and impacts.

Component 1: Hydrological modelling and VWB potential; assessment of results from existing conservation, restoration, and productive transformation; and establishment of baselines for each type of intervention. It evaluates the aggregated potential of interventions at the watershed level and demonstrates how their complementarity enables sustained change over time.

Component 2: Analysis of existing regulatory frameworks that enable financial solutions to scale, including the establishment of a financial baseline, and private sector interest in VWBs.

For each activity, the chapter explains its contribution to addressing the climate problem, the specific barriers and risks it targets, and the expected results. The content also outlines the key assumptions underpinning the feasibility assessment and explains paradigm shift elements for activities and components where it applies.

Part III. Project Description

Chapter 8. Description of Activities provides a detailed description of each proposed activity, including what will be implemented, when, how, and by whom. It outlines the implementation model, partners, beneficiaries, expected results, deliverables, and indicators. The chapter explains how each component and activity contributes to achieving the intended impacts, considering technical soundness, cost-efficiency, partner suitability, and the complementarity of co-financing. The activity design builds on the

feasibility assessment in Chapter 7 and reflects the most appropriate structure to address identified gaps, barriers, and risks.

Chapter 9. Expected impacts, indicators and measurement methodology. This chapter defines the expected impacts of the project and presents the indicators and measurement framework that will be used to assess performance, verify outcomes, and support long-term scaling. It translates the analytical foundations developed in the previous chapters into an operational results framework that links the climate problem, the identified barriers, the selected interventions, and the feasibility assessment with measurable adaptation outcomes, and explains how hydrological modelling, field validation, and socioeconomic and system-level monitoring will be combined to quantify results. The chapter places particular emphasis on the role of Volumetric Water Benefits (VWBs) as the central metric for measuring hydrological improvements across intervention types and for linking those improvements to monitoring reporting, investment relevance, and replication

Chapter 10. Expected performance against GCF Investment Criteria. This chapter assesses the project's expected performance against the Green Climate Fund's investment criteria and explains why the proposed intervention represents a strong and strategic use of concessional climate finance. Building on the climate rationale, barrier analysis, option analysis, theory of change, and feasibility assessment, the chapter demonstrates the project's contribution to impact potential, sustainable development, country ownership, efficiency and effectiveness, while placing particular emphasis on paradigm shift and exit strategy. It explains how the project moves beyond fragmented, short-term watershed interventions by establishing a watershed transformation model that combines ecosystem restoration and conservation, productive transformation, improved local water management, verifiable hydrological results, and long-term public and private financing pathways capable of scaling beyond the project period.

Chapter 11. Implementation strategy, institutional arrangements and scaling pathway presents the implementation model through which the project will be delivered and explains how institutional roles, coordination arrangements, and delivery mechanisms are structured to ensure technical quality, cost-efficiency, and feasibility within the project period. Building on the activity design presented in Chapter 8, the chapter describes how responsibilities are assigned according to comparative advantage and operational capacity, how implementation will be sequenced from territorial interventions to the consolidation of measurement and financing systems, and how stakeholder engagement and governance arrangements will support effective delivery in priority watersheds. It also explains how the project's implementation strategy is directly linked to sustainability and replication, ensuring that the project leaves in place not only completed activities but also an operational model, institutional arrangements, and financing pathways capable of sustaining and expanding watershed-based adaptation beyond GCF support.

Appendices

I. Justification for selected implementing partners
II. Link between EFA variables and project benefits
III. Mitigation co-benefit calculations
IV. Options analysis methodology and analysis
V. Volumetric Water Benefits Calculation
VI. Reduced/avoided runoff: InVEST modeling

Methodology approach and analytical framework for the feasibility assessment

The objective of the project is to demonstrate, at plot level, that conservation, restoration, and productive reconversion interventions generate measurable improvements in Value, Water, Wealth, and Well-being, and that these improvements can serve as a robust model for the mobilization of long-term public and private capital. Through a structured proof of concept, the project seeks to validate a replicable model in which nature-based solutions and sustainable production practices simultaneously strengthen climate resilience, improve productivity and livelihoods, reduce risk, and enhance the attractiveness of agricultural systems for climate-relevant investment.

The feasibility methodology is designed to connect the definition of the climate problem, the identification of barriers, the selection of interventions, and the validation of feasibility into a single analytical sequence. Rather than treating these analyses as separate exercises, the methodology integrates them into a coherent framework that shows how each step informs the next and ultimately justifies the proposed project design. In this sense, the methodology is not only diagnostic; it is also the basis for demonstrating that the selected interventions are technically sound, institutionally viable, and capable of generating measurable adaptation outcomes that can be translated into a credible investment proposition.

At the center of this approach is the Volumetric Water Benefits (VWB) functional framework, which is used both to define the intervention logic and to assess its feasibility. Under this framework, project outcomes—Value, Water, Wealth, and Well-being—are understood as the result of interacting inputs at plot level. The core methodological principle is the distinction between modifiable inputs, which the project can directly influence, and non-modifiable inputs, which shape results but cannot be altered by the intervention. Modifiable inputs include land management practices, water management, technical capacity, and access to productive assets or finance. Non-modifiable inputs include climate variability, baseline biophysical conditions, and broader market dynamics. This distinction is critical because it ensures that project activities are selected not as generic adaptation measures, but as targeted actions designed to influence the variables that determine VWB performance, while explicitly controlling external factors that could affect outcomes.

This methodological structure strengthens feasibility in three ways. First, it ensures input-based intervention design, meaning that each activity is selected because of its capacity to shift the modifiable drivers of VWB performance. Second, it supports outcome-based measurement, since project effectiveness is assessed through observed changes in VWB results at plot level, using baseline and endline comparisons. Third, it strengthens attribution and investment relevance, because controlling for non-modifiable factors allows the methodology to isolate the contribution of project activities to the observed results. This is essential to demonstrate that improvements are causal, reliable, and scalable, and that they can therefore form the basis of a credible value proposition for investors.

Analytical Sequence

1. Baseline and Climate Problem Definition

The methodological sequence begins with the characterization of baseline conditions and non-climate drivers of water vulnerability in the Bogotá Region. This step establishes that the region's water insecurity is not caused by climate change alone, but by the interaction between ecological stress, land-use pressures, structural water imbalance, and uneven institutional capacity. On this basis, the Climate

Change Vulnerability Assessment (CCVA) applies the IPCC AR6 framework to analyze hazard, exposure, and vulnerability, using observed climate trends, downscaled projections, and socioeconomic indicators. The CCVA produces the climate rationale for intervention by identifying how warming, irregular precipitation, drought, runoff intensification, wildfire, and ecosystem degradation affect water security, populations, and strategic ecosystems.

2. Gap and Barrier Analysis

Once the climate problem is defined, the methodology examines why it persists. This is done through a structured analysis of adaptation gaps and barriers, focusing on the conditions that prevent climate-resilient water management from taking place at the required scale. The annex identifies four priority adaptation gaps: insufficient long-term financing for watershed resilience, inadequate integration of climate risk into land-use and water planning, weak implementation capacity in upstream territories and community-run systems, and the absence of an operational MRV architecture capable of linking interventions to measurable hydrological outcomes. These gaps are then linked to four categories of structural barriers: financial, regulatory and planning, institutional, and technical. This step is methodologically important because it moves the analysis from identifying impacts to identifying the causes of inaction, thereby providing the rationale for why concessional climate finance and targeted project intervention are needed.

3. Spatial Prioritization of Intervention Areas

The next step is to determine where the project should intervene in order to maximize adaptation impact and feasibility. This is done through a multi-criteria prioritization process that combines climate risk, hydrological relevance, ecological condition, and implementation feasibility. At landscape level, the methodology identifies high-priority watersheds based on their importance for water regulation and supply, their exposure to climate risk, and the existence of institutional conditions that can support implementation. At sub-basin and property level, the analysis differentiates between conservation-oriented and production-oriented intervention areas, ensuring that restoration, conservation, and climate-resilient production measures are matched to the ecological and socioeconomic conditions of each site. This step is therefore not only spatial targeting; it is the mechanism by which the project ensures that interventions are concentrated where they can generate the greatest measurable water benefits and the strongest proof of concept.

4. Options Analysis and Selection of the Preferred Intervention Package

Having defined the problem, the barriers, and the priority intervention areas, the methodology then evaluates the available response options. The options analysis compares grey, green, and hybrid alternatives using a multi-criteria framework that considers economic, social, environmental, institutional, and equity dimensions, in line with GCF expectations and Colombian public investment standards. The annex concludes that nature-based, watershed-scale interventions perform best overall because they address the root causes of water insecurity, generate multiple co-benefits, and offer stronger institutional and financial scalability than grey or hybrid alternatives. This analysis directly informs the project design by justifying the preferred intervention package: conservation and restoration of strategic ecosystems, climate-resilient productive transformation, improved efficiency in community-run water systems, and the establishment of a financing and governance architecture capable of sustaining these actions over time.

5. Feasibility Assessment

The final analytical step is the feasibility assessment itself. Within this methodology, feasibility is not treated as a separate or purely technical exercise, but as evidence-based confirmation that the selected intervention package can generate the intended adaptation outcomes under real territorial, institutional, and regulatory conditions. The assessment is grounded in hydrological and biophysical evidence, empirical studies from comparable contexts, and consistency with the economic and financial analysis. Each intervention is assessed through a standard logic: what the intervention changes, how this change is expected to affect hydrological performance, what evidence supports that relationship, what results are expected, and under what assumptions those results can be achieved. This structure ensures that feasibility is demonstrated through a transparent causal chain linking activities, landscape change, hydrological response, and measurable benefits, rather than through general assumptions about the desirability of adaptation measures.

Under the VWB-driven approach, feasibility is assessed through three complementary lenses. First, the project verifies that interventions act directly on the modifiable inputs that influence water regulation, productivity, and livelihoods. Second, it measures whether these interventions lead to observable changes in VWB outcomes. Third, it tests whether these outcomes are sufficiently robust and attributable to support a future investment case. In practical terms, this means that feasibility is demonstrated not only by showing that conservation, restoration, or productive reconversion are good practices in principle, but by showing that they can generate measurable water-related and economic signals that reduce risk and improve the investment profile of rural production systems.

Implications for Project Design

The methodological sequence described above leads directly to the project's two-component structure. Component 1 is designed to generate measurable VWB results by acting on plot-level modifiable inputs through conservation, restoration, productive transformation, and improvements in community water-system efficiency. Component 2 is designed to convert those verified outcomes into long-term finance through tariff-based environmental investment and a private-sector financing mechanism. In this way, the proof of concept is not limited to demonstrating ecological or hydrological benefits;. Taken together, the methodology provides the full analytical foundation for the project. It links climate evidence, barrier analysis, territorial prioritization, options analysis, and feasibility assessment into a single logic that supports both project design and investment justification. Its added value lies in making explicit the pathway from climate problem to adaptation need, from adaptation need to targeted intervention, and from targeted intervention to measurable and financeable results.

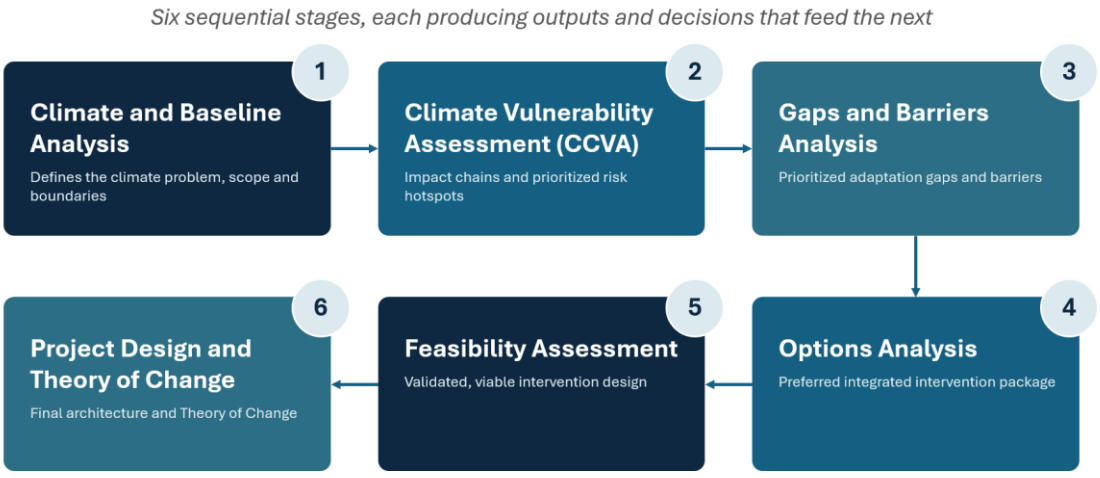


Figure 1. Analytical sequence of the feasibility study

PART I. Climate problem definition

1. Context of the Bogota Region: Status quo and non-climate drivers of water vulnerability

This chapter defines the baseline conditions that explain why water vulnerability in the Bogotá Region is already structurally high, even before considering the additional pressure imposed by climate change. The key point is that the region's water insecurity does not stem from a single shortage problem, but from the interaction of three underlying conditions: first, Bogotá depends on a regional hydrological system that extends far beyond its administrative boundaries; second, that system is sustained by high-mountain ecosystems whose regulating functions are increasingly stressed; and third, the territories that provide those hydrological services face persistent social, productive, and institutional constraints that weaken their capacity to sustain long-term watershed management (Congreso de la República de Colombia, 2022; CAR, 2019; DANE, 2025).

Taken together, these baseline conditions show that the climate problem emerges in a system that is already exposed, unevenly governed, and under pressure from non-climate drivers. The purpose of this chapter is therefore not only descriptive. It is to establish why the region's current geographic, ecological, socioeconomic, and institutional configuration amplifies water vulnerability and why those factors must be addressed if climate adaptation is to produce lasting water-security outcomes (IDEAM-ENA, 2022; IDB-CI-C&C, 2022).

1.1. Geographic scope and regional interdependence

Water vulnerability in the Bogotá Region (Figure 2) is already high under current conditions because the regional water system combines strong territorial dependence, ecological fragility, growing demand pressure, and uneven institutional capacity. The region covers 829,212 hectares (8,292 km²), and includes 68 municipalities across Bogotá D.C., Cundinamarca, and Meta, which means that the system that supports water security is spatially extensive, administratively fragmented, and functionally interdependent (DANE, 2025). This territorial scale matters because the hydrological processes that sustain Bogotá's water supply occur across a regional landscape that includes urban centers, rural communities, forests, páramos[1], wetlands, and reservoirs, rather than within the Capital District alone (Congreso de la República de Colombia, 2022; CAR, 2019).

The regional water system is physically structured by five main catchments: the Bogotá, Guavio, Guayuriba, Guatiquía, and Sumapaz rivers (Figure 3); and by more than 31 basins, while elevation ranges from roughly 2,600 m on the Bogotá savanna to more than 3,300 m in the surrounding mountains and páramo summits such as Monserrate and Guadalupe (Gómez et al., 2015; Armenta & Dorado, 2015; Secretaría Distrital de Ambiente, 2020). These topographic conditions are not incidental. Steep slopes, short drainage paths, and strong altitudinal gradients accelerate runoff concentration and increase

[1] Páramos are high-altitude neotropical mountain ecosystems located between the upper limit of Andean forests and the lower limit of permanent snow, typically between about 3,000 and 4,500 meters above sea level, characterized by cold, humid conditions and a mosaic of grasslands, shrubs, wetlands and dwarf forests with exceptional capacity to store, regulate and slowly release freshwater to downstream areas.

erosion and sediment transport, which means that upper-basin land use directly affects downstream water regulation. For that reason, water vulnerability in the region cannot be understood as a problem of urban service provision alone; it is the expression of a watershed system in which upstream ecological condition and downstream water reliability are tightly coupled (CAR, 2019; Gómez et al., 2015).

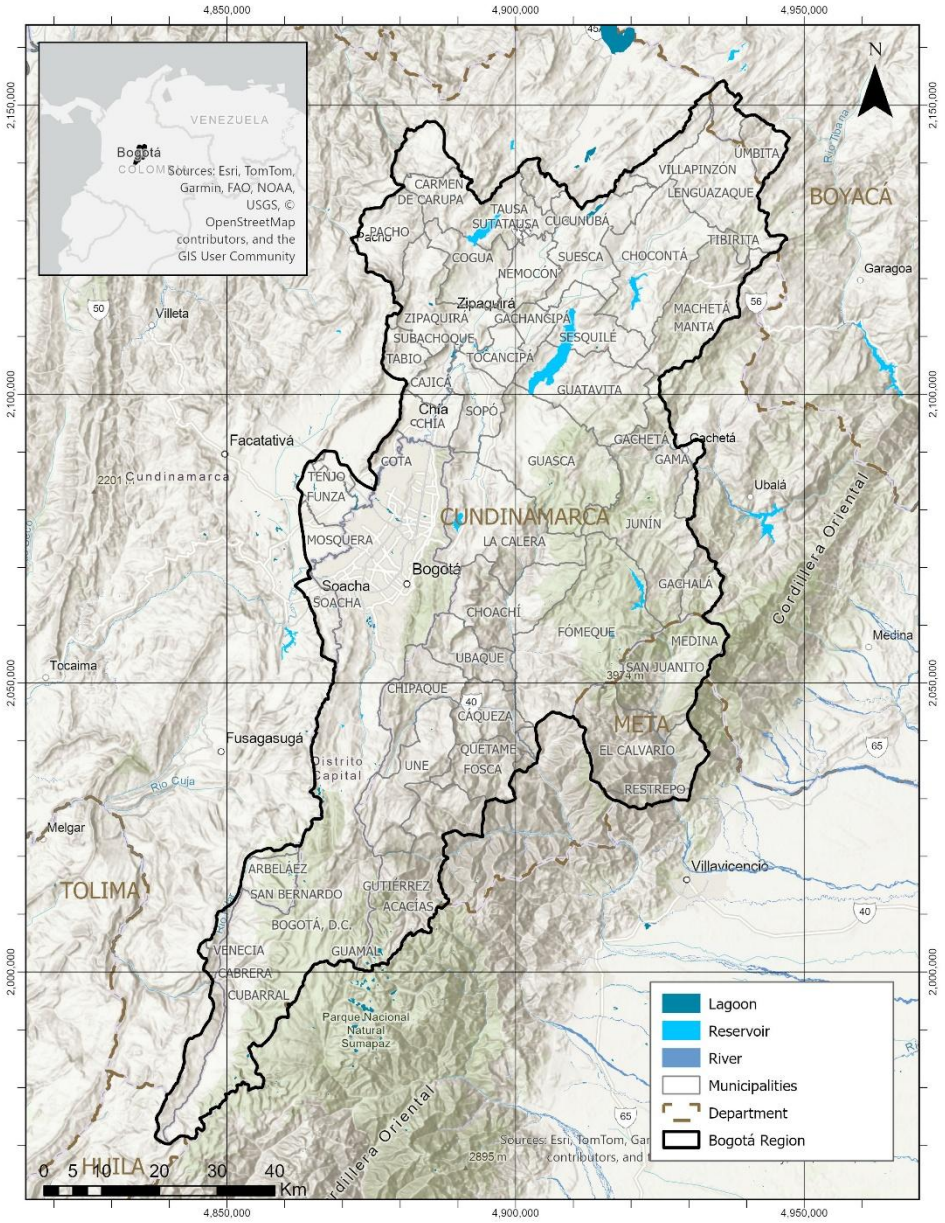


Figure 2. Bogota Region.
Source: IDOM 2025.

This regional logic is also institutionally recognized. The ecological, economic, and social interdependence between Bogotá and its surrounding municipalities led to the creation of the Bogotá-Cundinamarca Metropolitan Region under Law 2199 of 2022, explicitly acknowledging that administrative boundaries do not align with ecological processes or urban-regional dynamics (Congreso de la República

de Colombia, 2022). At the same time, many of the region's pressures stem from the country's centralized political structure, which concentrates decision-making and demographic growth in the capital while driving land-use change in surrounding agricultural and conservation-value areas, including páramos (IDB-CI-C&C, 2022). The first conclusion of this chapter therefore follows directly from the baseline evidence: the water-security problem is regional, while the governance system remains only partially aligned with that regional ecological reality (Congreso de la República de Colombia, 2022; CAR, 2019).

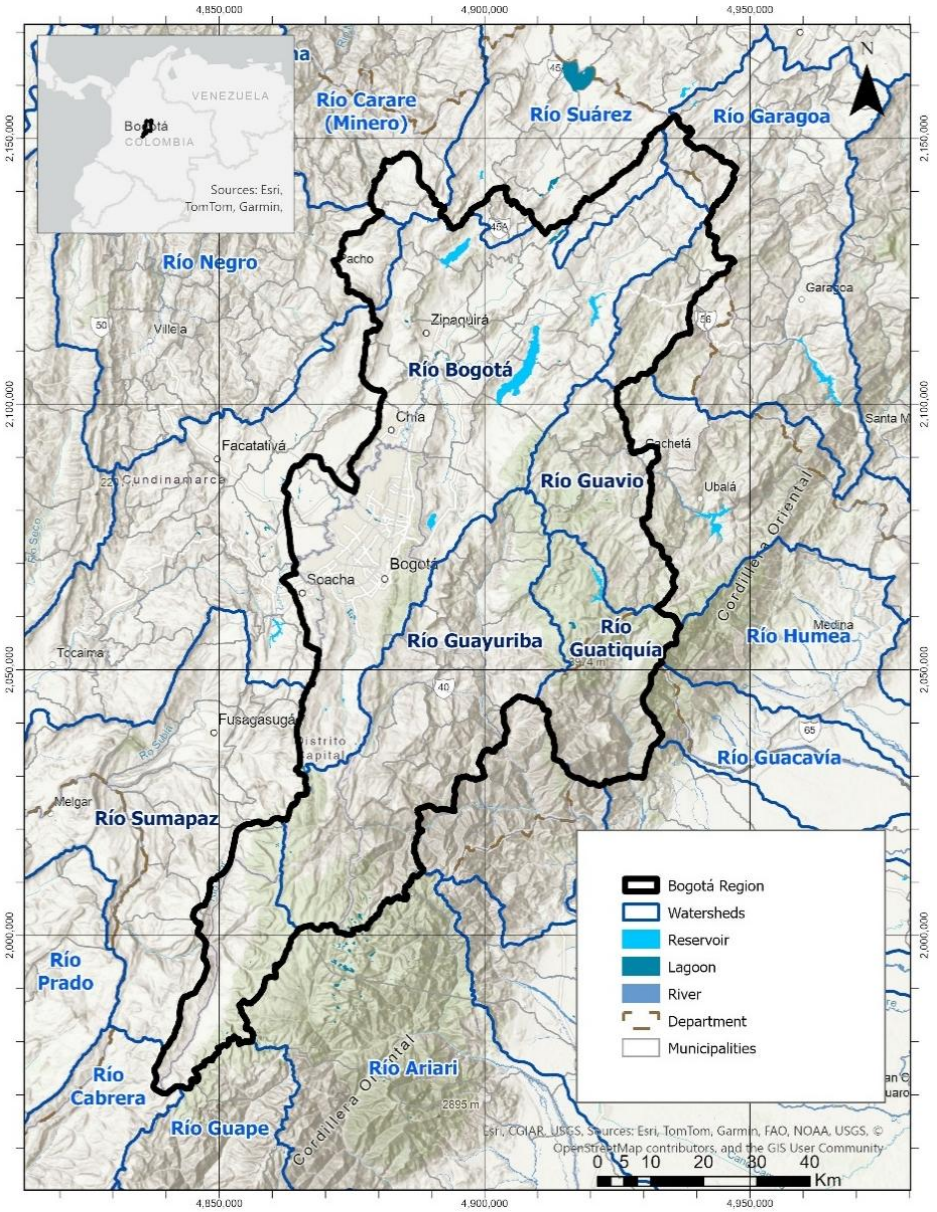


Figure 3. Catchments in the Bogota Region.
Source: IDOM with data from IDEAM.

1.2. Water-supply systems and their ecological dependence

The current water vulnerability of the region is inseparable from the design of its water-supply systems and from their dependence on high-mountain ecosystems. Bogotá's supply is distributed across three

major systems: Chingaza provides about 70% of the city's water, the North system about 25%, and the South/Tunjuelo system about 5% (IDEAM, 2018; WWF Colombia, 2025; Jiménez-Aldana & Santana-López, 2017). These proportions are critical because they show that a quarter of metropolitan supply already depends on the North system, where three of the four intervention landscapes are located, while the southern landscape connects directly to the South/Tunjuelo system.

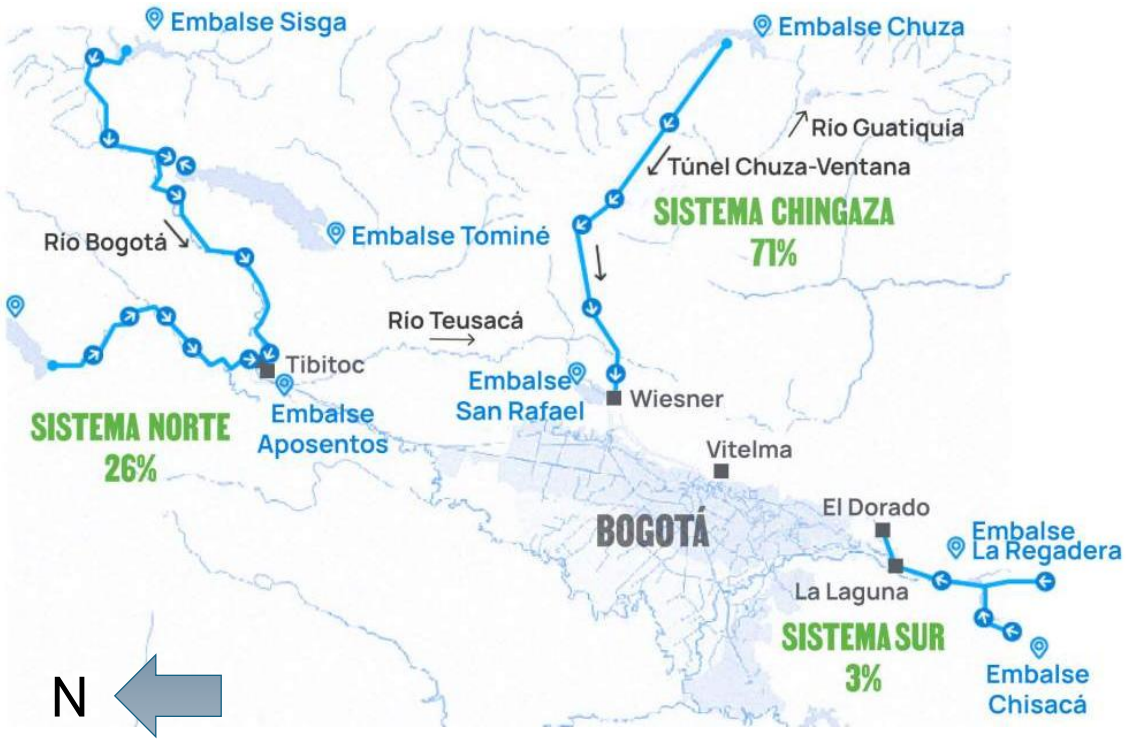


Figure 4. Bogota water supply systems (North, South and Chingaza).
Source: La Silla Vacía with data from EAAB.
The blue lines represent the EAAB's supply system connections. The green percentage indicates the proportion of water supplied by each specific system.

The infrastructure footprint of this system is large. Empresa de Acueducto y Alcantarillado de Bogota (EAAB)[2] operates more than 10,500 km of pipelines, three major treatment plants—Francisco Wiesner, Tibitoc, and Vitelma—and seven reservoirs with a combined storage capacity of nearly 1.12 billion m³ (IDEAM, 2018; WWF Colombia, 2025; Jiménez-Aldana & Santana-López, 2017). Within that system, the North supply component relies on Tominé with 689 hm³ (or 689,000,000m[3]) of storage, Neusa with 102 hm³, and Sisga with 94.3 hm³, while Chuza and San Rafael support Chingaza and La Regadera and Chisacá support the southern system. These data show that Bogotá has extensive grey infrastructure, but they also clarify its limits: storage and conveyance capacity depend on the quantity, timing, and quality of water arriving from upstream watersheds.

Table 1. Storage capacity of the EAAB reservoir system.[3]

Supply system	Reservoir	Capacity (hm³)

[2] The Bogotá Water and Sewerage Company (Empresa de Acueducto y Alcantarillado de Bogotá – EAAB E.S.P.) is the public utility of the Capital District responsible for integrated water and sanitation services, including abstraction, treatment and distribution of drinking water and the collection and conveyance of wastewater and stormwater for Bogotá and several neighbouring municipalities

[3]One cubic hectometer (hm3) is equivalent to 1,000,000 cubic meters.

Tibitoc — "Agregado Norte"	Tominé	689
Tibitoc — "Agregado Norte"	Neusa	102
Tibitoc — "Agregado Norte"	Sisga	94.3
Chingaza	San Rafael	70–75
Chingaza	Chuza	254
Tunjuelito (South)	La Regadera	3.7
Tunjuelito (South)	Chisacá	6.7

Source: EAAB infrastructure data.

The source areas of the system are composed of páramos, high-Andean forests, wetlands, and organic soils that capture around 40% of horizontal precipitation, regulate runoff, sustain baseflows in dry periods, and buffer climatic variability (Instituto Humboldt, 2023; Ministerio de Ambiente y Desarrollo Sostenible, 2023e). Those functions are not ancillary environmental services; they are part of the operational basis of the water-supply system. Reservoirs can store water once it enters the system, but they cannot replace the infiltration, retention, and gradual release functions performed in upstream ecosystems. The dependence is therefore hydrological, not symbolic.

Beyond Bogotá D.C., EAAB provides bulk water to 11 municipalities, reaching a served population of approximately 9.8 million people directly or indirectly (EAAB, 2023), while an additional 18 municipalities rely on municipal and community-run systems that are even more exposed to local hydrological conditions (DANE, 2025). Watershed degradation affects not only the capital's bulk supply but also smaller municipal systems with lower technical and financial capacity to respond.

The conclusion from these data is direct: the Bogotá Region's water-supply systems are not simply associated with high-mountain ecosystems; they are operationally dependent on them. Water vulnerability is therefore amplified when those ecosystems lose their ability to retain moisture, regulate runoff, and sustain flow stability before water reaches reservoirs, treatment plants, and municipal intakes (Restrepo, 2024; Instituto Humboldt, 2023).

1.3. Physical and ecological conditions that shape hydrological regulation

The hydrological role of the region's ecosystems is inseparable from its geography. The Bogotá savanna and surrounding mountains form a tectonic-sedimentary basin with strong altitudinal and slope contrasts, and those contrasts shape water retention, runoff formation, and sediment transport (Gómez et al., 2015; Armenta & Dorado, 2015). East-facing slopes receive greater humidity and tend to support denser vegetation and more retentive soils, while western slopes facing the savanna are more exposed to urban pressure and reduced ecological cover. This asymmetry matters because it influences how much rainfall is infiltrated and stored versus how much is converted into rapid surface runoff.

The region still retains ecosystems with high water-regulation value. These include páramos such as Chingaza, Sumapaz, Guerrero, and Guacheneque, as well as high-Andean forests, wetlands, and associated organic soils that support infiltration, storage, and gradual water release (Instituto Humboldt, 2023; Ministerio de Ambiente y Desarrollo Sostenible, 2023e). However, the document also shows that these regulating systems are already degraded in important ways. Roughly 70% of Bogotá-Region's wetlands are hydrologically altered, reducing their flood-regulation capacity (Instituto Humboldt, 2019b). In the Chingaza–Sumapaz–Guerrero system, about 27% of the territory receives insufficient rainfall to

sustain high-mountain ecosystems, and water use exceeds sustainable levels across 45% of the territory in dry years (Banco Interamericano de Desarrollo, 2022b). These are not generic environmental trends; they are direct indicators that the ecological systems expected to regulate flows are already under measurable stress.

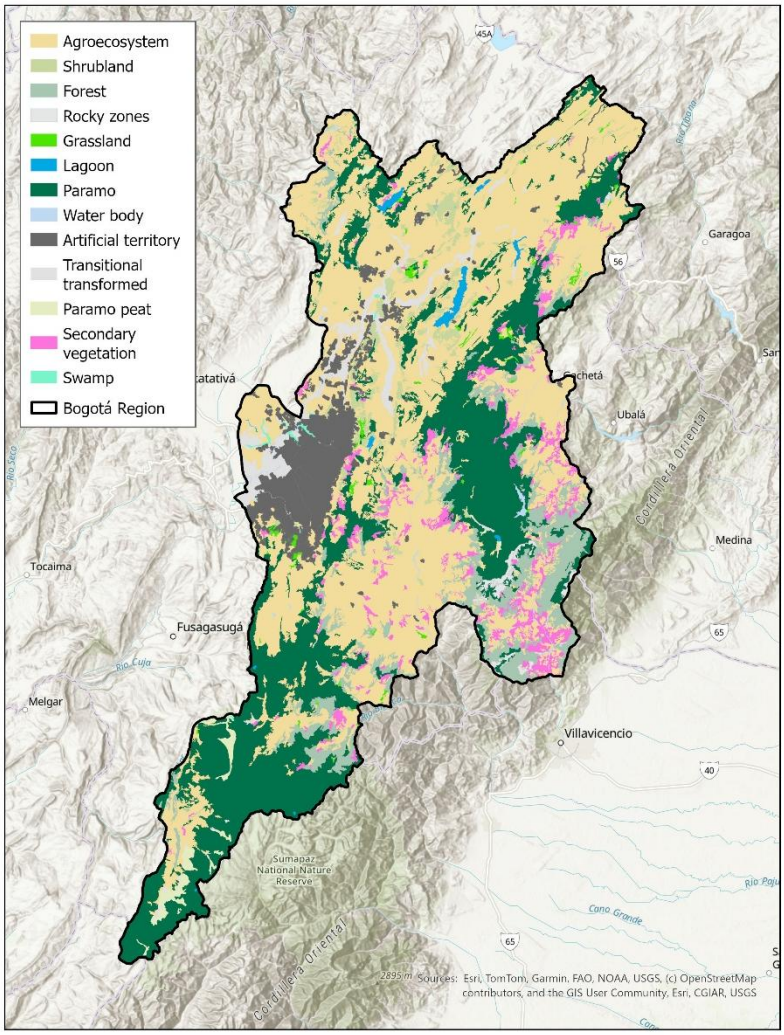


Figure 5. Ecosystems in the Bogota Region.
Source: IDOM, 2026 with data from IDEAM, 2017.

The ecosystem map (Figure 5)) and the description of regional physiography show that these regulating assets are distributed across the same landscapes where social and productive pressures are strongest. This matters because the continued existence of those ecosystems does not mean that hydrological resilience is secure. Rather, it means the region still retains enough ecological functionality for restoration and protection to be viable, but only if those actions occur before degradation crosses thresholds that compromise regulation capacity more deeply (CAR, 2019; Instituto Humboldt, 2019b, 2023).

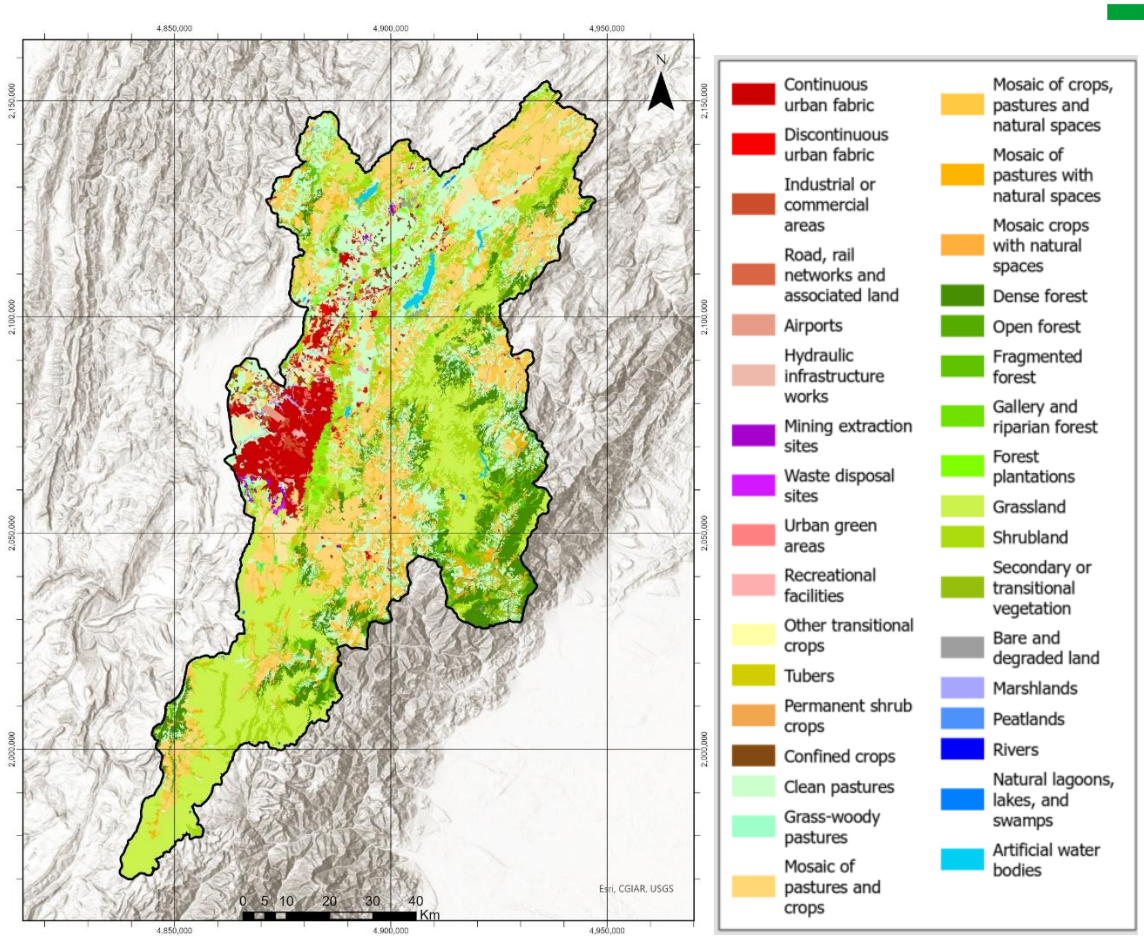


Figure 6. Land Cover for the Bogota-Region.
Source: IDEAM, 2020.

The hydrological function of soils is particularly important in this regard. Organic soils and vegetated upper-basin areas store moisture, support infiltration, and reduce the speed with which rainfall is converted into surface runoff. When these systems are altered, runoff peaks intensify, baseflow stability declines, and downstream systems face higher sediment and treatment burdens. Thus, the ecological baseline of the region is best understood as a contested asset: it remains sufficiently functional to underpin adaptation, but it is already under stress and cannot be treated as a stable or self-sustaining background condition (IDEAM-ENA, 2022; Ministerio de Ambiente y Desarrollo Sostenible, 2023e).

Taken together, these data indicate that the region still has significant ecological functionality, but that functionality is already being eroded. The implication for problem definition is important: the water-security challenge is not occurring in a fully degraded landscape where action would be too late, nor in a stable one where ecological regulation can be taken for granted. It is occurring in a stressed but still recoverable system, which is precisely why watershed-based adaptation remains both necessary and viable (Instituto Humboldt, 2019b, 2023; Banco Interamericano de Desarrollo, 2022b).

1.3. Biodiversity and ecosystem services as evidence of water security relevance

Biodiversity and ecosystem-services evidence confirm that the landscapes most relevant for water supply in the Bogotá Region are also areas of high ecological value under increasing pressure. The region records 5,757 species (around 7.2% of Colombia's total), including approximately 1,126 endemic and 498 nationally threatened species, many concentrated in páramos, high-Andean forests and associated wetlands that are critical for water regulation (SiB Colombia, 2025a; UICN, 2025). These figures highlight that the project targets strategic socio-ecological systems where biodiversity conservation and water security strongly intersect.

High-Andean ecosystems function as natural water infrastructure. Páramos and high-Andean forests regulate runoff, enhance infiltration, retain sediments and nutrients, reduce erosion, and sustain dry-season flows, directly influencing water availability and quality for downstream users (Ministerio de Ambiente y Desarrollo Sostenible, 2019, 2023e; Instituto Humboldt, 2023). Evidence from Andean catchments shows that basins dominated by forest and páramo cover exhibit greater infiltration and more stable hydrological behavior than those dominated by pasture or herbaceous cover, confirming the link between ecological integrity and hydrological performance (Mosquera et al., 2022; Llambí et al., 2020; Hernández, 2022; Rubio, 2021; Tobón, 2009).

In practical terms, ecosystem degradation leads to simultaneous ecological and hydrological losses. The fragmentation or conversion of páramos and high-Andean forests reduces habitat for endemic and threatened species while weakening the capacity of landscapes to regulate flows, stabilize soils and protect water sources. This interdependence explains why watershed degradation directly translates into water insecurity for Bogotá and surrounding municipalities (Instituto Humboldt, 2019b, 2023; Etter et al., 2017).

Table 2. Representative indicators linking biodiversity and water security.

Indicator	Value / relevance	Why it matters for water security
Total recorded species	**5,757 species** in the Bogotá Region	Confirms that water-supplying landscapes are also biodiversity-rich systems, not isolated hydrological units (SiB Colombia, 2025a).
Endemic species	**1,126 endemic species**	High endemism means ecosystem degradation causes irreversible ecological losses in the same landscapes that regulate water (SiB Colombia, 2025a).
Nationally threatened species	**498 threatened species**	Threat status signals ecological stress in strategic high-mountain ecosystems that also sustain hydrological functions (UICN, 2025).
Key ecosystem services	Water regulation, erosion control, sediment and nutrient retention, microclimate buffering	These services determine whether rainfall is retained and released gradually or converted into runoff, sediment loads and downstream instability (Ministerio de Ambiente y Desarrollo Sostenible, 2023e; Instituto Humboldt, 2023).
Catchment performance by land cover	Forest- and páramo-dominated catchments show greater infiltration and more stable flows than pasture-dominated basins	Provides direct evidence that conserving ecological integrity improves hydrological regulation (Mosquera et al., 2022; Llambí et al., 2020; Hernández, 2022; Rubio, 2021; Tobón, 2009).

Source: IDOM, 2026.

High-Andean ecosystems and urban natural areas also provide a broader set of ecosystem services that support water security and climate resilience, including water-flow regulation, soil stabilization, carbon storage and microclimate buffering (Mosquera et al., 2022; Llambí et al., 2020; Ministerio de Ambiente y Desarrollo Sostenible, 2019, 2023a).

Table 3. Description of the ecosystem services provided by high Andean and urban natural areas in Bogota region.

Ecosystem Services	Description
Water Regulation	The Andean forests and páramos play a pivotal role in hydrological regulation, acting as natural sponges that retain and gradually release water. These ecosystems contribute to the recharge of aquifers and the regulation of streamflow, particularly in the upper basins of the Bogota River and its tributaries (Mosquera, et al., 2022) (Llambí, et al., 2020). The fragmentation of these ecosystems due to urban expansion threatens their capacity to maintain water quality and quantity. Studies comparing different land cover show that forested and páramo-dominated catchments exhibit greater water regulation capacity than basins dominated by pastures or herbaceous vegetation, due to higher infiltration rates, improved soil hydraulic properties, and enhanced subsurface flow pathways (Hernández, 2022) (Rubio, 2021) (Tobón, 2009).
Carbon Sequestration	High-altitude forests and páramos are significant carbon sinks. The organic soils of páramos, in particular, store large amounts of carbon due to their slow decomposition rates. According to national assessments, the carbon storage potential of these ecosystems is among the highest in Colombia, making them strategic assets in climate mitigation efforts (Díaz-Timoté, Isaacs-Cubides, & Arce-Plata, 2019) (Llambí, et al., 2020).
Soil Stabilization	Vegetation cover in montane ecosystems reduces erosion and stabilizes slopes, especially in areas with steep topography. The loss of forest cover due to deforestation and informal settlements increases the risk of landslides and sedimentation in water bodies, affecting both ecological integrity and infrastructure.
Climate Buffering	Urban green areas and surrounding natural ecosystems help regulate local microclimates by reducing surface temperatures and mitigating the urban heat island effect. Remote sensing analyses in northern Bogota show a clear inverse correlation between vegetation intensity and land surface temperature, highlighting the cooling effect of green infrastructure (ProBogotá Región, 2022) (ProBogotá Región, 2024).
Pollination and Biodiversity Support	Native flora in Bogota's peri-urban forests and páramos supports diverse pollinator communities, including a huge variety of insects, bats and birds. These species are essential for the reproduction of both wild and cultivated plants. Beyond their fundamental role in plant reproduction, pollinators contribute to ES associated with agricultural production by enhancing crop yield stability and improving product quality attributes such as fruit size, shape, and weight. In addition, pollination functions as a regulating ecosystem service by sustaining plant and animal biodiversity and the ecological interactions that underpin ecosystem resilience and human well-being. Despite these benefits, pollination services in the region are increasingly vulnerable to habitat fragmentation and the intensification of agrochemical use (Garibaldi, 2011).
Cultural and Recreational Services	Green spaces such as the Thomas Van Der Hammen Reserve and urban parks provide opportunities for recreation, environmental education, and cultural connection with nature. These areas are valued by residents for their aesthetic and spiritual significance, contributing to mental well-being and social cohesion.

Source: IDOM, 2025 with information from (Ministerio de Ambiente y Desarrollo Sostenible, 2019) (Ministerio de Ambiente y Desarrollo Sostenible, 2023a; PNUD & RAP-E Región Central, 2023).

Taken together, these indicators and services demonstrate that the same landscapes sustaining high levels of biodiversity are essential for maintaining water regulation, soil stability and climate resilience in the Bogotá Region. Their degradation therefore undermines both ecological integrity and the physical processes that secure water availability and reduce hydro-climatic risks (Instituto Humboldt, 2023; PNUD & RAP-E Región Central, 2023).

1.4. Structural water stress and current hydrological imbalance

The current water-security problem is intensified by the fact that the regional system is already under structural stress. According to the Estudio Nacional del Agua, the Bogotá River basin exhibits high water stress due to imbalance between water availability and demand, compounded by seasonal variability and

increasing pressure from urban growth and economic activity (IDEAM-ENA, 2022). The same source indicates that densely populated basins are operating close to or beyond sustainable thresholds, which raises the risk of supply deficits during dry periods and amplifies the impacts of extreme rainfall through higher runoff, erosion, and sediment transport (IDEAM-ENA, 2022).

These findings are consistent with the observed climate baseline. The region has mean annual precipitation of around 1,000–1,050 mm/year, but historical annual totals fluctuate between 750 mm and 1,450 mm under the influence of ENSO (IDEAM, 2025). Maximum temperature has increased by about 0.2 °C per decade over the 1991–2020 period (IDEAM, 2025). Those figures matter because they show that the water system already operates under considerable hydroclimatic variability. When that variability interacts with a basin under structural water stress, the result is greater vulnerability to both dry-period shortages and high-runoff events.

The historical disaster record reinforces this interpretation. Between 1912 and 2017, 676 hydrometeorological events were recorded in the region, including 244 floods, 121 landslides, and 110 forest fires (DesInventar, 2026). Flooding is especially concentrated in Bogotá D.C. with 170 recorded events, while landslides also show a strong concentration in Bogotá with 66 records and notable incidence in municipalities such as Zipaquirá, La Calera, Chocontá, and El Calvario (DesInventar, 2026). Forest fires are more broadly distributed, with around 27 events in Bogotá and intermediate levels in municipalities such as La Calera, Fómeque, Guasca, Tausa, Sesquilé, Guatavita, and Cogua (DesInventar, 2026). These data demonstrate that hydrological disturbance is already recurrent across the region and is not confined to a single municipality or hazard type.

The conclusion is that current water vulnerability is produced by the combination of structural imbalance and recurrent disturbance. The problem is not merely that future climate change may increase risk; it is that the basin is already stressed, already variable, and already experiencing frequent hydrometeorological impacts, which reduces its margin for absorbing additional shocks (IDEAM-ENA, 2022; IDEAM, 2025; DesInventar, 2026).

1.5. Productive land use as a driver of water vulnerability

The productive profile of the region explains why non-climate pressures continue to undermine hydrological regulation. The Bogotá Region concentrates around 32% of Colombia's GDP and more than 11.2 million inhabitants, making water resilience a macroeconomic and social priority as much as an environmental one (DANE, 2018; DNP, 2022; DNP, 2023, Cámara de Comercio de Bogotá, 2021). However, the same regional economy depends heavily on land uses that can intensify runoff, erosion, and pressure on strategic ecosystems when they are not managed under hydrologically compatible practices.

Livestock occupies 39.3% of productive land and potato cultivation 23.6%, while Cundinamarca contributes around 36% of national potato production (DNP, 2022; DNP, 2023; DANE, 2018). These figures show that production systems with strong influence on slopes, soils, and water demand dominate the productive matrix. In upper watersheds, that matters because cattle grazing and potato cultivation can increase soil exposure, reduce infiltration, compact soils, and elevate sediment and nutrient transport into rivers and reservoirs when poorly managed.

The vulnerability effect is reinforced by the structure of farms and the spatial concentration of livestock. The farm-size distribution in Cundinamarca is dominated by small and medium-sized holdings, with a large share of agricultural units under 20 hectares, which limits economies of scale for investing in soil conservation and water-efficient practices (ICA, 2025). At the same time, cattle inventories are highly

concentrated in the project's priority municipalities, where a significant proportion of the department's total herd is located, increasing pressure on high-mountain soils and headwater catchments (ICA, 2025).

Many of these productive units are small, family-based and weakly integrated into formal markets, and local production systems often respond to short-term economic incentives rather than long-term watershed compatibility (DNP, 2022; DNP, 2023). This means that land-use pressure persists not only because of ecological conditions, but because many producers have limited room to invest in alternative practices or absorb transition costs. Productive land use is therefore not peripheral to water vulnerability; it is one of the principal ways through which that vulnerability is reproduced in source landscapes.

1.6. Demographic concentration, local service fragility, and institutional constraints

The vulnerability of the regional water system is also shaped by the uneven distribution of institutional and adaptive capacity. The region serves more than 11.2 million people across Bogotá and surrounding municipalities, but the capacity to manage water risk is not evenly distributed across those territories (DANE, n.d.; DANE, 2025). The metropolitan core benefits from larger infrastructure and stronger institutional resources, while many source municipalities face limited fiscal space and depend on community-managed systems.

The data on municipal capacity is particularly important. Seventy-six percent of municipalities are classified in the sixth fiscal category, indicating weak own-source revenue and limited capacity to co-finance or sustain environmental investments (DNP, 2022; DNP, 2023). At household and producer level, there is large household size, low educational attainment among producers, small farm units, and restricted access to credit and organized market channels (DANE, 2018; DNP, 2022; DNP, 2023; FINAGRO, 2022). These conditions matter because they reduce the ability of local actors to adopt and maintain land-use change, water-efficiency investments, and restoration measures without sustained external support.

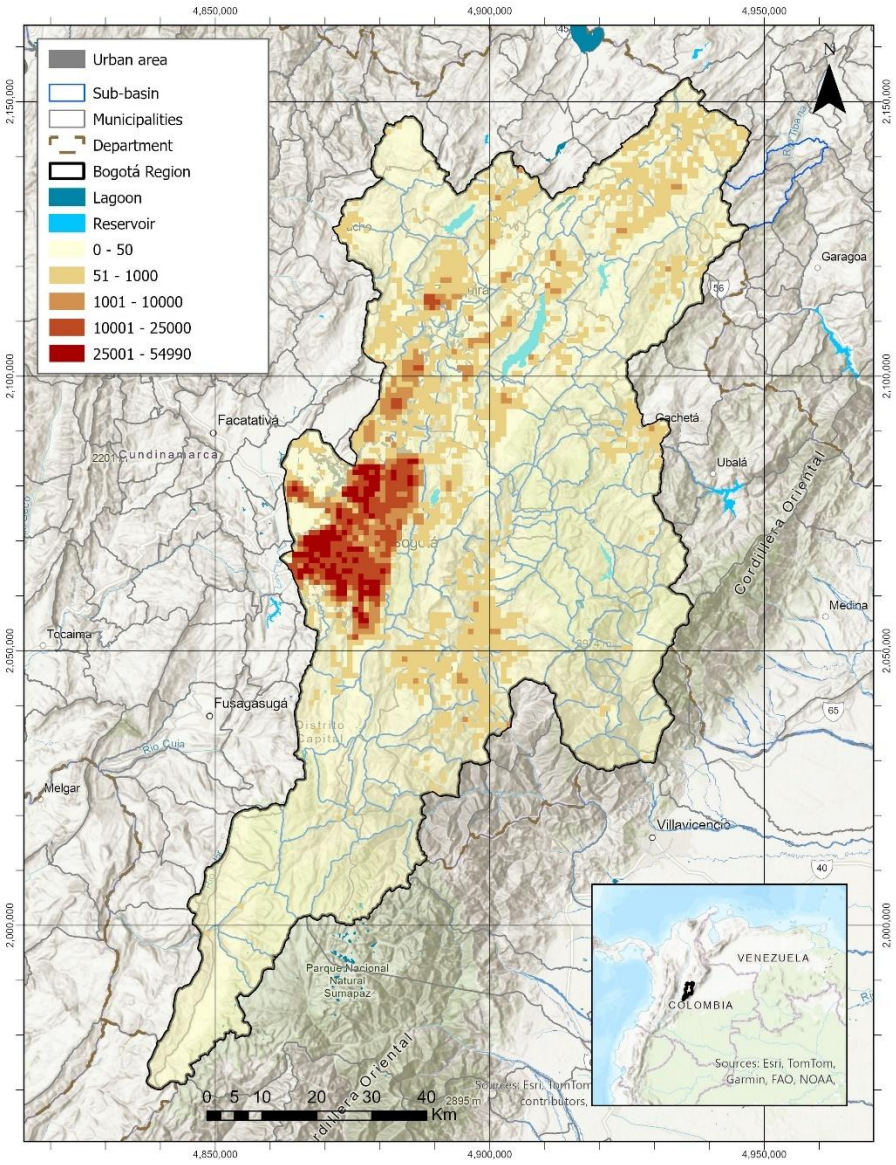


Figure 7. Population density (inhabitants per km²) 2018.

Source: DANE, 2018

Local service fragility is further illustrated by the role of community-run systems. More than half of productive units depend on community-run water systems, and the project identifies multiple rural and municipal intakes in priority watersheds (DNP, 2022; DANE, 2025). These systems tend to be highly exposed to local changes in flow and water quality, yet they often have limited technical, financial, and institutional capacity to adapt. This creates a strong territorial asymmetry: the rural landscapes that sustain Bogotá's water supply are often the same landscapes where service systems are least resilient.

Table 4. Community run rural water supply systems identified in the municipalities of the project.

Municipality	Community-run rural water supply systems	Main reported or expected use
Chocontá	Asociación de Usuarios del Servicio de Acueducto de las veredas Turmal, Cruces, Manaca, Chinata y Santa	Water abstraction, treatment and distribution

Municipality	Community-run rural water supply systems	Main reported or expected use
	Bárbara; Asociación de Usuarios del Servicio de Acueducto de la vereda Agua Caliente Alto, sector El Pantano; Acueducto Retiro de Blancos.	
Cogua	Asociación de Usuarios del Servicio de Acueducto y Alcantarillado de la Vereda El Olivo; Asociación de Acueducto Vereda El Olivo del municipio de Cogua Cundinamarca;	Drinking water rural, Water abstraction, treatment and distribution
Guasca	Asociación de Usuarios del Acueducto Rural Mariano Ospina E.S.P.; Acueducto Santa Bárbara sector Norte de Pastor Ospina; A Asociación de Usuarios del Acueducto de las veredas Pastor Ospina y Flores.	Drinking water rural, Water abstraction, treatment and distribution
Guatavita	Asociación de Usuarios del Acueducto Vereda Tominé de Indios; Asociación de Usuarios del Acueducto Rural de la Vereda Potrero Largo; Asociación de Suscriptores del Acueducto de la Vereda Potrerolargo, sector Palacio.	--
Sesquilé	A sociación de Usuarios del Servicio de Acueducto Vereda El Uval; Asociación AUSA La Villa; ASOLLANOGRANDE; Acueducto Minas.	--
Tausa	Asociación de Usuarios del Acueducto San Antonio de la Vereda San Antonio; Asociación de Usuarios del Acueducto Sector Las Minas de la Vereda Lagunitas; Asociación de Usuarios del Acueducto Sectorial El Charnal de la Vereda Pueblo Viejo; Asociación de Usuarios del Acueducto Regional de las veredas Rasgatá y otras.	Water abstraction, treatment and distribution
Villapinzón	Asociación de Usuarios del Acueducto Veredal de Chasquez; Asociación de Usuarios Junta Administradora del Acueducto de las veredas de Bosavita y Chinquira; Asociación de Usuarios del Acueducto Interveredal de Sonsa, Guanguita Alto, Guanguita Bajo, Nemoconcito y Tibita; Asociación de Usuarios del Servicio de Acueducto de las veredas Chigualá, Sonsa y Guanguita, sector El Altillo; Asociación de Usuarios del Servicio de Acueducto de las veredas San Pablo, La Joya y sector Salitre.	Drinking water rural, Water abstraction, treatment and distribution

Source: IDOM 2025 compilate from (CAR, 2019b).

The implication is that water vulnerability in the Bogotá Region is socially and institutionally uneven. The same hydrological system supports both the capital and smaller municipalities, but the burdens of ecosystem degradation and weak service resilience fall disproportionately on rural and peri-urban territories with less adaptive capacity. This asymmetry is itself a non-climate driver of vulnerability because it weakens the long-term basis for watershed stewardship unless financing, governance, and benefit-sharing become more balanced (IDB-CI-C&C, 2022; CAR, 2019).

1.7. Implications for climate problem definition

The data presented in this chapter show that the climate problem in the Bogotá Region is superimposed on a pre-existing condition of structural water vulnerability. The region spans 8,292 km² and 68 municipalities, depends on a multi-basin hydrological system, and relies on supply infrastructure that serves more than 11.2 million people directly while also sustaining municipal systems in surrounding territories (DANE, 2025; IDEAM, 2018; WWF Colombia, 2025). At the same time, hydrological regulation depends on ecosystems that capture around 40% of horizontal precipitation, yet 70% of wetlands are already hydrologically altered, 27% of the Chingaza–Sumapaz–Guerrero system receives insufficient rainfall to sustain high-mountain ecosystems, and water use exceeds sustainable levels across 45% of that territory in dry years (Instituto Humboldt, 2019b, 2023; Banco Interamericano de Desarrollo, 2022b).

These ecological constraints operate within a basin that already exhibits high structural water stress and high hydroclimatic variability, with annual precipitation ranging from 750 mm to 1,450 mm and a historical record of 676 hydrometeorological events, including 244 floods, 121 landslides, and 110 forest fires (IDEAM, 2025; IDEAM-ENA, 2022; DesInventar, 2026). They also coincide with a productive matrix dominated by livestock at 39.3% of productive land and potato cultivation at 23.6%, together with weak municipal fiscal capacity, extensive dependence on community-managed water systems, and strong territorial asymmetries in adaptive capacity (DNP, 2022; DNP, 2023; DANE, 2018). These are not isolated indicators. They show that climate hazards will affect a water system whose ecological buffers are already weakened, whose hydrological balances are already stressed, and whose capacity to respond is unevenly distributed across territories.

The conclusion is therefore evidence-based and direct: water vulnerability in the Bogotá Region is already materially constituted by non-climate drivers. Climate change will intensify the problem, but the current baseline is already defined by regional dependence on stressed ecosystems, structural water imbalance, land uses that increase hydrological pressure, and limited institutional capacity in source territories. The climate problem must therefore be framed as a compounded risk emerging from the interaction between climate pressures and an already vulnerable socio-ecological water system (IDEAM-ENA, 2022; CAR, 2019; IDB-CI-C&C, 2022).

2. Climate rationale: Observed and projected impacts on water security in the Bogotá Region

Water security in the Bogotá Region is already being affected by the interaction of climate change, ecosystem degradation, rising demand for water, and uneven territorial capacity to respond. The region depends on a socio-ecological system that extends beyond the administrative limits of Bogotá, including páramos, high-Andean forests, wetlands, headwater soils, reservoirs, and upper-basin productive landscapes that regulate runoff, sustain baseflows, and buffer hydro-climatic variability.

Following the IPCC Sixth Assessment Report (AR6) approach, this chapter frames climate risk as the interaction of climate hazards, exposure and vulnerability. On that basis, it presents: (i) the methodological approach and data sources for the climate change vulnerability assessment (CCVA); (ii) observed and projected climate hazards affecting the Bogotá Region; (iii) the exposure and vulnerability of populations, ecosystems and water systems; (iv) the characterization of climate risk and impact chains; and (v) the climate rationale for the proposed intervention and the key adaptation needs that emerge from the analysis.

The chapter is intended to provide a clear analytical bridge between evidence and design. It explains not only what climatic changes are being observed and projected, but also why these changes matter for water security, why the selected intervention landscapes are justified, and why the proposed solutions have not yet been implemented at the required scale.

2.1. Methodological approach, data sources and limitations

The assessment is aligned with the IPCC AR6 framework (Figure 8), which defines climate risk as the outcome of the interaction between hazard, exposure and vulnerability. Within this framework, hazard refers to current and projected climate-related stressors; exposure refers to the spatial distribution of people, ecosystems, infrastructure and productive systems located in areas affected by those stressors; and vulnerability refers to the propensity of exposed systems to be adversely affected, taking into account both sensitivity and adaptive capacity.



Figure 8. Risk in the IPCC Assessment.
Source: (IPCC, 2022).

The climate hazard assessment combines observed records from IDEAM meteorological stations with downscaled CMIP6 projections. Historical baseline conditions were defined using data from 13 meteorological stations for 1991–2020, while future climate conditions were analyzed under SSP2-4.5 and SSP5-8.5. Exposure was assessed by overlaying projected population distribution to 2035, productive systems, infrastructure, and the location of critical ecosystems, particularly páramos and high-Andean forests. Vulnerability was assessed through a composite index based on 26 indicators representing adaptive capacity and sensitivity at municipal level, using data from DANE, DNP and other official national sources (Figure 9).

Data were harmonized in terms of spatial resolution, temporal coverage and format (Table 5). Indicators expressed in different units were normalized using a min–max scaling approach. Hazard, exposure and vulnerability were first analyzed separately and were then integrated through a Multi-Criteria Decision Analysis (MCDA) and weighted GIS overlays to identify spatial convergence zones and climate-risk hotspots.

The methodology provides a robust basis for strategic prioritization, but it is subject to limitations. Climate projections remain uncertain, especially in mountainous terrain. Socioeconomic and institutional indicators are mostly available at municipal scale and therefore do not fully capture intra-municipal heterogeneity. Some datasets include temporal inconsistencies or gaps and required standardization or proxy indicators. These limitations do not invalidate the analysis, but they should be taken into account when interpreting the risk maps and territorial comparisons.

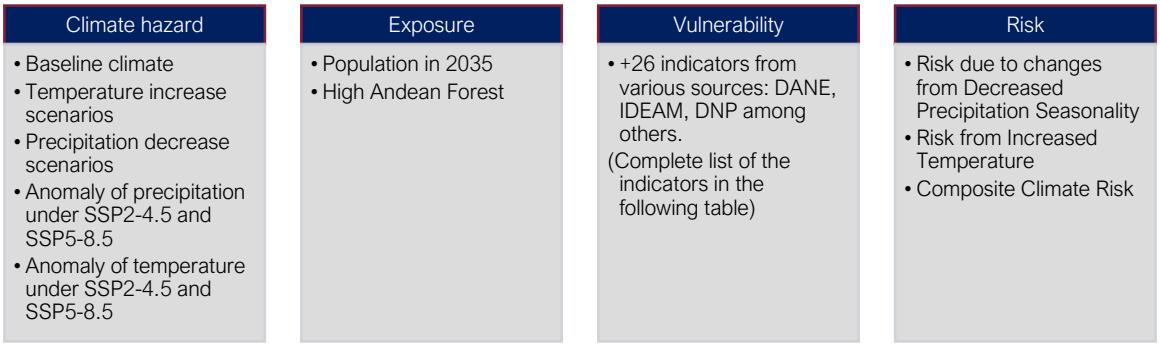


Figure 9. Methodological process for the identification of climate risk.
Source: compiled by IDOM.

Table 5. Summary of the analytical framework, variables and data sources.

Risk component	Main variables	Principal sources	Analytical function
Climate hazard	Observed temperature and precipitation trends; anomalies; ET-SCI indices; projected changes under SSP2-4.5 and SSP5-8.5	IDEAM (2024, 2025); WMO ET-SCI	Characterize current and future hydro-climatic pressures relevant to water security
Exposure	Population distribution and growth; productive systems;	DANE (2018, 2025); ecosystem and water-system datasets cited in the study	Identify the elements located in hazard-prone areas and

	ecosystems; infrastructure and water systems		dependent on water-regulating landscapes
Vulnerability	26 indicators of adaptive capacity and sensitivity at municipal level	DANE (2025); DNP (2025); other official national sources	Assess the relative capacity of territories to respond, cope and adapt to climate impacts
Integrated risk	Normalized and weighted overlays of hazard, exposure and vulnerability	IDOM processing based on the sources above	Identify risk hotspots and inform site prioritization and adaptation design

Source: IDOM, 2026.

2.2. Observed climate change in the Bogotá Region

The baseline climate for the Bogota-Cundinamarca-Meta region was constructed using 14 meteorological stations from IDEAM with 85% data completeness, following World Meteorological Organization recommendations (WMO, 2018) (IDEAM, 2025). The region exhibits a bimodal precipitation regime with mean annual values of 1,000-1,050 mm/year, characterized by two rainy seasons (April-May and October-November) and a relative dry period (June-August) (IDEAM, 2025) (Table 6).

Table 6. Summary of baseline climatological values (1991–2020) used for trend and anomaly analysis.

Variable	Mean annual value	Mean monthly minimum	Mean monthly maximum	Observed range (monthly)
Precipitation (mm)	~1,000–1,050 mm/year	~48 mm (Jul–Aug)	~120 mm (April)	~48–120 mm/month
Maximum Temperature (°C)	~21.0 °C	~20.3 °C (Jun–Jul)	~22.0 °C (Feb)	~20.3–22.0 °C
Minimum Temperature (°C)	~10.4 °C	~9.0 °C (Jan–Jul)	~11.0 °C (Mar–May, Oct–Nov)	~9.0–11.0 °C

Source: IDOM with information from (IDEAM, 2025).

Observed climate records show measurable climate change in the Bogotá Region. Over the 1991–2020 baseline, maximum temperature increased by approximately 0.2°C per decade. At the same time, annual precipitation fluctuated markedly between 750 mm and 1,450 mm under the influence of the El Niño–Southern Oscillation (ENSO). The regional baseline shows a bimodal precipitation regime with mean annual rainfall of approximately 1,000–1,050 mm/year, maximum temperature around 21.0°C and minimum temperature around 10.4°C.

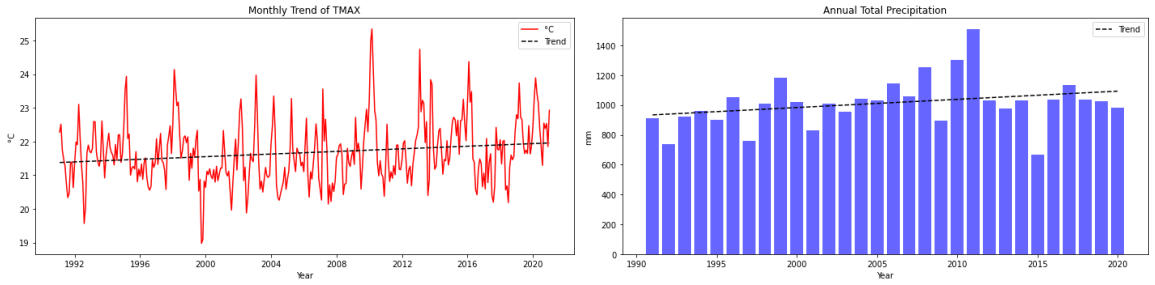
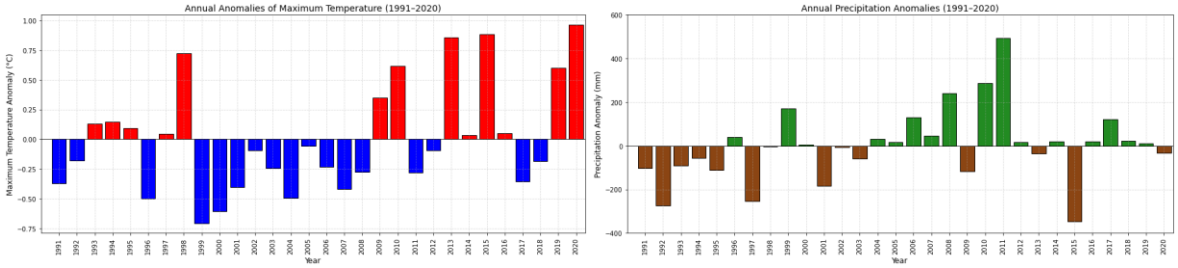


Figure 10. Linear trend of monthly maximum temperature (left) and annual total precipitation (right) (1991–2020).
Source: IDOM with information from IDEAM, 2025.

Figure 11. Annual anomalies of maximum temperature (left) and annual anomalies of total precipitation (right) (1991–2020) relative to baseline climatology.



Source: IDOM with information from (IDEAM, 2025).

This variability has translated into recurrent hydrometeorological impacts. Historical records compiled from DesInventar for 1912–2017 show approximately 676 events in the region, dominated by floods (244), landslides (121) and forest fires (110). The hazard profile is therefore not hypothetical or recent; it is already reflected in a long event record affecting both urban and rural territories.

Recent events confirm the practical relevance of these trends for water security. The 2024–2025 drought exposed the vulnerability of the regional supply system and demonstrated that water shortages can affect not only households but also productive and institutional users. This recent crisis is particularly important because it validates the climate-risk narrative with observed impacts on water supply reliability.

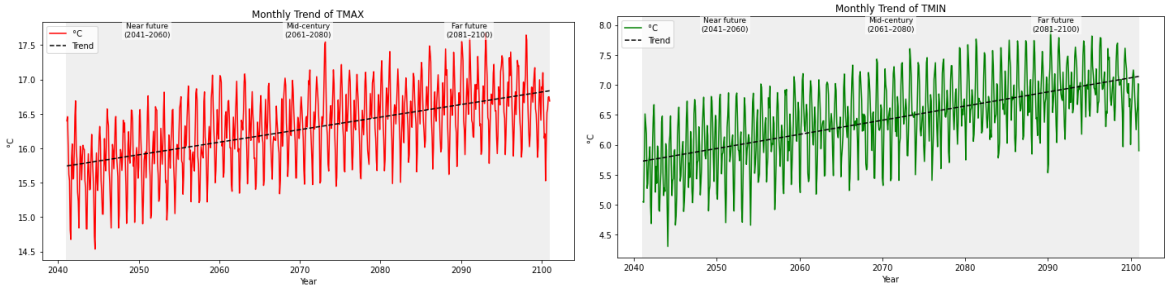
2.3. Projected climate change and hydro-climatic hazards

Climate projections are derived from Coupled Model Intercomparison Project Phase 6 (CMIP6) global circulation models, downscaled by IDEAM to high spatial resolution (~10 km) to capture the complex topography of the Eastern Andes (IDEAM, 2024). The downscaling approach combines statistical correction techniques with dynamical modeling, integrating regional atmospheric circulation patterns refined through collaboration between IDEAM, the Ministry of Environment and Sustainable Development, and academic institutions (IDEAM, 2024) (Riahi K. , 2017).

Two Shared Socioeconomic Pathways were analyzed: SSP2-4.5 (moderate mitigation scenario representing middle-of-the-road development with partial climate policy implementation) and SSP5-8.5 (high emissions scenario depicting fossil-fueled development with limited mitigation) for three time horizons: 2021-2040, 2041-2060, and 2081-2100 (Riahi K. , 2017) (IPCC, Sixth Assessment Report (AR6): Climate Change 2021, 2021) (IDEAM, 2024).

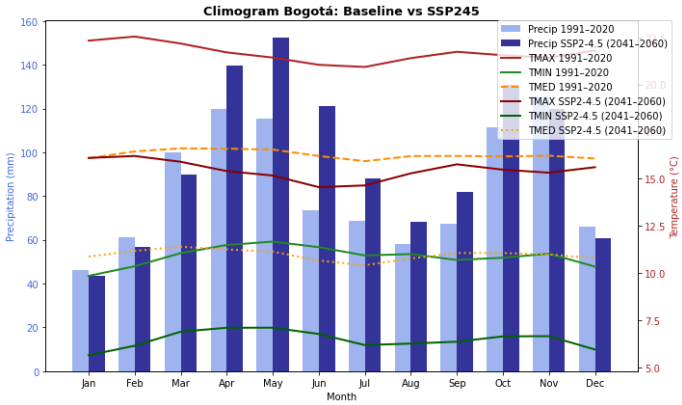
Future climate projections indicate continued warming and increasing variability. Under SSP2-4.5, maximum temperature is projected to increase by approximately 1.5–2.0°C by late century and minimum temperature by around 2.0°C. Under SSP5-8.5, warming becomes substantially stronger, with maximum temperature increasing by 3.0–3.5°C and minimum temperature by 3.5–4.0°C by late century.

Figure 12. Projected monthly trend of maximum (left) and minimum (right) temperature (Tmax and Tmin) under SSP2-4.5, 2041-2100.



Source: IDEAM (2025); compiled IDOM.

Figure 13. Climogram of Bogota (Climatology 2041-2060) under SSP2-4.5.



Source: (IDEAM, 2025); compiled by IDOM.

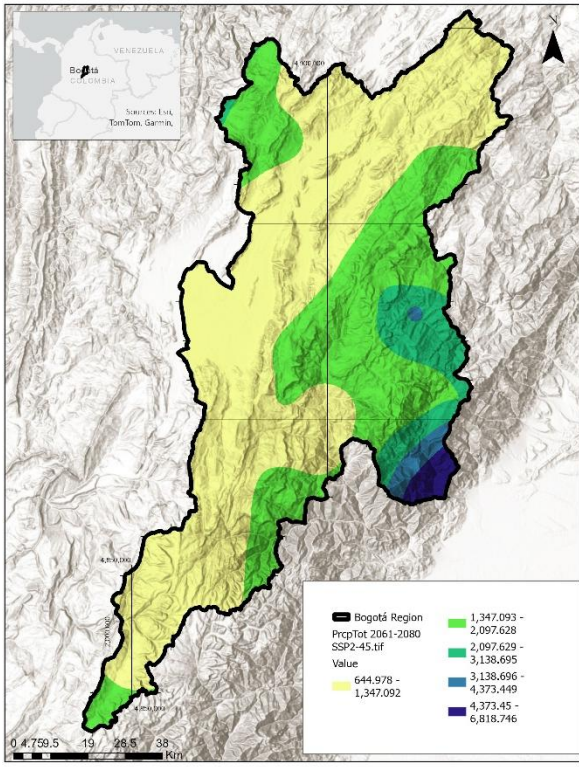


Figure 14. Spatial distribution of average precipitation under SSP2-4.5 (2061–2080).
Source: IDEAM, (2025); compiled by IDOM.

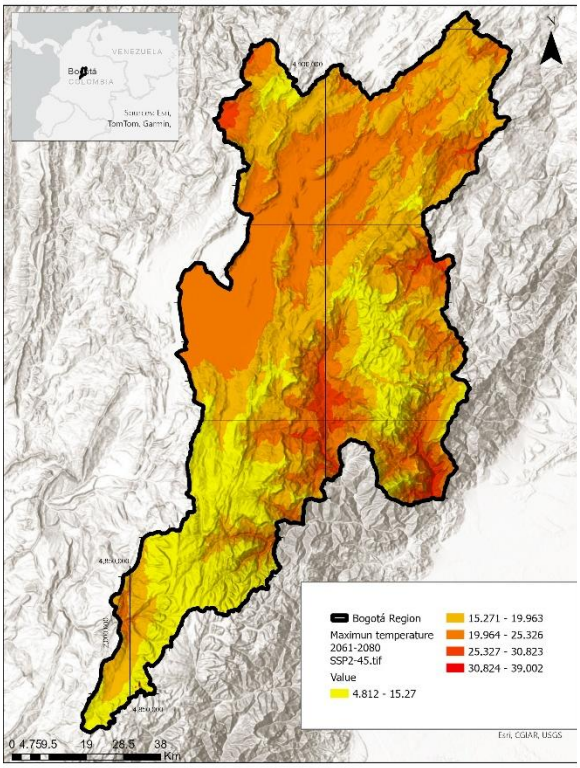


Figure 15. Spatial distribution of average maximum temperature under SSP2-4.5 (2061–2080).
Source: IDEAM, (2025); compiled by IDOM.

Projected precipitation retains a bimodal regime but with stronger rainy-season peaks and greater interannual variability. Under SSP2-4.5, April–May precipitation peaks reach approximately 270–300 mm/month, while under SSP5-8.5 they reach approximately 280–310 mm/month. The hazard signal therefore consists not simply of less or more rainfall, but of more irregular rainfall delivered through more intense episodes and accompanied by longer dry periods.

The assessment prioritizes five hazard types because of their direct relevance to water security: (i) increasing temperature and heat extremes; (ii) changes in precipitation patterns and variability; (iii) extreme rainfall leading to flooding and erosion; (iv) drought conditions and prolonged dry periods; and (v) climate conditions conducive to wildfires. These hazards were selected because they directly affect runoff dynamics, soil moisture, infiltration, water storage and regulation functions in the high-Andean ecosystems that sustain the region's water supply systems.

2.3.1. Projected changes in temperature

The SSP2-4.5 and SSP5-8.5 scenarios both project significant warming across the Bogotá Region, with the strongest increases under SSP5-8.5 (IDEAM, 2025). Maximum temperature anomalies for 2061–2080 show a general increase strongly influenced by altitude: lower-elevation areas exhibit the largest warming in both scenarios, while high-mountain areas show more moderate increases and even localized negative anomalies in the intermediate scenario. Under SSP5-8.5, moderate-increase areas exceed 4°C of additional warming, reducing the characteristic buffering effect of high-mountain ecosystems and leading to greater regional thermal homogenization (IDEAM, 2025).

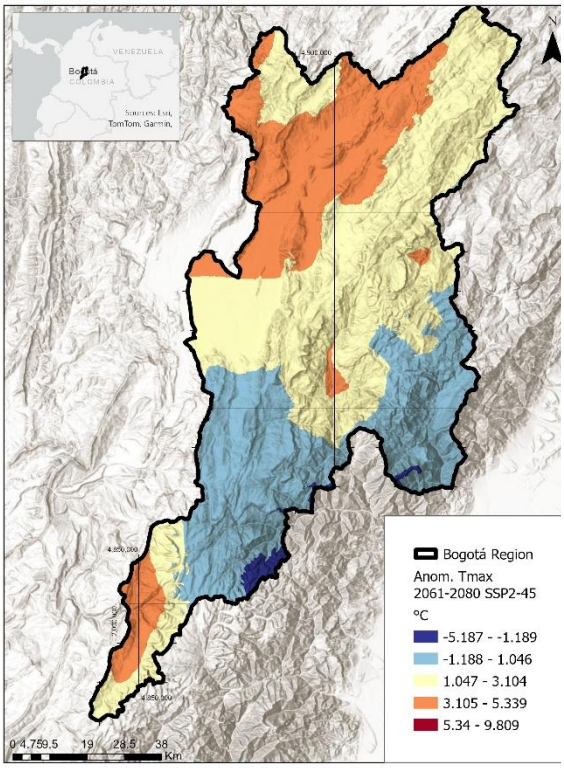


Figure 16. Anomaly of maximum temperature under SSP2-4-.5 (2061–2080).

Source: IDEAM, (2025); compiled by IDOM.

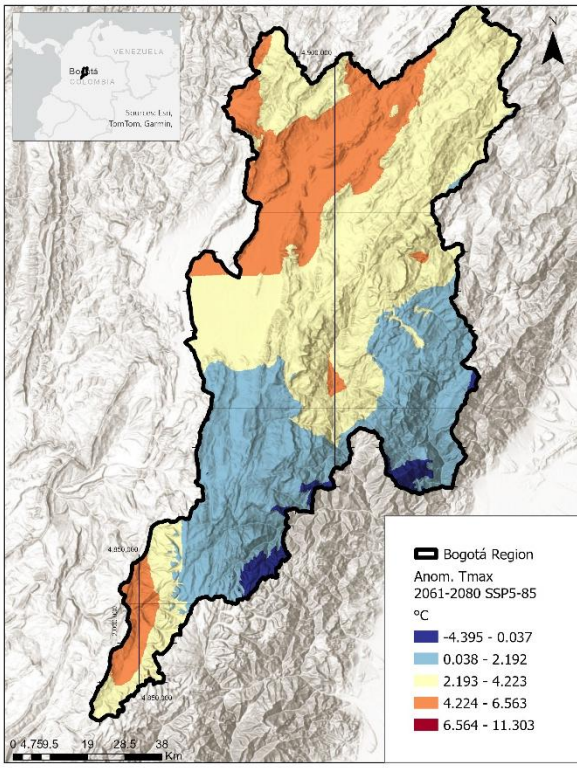


Figure 17. Anomaly of maximum temperature under SSP5-8.5 (2061–2080).

Source: IDEAM, (2025); compiled by IDOM.

High and very high temperature-increase categories are concentrated mainly in eastern and south-eastern sectors, significant portions of the Guatavita and Villapinzón systems, and the central–southern sector of the Guandoque–Tominé corridor (IDEAM, 2025). Spatial overlap between these warming hotspots and páramo zones substantially increases risk because rising temperatures favour altitudinal species shifts, loss of characteristic vegetation, increased evapotranspiration and disruption of water-regulation functions (Fadrique et al., 2018; Murad, Pearse, & Huguet, 2024). Areas experiencing strong warming combined with weak institutional and financial adaptive capacity are at particular risk, given the greater difficulty of implementing preventive, adaptation and ecosystem-conservation measures in the short and medium term (IPCC, 2022; DANE, 2025).

2.3.2. Projected changes in precipitation

Precipitation projections indicate that the regional climate regime will continue to exhibit a bimodal pattern but with important changes in intensity, distribution and seasonality. Although some areas show positive precipitation anomalies, the predominance of negative anomalies suggests a tendency toward less frequent rainfall events of shorter duration, while total rainfall becomes more concentrated in intense episodes (IDEAM, 2025). Combined with rising temperatures, this points to shorter and less persistent

wet periods and greater intra-annual variability in water availability, with potential implications for groundwater recharge, ecosystem stability and water-dependent productive activities (IDEAM, 2025).

Precipitation anomaly maps for SSP2-4.5 and SSP5-8.5 (2061–2080) show a consistent pattern in the area corresponding to Guandoque, Villapinzón, Tunjuelo and the Tominé region, where moderate positive anomalies indicate potential increases in annual rainfall totals, surrounded by extensive areas with negative or near-neutral anomalies. This suggests that, although total precipitation may increase during certain periods in these headwater areas, rainfall is likely to occur in a more irregular and concentrated manner, with more sporadic events and shorter wet periods. Ultimately, this translates into a reduction in the duration and sustained intensity of rainfall episodes, with potential impacts on hydrological regulation and groundwater recharge (IDEAM, 2025).

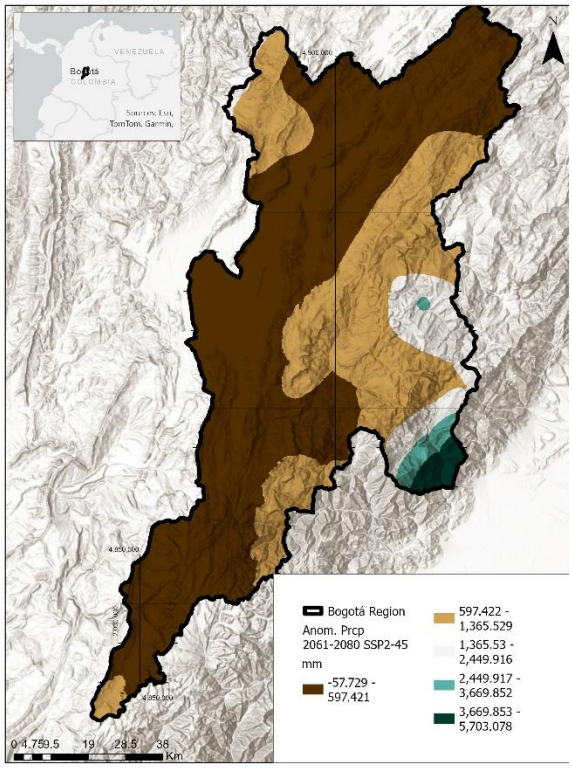


Figure 18. Anomaly of precipitation under SSP2-4-.5 (2061–2080).

Source: IDEAM, **(2025)**; compiled by IDOM.

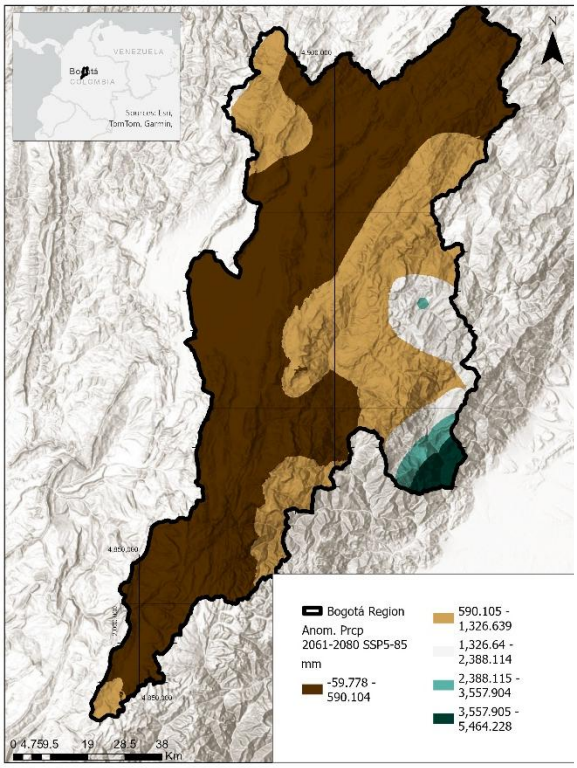


Figure 19. Anomaly of precipitation under SSP5-8.5 (2061–2080).

Source: IDEAM, (2025); compiled by IDOM.

Comparative analysis of precipitation anomalies reveals a persistent west–east gradient. The western part of the region shows limited reductions or increases in precipitation, while the eastern part experiences more pronounced increases, particularly under SSP5-8.5 (IDEAM, 2025). This behavior is consistent with intensification of the hydrological cycle, in which humid regions become wetter and areas with lower relative precipitation experience persistent deficits or marginal increases (IPCC, 2022). These dynamics have direct implications for regional water security. Headwater basins, including those associated with strategic supply systems such as Chingaza, could experience increased water availability,

but this comes with greater risks of degradation to páramo ecosystems and more extreme events. Conversely, the central and southern regions, which have the highest population density, show a lower tendency toward increased precipitation, potentially exacerbating the structural imbalance between water supply and demand under climate-change scenarios (IPCC, 2022; DANE, 2025).

2.3.3. Climate extremes and hydro-climatic hazards

Analysis of ET-SCI (WMO Expert Team on Sector-specific Climate Indices) reveals increasing frequency and intensity of climate extremes across both scenarios, following methodology established by WMO (2017) and applied by IDEAM (2025). Key temperature-related hazards include more frequent warm days (Tx90p), fewer cold nights (TN10p), and more heatwave events (HWN), especially under SSP5-8.5, with implications for public health, energy demand, and ecosystem stress (IDEAM, 2025) (WMO, 2017). Precipitation-related indices such as CDD, Rx1day, R95pTOT and SPI-12 indicate longer dry spells, more intense short-duration rainfall and greater concentration of precipitation, which together heighten drought and flood risks and increase runoff, erosion and sediment transport (IDEAM, 2025; IPCC, 2022).

Table 7. Selected ET-SCI climate indices and their sectoral applications.

Indicator	Description / Purpose	Sectoral relevance
Tx90p – Warm days above the 90th percentile	Percentage of days when Tmax exceeds the 90th percentile of the baseline. Identifies hot extremes and heatwave frequency.	Human health, energy, urban infrastructure
TN10p – Cold nights below the 10th percentile	Percentage of nights when Tmin falls below the 10th percentile. Indicates cold extremes affecting sensitive crops or ecosystems.	Agriculture, ecosystems, biodiversity
CDD – Consecutive Dry Days	Maximum number of consecutive days with precipitation < 1 mm. Reflects drought persistence.	Agriculture, water resources, forestry
Rx1day – Maximum 1-day precipitation	Highest 24-hour rainfall total in a year; describes short-duration extreme precipitation.	Urban drainage, flood management, infrastructure
R95pTOT – Very wet days total	Total precipitation from days exceeding the 95th percentile. Captures rainfall concentration and flood potential.	Hydrology, disaster risk reduction, agriculture
SPI-12 – Standardized Precipitation Index	Standardized measure of rainfall deficit or surplus over 12 months. Represents wetness/dryness cycles.	Drought monitoring, water supply planning
HWN – Heatwave number	Number of events with ≥3 consecutive days above the 90th percentile of Tmax. Quantifies extreme temperature episodes.	Public health, energy demand, tourism

Source: IDOM with information from IDEAM (2025), WMO ET-SCI (2023), and IPCC AR6 (2021).

Enhanced extreme precipitation events (Rx1day, R95pTOT) and increased surface runoff due to intense rainfall concentrated over shorter periods underpin flood hazards in the region (IDEAM, 2025). Flooding occurs most frequently during La Niña events, with significant episodes recorded in 1988, 2000, 2010, 2011 and 2012, affecting municipalities including Tausa, Zipaquirá and Guatavita (IDEAM, 2025). Steep slopes and fragile soils make the Chingaza–Sumapaz–Guerrero corridor intrinsically susceptible to mass-movement processes, with erratic rainfall rapidly saturating soils and reducing cohesion; Villapinzón exhibits the highest landslide hazard, with slopes ranging from 54° to 71° (IDEAM, 2025).

Prolonged dry periods (CDD, SPI-12) reduce páramo water-regulation capacity and heighten competition for water resources, with municipalities most affected by meteorological drought including Guatavita, Sesquilé, Chocontá and Villapinzón (IDEAM, 2025). Higher temperatures and prolonged dry periods have increased fire susceptibility, with affected area rising from 4,100 hectares in 2023 to 6,500 hectares in 2024 in municipalities including Guasca, Chocontá, Villapinzón and Cogua (IDEAM, 2025). Non-seasonal frosts increasingly damage sensitive crops and páramo vegetation, with Villapinzón experiencing 5–9 frost days per year when temperatures reach 0°C (IDEAM, 2025).

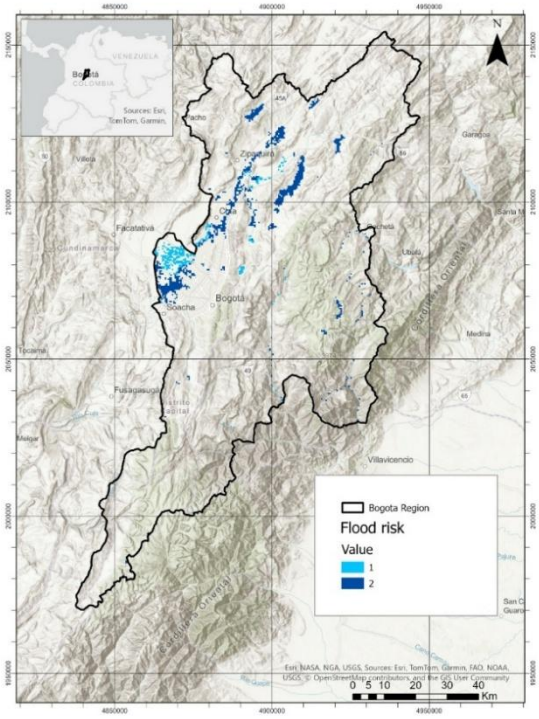


Figure 20. Flood risk map for the Bogota-Region.
Source: IDEAM, (2020); compiled by IDOM.

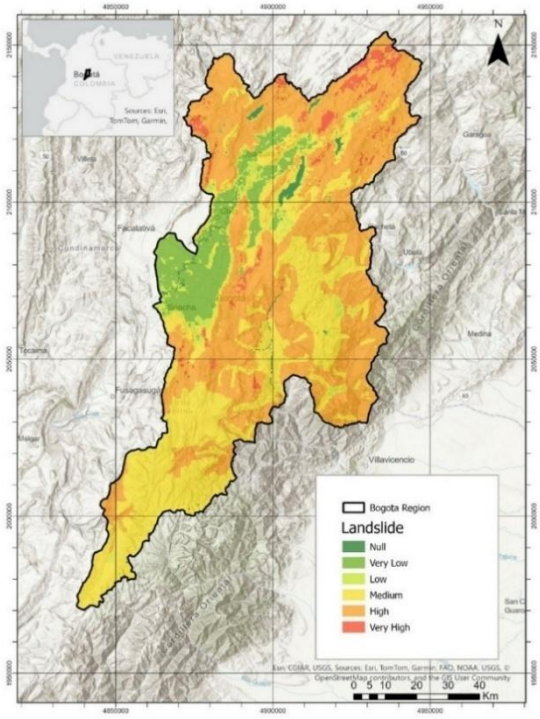


Figure 21. Landslide hazard for the Bogota-Region.
Source: IDOM, 2025 with information from IDEAM.

Steep slopes and fragile soils make the Chingaza-Sumapaz-Guerrero corridor intrinsically susceptible to mass displacement processes, with erratic rainfall patterns rapidly saturating soils and reducing cohesion (IDEAM, 2025). Villapinzón exhibits the highest landslide hazard, with slopes ranging from 54° to 71° (IDEAM, 2025).

Prolonged dry periods (CDD, SPI-12) reduce páramo water regulation capacity and heighten competition for water resources, with municipalities most affected by meteorological drought including Guatavita, Sesquilé, Chocontá, and Villapinzón (IDEAM, 2025). Higher temperatures and prolonged dry periods have increased fire susceptibility, with affected area rising from 4,100 hectares in 2023 to 6,500 hectares in 2024 in municipalities including Guasca, Chocontá, Villapinzón, and Cogua (IDEAM, 2025).

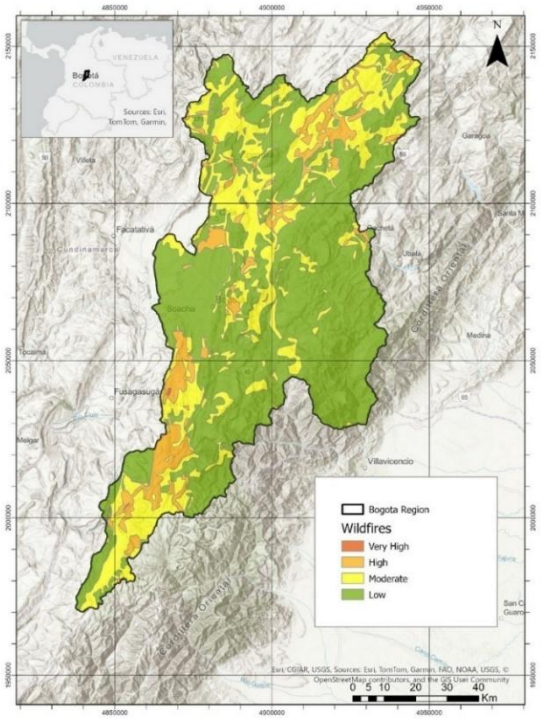


Figure 22. Wildfire hazard map for the Bogota-Region.
Source: IDOM, 2025 with information from ICDE.

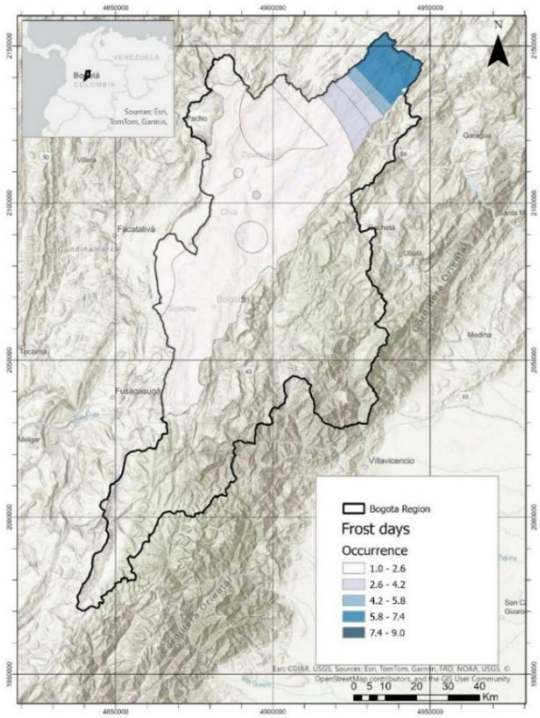


Figure 23. Frost days map for the Bogota-Region.
Source: IDOM, 2025 with information from ICDE.

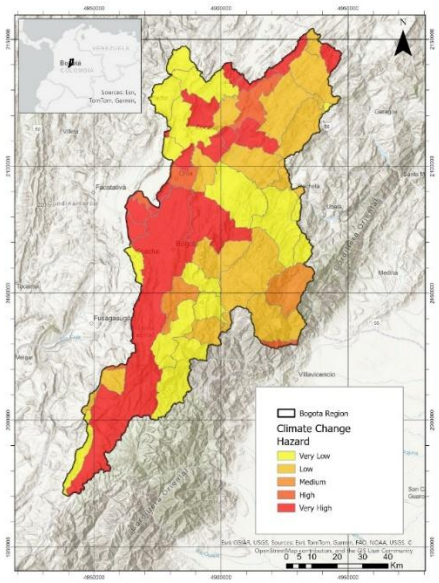


Figure 24. Climate Change Hazard Map for Bogota Region.
Source: IDEAM, (2020); compiled by IDOM.

In addition to the projected intensification of hydro-climatic extremes, including more frequent and severe droughts, extreme precipitation events and increasing intra-annual variability, the basin is already subject to significant structural water-stress conditions that amplify climate-related risks. According to the Estudio Nacional del Agua (ENA), several regions of Colombia, including the Bogotá River Basin, exhibit high levels of water stress driven by imbalances between water availability and demand, compounded by seasonal variability and increasing pressures from urban growth and economic activities (IDEAM-ENA, 2022). The ENA also highlights that water-resource systems in densely populated basins are operating close to or beyond sustainable thresholds, with a growing risk of supply deficits during dry periods and higher runoff, erosion and sediment transport during extreme rainfall events (IDEAM-ENA, 2022).

As documented in the previous chapter on baseline and non-climate drivers, the Bogotá Region's water system is therefore already structurally stressed before considering additional climatic pressures. In this context, observed and projected climate hazards do not occur in isolation; they interact with pre-existing hydrological imbalances and structural inefficiencies in water use, allocation and management, reducing the system's capacity to buffer shocks and maintaining reliable service provision. The interaction between climate-induced variability and a highly stressed water system is thus a key driver of risk amplification for populations, productive sectors and strategic ecosystems, particularly high-Andean ecosystems that underpin hydrological regulation in the region.

2.4. Structural water stress and the role of El Niño-Southern Oscillation (ENSO)

Interannual climate variability in the Bogota Region is strongly influenced by large-scale ocean–atmosphere interactions, particularly those associated with the El Niño–Southern Oscillation (ENSO). In Colombia, ENSO constitutes one of the main drivers of interannual hydroclimatic variability, producing marked anomalies in precipitation and temperature that affect the Andean region in different ways depending on the phase of the oscillation (Jose & Daniel, 2000). El Niño episodes are generally associated with precipitation deficits and warmer conditions, whereas La Niña episodes tend to favor rainfall surpluses and wetter-than-normal conditions. These relationships have been documented for Colombia by Jose Edgar Montealegre Bocanegra and Jose Daniel Pabon Caicedo, who identify years such as 1982–1983, 1991–1992, and 1997–1998 as relevant warm ENSO episodes affecting the country.

ENSO further amplifies water shortage and flooding risk. Historical analysis shows that cold ENSO phases are more strongly associated with floods, landslides and intense rainfall, while warm ENSO phases are more consistent with drought-prone and fire-prone conditions. In practical terms, this means that the region's water systems are exposed both to long-term climatic shifts and to episodic large-scale drivers that intensify extremes (either excess water or water deficits) over shorter time scales.

The temporal evolution of the Oceanic Niño Index (ONI) is consistent with the historical occurrence of extreme events in the study area. A review of DesInventar records indicates that the highest concentration of hydrometeorological events occurred during recent cold ENSO conditions. In particular, 2010 registered 24 events, while 2011 and 2012 registered 27 events each, making this the most active period in the available historical record. For 2011, the records report 10 flood events, 7 landslides, 8 strong-wind events and 1 rainfall event; for 2012, the records report 10 floods, 5 landslides and 1 torrential-flow event, indicating a clear clustering of hazards linked to excess moisture and slope instability.

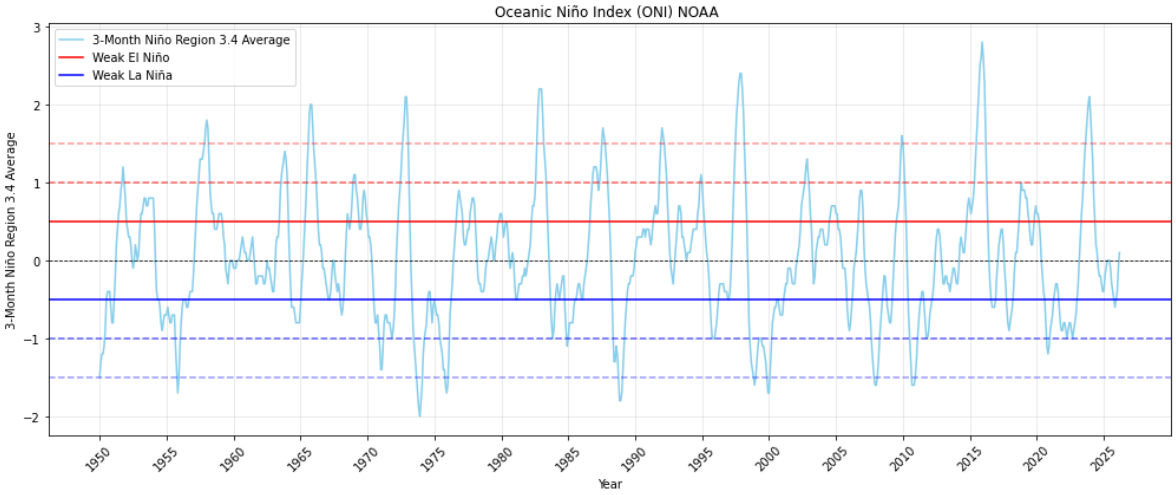


Figure 25. ENSO variability (ONI index) and associated periods of El Niño and La Niña used for the interpretation of extreme events in the study area.

Source: IDOM 2026 with data from https://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php.

By contrast, years associated with warm ENSO conditions show lower annual totals in the historical record. For example, 1991 registered 6 events, 1992 registered 4, 1997 registered 7, and 1998 registered 6. Although some flood- and landslide-related events are still present in those years, the overall frequency is substantially lower than during the cold ENSO period of 2010–2012. At the same time, the historical record also captures dry-condition signals during warm phases, including a drought event in 1997 and the occurrence of forest-fire events in years associated with or following warm ENSO anomalies.

Taken together, these records support the interpretation that ENSO does not simply modulate background climate variability but acts as a major intensifier of extreme-event occurrence in the region. The historical evidence suggests that cold ENSO phases are more strongly associated with floods, landslides and other rainfall-related hazards, while warm ENSO phases are more consistent with drought-prone and fire-prone conditions, in agreement with the broader climatological behavior documented for Colombia. This reinforces the need to incorporate ENSO monitoring into climate-risk analysis and anticipatory water-management planning in the intervention landscapes.

2.5. Exposure of populations, ecosystems and infrastructure

Exposure in the Bogotá Region is exceptionally high because climate hazards affect a large dependent population, strategic ecosystems and operationally critical water systems at the same time.

The Bogota region is home to approximately 20% of Colombia's population and provides water for more than 11.2 million people across 22 municipalities, including rural and urban areas of Bogota D.C. (DANE, n.d.). The population comprises predominantly small-scale farmers practicing traditional farming and livestock methods in rural areas, alongside the 11.2 million inhabitants of metropolitan Bogota, according to demographic data from the National Administrative Department of Statistics (DANE, n.d.) (CDN-DANE, 2018)(DANE, n.d.; CDN-DANE, 2018).

Rural populations are located in territories that coincide with key ecosystem service production areas critical for regional water security, though these communities face challenges including limited access to basic services, education, and healthcare (CDN-DANE, 2018) (Inter-American Development Bank, Conservation International, & Cities and Clima Change Initiative, 2022).

Demographic projections to 2035 indicate that Zipaquirá's population will increase by approximately 35%, compared to around 25% in Cogua and 20% in Tausa, concentrating growth in the urban–rural interface and placing nearby páramo ecosystems under greater pressure from urban expansion (DANE, 2025).

Ecosystem exposure is equally significant. Particularly páramos and High Andean forests, face multiple climate stressors and anthropogenic pressures that affect their capacity to provide essential services including hydrological regulation, flood control, biodiversity conservation, carbon sequestration, and support to human well-being (Instituto Humboldt, 2023) (Minsterio de Ambiente y Desarrollo Sostenible, 2023e). The Chingaza-Sumapaz-Guerrero high-mountain system plays a pivotal hydrological role, regulating water through low evapotranspiration and horizontal precipitation processes (Banco Interamericano de Desarrollo, 2022b).

However, approximately 27% of the high-mountain territory already falls below rainfall thresholds needed to sustain páramos and high Andean forests, added to that in areas where land cover has been transformed, hydrological regulation capacity has declined leading to more pronounced seasonal variability in river flows (Banco Interamericano de Desarrollo, 2022b). At the same time, soil degradation compounds these pressures: approximately 32% of soils show very low organic carbon content and 23% exhibit very low available moisture, which further undermines ecosystem stability and productivity (Banco Interamericano de Desarrollo, 2022b).

Water demand further exacerbates vulnerability, as 45% of the territory exceeds sustainable water use during dry years and 41% do so annually (Banco Interamericano de Desarrollo, 2022b). Urban expansion and infrastructure development have significantly reduced natural cover, weakened ecological connectivity, and altered hydrological dynamics. (Región Metropolitana Bogotá–Cundinamarca, 2025).

Infrastructure exposure is mediated by ecological dependence. Bogotá's supply relies on three systems: Chingaza (about 70%), the North system on the upper Bogotá River (about 25%) and the South/Tunjuelo system (about 5%). This configuration means that climate impacts affecting upstream ecosystems and source watersheds translate directly into supply risks for metropolitan users, municipal intakes and smaller community-run systems that have much less operational flexibility than the main utility.

2.6. Ecosystem sensitivity and systemic vulnerability

While exposure determines the presence of systems at risk, vulnerability explains their capacity to cope with climate hazards. Therefore, this section assesses the sensitivity and adaptive capacity of the exposed systems, identifying the structural conditions that amplify or reduce climate impacts.

This section presents a detailed analysis of vulnerability to climate change across key socio ecological system components of the Bogotá Region, including ecosystems, population and critical infrastructure. In line with the IPCC AR6 framework, vulnerability is understood as the propensity of these systems to be adversely affected by climate hazards and is determined by their sensitivity and adaptive capacity. While previous sections identified climate hazards and exposure patterns, this section focuses on how different systems respond to these stressors. Specifically, it analyses ecosystem sensitivity (particularly páramos and High Andean forests as critical water regulating systems), population dynamics and demographic pressures, and the vulnerability of water supply and infrastructure systems. This integrated approach

ensures that vulnerability is not assessed in isolation, but as a function of the interactions between biophysical processes, human systems and service provision conditions. The objective is to identify the underlying factors that amplify climate impacts and to provide a more operational understanding of the constraints that must be addressed to ensure the effectiveness and sustainability of proposed adaptation measures.

Strategic ecosystems in the Bogota Region exhibit varying levels of sensitivity to climate variables, affecting biodiversity, ecosystem service provision, and resilience to environmental disturbances (Instituto Humboldt, 2017c) (Instituto Humboldt, 2017d) (Instituto Humboldt, 2022).

Table 8. Ecosystem Services Most at Risk in Colombia.

Ecosystem Type	Main Ecosystems Services	Climatic Stressors	Services Most at Risk
Páramos	Water regulations and storage, biodiversity support, climate regulation	+ Temperature -Precipitation stability	Water provision, biodiversity maintenance
Hight Andean Forests	Erosion control, carbon sequestration, habitat connectivity	Extreme rainfall events, drought	Erosion control, soil stability
Urban Wetlands	Flood control, water purification, habitat for birds and amphibians	Drought, pollution, sedimentation	Hydrological regulation, biodiversity support

Source: IDOM 2025.

In this assessment, ecosystem sensitivity refers to the degree to which páramos and High Andean forests may be affected by climate hazards due to their ecological characteristics, climatic thresholds and role in water regulation. Sensitivity does not necessarily imply immediate ecosystem loss, but rather the potential alteration of key ecological and hydrological functions, including soil moisture retention, water storage, baseflow regulation, vegetation composition, species distribution, erosion control and resilience to fire or drought. Therefore, when páramos and High Andean forests are described as sensitive, the analysis refers to their limited tolerance to sustained warming, rainfall variability, prolonged dry periods and extreme events, which may reduce their capacity to provide water-regulating ecosystem services.

2.6.1. Páramos

Páramo ecosystems exhibit very high sensitivity to climate change due to dependence on stable temperature and precipitation regimes to sustain soil moisture, water storage, and regulation functions (Inter-American Development Bank, Conservation International, & Cities and Clima Change Initiative, 2022). Projected temperature increases of 1-5°C by end of century pose critical risks, potentially leading to significant loss of páramo area and affecting hundreds of endemic species adapted to cold, humid conditions (Inter-American Development Bank, Conservation International, & Cities and Clima Change Initiative, 2022) SiB Colombia, 2025a). These climate pressures, combined with agricultural expansion, grazing, and fire risk, substantially weaken páramo resilience and capacity to provide essential ecosystem services (Díaz-Granados & Navarrete González, 2005) (Cáceres-Martínez, 2020a).

Páramo ecosystems are highly sensitive to climate change because their ecological functioning depends on relatively stable cold and humid conditions. In practical terms, sensitivity in páramos means that increases in temperature, reduced precipitation stability and longer dry periods may alter soil moisture regimes, reduce water storage capacity, affect characteristic vegetation communities and weaken their ability to regulate runoff and sustain baseflows. These changes may also contribute to altitudinal shifts in species distribution and increase the susceptibility of páramo vegetation and soils to degradation, fire and erosion. Therefore, the main concern is not only potential ecosystem contraction, but the progressive reduction of the hydrological functions that make páramos critical for regional water security.

2.6.2. High Andean Forests

High Andean forests are highly sensitive to rising temperatures, altered soil moisture regimes, and increased frequency of extreme events, affecting their role in water regulation, slope stabilization, and biodiversity conservation (Banco Interamericano de Desarrollo, 2022b). Warming trends favor altitudinal shifts in species distributions, altering forest composition and reducing habitat availability for climate-sensitive species (Fadrique, Báez, & Duque, 2018) (Murad C. , 2024).

Changes in precipitation and soil moisture increase vulnerability to erosion and wildfires, particularly in fragmented landscapes where human pressures reduce adaptive capacity (Instituto Humboldt, 2022). Combined effects of climate variability, deforestation, and land-use change weaken carbon sequestration potential and hydrological regulation of these forests, intensifying ecosystem degradation and increasing downstream risks for water supply and livelihoods (Instituto Humboldt, 2021b) (Instituto Humboldt, 2025b)

2.6.3. Population in 2035

Population projections for Bogotá's municipalities through 2035, developed using cohort-component models with a multiregional approach, suggest the continuation of recent demographic trends. These trends are characterized by territorially differentiated population growth, progressive demographic transition, and changes in age structure. Specifically, a sustained increase in the urban population is anticipated in municipalities with greater economic dynamism. This will be accompanied by processes of relative aging and possible stagnation or decline in rural areas and smaller municipalities. These dynamics imply that the project must consider the increased pressure on infrastructure, basic services, and urban support systems, such as water, sanitation, and transportation. It must also adapt interventions to a growing proportion of older adults in the population and changing labor demand. The territorial heterogeneity in population growth also underscores the need for tailored planning approaches, investment priorities, and strengthened local capacities to ensure sustainability, inclusivity, and resilience of the proposed solutions in the face of projected demographic shifts (DANE, 2025).

2.6.4. Infrastructure vulnerability and dependence on isolated sources

The system's vulnerability is therefore not driven by climate hazards alone, but by its structural dependence on a limited number of highly stressed and unevenly performing water supply systems. While the Chingaza system provides a significant share of Bogotá's water supply, its concentration of supply and limited regulation capacity relative to demand increases systemic risk under climate variability. At the same time, the Bogotá River system, although strategic, is constrained by water quality issues, flow irregularity and higher treatment requirements. This combination creates a structurally constrained and climate-sensitive system, where both source reliability and water quality are under increasing pressure.

These conditions are particularly critical in upstream watersheds and high-Andean ecosystems that regulate water flows and sustain supply systems. As a result, the prioritization of intervention landscapes is not based solely on climate hazard intensity, but on the convergence of climate pressures, ecosystem degradation, system dependency and population reliance on these water sources. This justifies the selection of intervention areas where restoring ecosystem functionality and improving watershed management can generate the highest impact on water security and system resilience under climate change.

To clarify how vulnerability is assessed across different components of the socio-ecological system, Table 10 integrates both sensitivity and adaptive capacity for ecosystems, population and infrastructure. While sensitivity reflects how systems are affected by climate hazards, adaptive capacity captures the institutional, financial, technical and social conditions that determine their ability to respond, cope and adapt. This combined perspective allows a more complete understanding of vulnerability, consistent with the IPCC AR6 framework, and highlights that climate impacts depend not only on exposure and sensitivity, but also on the ability of systems to manage and recover from these impacts.

Table 9. Sensitivity and Adaptive Capacity across System Components.

System component	Sensitivity (what is affected)	Main climate drivers	Potential functional change	Adaptive capacity (what determines response ability)	Relevance for the project
Páramos	High dependence on stable cold and humid conditions for water storage and regulation	Rising temperature, precipitation variability, drought, wildfire conditions	Reduced soil moisture retention, altered vegetation composition, reduced water storage and baseflow regulation, increased erosion and fire risk	Institutional capacity for conservation, availability of restoration financing, local governance and monitoring capacity, land-use management	Justifies conservation and restoration to maintain hydrological regulation and downstream water supply
High Andean forests	Sensitivity of forest structure, species distribution and soil stability	Temperature increase, extreme rainfall, drought, wildfire conditions	Increased evapotranspiration, altered species composition, reduced slope stability, increased erosion and weaker hydrological regulation	Capacity for sustainable land management, forest governance, technical support, connectivity and restoration programs	Supports restoration, connectivity and climate-resilient landscape management interventions
Population (2035 projections)	Exposure of growing population to water supply variability and climate impacts	Climate variability, drought, extreme rainfall events	Increased demand for water, higher exposure of vulnerable groups, pressure on services and ecosystems, potential service interruptions	Access to basic services, income levels, education, health coverage, institutional support and social protection mechanisms	Defines target beneficiaries and highlights need for inclusive and resilient adaptation measures
Infrastructure and water supply systems	Dependence of infrastructure on climate-sensitive natural systems and operational constraints	Drought, reduced baseflows, extreme rainfall, sedimentation, water quality deterioration	Reduced reliability of supply, increased treatment costs, service disruptions, limited flexibility in smaller systems	Operational capacity, investment resources, governance of water utilities, redundancy and system diversification, technical capacity	Justifies interventions in water management, efficiency, infrastructure resilience and financing mechanisms
Water-regulating ecosystem services (cross-cutting)	Sensitivity of key hydrological functions (infiltration, storage, runoff regulation) to climate and land-use pressures	Combined climate hazards and ecosystem degradation	Increased runoff variability, reduced infiltration, sedimentation, declining water quality and availability	Integrated watershed governance, financing mechanisms, ecosystem restoration capacity and long-term management structures	Links ecosystem sensitivity and adaptive capacity to systemic water security outcomes

Source: IDOM 2025.

The table shows that vulnerability in the Bogotá Region is shaped by the interaction between climate-sensitive ecosystems, increasing population pressure and infrastructure constraints, but also by uneven adaptive capacity across territories. This reinforces the need for a systemic approach to adaptation, where interventions address not only ecological restoration, but also institutional strengthening, financing mechanisms and service provision, ensuring long-term resilience of water systems.

2.7. Climate risk mapping

Climate risk mapping represents the integration of hazard, exposure and vulnerability. Rather than showing climate trends in isolation, the maps identify where projected changes in precipitation and temperature converge with ecosystem degradation, population dependence on water-regulating landscapes and socio-institutional constraints.

The analysis reflects the climate hazard and a composite risk resulting from the interaction between: (i) projected maximum temperature and precipitation anomalies under the SSP5-8.5 scenario, (ii) the spatial location of the páramos (high-altitude Andean ecosystems), and (iii) territorial vulnerability as measured by adaptive capacity and sensitivity indicators. Thus, the resulting pattern depends on both projected climate change and the institutional, fiscal, social, service, health, education, and security conditions of the associated territories.

Adaptive capacity incorporates variables reflecting the institutional and financial strength of municipalities, including per capita tax revenue, resources for investment, organizational structure, accountability, citizen services, land-use planning instruments, and project management. Sensitivity considers social and infrastructure conditions that can amplify or reduce the impact of climate change. These include education and health coverage, infant mortality, rural electrification, broadband internet access, sanitation, and rates of theft, homicide, and domestic violence, as well as the number of recorded emergencies during the year. Taken together, these indicators allow us to identify which páramo areas will be exposed to greater climate change and which have less capacity to respond or are more structurally fragile.

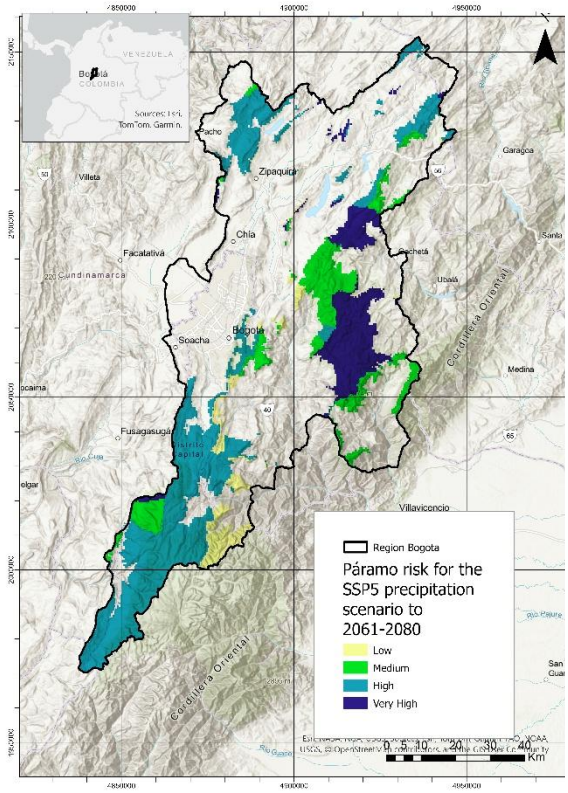


Figure 26. Paramo risk for the SSP5-8.5 precipitation to (2061–2080).
Source: IDEAM, (2025); compiled by IDOM.

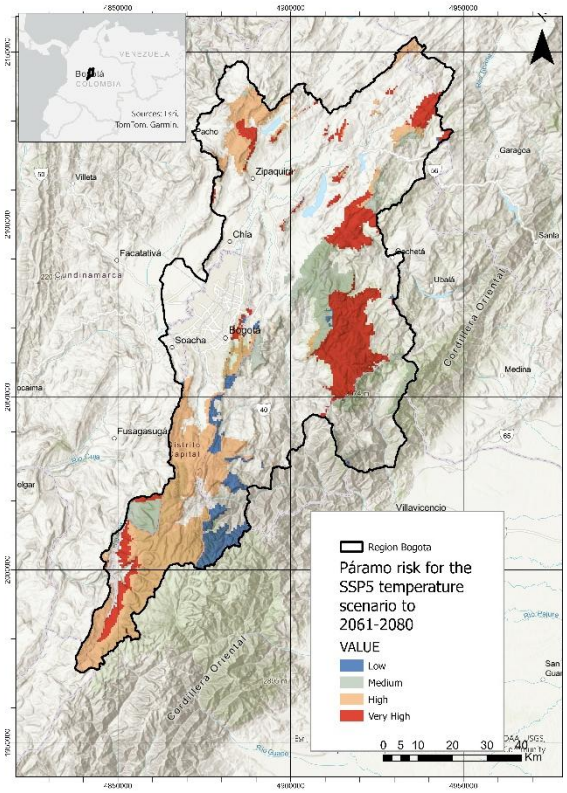


Figure 27. Paramo risk for the SSP5-8.5 temperature to (2061–2080).
Source: IDEAM, (2025); compiled by IDOM.

A comparison of the two maps reveals areas where the risk is high or very high due to temperature and precipitation. The main convergence hotspot is visually apparent in the central-eastern part of the region, where both maps show a very pronounced core of risk. Similarities are also observed in the northeastern and southeastern sectors, though there are differences in extent and continuity.

The main difference between the maps is that the maximum temperature risk is more concentrated in specific areas, while the precipitation risk is more widespread, especially along the southern corridor. This suggests that thermal stress could generate localized critical hotspots in terms of planning, while alterations in the rainfall regime could constitute a broader regional pressure factor on the páramo ecosystem.

In both cases, incorporating vulnerability into risk calculation means the results do not depend exclusively on the physical behavior of the climate. The maps show that risk increases where climate threats coincide with territories that have unfavorable governance conditions, weak institutions, and significant social and infrastructural deficiencies. Therefore, risk to páramo ecosystems should be understood as a territorial expression of the interaction between climate change and development, not solely as a biophysical issue.

In the case of population risk under SSP5-8.5, the results show that the Bogotá region has a highly concentrated configuration of climate risk, which is dominated by the interaction between population growth and projected climate pressures. Specifically, the urban corridor integrating Bogotá, Soacha, and the southern axis municipalities constitutes the main risk hotspot, where temperature increases, changes in precipitation, high population density, and vulnerable structural conditions coincide.

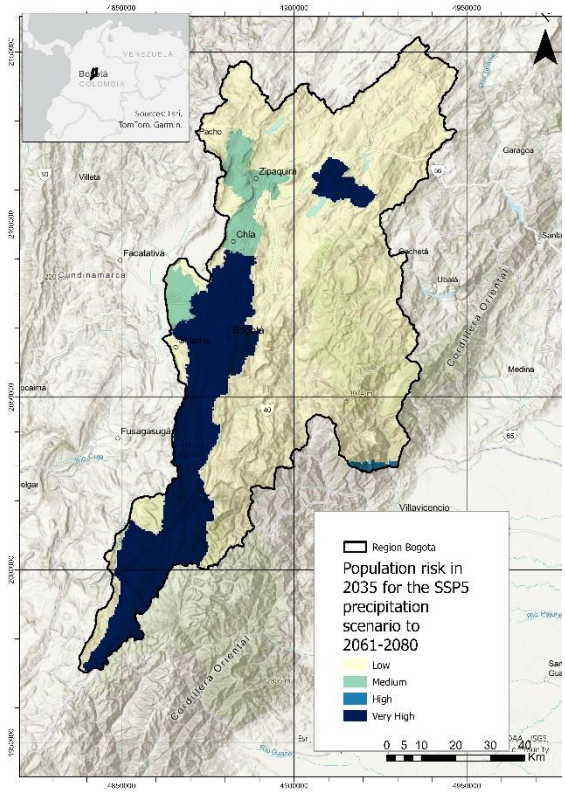


Figure 28. Population risk in 2035 for the SSP5-8.5 precipitation to (2061–2080).
Source: IDEAM, **(2025)**; compiled by IDOM.

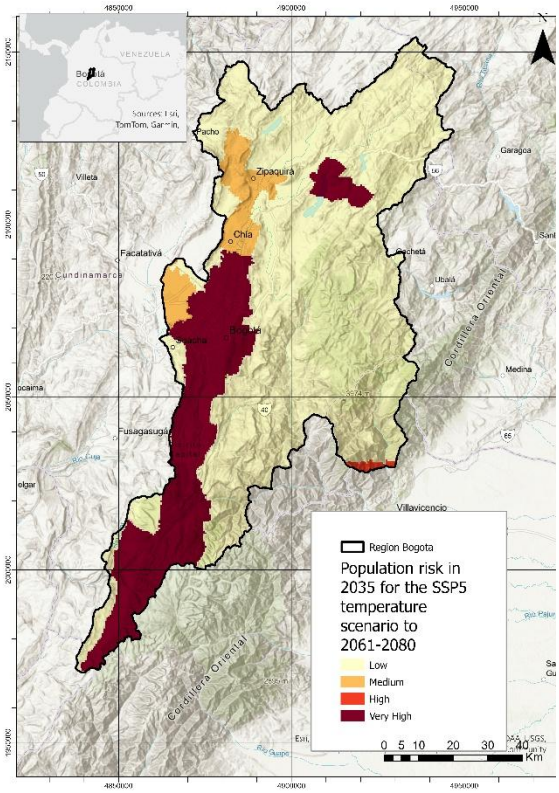


Figure 29. Population risk in 2035 for the SSP5-8.5 temperature to (2061–2080).
Source: IDEAM, (2025); compiled by IDOM.

A comparison of risks associated with temperature and precipitation shows that although both factors have significant impacts, precipitation has a more extensive and continuous territorial effect. This reflects the sensitivity of urban and service systems to changes in the hydrological regime. On the other hand, thermal risk is expressed in a more focused, yet equally critical, manner in densely populated areas, where it can intensify phenomena such as urban heat islands and heat stress.

Overall, the results confirm that climate risk in the region is determined by both the magnitude of climate changes and their interaction with population distribution and territorial vulnerability conditions. This underscores the importance of an integrated approach to adaptation that incorporates urban infrastructure interventions, institutional strengthening, land-use planning, and social condition improvements to mitigate risk in major population centers and bolster regional resilience to climate change.

The integrated climate risk map (Figure 30) presents the spatial distribution of composite climate risk across the Bogotá Region by combining projected climate hazards, exposure patterns, and territorial vulnerability into a single composite indicator. This analysis represents the convergence of multiple layers of information, including: (i) projected anomalies in temperature and precipitation under the SSP5-8.5 scenario, (ii) spatial climate projections of temperature and precipitation derived from IDEAM, (iii) population distribution projected to 2035 based on DANE data, (iv) the geographic distribution of páramo ecosystems as critical water-regulating units, and (v) a composite vulnerability index constructed from 26 socioeconomic, institutional, and service-related indicators reflecting adaptive capacity and sensitivity at the municipal scale.

Integrated climate risk map was constructed through the spatial integration of multiple datasets representing the three components of climate risk. Climate hazards were characterized using projected temperature and precipitation anomalies and scenarios under SSP5-8.5, based on IDEAM data. Exposure was represented through projected population distribution to 2035 and the spatial location of páramo ecosystems as critical water-regulating units. Vulnerability was assessed through a composite index built from 26 indicators reflecting adaptive capacity and sensitivity at the municipal level, including fiscal capacity, service provision, infrastructure access, social conditions and emergency response capacity. All layers were normalized and combined into a composite index to identify zones of convergence where multiple drivers of risk overlap.

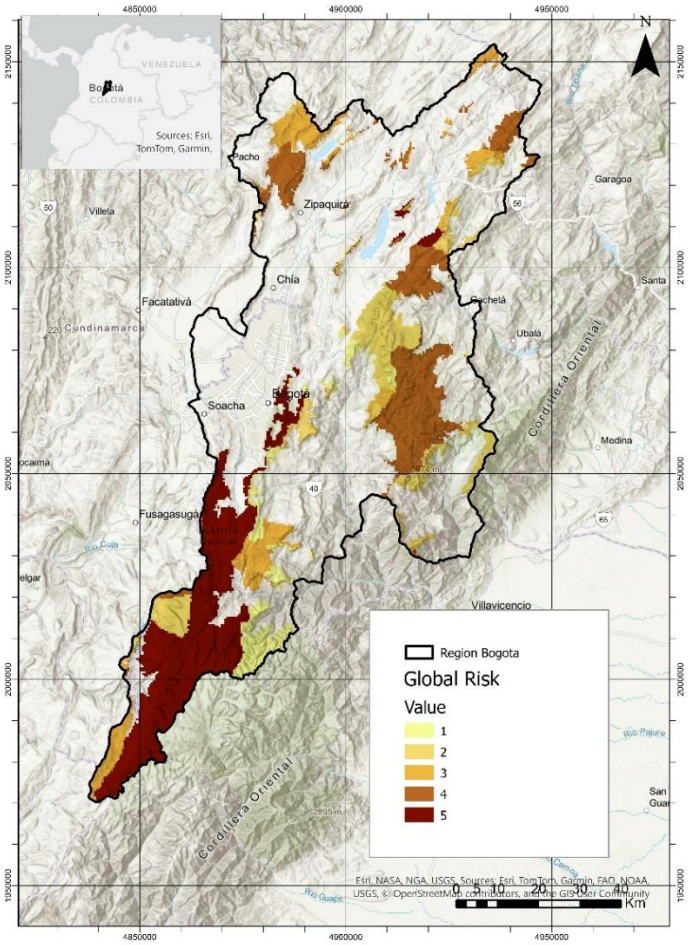


Figure 30. Integrated Climate Risk Map.
Source: IDEAM, *DANE, (2025); compiled by IDOM.*

The resulting map identifies a gradient of risk values across the region, ranging from low (1) to very high (5), where higher values represent areas where climate hazards, exposed systems, and structural vulnerability conditions converge most intensely. Spatially, high and very high-risk hotspots are concentrated along the southern and southeastern corridors of the Bogotá Region, as well as in specific high-mountain areas where páramo ecosystems coincide with projected increases in temperature and precipitation variability, high population dependence, and limited adaptive capacity.

This spatial pattern highlights that risk is not solely driven by the magnitude of projected climate change, but by the interaction between climate stressors and territorial conditions. In particular, areas where degraded or stressed páramo ecosystems overlap with high downstream water demand and weaker institutional and financial capacities exhibit the highest risk levels. These hotspots reflect zones where reduced hydrological regulation capacity, increased runoff variability, and growing water stress are most likely to materialize under future climate conditions.

Conversely, areas with moderate climate signals but stronger institutional capacity or lower exposure levels exhibit lower composite risk values, reinforcing the importance of considering vulnerability and exposure alongside climate projections in risk assessments.

The risk is no longer hypothetical: it materialized during the 2024–2025 drought. In April 2024, critically low levels in the Chingaza System led Bogotá to implement rotational rationing with 24-hour service suspensions by zone, also affecting neighboring municipalities. Reuters reported that the restrictions affected around 9 million people and that Chingaza, the system's main source, reached historically low levels. The World Bank described 2024 as one of the driest years on record for Bogotá's potable water supply systems since the 1960s (World Bank, 2025).

The crisis also demonstrated the vulnerability of the economic fabric that depends on the system (Reuters, 2024). Private users connected to the network—industry, commerce, services, facilities and other large consumers—also experienced periodic supply cuts. For these activities, lack of water supply reliability is not merely an operational inconvenience: it can imply production losses, service interruptions, logistical costs, the need for on-site storage and reduced confidence in the continuity of the urban business environment. This experience has created a window of opportunity to involve the private sector in investment mechanisms aimed at strengthening the resilience of the sources on which its own activity depends.

2.8. Impact chains, climate problem and adaptation logic

The climate problem in the Bogotá Region can be summarized as follows: sustained warming, more irregular precipitation, stronger extreme rainfall, prolonged drought, wildfire and frost risk, and structural water stress are reducing the capacity of high-Andean ecosystems and productive landscapes to regulate water. This alters runoff patterns, increases erosion and sediment transport, reduces baseflows, weakens water quality and undermines infrastructure reliability. The consequences are felt both in upstream municipalities and in the metropolitan population that depends on these landscapes for supply.

This section is structured around the impact chain that underpins the project design: climate hazards affect high-Andean ecosystems and water-regulating landscapes; these impacts reduce hydrological regulation, increase runoff variability, sedimentation, drought stress and water supply reliability risks; and the proposed solutions—ecosystem conservation and restoration, climate-resilient productive practices, improved community water systems and long-term watershed financing—are designed to address the underlying drivers of risk rather than only their symptoms.

To further clarify how the results of the climate risk assessment translate into project design, the analysis is structured through impact chains that explicitly link climate hazards, biophysical and socioeconomic impacts, and the proposed adaptation solutions. This approach allows the assessment to move from a descriptive analysis of climate trends to a causal understanding of how risks materialize and why targeted interventions are required. The table below summarizes the key impact pathways identified in the Bogotá Region.

Table 10. Project impact chain.

Climate hazard	Impact pathway	Exposed/vulnerable system	Why risk increases	Solutions
Increased temperature and heat extremes	Higher evapotranspiration, soil moisture loss, ecosystem stress and reduced water-regulation capacity	Páramos, High Andean forests, wetlands and upper-basin soils	Strategic ecosystems become less able to regulate runoff and sustain baseflows, affecting downstream water security	Conservation and restoration of high-Andean ecosystems, including active and passive restoration, soil recovery and ecological connectivity
More irregular precipitation and shorter wet periods	Reduced sustained rainfall, lower infiltration, greater seasonal water variability and increased dry-period stress	Water supply watersheds, rural communities, productive systems and urban water users	Water availability becomes less reliable, especially where demand is high and regulation capacity is degraded	Nature-based solutions to increase infiltration, soil-water retention and hydrological regulation at plot, landscape and watershed scale
Extreme rainfall events	Increased surface runoff, erosion, sediment transport, flooding and water-quality deterioration	Upper watersheds, community water systems, reservoirs and downstream users	Degraded landscapes generate higher runoff peaks and sediment loads, increasing treatment needs and infrastructure stress	Restoration, revegetation, sustainable productive systems and on-farm water management to reduce runoff and erosion
Drought and prolonged dry periods	Reduced baseflows, water scarcity, pressure on reservoirs and higher competition for water	Bogotá's water supply system, rural aqueducts, smallholder producers and ecosystems	Existing water systems and rural municipalities have limited technical, financial and institutional capacity to buffer prolonged deficits	Climate-resilient productive practices, water-use efficiency in community-run water systems and improved watershed management
Increased wildfire conditions	Loss of vegetation cover, soil degradation, biodiversity loss and reduced hydrological regulation	Páramos, High Andean forests and productive landscapes	Fire-prone and degraded areas lose ecological functionality, increasing downstream hydrological risk	Ecosystem protection, restoration, sustainable land management and community-based prevention measures
Compound climate variability, including ENSO-related extremes	Alternating drought, intense rainfall, landslides and hydrological instability	Regional water supply systems and intervention landscapes	Climate variability interacts with ecosystem degradation, urban demand and institutional constraints, producing systemic water-security risk	Integrated watershed resilience model combining NbS, livelihoods, governance and sustainable financing

Source: IDOM 2025.

Overall, the impact chain analysis demonstrates that climate risks in the Bogotá Region are not driven by climate hazards alone, but by their interaction with ecosystem degradation, increasing water demand, and uneven adaptive capacity across territories. The assessment shows that high-Andean ecosystems play a critical role in regulating water flows, yet their functionality is being progressively reduced by both climate variability and land-use pressures. As a result, downstream populations, productive systems and water supply infrastructure are increasingly exposed to water scarcity, runoff variability and declining water quality.

The project's adaptation logic responds directly to these pathways. Ecosystem conservation and restoration are intended to maintain or recover infiltration, soil-water retention and regulation in strategic headwaters and upper basins. Climate-resilient productive systems respond to the same problem in transformed rural landscapes by reducing erosion, improving soil function and lowering pressure on strategic ecosystems. Community water-system efficiency responds to drought, flow variability and local service vulnerability. Long-term financing mechanisms respond to the structural barrier that has prevented adaptation from reaching the required scale.

PART II. Project design

3. Analysis of gaps and barriers to address the climate problem

For the purposes of this chapter, gaps are understood as the missing conditions, capacities, investments, and delivery systems required to achieve climate-resilient water security in the Bogotá Region, while barriers are the structural factors that have prevented those gaps from being addressed to date. In practice, the climate problem persists not only because climate risks are intensifying, but because critical adaptation gaps remain unresolved and are reinforced by financial, regulatory, institutional, and technical barriers. This chapter therefore identifies both the priority gaps that must be closed and the barriers that explain why they persist, focusing only on those that the project will address.

The climate problem in the Bogotá Region is not defined by a single hazard or by a simple lack of project ideas. As evidenced in Chapter 2, the region is already exposed to rising temperatures, more variable and concentrated rainfall, recurrent drought, floods, landslides, forest fires, and mounting pressure on strategic water-regulation ecosystems (IDEAM, 2025; IPCC, 2022). The core challenge is not the absence of climate diagnostics, but the persistence of structural barriers that disconnect climate risk evidence from territorial planning, watershed management and sustained finance. The chapter therefore links the analysis of gaps and barriers to the climate problem definition, the climate change vulnerability and impact assessment (CCVA), and the risk assessment.

This chapter argues that four barrier groups mutually reinforce each other in the Bogotá Region: (i) financial barriers that prevent watershed interventions from becoming recurrently financed; (ii) regulatory and planning barriers that fragment the response across land, water, and climate instruments; (iii) institutional barriers that weaken coordination and local implementation capacity; and (iv) technical barriers that prevent climate and hydrological information from being translated into credible, monitorable and financeable adaptation outcomes.

The gaps and barriers presented in this chapter were selected and prioritized based on four criteria: (i) their direct relevance to the climate risks and impacts identified in Chapter 2; (ii) available quantitative and qualitative evidence from the Bogotá Region; (iii) their material influence on the feasibility, scale, and sustainability of adaptation action; and (iv) their relevance to the project's proposed scope of intervention. Accordingly, this chapter focuses only on those gaps and barriers that are both critical to solving the climate problem and realistically addressable through the proposed project.

Priority gaps were identified through specific analytical processes: (i) the financing gap through analysis of annual financing flows, legal mandates, and execution of watershed-related investments; (ii) the planning gap through spatial analysis of land use, hydrological modelling, and multi-criteria prioritization of intervention areas; (iii) the implementation-capacity gap through assessment of municipal conditions and community-run water systems; and (iv) the MRV and evidence gap through review of existing climate and hydrological information and its operational use for investment and decision-making. These analyses provide the empirical basis for defining what still needs to be done in the Bogotá Region to achieve climate-resilient water security.

3.1. Priority adaptation gaps

Before assessing structural barriers, it is necessary to clarify the main adaptation gaps that remain unresolved in the Bogotá Region. Four priority gaps emerge from the evidence and analytical work:

- Insufficient long-term financing for watershed resilience.
- Inadequate integration of climate risk into land-use, watershed, and water-security planning.
- Weak local implementation capacity in upstream municipalities and community-run water systems.
- Absence of an operational monitoring, reporting, and verification (MRV) architecture capable of translating hydrological outcomes into decision-making and investment.

The following subsections synthesize how each gap was identified and what still needs to be done to close it.

3.1.1. Financing gap

The financing gap was identified by comparing legal mandates, potential resources, and actual execution of watershed-related investments. Colombia's legal framework requires departments, districts, and municipalities to allocate at least 1% of unrestricted current revenues to the acquisition, restoration, and conservation of strategic water-source areas (Ley 99 de 1993; Ley 2320 de 2023). However, evidence shows that this obligation is only partially implemented: departments executed only 17% of their potential resources in 2020, and large cities such as Bogotá operated well below the required threshold, leaving an execution gap of over 80% of legally available funding (Brigard Urrutia, s.f.).

Complementary analysis of financing actors shows that multiple potential flows remain disconnected. Territorial governments under-execute mandatory budget allocations; utilities such as EAAB can finance environmental investments through tariffs under CRA Resolution 1032 of 2026; and private companies are required under Law 2173 of 2021 and Resolution 1491 of 2025 to invest in ecological restoration through "Áreas de Vida". Nonetheless, these public, tariff-based, and private flows operate in isolation and are not linked to a common framework for watershed investment or hydrological performance (CRA, 2019; Ley 2173 de 2021; Resolución 1491 de 2025).

At the same time, the magnitude of system needs underscores the financing gap. The Bogotá water system supplies more than 9.8 million people with an estimated demand of 16–17 m^3/s (approximately 536 hm^3/year), exceeding the useful storage capacity of key infrastructure such as the Chuza reservoir (~223 hm^3), while around 37% of water is lost as non-revenue water (EAAB, 2025; RAP-E Región Central, 2021). This imbalance confirms that current and potential investment flows are neither sufficient nor structured to address system-level climate risks.

What still needs to be done is to establish a coordinated watershed financing architecture capable of aggregating public, tariff-based, and private flows, increasing execution rates of existing instruments, and linking investments to measurable hydrological and adaptation outcomes. This implies moving from fragmented, project-based spending to a long-term, performance-oriented finance system consistent with GCF's paradigm shift objectives.

3.1.2. Planning gap

The planning gap was identified through spatial analysis of land use, hydrological modelling, and the multi-criteria prioritization of intervention areas across the Bogotá Region. Water use exceeds sustainable supply in 45% of the territory in dry years and 41% under average conditions, evidencing structural pressure on water resources (IDEAM, 2022).

Despite the existence of planning instruments such as POMCA and POT, the continuation of these land-use patterns demonstrates that hydrological priorities and climate risks are not effectively integrated into territorial decision-making or enforced through regulation. The result is a persistent mismatch between productive land uses and hydrological sustainability, which amplifies drought, flood, and water-quality risks in a changing climate.

What still needs to be done is to align land-use planning, enforcement, and investment decisions with watershed and climate priorities, ensuring that strategic water-regulation areas (páramos, high-Andean forests, wetlands, riparian corridors) are effectively protected, restored, and managed. This requires risk-informed territorial governance that explicitly incorporates climate scenarios, hydrological modelling, and ecosystem thresholds into binding planning and investment processes.

3.1.3. Implementation capacity gap

The implementation-capacity gap was identified through assessment of municipal socioeconomic conditions, service coverage, and the operational situation of community-run water systems in upstream municipalities. Indicators such as low internet access (e.g., Tausa 2.62%, Villapinzón 5.26%), limited sewerage coverage, and weak municipal investment capacity reveal structural constraints for technical assistance, coordination, and sustained implementation (DANE, 2025). These constraints are especially acute in upstream areas that are critical for watershed regulation but have lower fiscal and institutional capacity.

This gap is particularly visible in community-run rural water systems (*acueductos veredales*), which are central to rural water supply but face significant operational challenges. Evidence indicates that 53% of productive units depend on rural systems and 23% on surface sources, while many systems lack macrometric measurement, efficient infrastructure, and adequate treatment capacity (Empresas Públicas de Cundinamarca, 2023; DNP, 2023). These conditions result in high levels of water loss, operational inefficiencies, and increased vulnerability to climate variability and extremes.

What still needs to be done is to strengthen technical, organizational, and operational capacity in municipalities and community systems so they can plan, implement, and maintain adaptation measures over time. This entails building stable local capacities for risk-informed planning, operation and maintenance, and community-based governance of water and ecosystem services.

3.1.4. MRV and evidence gap

The MRV and evidence gap was identified by contrasting the availability of climate and hydrological data with the absence of an operational system capable of translating that information into measurable, reportable, and investment-relevant outcomes. The Bogotá Region has robust monitoring infrastructure, including meteorological stations, historical climate series, and hydrological models such as SWAT applied to the San Francisco–Aves system using IDEAM and CAR data (IDEAM, 2025; CAR, 2019b).

However, these systems are primarily used for planning and regulatory purposes and are not structured to evaluate the hydrological performance of specific adaptation interventions.

Regulatory requirements further highlight this gap. Colombia's water tariff framework (updated by Resolution CRA 1032 of 2026) requires utilities to justify environmental investments within tariff structures, and Resolution 1491 of 2025 obliges companies to report restoration outcomes, but no integrated MRV system currently links these obligations to standardized hydrological performance metrics (CRA, 2026; Resolución 1491 de 2025). As a result, it remains difficult to demonstrate the climate and hydrological benefits of watershed interventions in a way that supports performance-based or blended finance.

What still needs to be done is to establish a watershed-scale MRV architecture that connects interventions to hydrological outcomes and adaptation indicators, and that is aligned with tariff regulation, corporate reporting, and climate-finance requirements. This is a precondition for scaling performance-based investments, including those supported by the GCF.

3.2. Barriers

While the previous section defined what is still missing for climate-resilient water security, the present section analyzes why these gaps remain unresolved. In this context, barriers are understood as the systemic financial, regulatory, institutional, and technical constraints that limit the ability of existing actors and instruments to close the identified gaps at scale. Only those barriers that the project will address through specific activities are presented.3.2.1. Financial barriers.

The most fundamental financial barrier identified is the lack of a structured and scalable financing architecture for watershed resilience. The problem is not merely limited resources in the abstract, but the absence of an operational mechanism that can translate watershed interventions and hydrological benefits into investment decisions that are credible, traceable, and attractive to a broader group of public and private actors (GIZ, 2019; EAAB, 2025; IDB-CI-C&C, 2022). This is a classic adaptation finance barrier: climate-relevant ecosystem and watershed functions generate public and quasi-public benefits, but these benefits are not yet consistently measured, valued, packaged, or linked to recurrent financial flows.

These constraints persist because existing financing instruments operate under different mandates, incentives, and institutional logics, preventing coordination and aggregation of resources at watershed scale.. First, existing finance is fragmented across institutions and territories, which reduces continuity and weakens basin-scale prioritization. Second, hydrological benefits are not yet translated into measurable and verified outcomes through calibrated fieldsystems. Third, private participation remains weak and mostly philanthropic rather than structured around long-term risk reduction or resilience value. Fourth, local governments and local actors often lack the fiscal space or financial management capacity to sustain adaptation interventions over time (DNP, 2025; GIZ, 2019; EAAB, 2025).

The Bogotá Region exhibits clear evidence of structural financial constraints that limit climate-resilient watershed management.

First, the scale of water demand relative to system capacity illustrates the magnitude of the financing challenge. The regional water system supplies more than 9.8 million people across 22 municipalities, with estimated demand in the range of 16–17 m^3/s, equivalent to approximately 536 hm^3/year, which significantly exceeds the useful storage capacity of key infrastructure such as the Chuza reservoir (~223 hm^3) (EAAB, 2025; DANE, n.d.).

Second, water losses and inefficiencies further increase financing pressure. The system reportedly loses around 37% of supplied water as non-revenue water[4], implying that a substantial portion of existing investments does not translate into effective service delivery and requiring additional capital to compensate for inefficiencies (RAP-E Región Central, 2021).

Third, municipal fiscal capacity is insufficient to finance adaptation at scale. This means that local governments cannot co-finance or sustain climate adaptation investments, particularly in upstream watersheds that are critical for regional water security.

Fourth, environmental degradation continues despite existing spending, indicating ineffective allocation (Banco Interamericano de Desarrollo, 2022b; RAP-E Región Central, 2021):

- 49% of natural ecosystems transformed
- 17.8% of páramo ecosystems degraded

This shows that current financial flows are not sufficient, not sustained, and not strategically targeted toward watershed resilience.

The financial barrier is not simply a lack of resources, but a systemic failure to mobilize, structure, and sustain investment in watershed functions, justifying concessional climate finance.

These barriers matter because the region's water security challenge is structurally larger than isolated project cycles. Without a financing mechanism that can aggregate investments, reward hydrological performance, and sustain interventions beyond one-off restoration projects, watershed management remains chronically underfunded in relation to climate risk.

Table 11. Financial barriers and why they are climate-relevant.

Financial barrier	Evidence from the source base	Why this is a-relevant barrier
Fragmented funding for watershed action	Existing funding is fragmented and not organized as an operational financing architecture for watershed resilience (GIZ, 2019; EAAB, 2025).	Prevents scale, continuity, and the long-term co-financing pathway needed for transformational adaptation.
Hydrological benefits are not yet consistently measured and verified	Insufficient operationalization of monitoring and verification systems and limited translation of hydrological results into metrics that support private sector long-term contributions (GIZ, 2019; IDB-CI-C&C, 2022).	Weak confidence from public-private participation that financing nature based solutions delivers credible hydrological benefits
Weak municipal fiscal and project management capacity	Tausa is cited with own investment resources of 10.25% and a Royalties Project Management Index of 0; Villapinzón is cited with own investment resources of 8.78% (DANE, 2025).	Constrains local co-financing, implementation continuity, and absorption capacity for adaptation finance.
Private participation remains limited	Private participation remains weak and mostly philanthropic rather than investment-structured (GIZ, 2019; EAAB, 2025).	Reduces leverage and undermines long-term sustainability beyond grant cycles.

Source: IDOM, 2026.

[4] Non-revenue water is water produced and treated by a utility that is lost before it reaches paying customers, due to leaks, theft, metering inaccuracies, or authorized unbilled use.

3.2.2. Regulatory and planning barriers

A second barrier lies in the regulatory and territorial planning framework. Colombia doesn't lack environmental or climate policy instruments, instead, these instruments are not consistently operationalized in a way that aligns land-use, watershed protection, climate adaptation, and water-security planning in the territories that sustain Bogotá's water supply (IDEAM, 2025; DNP, 2025). In practice, this means that risk-informed watershed management is not yet fully embedded in territorial decision-making.

The consequences are already visible in the territorial baseline described in Chapter 1. Current pressures include continued loss of natural cover, contamination from agrochemicals and livestock waste, erosion and sediment transport, and pressure from productive land uses in supplying watersheds (IDB-CI-C&C, 2022). There is strong empirical evidence that territorial dynamics continue to undermine water security despite existing policy frameworks.

There is a structural mismatch between land-use decisions and water security, reflecting the weak integration and enforcement of existing regulatory instruments. At municipal level, the uneven use of risk-informed planning tools is particularly problematic in municipalities exposed to multiple hazards (frost, landslides, forest fires, drought), where climate risk is still addressed mainly through emergency response rather than preventive land and water management (IDEAM, 2025; DANE, 2025).

3.2.3. Institutional barriers

Institutional fragmentation is a third, decisive barrier. There is a mismatch between the scale at which climate and hydrological processes operate and the scale at which decisions and resources are organized. Water management, ecosystem conservation, local planning, and climate action are distributed across multiple authorities and jurisdictions, but coordination mechanisms remain insufficient to produce integrated watershed-scale adaptation (GIZ, 2019; DNP, 2025; EAAB, 2025).

The region exhibits highly uneven institutional and socioeconomic capacities. For example, internet access is as low as 2.62% in Tausa, 5.26% in Villapinzón, and 10.09% in Cogua; health coverage in Cogua reaches only 46.30%; and sewerage coverage is 47.97% in Villapinzón and 62.12% in Cogua (DANE, 2025). At the same time, the Bogotá Region concentrates around 20% of Colombia's population, and the Tunjuelo landscape, including Bogotá D.C. and Soacha, is classified as highly vulnerable (IDEAM, 2025; DANE, 2025).

This combination produces a high-risk/high-demand governance scenario: large downstream dependence on upstream ecosystems, weak upstream institutional capacity, and fragmented coordination across jurisdictions. The barrier is not simply "weak institutions", but a structural mismatch between high climate exposure and uneven local capacity, which limits the implementation of coordinated, basin-scale adaptation.

3.2.4. Technical barriers

A fourth barrier is technical rather than conceptual. As seen in Chapter 2, substantial climate information already exists, including historical observations, downscaled CMIP6 projections, ET-SCI indicators, hazard mapping, and a multi-indicator municipal vulnerability assessment (IDEAM, 2025; WMO ET-SCI, 2023; IPCC, 2022). The monitoring network includes 14 meteorological stations with at least 85% data

completeness, providing a 1991–2020 baseline, and providing the basis for downscaled projections at 10 km resolution (IDEAM, 2025; WMO, 2023).

Climate impacts are intensifying. Between 1912 and 2017, 676 hydrometeorological events were recorded in the region (244 floods, 121 landslides, 110 forest fires), and the 2024–2025 drought led to water rationing affecting roughly 9 million people, while area affected by wildfires increased from 4,100 ha in 2023 to 6,500 ha in 2024 (DesInventar, 2026; Reuters, 2024; IDEAM, 2025). Soils are also degraded, with 32% presenting very low organic carbon and 23% very low available moisture (Banco Interamericano de Desarrollo, 2022b).

This evidence shows that climate and hydrological data exist but are not systematically linked to planning decisions, performance-based investment frameworks, or operational watershed management systems. The technical barrier lies in the lack of operationalization of information, particularly the absence of an integrated MRV and decision-support architecture that can translate data into prioritization, monitoring, and finance.

3.3. Why these barriers have not yet been resolved

The persistence of these barriers is itself a core part of the climate rationale. The problem is not the simple absence of institutions or legal instruments, but the absence of an operational finance-and-governance architecture capable of linking watershed interventions, hydrological evidence, institutional coordination, and long-term implementation (GIZ, 2019; EAAB, 2025; DNP, 2025). In other words, the enabling conditions for climate-resilient watershed management remain incomplete, even though the climate problem is already visible and worsening.

This persistence can be understood as a lock-in problem. Because finance is fragmented, investments remain short term and are often in the form of projects. Because investments remain fragmented, actors have weak incentives to build basin-scale monitoring and verification systems. Because technical systems are weak, it is difficult to demonstrate credible hydrological performance or attract more structured finance. Because governance remains fragmented, land-use and watershed decisions continue to undermine ecosystem services that adaptation depends on (IDEAM, 2025; GIZ, 2019; EAAB, 2025). The result is a recurring cycle of underinvestment, partial implementation, and reactive management under growing climate stress.

Table 12. Evidence of structural barriers to climate-resilient watershed management in the Bogotá Region (summary).

Barrier	Quantitative evidence (Bogotá Region)	Climate relevance	Interpretation	Sources
Financial barriers	• Water demand: 16–17 m³/s (~536 hm³/year) supplying >9.8 million people across 22 municipalities • Storage constraint: Chuza reservoir ~223 hm³ • 37% non-revenue water losses • Municipal investment capacity: Tausa (10.25%), Villapinzón (8.78%) • Royalties project management index: 0 (Tausa)	Increasing demand + climate variability reduce system reliability and increase drought risk	Existing financial flows are insufficient relative to system scale, while weak local fiscal capacity prevents co-financing and sustainability → strong justification for concessional climate finance	EAAB (2025); DANE (2025); RAP-E Región Central (2021)

Regulatory & planning barriers	• 49% of natural ecosystems transformed • 17.8% of páramo degraded • 18,500 ha authorized for mining (Sabana de Bogotá) • Water use exceeds sustainable supply: 45% (dry years), 41% (annual) • Forest cover limited (~6,976 ha) vs. agriculture (~56,335 ha)	Ecosystem degradation reduces infiltration, baseflow, and water quality while increasing flood and drought risk	Demonstrates structural misalignment between land use and water security → regulatory instruments insufficiently enforced or integrated into planning	BID (2022b); IDEAM (2022); Región Metropolitana Bogotá–Cundinamarca (2025)
Institutional barriers	• Internet access: Tausa (2.62%), Villapinzón (5.26%), Cogua (10.09%) • Health coverage: Cogua (46.30%) • Sewerage: Villapinzón (47.97%) • Bogotá region hosts ~20% of Colombia's population • High vulnerability classification: Bogotá D.C. and Soacha	High exposure combined with low adaptive capacity limits implementation of risk reduction measures	Reveals mismatch between high dependency on upstream ecosystems and weak local institutional capacity → limits effective adaptation delivery and coordination	DANE (2025); IDEAM (2025)
Technical barriers	• Climate data available: 14 stations (>85% completeness), CMIP6 projections (~10 km resolution) • 676 hydrometeorological events (1912–2017): floods (244), landslides (121), fires (110) • Recent drought (2024–2025): ~9 million people affected by water rationing • Wildfires increased from 4,100 ha (2023) to 6,500 ha (2024) • Soil degradation: 32% low carbon, 23% low moisture	Climate hazards are intensifying despite data availability, indicating weak operational use of information	Confirms the core gap: climate information exists but is not translated into planning, monitoring, or investment decisions → justifies investment in MRV and decision-support systems	IDEAM (2025); DesInventar (2026); Reuters (2024); WMO (2023); BID (2022b)

Source: IDOM, 2026.

The evidence demonstrates that the barriers to climate-resilient watershed management in the Bogotá Region are structural and measurable. Financial constraints are reflected in a mismatch between system demand and investment capacity; regulatory gaps allow continued degradation of critical ecosystems; institutional weaknesses limit implementation in high-exposure territories; and technical constraints prevent the translation of climate information into decision-making and finance.

These barriers jointly explain why climate risks, such as drought-induced water rationing, increasing wildfire extent, and persistent flood and landslide impacts, continue to intensify despite the existence of climate data, policies, and institutions. Addressing these barriers is therefore essential to enable a systemic and sustained response to climate risk and provides a strong justification for concessional climate finance.

3.4. Linked solutions: how the project should respond to the barriers

The purpose of this section is not to describe the full design of the project, but to clarify the response logic required to overcome the identified gaps and barriers. Based on this analysis, four broad response areas emerge as necessary conditions for climate-resilient watershed management in the Bogotá Region. Chapter 8 explains in detail how the proposed project activities are designed, sequenced, and financed to address these gaps and remove the prioritized barriers.

The selection of the four activity clusters is directly rooted in the barrier analysis presented in Sections 3.1–3.3 and in the implementation gaps described in Section 3.5. Each cluster corresponds to a specific combination of financial, regulatory/planning, institutional, and technical barriers that currently prevents the closure of the priority adaptation gaps in the Bogotá Region. Rather than reflecting generic adaptation "best practices", the clusters were identified by mapping: (i) which structural barriers most constrain ecosystem and watershed resilience; (ii) how these barriers materialize in implementation gaps (capacity, markets, finance, governance, data); and (iii) which types of interventions are both technically and institutionally viable to remove those barriers at scale.

First, protection and restoration of strategic high-Andean and source-water ecosystems was selected as a response to the regulatory and planning barriers that allow continued degradation of critical regulating ecosystems, as well as to the technical barrier associated with the lack of operational hydrological baselines for performance-based investments. The evidence of 49% of natural ecosystems transformed, 17.8% of páramo degraded, shows that regulatory instruments are insufficiently enforced, and land-use decisions remain misaligned with water-security needs (BID, 2022b; IDEAM, 2022; Región Metropolitana Bogotá–Cundinamarca, 2025). Ecosystem protection and restoration in source-water landscapes are therefore not stand-alone conservation measures, but the necessary physical and regulatory response to a barrier that allows unsustainable land-use patterns to persist under increasing climate stress.

Second, climate-resilient transformation of productive systems in priority watersheds responds to the interaction between regulatory/planning barriers and social-economic implementation gaps, which manifest as market and livelihood disincentives. The dominance of traditional production systems, agrochemical contamination, and livestock pressure, combined with limited access to differentiated markets and value chains, lock producers into low-productivity, climate-vulnerable systems even where alternative practices exist (IDB-CI-C&C, 2022). This activity cluster was therefore selected to tackle the barrier that current planning and market structures fail to encourage or reward climate-resilient land uses, by creating concrete pathways for producers to transition to practices compatible with watershed regulation and climate-resilient water security.

Third, strengthening of community-run and municipal water systems and territorial adaptive capacity directly addresses the institutional barriers and capacity-related implementation gaps identified in upstream municipalities. Very low internet access, limited sewerage and health coverage, and low municipal investment and project management capacity constrain the ability to plan, implement, and maintain adaptation measures (DANE, 2025). At the same time, community-run rural water systems that supply more than half of productive units lack basic metering, efficient infrastructure, and treatment (Empresas Públicas de Cundinamarca, 2023; DNP, 2023). The cluster was therefore selected as the operational response to the barrier that high climate exposure coincides with weak local institutional and service-delivery capacity, which fundamentally limits adaptation delivery in critical upstream territories.

Fourth, development of a watershed finance, monitoring, and governance architecture capable of sustaining adaptation over time was selected as the central response to the financial and technical barriers identified in this chapter. On the one hand, the analysis shows that departments executed only 17% of potential 1%-earmarked resources in 2020. Bogotá operates below its legal obligation, and multiple instruments (1% revenues, CRA 1035/2026 tariffs, "Áreas de Vida" obligations) remain fragmented and uncoordinated (Brigard Urrutia, s.f.; CRA, 2019; Ley 2173 de 2021; Resolución 1491 de 2025). On the other hand, climate and hydrological data (14 stations, CMIP6 projections, SWAT modelling) are not operationalized through an integrated MRV system that can convert hydrological benefits into quantified and measurable outcomes and justify performance-based or blended finance (IDEAM, 2025; WMO, 2023; GIZ, 2019). This cluster therefore responds to the combined barrier of fragmented and under-executed finance and non-operational technical systems, by creating the enabling finance, MRV, and governance architecture required for long-term, scalable climate-resilient watershed management.

In summary, the four activity clusters were selected because each of them is necessary to remove a specific set of structural barriers that currently prevent the closure of the priority gaps:

- Ecosystem protection and restoration remove the barrier of continued degradation of regulating ecosystems under weak enforcement.
- Productive transformation removes market and livelihood barriers that sustain unsustainable land use.
- Strengthening local systems removes institutional capacity barriers that limit implementation in highly exposed territories.
- The finance, monitoring, and governance architecture removes financial and technical barriers that prevent hydrological benefits from being captured and reinvested.

This alignment ensures that the project does not merely fund isolated interventions, but systematically targets and removes the reasons why adaptation has not yet been scaled in the Bogotá Region.

For the purposes of linking the barrier analysis to the project response, Table 13 translates these structural barriers into the specific intervention barriers that the project is designed to address in the Bogotá Region. In this sense, some rows in the table do not represent new barrier categories, but rather the territorial manifestation of the structural barriers already described above, particularly in relation to ecosystem degradation, unsustainable productive pressures, weak local implementation capacity, and the limited operational use of climate and hydrological information.

Table 13. Barriers identified and solutions to overcome them.

Barrier	Why it matters for climate adaptation	Project response / solution logic	Linked identified activities for the Bogotá Region
Financial: Fragmented and insufficient watershed finance	Prevents scaling and continuity of adaptation in strategic water-supply landscapes.	Create an operational watershed finance architecture and improve the ability to package hydrological benefits as quantifiable and verifiable adaptation outcomes.	Activities related to sustained watershed finance, monitoring and governance architecture; development of mechanisms that can support recurrent public and private investment.
Regulatory/Planning: Loss and degradation of regulating ecosystems	Reduces infiltration, dry-season regulation, water quality protection, and resilience to drought and intense rainfall.	Protect and restore páramos, high-Andean forests, wetlands, riparian areas, and other strategic ecosystems in supplying watersheds.	Activities on protection and restoration of strategic high-Andean ecosystems and source-water landscapes.

Barrier	Why it matters for climate adaptation	Project response / solution logic	Linked identified activities for the Bogotá Region
Regulatory/Planning: Unsustainable productive pressures in priority watersheds	Increases erosion, contamination, sediment transport, and water-quality deterioration under climate stress.	Promote climate-resilient productive transformation in high-pressure landscapes, especially where current land uses undermine watershed function.	Activities related to climate-resilient productive transformation in priority landscapes, including changes in agricultural and livestock practices where relevant in the source base.
Institutional: Weak local capacity of municipal and community systems	Limits adaptation delivery, operation and maintenance, and risk-informed planning in exposed territories.	Strengthen community-run and municipal water systems and territorial adaptive capacity.	Activities on capacity strengthening, support to water systems, and improved local implementation conditions.
Technical: Insufficient operational use of climate and hydrological information	Reduces prioritization quality, weakens MRV, and limits confidence for performance-based finance.	Develop an integrated monitoring and evidence architecture linked to hydrological benefits and adaptation outcomes.	Activities on climate information integration, monitoring, governance, and traceable reporting of hydrological results.

Source: IDOM, 2026.

The Bogotá Region does not simply require more environmental spending; it requires concessional climate finance to overcome structural barriers that conventional budgets and fragmented initiatives have not resolved. Climate change is increasing the volatility and severity of water-security risks, but watershed-scale adaptation remains underfinanced because hydrological resilience benefits are not yet systematically captured by existing public budgets or private incentives (IPCC, 2022; IDEAM, 2025; GIZ, 2019). In this context, concessional finance is justified to absorb early-stage risk, strengthen institutional and technical systems, and establish the enabling conditions for longer-term and larger-scale investment.

The identified activities are designed to remove these barriers rather than work around them. By combining ecosystem restoration, productive transformation, stronger local water-system capacity, and a watershed finance and monitoring architecture, the project addresses the reasons why adaptation has not yet been scaled.

3.5. Operational constraints

This section clarifies how the structural barriers, presented earlier in Chapter 3, translate into concrete operational constraints and risks for the implementation of the proposed activities. These operational conditions help explain where and why adaptation delivery is likely to face greater challenges and therefore inform the design of implementation arrangements, risk management, and capacity-building measures

3.5.1. Transition of structural barriers into operational constraints

First, the institutional and technical barriers identified earlier, translate directly into **capacity and technical gaps at the local level.** These include insufficient technical knowledge among producers, weak organizational structures, and limited capacity of rural water systems to support implementation and long-term management. In highly exposed territories such as Villapinzón, Tausa, and other upstream municipalities, these constraints significantly reduce the feasibility of sustaining ecosystem-based and productive transformation interventions over time.

At the same time, regulatory and planning barriers, reflected in the persistent misalignment between land use and water security, are expressed as **market and livelihood gaps**. The dominance of traditional production systems, combined with weak market access and limited incentives for sustainable practices, reinforces unsustainable land-use patterns already documented in the region. In practice, this means that even where climate-resilient alternatives exist, producers face structural disincentives to adopt them, including lack of access to differentiated markets, limited value chain integration, and socio-cultural resistance to change.

In parallel, the financial barriers described in this chapter are directly reflected in **financial and investment gaps**. These include the lack of long-term and predictable funding flows, insufficient scaling of existing instruments such as payments for ecosystem services (PES), and the absence of mechanisms capable of aggregating and channeling investments at watershed scale. As evidenced by low municipal investment capacity and weak financial structuring, current financing conditions are insufficient to sustain large-scale or long-term adaptation interventions.

Similarly, the previously identified institutional fragmentation translates into **governance and coordination gaps** that limit implementation effectiveness. The absence of integrated frameworks capable of aligning ecosystem restoration, productive transformation, and financing mechanisms results in disjointed interventions and weak prioritization. This fragmentation is particularly critical in a region where upstream–downstream dependencies require coordinated action across jurisdictions and sectors.

The technical barrier related to the operational use of data also leads to **data and knowledge gaps,** including incomplete ecological baselines, fragmented datasets, and limited monitoring systems. While climate information exists, its limited integration into decision-making processes reduces its effectiveness for targeting, prioritization, and performance tracking, ultimately weakening the investment case for watershed interventions.

Finally, cross-cutting social and structural barriers, including inequality, poverty, and dependence on subsistence agriculture, are reflected in broader **social implementation gaps**. These include insecure land tenure, weak benefit-sharing mechanisms, and insufficient integration of gender and social inclusion considerations. These factors not only increase vulnerability but also reduce the adoption and long-term sustainability of adaptation measures.

Table 14 summarizes the main operational constraints that derive from the structural barriers analyzed in this chapter, indicating the evidence base, their implications for implementation, and their climate relevance

Table 14. Operational constraints for implementation in the Bogotá Region.

Operational constraints	Evidence (Bogotá Region)	What this means for implementation	Climate relevance
1. Capacity and technical constraints	• Internet access extremely low: Tausa (2.62%), Villapinzón (5.26%), Cogua (10.09%) • Sewerage coverage: Villapinzón (47.97%) • Health coverage: Cogua (46.30%) • Municipal project management index: 0 (Tausa)	Limited access to information, weak institutional capacity, and low service coverage constrain technical assistance, monitoring, and sustained implementation of interventions	Reduces ability to implement and maintain adaptation measures in highly exposed territories, increasing long-term vulnerability

Operational constraints	Evidence (Bogotá Region)	What this means for implementation	Climate relevance
2. Market and livelihood constraints	• Dominance of agricultural land: ~56,335 ha vs forest cover ~6,976 ha • Continued use of traditional productive systems • Evidence of agrochemical contamination and livestock pressure	Producers remain locked into low-productivity, climate-vulnerable systems with limited incentives to transition	Maintains land-use practices that increase erosion, reduce infiltration, and degrade water quality under climate stress
3. Financial and investment constraints	• Water demand: 16–17 m^3/s (~536 hm^3/year) for >9.8 million people • Storage constraint: Chuza reservoir ~223 hm^3 • 37% non-revenue water losses • Municipal investment capacity: Tausa (10.25%), Villapinzón (8.78%)	Insufficient financial capacity to invest in watershed restoration and sustain long-term adaptation; existing inefficiencies increase funding needs	Limits ability to adapt to increasing climate variability, especially droughts and demand pressure on water systems
4. Governance and institutional constraints	• Region supplies water to >9.8 million people across 22 municipalities • Bogotá region concentrates ~20% of Colombia's population • High vulnerability in Bogotá D.C. and Soacha • Fragmented upstream–downstream management	Complex multi-actor system with weak coordination reduces effectiveness of watershed-scale planning and implementation	Weak governance reduces capacity to manage systemic risks (drought, floods) at basin scale
5. Environmental and system-level constraints	• 49% of ecosystems transformed • 17.8% of páramo degraded • 32% soils low carbon, 23% low moisture • 45% territory exceeds water use limits in dry years	Baseline degradation reduces effectiveness of interventions and increases costs (e.g. sediment, variability, lower regulation capacity)	Weakens natural water regulation, increasing exposure to drought, floods, and water quality degradation
6. Data and knowledge constraints	• Climate system: 14 stations (≥85% completeness) + CMIP6 projections (~10 km) • Yet 676 events recorded (1912–2017): floods (244), landslides (121), fires (110) • Lack of integrated monitoring systems identified	Data exists but is fragmented and not operationalized; limits targeting, prioritization, and tracking of results	Prevents development of performance-based adaptation investments and reduces effectiveness of climate-informed decision-making
7. Social and structural constraints	• High dependence on rural livelihoods in upstream municipalities • Strong inequality between urban demand	Communities face economic constraints that limit adoption of sustainable practices and long-term participation	Reinforces vulnerability and reduces uptake of adaptation measures needed to protect water sources

Operational constraints	Evidence (Bogotá Region)	What this means for implementation	Climate relevance
	(Bogotá) and rural supply areas • Limited access to services and economic opportunities in rural areas		
8. Cross-cutting implementation risks	• Recent drought (2024–2025) → water rationing affecting ~9 million people • Increase in wildfire area: 4,100 ha (2023) → 6,500 ha (2024) • Persistent flood and landslide events (historical record)	Increasing frequency and severity of shocks may disrupt implementation and increase uncertainty in investment planning	Demonstrates urgency and volatility of climate risk, reinforcing need for resilient, flexible, and long-term interventions

Source: IDOM, 2026.

Closing these operational constraints is therefore not only necessary for the success of the proposed project, but essential to shift the region from a fragmented and reactive response to a systemic, sustained, and climate-resilient water security pathway.

4. Prioritization of intervention landscapes and watersheds

Building on the climate problems identified in Chapter 2 and the base line conditions and non-climate drivers in Chapter 1, this chapter explains where the project will act and why. It applies the project's prioritization methodology to select the intervention landscapes: the Level 1 criteria that identify the priority watersheds within the upper Bogotá River system (4.1); the Level 2 multi-criteria analysis that selects priority properties and distinguishes areas for conservation from areas for transformation of practices (4.2); the protected areas linked to each landscape (4.3); and the explicit link from the dominant climate hazards to each landscape and its activities (4.4). This information is critical for project design because it defines the spatial scope of the proof of concept and demonstrates that interventions are concentrated where they most influence runoff regimes and Bogotá's water supply.

This prioritization approach is also directly informed by the gaps and barriers identified in Chapter 3. In particular, the selection of intervention landscapes reflects the need to overcome fragmentation in watershed planning, address ecosystem degradation in critical supply areas, strengthen local implementation capacity in upstream territories, and enable the generation of hydrological evidence to support long-term financing. By focusing on areas where these constraints are most pronounced but also most addressable, the prioritization ensures that project interventions are not only geographically targeted, but structurally relevant to the underlying causes of climate vulnerability.

To facilitate territorial management and water governance, the project area is organized into four intervention landscapes, each delineated by hydrological features that are defined by sub-basins. This spatial configuration provides a robust framework for planning, as it integrates key ecological corridors, high-altitude ecosystems such as páramos, critical headwaters of the Bogota River and Tunjuelo River. By linking ecological integrity with water regulation and local development, the definition of this project intervention's area ensures that conservation and climate resilience actions respond to both environmental priorities and community needs.

Prioritization builds not only on climate risk and vulnerability, but also on the broader baseline and non-climate drivers identified in previous chapters, including land-use dynamics, ecosystem degradation, socioeconomic pressures, and institutional conditions that influence water security outcomes.

4.1. Selection criteria

The selection of priority watersheds and intervention landscapes (Level 1) in the upper Bogota River basin is grounded in a robust, multi-criteria methodology designed to maximize climate impact and water benefits at scale, while delivering a credible proof of concept during the project implementation period. The upper Bogota River system, regulated by the Tominé, Neusa and Sisga reservoirs, feeds EAAB's north (Tibitoc) system and can supply up to 25% of Bogota's water demand (Alcaldía Mayor de Bogotá, 2024) (EAAB, s.f.), plus eleven surrounding municipalities, when operating at maximum capacity, and was instrumental in responding to the 2024 water-rationing episode triggered by shortages in the Chingaza system. EAAB has identified the system as having the potential to temporarily provide a substantially larger share during drought conditions, subject to operational and concession restraints (Avendaño, 2025).

Focusing the project's investments on this part of the system ensures that hydrological improvements translate directly into enhanced regional water security for more than 9.8 million people and for key economic sectors.

Within this strategic context, priority areas (intervention landscapes) were chosen based on their role in supporting reservoirs and local urban water supply systems, as well as a robust and strategic approach based on the following factors:

- Climate risk: A central criterion guiding the prioritization of intervention landscapes is the spatial distribution of integrated climate risk, as identified in Chapter 2 through the combined analysis of hazard, exposure, and vulnerability. The integrated risk mapping highlights areas where hydro-climatic hazards, such as droughts, floods, landslides, and wildfires, coincide with high population dependency on water resources and limited adaptive capacity at the municipal level. This spatial convergence is particularly evident in upstream watersheds that regulate flows toward Bogotá's supply system, as well as in densely populated downstream areas such as the Bogotá–Soacha corridor. Prioritizing landscapes within these risk hotspots ensures that project interventions are targeted where climate impacts are expected to be most severe and where improvements in ecosystem condition and water regulation can generate the greatest reduction in systemic risk. In this sense, the climate risk criterion not only identifies areas of high vulnerability but also guides investments toward territories where ecosystem-based adaptation and climate-resilient land management can maximize both hydrological and social resilience under current and projected climate scenarios (IDEAM, 2025; IPCC, 2022).
- Water regulation impact (current and future runoff): the potential of changes in vegetation cover and land management to reduce runoff peaks and sustain baseflows, strengthening watershed-level regulation under current climate and under projected scenarios.
- Environmental and ecological criteria were used to prioritize intervention landscapes with high current condition and connectivity of páramos, Andean forests and riparian ecosystems, reflected in habitat quality, biodiversity, soil stability and natural flow-regulation capacity. These ecosystems are critical regulators of infiltration, storage and baseflow in the upper Bogota basin and also underpin national and international biodiversity objectives, including Colombia's commitments under the Convention on Biological Diversity.
- Socioeconomic diversity played a decisive role in selecting intervention landscapes. The chosen areas host a wide range of agricultural systems (dairy, potato, mixed crops, diversified Andean value chains) and socioeconomic contexts, which allows the project to test and refine climate-resilient production and market approaches across different configurations typical of the Bogota Region.
- Stakeholder engagement values that CI Colombia and partners have an established track record in several of these territories, with prior projects that have built trust and working relationships with producer organizations, community-run water suppliers and local governments. This pre-existing engagement reduces implementation risk and increases the likelihood of rapid uptake of conservation agreements, productive transformation and community-level water-efficiency measures during the project period.
- Institutional and governance considerations were central to the selection process. The three proof-of-concept intervention landscapes combine high climate-hydrological priority with strong institutional presence and co-financing potential from EAAB, CAR Cundinamarca, SDA, municipal governments and private sector. Regional environmental authorities (CAR Cundinamarca, Corpoguavio), Bogota D.C. institutions and municipal governments provide a dense governance fabric capable of supporting implementation, replication and policy uptake, including the future operationalization of the environmental investment in the water tariff and the long-term private investment mechanism. This institutional density, together with alignment with POMCAs and POTs,[5]

[5] POMCAS - Planes de Ordenación y Manejo de Cuencas Hidrográficas: This is an environmental planning tool aimed at managing, conserving, and rationalizing the use of renewable natural resources within a specific water basin. It involves managing biodiversity, mitigating environmental risks (like those caused by El Niño or La Niña), and adapting to climate change.

ensures that project interventions are not isolated pilots but embedded in planning instruments that facilitate scale-up across the Bogota Region.

Taken together, these hydrological, climatic, environmental, socioeconomic, engagement and institutional criteria explain and justify the focus on the upper Bogota River basin and on the three selected intervention landscapes for proof of concept. By concentrating interventions where they can most effectively influence runoff regimes, protect critical regulation ecosystems, test solutions across diverse rural contexts and leverage strong territorial institutions, the project maximizes its ability to generate verifiable Volumetric Water Benefits, demonstrate scalable models for ecosystem-based adaptation and water-resilient livelihoods, and provide a compelling case for long-term public and private investment in watershed resilience.

Level 1 priority areas, referred to as **intervention landscapes** in this project, group 2nd order sub-basins important for water supply and regulation (IDEAM, 2013)[6], specifically those that feed reservoirs and municipal systems. Three priority intervention landscapes Guandoque (Guandoque–Salitre–Susagua watershed), Villapinzón (Upper Bogota River watershed), and Tominé (San Francisco–Aves–Chipata watershed) were selected due to their climate-hydrological significance, feasibility, co-financing partners, and active community groups (Figure 32). Watersheds (4th order sub-basins) were chosen for Component 1 because they are suitable for measurable hydrological outcomes and local planning, aligning with municipal and Bogota water sources.

Because the Bogota Region covers a vast area, specific landscapes were chosen for intervention to target project activities more effectively. Prioritization of intervention areas was conducted through a two-level methodology developed by Conservation International Colombia. Level 1 prioritizes strategic watersheds based on a multi-criteria analysis at the regional scale and groups them in intervention landscapes; Level 2 prioritizes specific properties and parcels within high-priority watersheds, integrating territorial and socio-economic determinants.

Table 15. List of municipalities within the intervention landscapes of the Bogota Region project.

Municipality	Department	DANE Code	Profile URL
Chocontá	Cundinamarca	25183	Chocontá
Cogua	Cundinamarca	25200	Cogua
Guasca	Cundinamarca	25322	Guasca
Guatavita	Cundinamarca	25326	Guatavita
Sesquilé	Cundinamarca	25736	Sesquilé
Tausa	Cundinamarca	25793	Tausa
Villapinzón	Cundinamarca	25873	Villapinzón
Zipaquirá	Cundinamarca	25899	Zipaquirá
Bogotá D.C.	Cudinamarca	11001	

Source: IDOM, 2025 with information from DANE.

POT - POT (Plan de Ordenamiento Territorial): This is a municipal-level blueprint that guides how a city or town develops. It determines where people can build (urban vs. rural), designates industrial/commercial/residential zones, and dictates infrastructure requirements and disaster risk zones for the municipality.

[6] IDEAM maps Colombia's hydrographic and hydrogeological units at a 1:500,000 scale, beginning with five main hydrographic areas (Caribbean, Magdalena-Cauca, Orinoco, Amazon, Pacific) that are divided into zones, sub-zones, and smaller units. Lower-order units in this project include watersheds (e.g., Río Bogota), second-order sub-basins (e.g., Embalse de Tominé), and fourth-order sub-basins (e.g., Río Susagua).

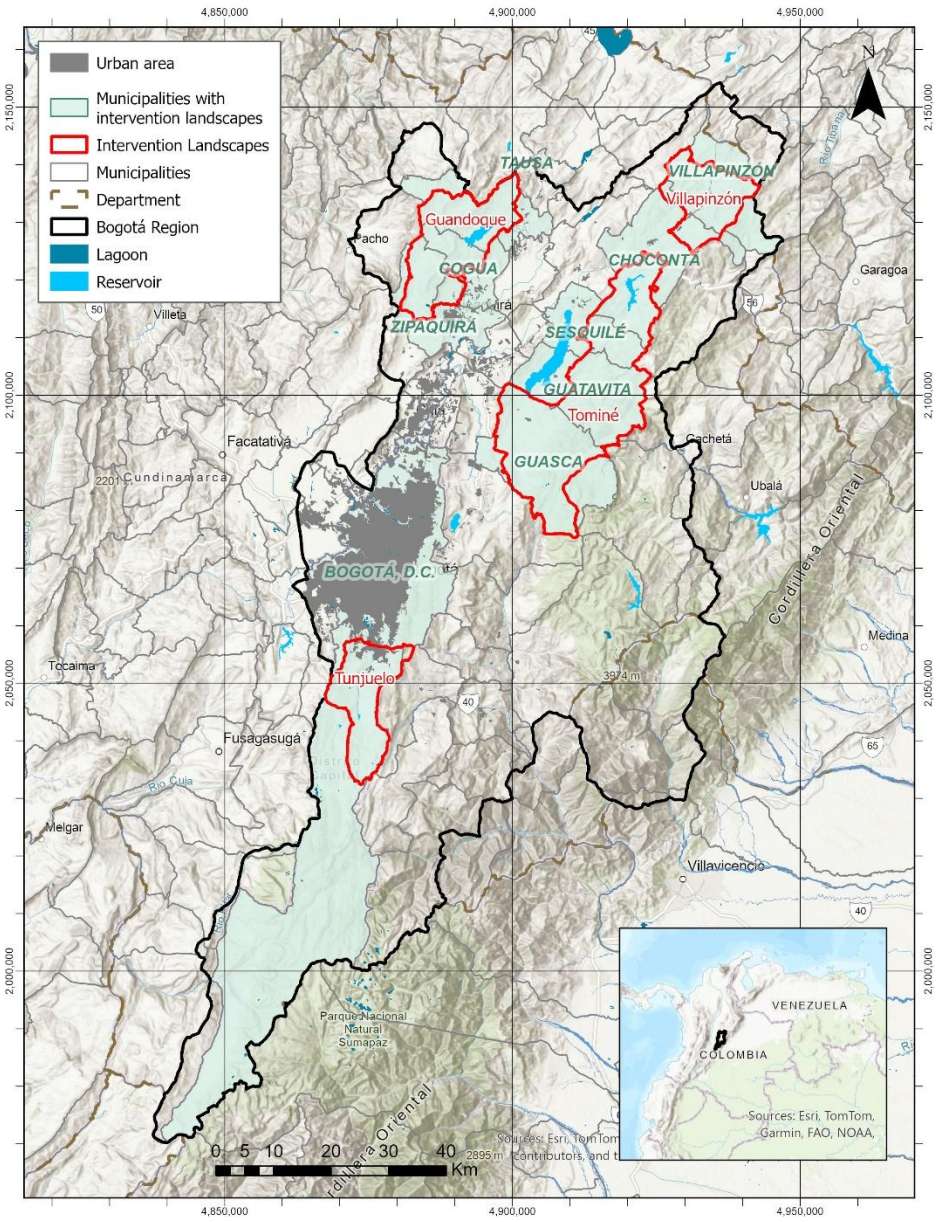


Figure 31. Project territorial scope: Bogota Region and the municipalities with intervention landscapes.
Source: IDOM 2026.

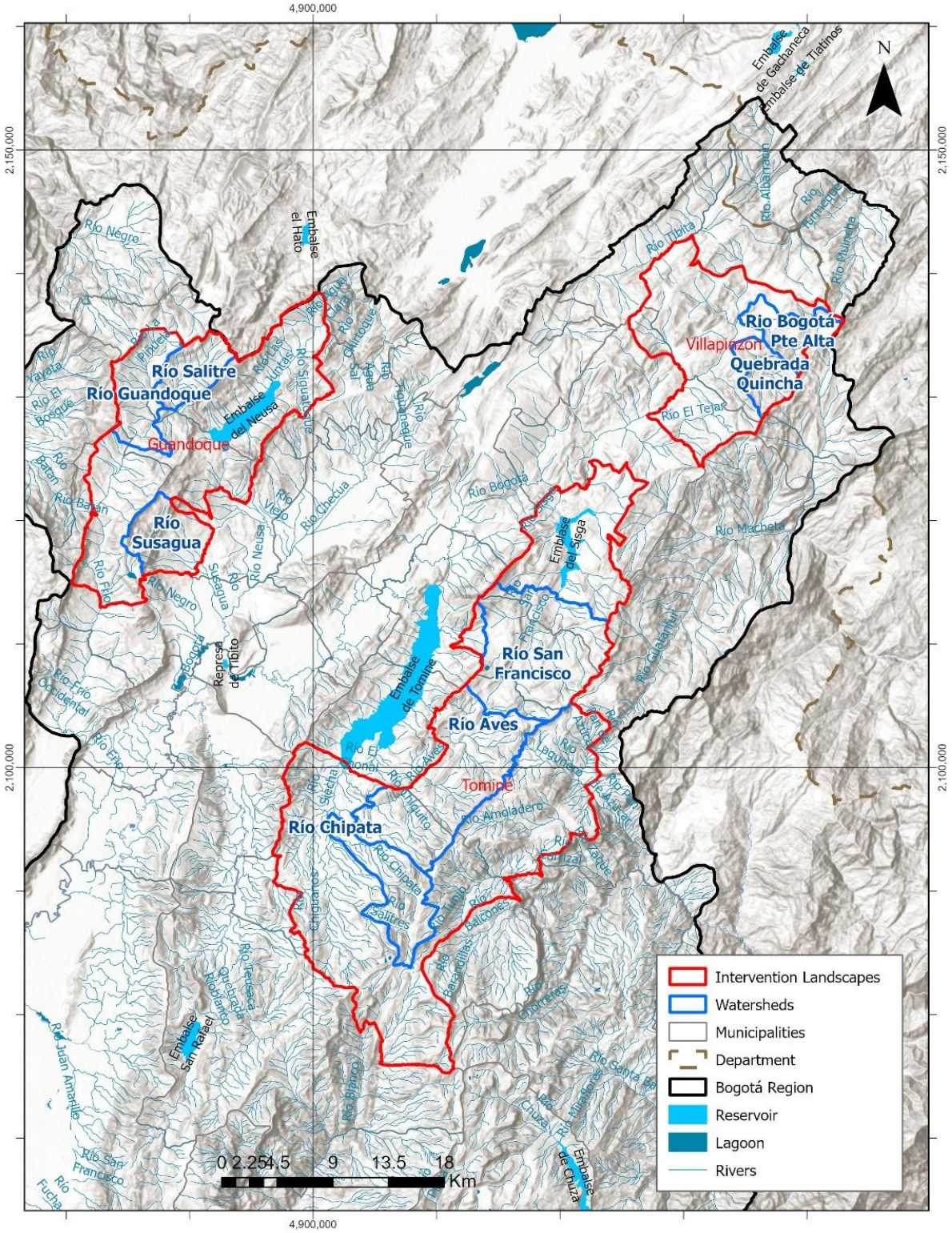


Figure 32. Intervention Landscapes and selected watersheds (4th order sub-basins) in EAAB's North System.
Source: IDOM, 2026.

In addition to the three intervention landscapes prioritized by the logic exposed before, **a fourth intervention landscape** was selected considering these criteria:

- **Strategic hydrological relevance to the water-supply system**. The area sustains the Southern Supply System: the upper Tunjuelo basin hosts La Regadera reservoir, which together with Chisacá, feed the La Laguna, El Dorado and Vitelma drinking-water treatment plants. Although a relatively small share of Bogotá's overall supply, it serves sectors with limited operational flexibility and effectively captive service areas, and a significant proportion of the river's flow is diverted for drinking-water production. Interventions apply the same rationale as the northern area: protecting and enhancing the hydrological functionality of the source watersheds.
- **Ecosystem degradation and restoration potential.** The area shows soil degradation, loss of natural hydrological regulation, loss of vegetation cover, erosion, sediment transport and encroachment into riparian corridors, exerting pressure on Bogotá's Ecological Main Structure, conditions that make ecosystem restoration, spring protection and soil management both necessary and measurable.
- **Documented water-quality and pollution pressures**. The Bogotá Environmental Secretariat (SDA) has identified odour problems in the middle and lower reaches of the Tunjuelo River as it enters the urban area, associated with stagnant water and upstream discharges into tributaries and sub-basins, especially during dry periods (SGA - Alcaldía Mayor de Bogotá). Diffuse discharges and wastewater pressures justify upstream land-management responses.
- **Institutional and policy readiness (implementability).** The area contains four Sustainable Landscapes officially recognized by the City Administration — Paso Colorado–Peñas Blancas, La Requilina–El Uval, Los Soches and Quiba — established under Bogotá's Land Use Plan (POT) and promoted by the SDA (SGA, 2024). Their existence transforms a standing district priority into a ready climate-adaptation investment platform.
- **Urban–rural coexistence and territorial-driver focus**. The area demonstrates that climate adaptation can reduce risk by addressing the territorial drivers of vulnerability rather than expanding supply infrastructure alone. Maintaining a functional rural landscape around Bogotá supports sustainable rural livelihoods while stabilizing soils and protecting local water sources.

The incorporation of the Tunjuelo intervention landscape (Figure 33) strengthens the long-term sustainability of the operation by linking water security, ecological restoration, and urban-rural coexistence. In a climate change context, maintaining a functional rural landscape around Bogotá is not merely an environmental objective; it is a prerequisite for reducing impacts on the city, protecting water supply sources, stabilizing soils, improving water quality, and sustaining critical ecosystem services that underpin urban resilience and water security.

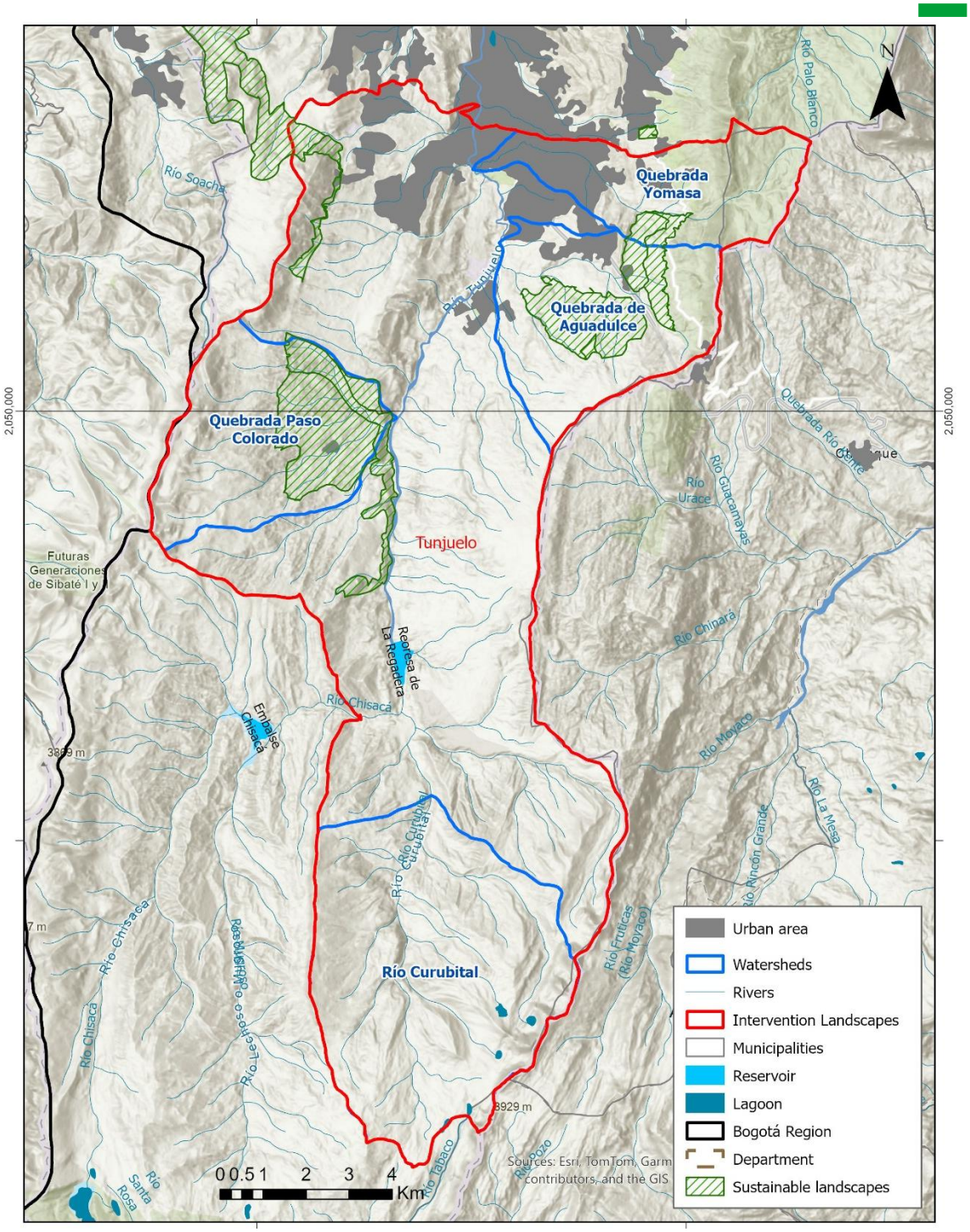


Figure 33. Intervention Landscape and selected watersheds (4th order sub-basins) in EAAB's South System.
(See section 4.3.4 for information on sustainable landscapes, a legal land designation).
Source: IDOM, 2026.

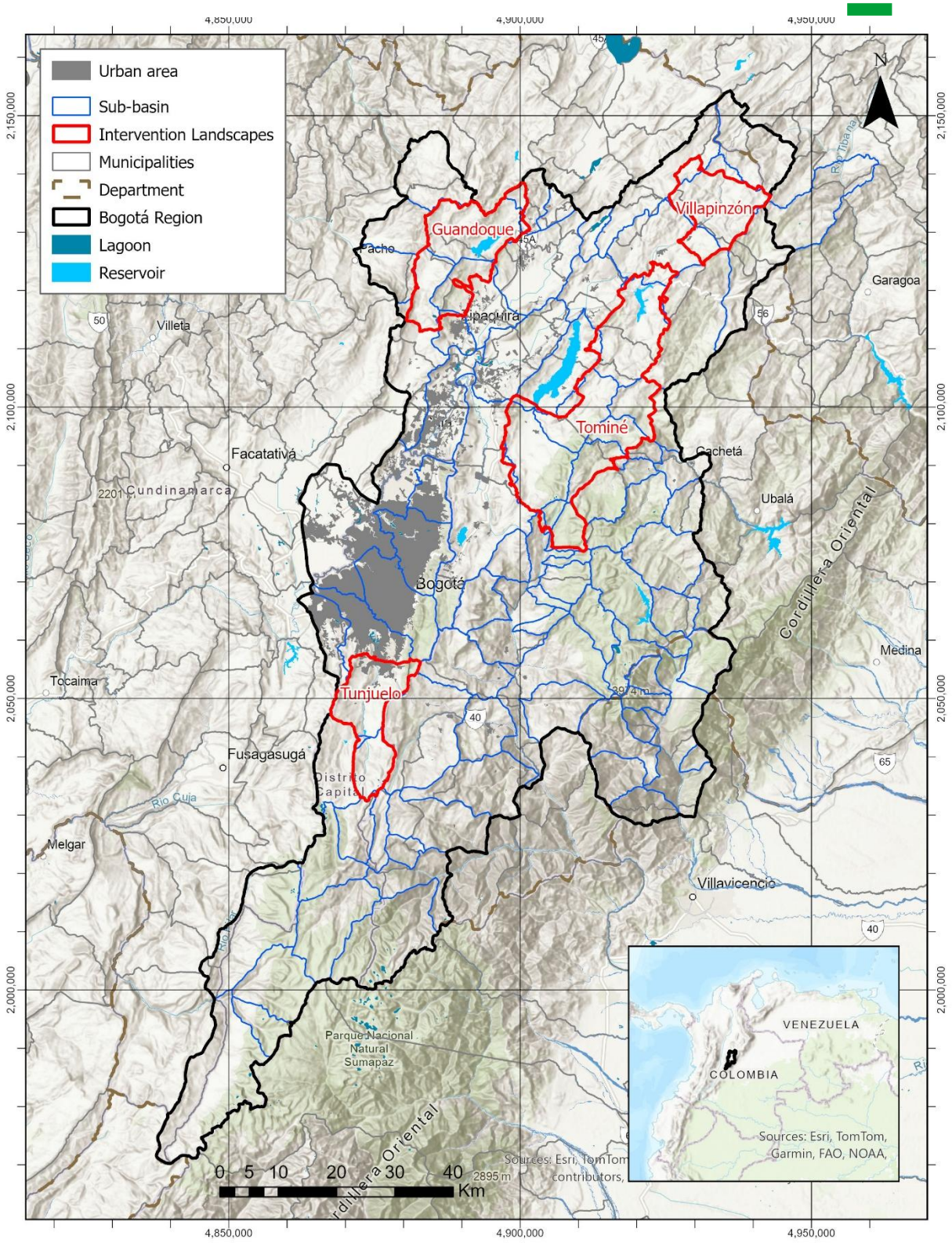


Figure 34. Intervention landscapes and sub-basins (2nd order).
Source: IDOM, 2026.

4.2. Multicriteria prioritization of watersheds and territories

Within each selected landscape, a second level of prioritization was applied to identify priority watersheds and intervention areas. This process follows a multi-criteria approach that integrates environmental, biophysical, climatic, and socioeconomic variables.

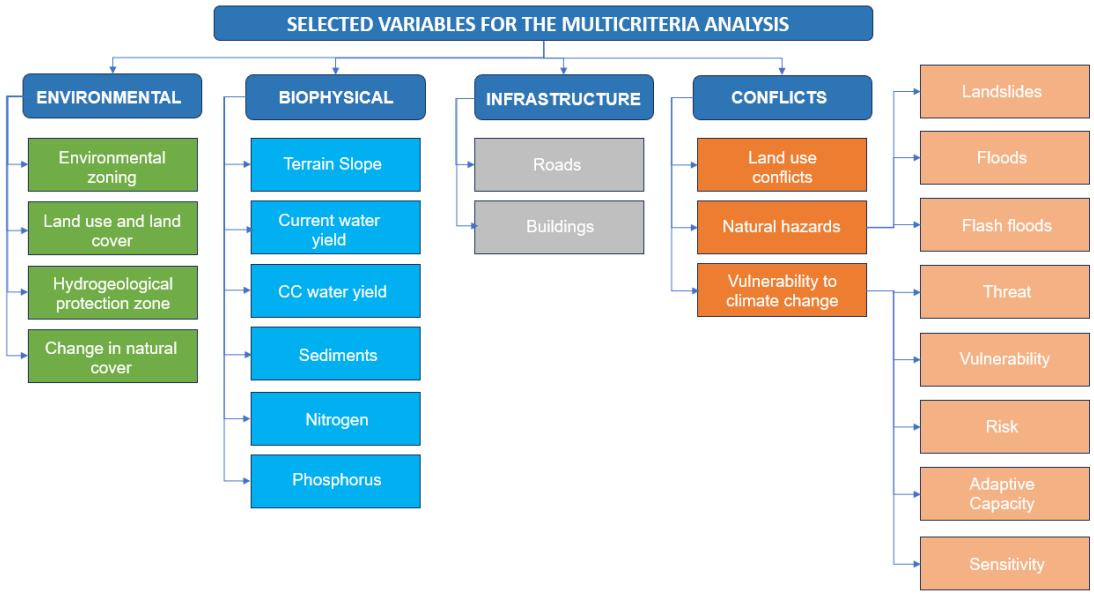


Figure 35. Criteria and variables for Level 2 multicriteria.
Source: CI-Colombia, 2023.

At this level, the methodology assigns the highest weight to environmental and biophysical conditions, including ecosystem integrity, hydrological function, and land-use conflicts, followed by climate vulnerability indicators and implementation feasibility considerations.

Table 16. Weights assigned to criteria and variables for Level 2 multicriteria.

VALUE		CRITERIA		WEIGHT
50	Environmental	Environmental zoning		10
		Land use and land cover		25
		Hydrogeological protection zone		5
		Natural cover changes		10
30	Biophysics	Terrain slopes		4
		Current water yield		10
		Water yields climate change		10
		Sediment production		2
		Nitrogen		2
		Phosphorus		2
20	Conflicts	Land use conflicts		10
		Natural hazards	Mass movements	2
			Floods	1
			Torrential floods	2
		Vulnerability of water yield to CC	Threat	1
			Vulnerability	1

	Risk	1
	Adaptive capacity	1
	Sensitivity	1
TOTAL		100

Source: CI-Colombia, 2023.

Two complementary prioritization focuses were defined and applied within each watershed:

- Conservation Focus (FC): Prioritizes areas where restoration (active or passive), or conservation of strategic ecosystems (páramos, high Andean forests, wetlands) generate the greatest hydrological benefits. Highly values variables such as current natural cover, environmental zoning, hydrogeological protection areas, current and future water yield, sediment and nutrient production. This is the dominant approach for plots within protected areas, RNSC (Civil Society Nature Reserves), páramo zones and buffer areas of National Natural Parks.
- Production Focus (FP): Prioritizes areas where sustainable productive transformation (silvopastoral systems, agroecological agriculture, efficient water use) can generate hydrological benefits without sacrificing rural livelihoods. Highly values variables such as land-use compatibility, moderate slopes, market access, productive system diversification, potential for reconversion of traditional dairy and potato systems. This is the dominant approach for private properties with active agricultural use, small and medium rural producers in priority areas but outside strict protected areas.

This differentiation ensures that interventions are tailored to the ecological and socioeconomic characteristics of each site, avoiding one-size-fits-all approaches and maximizing both environmental impact and social acceptability.

Table 17. Conservation focus (FC) and Production focus (FP) prioritization criteria and their spatial implementation.

Criterion	Variables included	Weight (Conservation Focus FC)	Weight (Production Focus FP)	Target property types
Environmental	Environmental zoning (10%), Land use and land cover (25%), Hydrogeological protection zones (5%), Natural-cover changes (10%).	**50%** (high)	30% (moderate)	Public PA, RNSC, páramo private properties.
Biophysical / hydrological	Terrain slopes (4%), Current water yield (10%), Water yields under climate change (10%), Sediment production (2%), Nitrogen (2%), Phosphorus (2%).	**38%** (high)	40% (high)	All properties in high water-yield sub-basins.
Land-use conflicts	Land-use conflicts (10%).	10% (moderate)	**20%** (high)	Private agricultural properties in areas zoned for protection or restoration.
Natural hazards / climate vulnerability	Mass movements (2%), Floods (1%), Torrential floods (2%), Threat (1%), Vulnerability (1%), Risk (1%), Adaptive capacity (1%), Sensitivity (1%).	2% (low)	**10%** (moderate)	Peri-urban and rural-urban edge properties, Southern Crescent, flood-prone areas.

Note: Weights reflect strategic importance for generating hydrological outcomes quantified through VWBsunder each focus. Variables are normalized on a 1–10 scale and weighted-summed to produce the Multi-Criteria Evaluation (EMC) maps for FC and FP. Properties in EMC classes 4 and 5 within high water-yield sub-basins are retained as priority parcels.

Source: Conservation International, 2023.

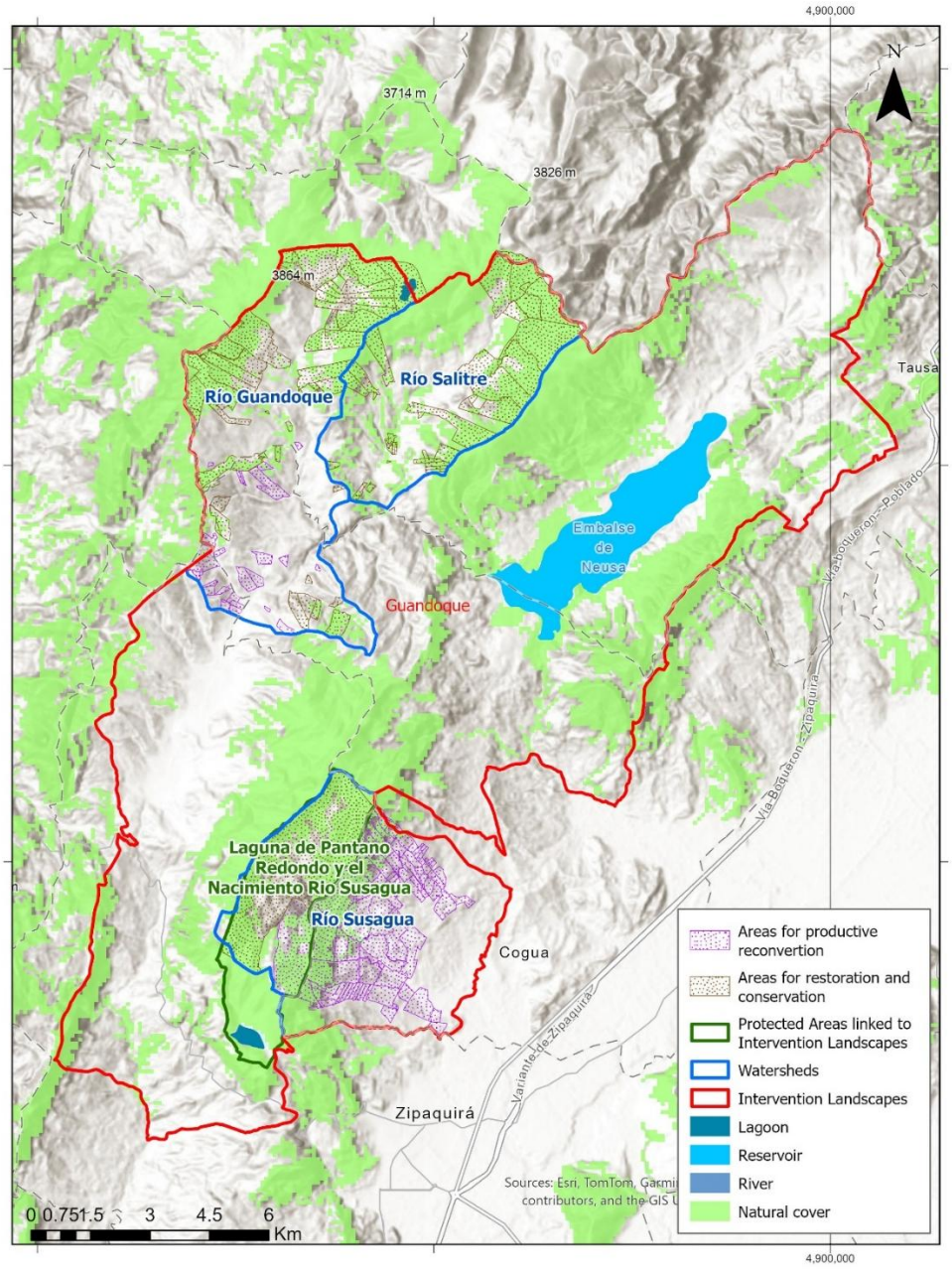


Figure 36. Intervention Landscape 1: Guandoque.
Source: IDOM, 2026.

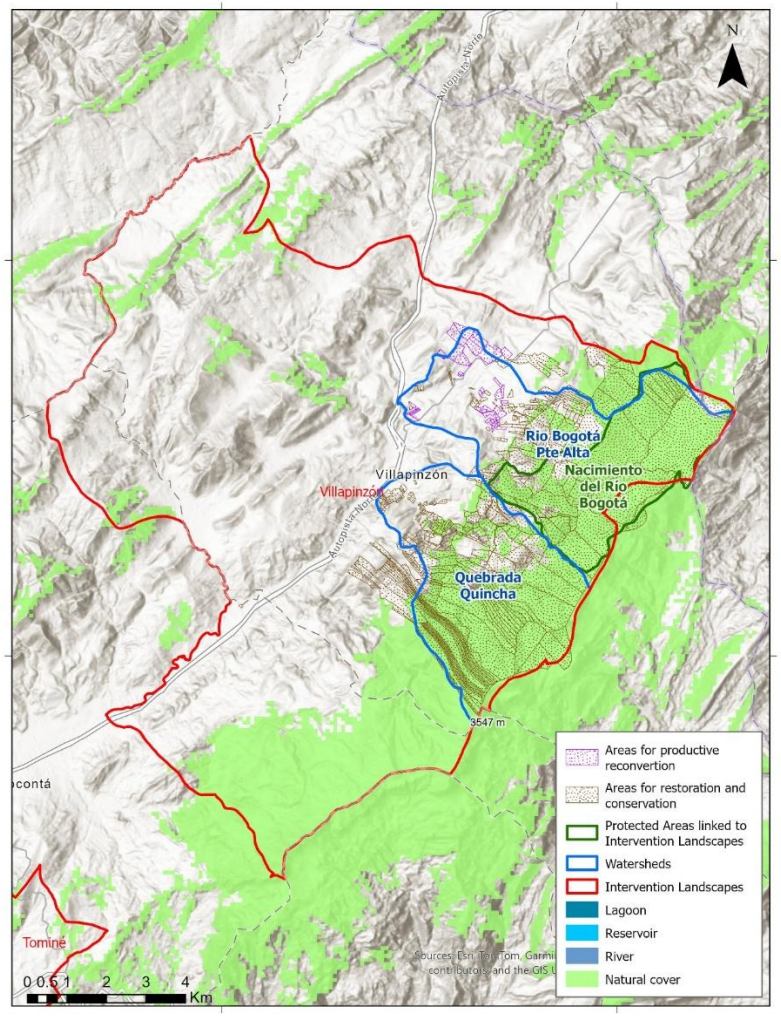


Figure 37. Intervention Landscape 2: Villapinzón.
Source: IDOM, 2026.

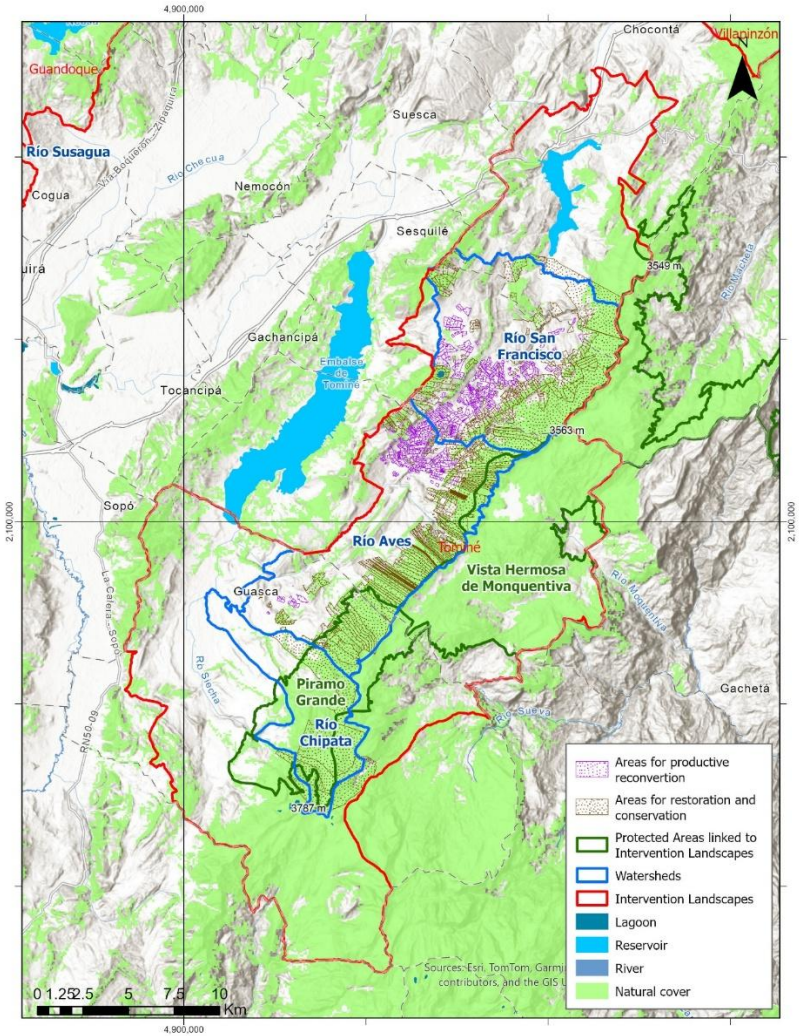


Figure 38. Intervention Landscape 3: Tominé.
Source: IDOM, 2026.

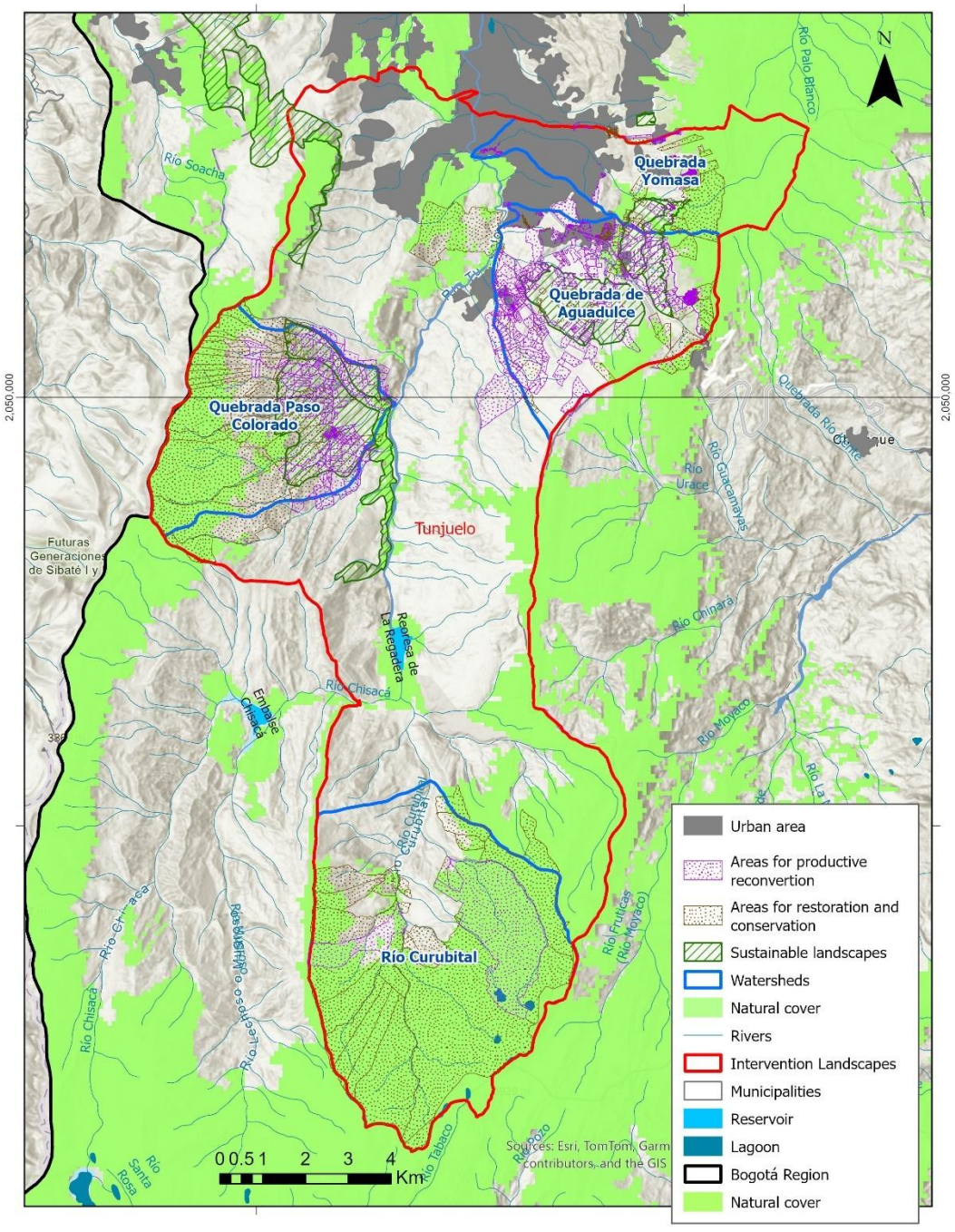


Figure 39. Intervention Landscape 4: Tunjuelo.
Source: IDOM, 2026.

4.3. Protected areas linked to intervention landscapes

As seen in Figure 36, Figure 37, Figure 38 and Figure 39 each of the Intervention Landscapes are linked with a protected area that is in the upper part of the watershed. These areas safeguard headwaters and páramo complexes that are strategic for water regulation. They function as central nodes of ecological connectivity and the starting point of key rivers that supply the EAAB and rural municipal and community-run water supply systems.

4.3.1. Guandoque intervention landscape: Laguna de Pantano Redondo y Nacimiento del Río Susagua

In Guandoque, project interventions in protected areas are linked to the high-mountain protected area that includes Laguna de Pantano Redondo y Nacimiento del Río Susagua, within the Guandoque–Salitre–Susagua watershed system. This protected zone conserves a mosaic of páramo, high-Andean forest and wetlands that regulate flows toward downstream reservoirs and municipal water supply systems and was prioritized due to its very high climate–hydrological importance and its role in buffering projected climate-driven changes in runoff and baseflows.

The presence of this protected area in the headwaters makes this area particularly suitable for conservation, restoration and sustainable production measures designed to reduce peak runoff and enhance storage in soils and peatlands. By concentrating passive and active restoration, conservation agreements and climate-resilient production in surrounding private lands, the project strengthens the ecological integrity of this protected area and its capacity to sustain water supply for downstream users.

Table 18. Main characteristics of Laguna de Pantano Redondo y Nacimiento del Río Susagua.

Aspect	Main characteristics
Category	Regional Protector Forest Reserve (a sustainable-use protection category aimed at conserving soils, water and forest cover).
Jurisdiction and authority	CAR
Ecosystem type	High Andean sub-páramo and páramo mosaics with high-Andean forest patches and wetlands.
Elevation range	Approximately 3,000–3,400 m a.s.l., typical of sub-páramo/páramo belts in the eastern cordillera of Cundinamarca.
Biodiversity highlights	Presence of páramo flora (e.g. *Espeletia spp*. frailejones), high-Andean shrubs and grasses, and associated bird and small mammal communities characteristic of high-mountain wetlands; municipal forest reserve of about 2,100 ha with sub-páramo, páramo and high-Andean forest formations.
Hydrological role	Headwaters area where the Río Susagua originates; considered one of the most important "natural water parks" in the region, providing baseflow regulation and sustained water supply for Zipaquirá and neighboring municipalities.
Key ecosystem services	Water regulation and storage (wetlands, organic soils and forest cover buffering flows), baseflow maintenance for downstream aqueducts, soil protection on steep slopes, habitat for high-mountain biodiversity, and cultural–recreational values linked to scenic landscapes and environmental education.

Source: IDOM, with data from: (RUNAP) (CAR, 1992).

4.3.2. Villapinzón intervention landscape: Nacimiento del Río Bogotá

In Villapinzón landscape, interventions in protected areas are associated with the protected area that encompasses the *nacimiento* (source) of the Río Bogota and its upper basin. This zone was identified as a strategic high-mountain watershed because it combines very high hydrological priority, high importance for the Bogota water system and high priority for connectivity under climate change scenarios.

The protected headwaters of the Río Bogota function as a critical regulator for the entire basin, influencing flows that later feed major reservoirs and supply systems. Project activities in surrounding rural properties (restoration, conservation and productive reconversion) are therefore designed to act as a protective buffer around this headwater protected area, reducing land-use pressures and reinforcing its role in maintaining baseflows and water quality for millions of downstream users.

Table 19. Main characteristics of Nacimiento del Río Bogota.

Aspect	Main characteristics
Category	Regional Protective Forest Reserve
Jurisdiction and authority	CAR
Ecosystem type	High Andean páramo complex (Rabanal–Río Bogota) with peat-forming wetlands, lagoons and high-Andean forest remnants in upper slopes.
Elevation range	Source area of the Río Bogota located above ~3,400 m a.s.l., with surrounding páramo surfaces extending roughly between 3,200–3,600 m a.s.l.
Biodiversity highlights	Rich páramo flora (mosses, cushion plants and frailejones), habitat for endemic and threatened Andean bird and mammal species typical of Colombian páramos; the protected block "*Reserva Forestal Protectora Nacimiento del Río Bogota*" is part of the larger Rabanal–Río Bogota páramo complex.
Hydrological role	Origin of the Río Bogota, which runs ~380 km across 47 municipalities before reaching the Magdalena River; the headwaters páramo acts as a natural "water factory" regulating flows, storing water in organic soils and vegetation, and releasing it gradually to downstream reservoirs and aqueduct intakes.
Key ecosystem services	Regulation and reliable provision of potable water for the Bogota basin, carbon sequestration in organic soils and peat, soil protection against erosion, biodiversity conservation, and cultural services linked to the symbolic value of the river for local communities and the Muisca heritage.

Source: IDOM, with data from: (CAR, 2018).

4.3.3. Tominé landscape: Vista Hermosa–Monquentiva and Páramo Grande

In the Tominé landscape, the interventions in protected areas are directly connected to two key protected areas: the *Parque Natural Regional Vista Hermosa–Monquentiva* and the *Reserva Forestal Protectora Nacional Páramo Grande*. These areas form a highly connected block of páramo and high-Andean forest that supplies and regulates flows to the San Francisco, Aves and Chipatá rivers and, ultimately, to the Tominé and Sisga reservoirs that support the north system of the Bogota Water Utility.

Vista Hermosa–Monquentiva and *Páramo Grande* were prioritized because they combine high natural water yields, sensitivity to climate change and strong potential for NbS to enhance water ecosystem services. By focusing conservation agreements, restoration treatments and climate-resilient production around these protected blocks, the project increases ecological connectivity along altitudinal gradients and secures the hydrological functions of the páramo complex that underpin regional water resilience.

Table 20. Main characteristics of Vista Hermosa-Monquentiva.

Aspect	Main characteristics

Category	Regional Natural Park (Parque Natural Regional – PNR), strict conservation category within the National System of Protected Areas (SINAP)
Jurisdiction and authority	CAR
Ecosystem type	High-mountain block combining high-Andean forest, sub-páramo and páramo belts, with headwater streams, ravines and cloud-forest remnants.
Elevation range	Approximately 2,800–3,600 m a.s.l., spanning upper montane forest to páramo zones in the Eastern Cordillera.
Key biodiversity	High Andean biodiversity, including endemic and threatened birds, mammals and amphibians; reports mention multiple endemic bird and mammal families, threatened mammals and amphibians, and migratory bird species.detour.cundinamarca.gov+1
Main ecosystem services	Water regulation and baseflow support for rivers draining toward the Guavio and upper Bogota basins, carbon storage in high-elevation forests and soils, erosion control on steep slopes, conservation of high-mountain habitats, and provision of low-impact ecotourism and environmental education opportunities.

Source: IDOM with data from (CAR, 2017).

Table 21. Main characteristics of Páramo Grande.

Aspect	Main characteristics
Category	National Protective Forest Reserve, sustainable-use protection category focused on conserving forest cover, soils and water resources.
Jurisdiction and authority	National-level protected area under the Ministry of Environment and Sustainable Development (MADS); environmental management and enforcement coordinated with Corpoguavio and other regional authorities.
Ecosystem type	High-altitude páramo system with extensive frailejón stands, grass-shrub páramo and associated high-Andean wetlands, embedded within the broader Chingaza high-mountain complex.
Elevation range	Mainly above ~3,300 m a.s.l., occupying the upper páramo fringe that feeds headwaters of tributaries to the upper Bogota River and Guavio basin.
Key biodiversity	Typical páramo flora (*Espeletia spp.*, cushion plants, mosses) and fauna such as Andean bear, high-Andean deer and diverse amphibian and bird communities; identified as part of a priority high-mountain conservation corridor.
Main ecosystem services	Primary "water factory" for headwaters supplying rivers such as San Francisco, Aves and Chipatá and, through them, the Sisga and Tominé reservoirs; high carbon storage in organic soils and vegetation, erosion control, climate regulation and maintenance of connectivity among Andean high-mountain habitats.20260104_Description-of-Activities.docx+1water-alternatives+1

Source: (MADS, 2024).

4.3.4. Tunjuelo landscape: sustainable landscapes

This landscape doesn't have a traditional protected area associated but includes four Sustainable Landscapes officially recognized by the Bogotá City Administration: Paso Colorado–Peñas Blancas, La Requilina–El Uval, Los Soches and Quiba (SGA, 2024). Sustainable Landscapes (Paisajes Sostenibles) are a rural land-management category created by the District of Bogotá through its Land Use Plan (POT, Decree 555 of 2021) and led by the Secretaría Distrital de Ambiente (SDA). The SDA defines them as protected areas with a sustainable agricultural vocation, where agricultural and livestock activities are permitted together with environmental-protection elements, in harmony with the ecological and cultural values of the city's rural territory (Secretaría Distrital de Ambiente, s.f.). Rather than excluding rural inhabitants, the figure explicitly recognizes *campesino*[7] knowledge and culture and seeks to reconcile productive activity with conservation. It is supported by an inter-institutional governance arrangement, a standing planning roundtable for each landscape, linked to the District's Rural Development Advisory Council, and by management guidelines centered on conserving natural cover and water sources (Secretaría Distrital de Ambiente, s.f.).

[7] Smallholder farmer

Within this project, the Sustainable Landscapes serve as a ready-made institutional and territorial platform that converts a standing District priority into a climate-adaptation investment vehicle. Because they are already formally delimited, governed through participatory roundtables, and oriented toward reconciling rural livelihoods with environmental protection, they provide a legitimate and operational entry point for the project's nature-based actions: ecosystem restoration, sustainable production systems, spring and water-source protection, soil management, and the reduction of pressures on Bogotá's Ecological Main Structure (SGA, 2024). This alignment lets the project act on the territorial drivers of water insecurity in the upper Tunjuelo basin, which sustains the Southern Supply System, while reinforcing existing district instruments, thereby strengthening hydrological regulation, protecting local water sources, and supporting urban–rural coexistence as part of Bogotá's long-term water-security and resilience strategy.

Table 22. Watershed area and its population.

Watershed	ha	Population (2018)	Men	Women	Population density (inhabitants/ha)
Susagua	3,123	11,032	5,448	5,584	3.5
Salitre	2,337	156	83	73	0.1
Guandoque	3,404	407	202	205	0.1
Parte Alta Río Bogota	2,232	1,400	709	691	0.6
Quebrada Quincha	1,907	6,434	3,258	3,176	3.4
San Francisco	9,065	1,653	829	824	0.2
Aves	9,425	8,555	4,305	4,250	0.9
Chipatá	3,933	6,867	3,432	3,435	1.7
Curubital	3,663	260	130	130	0.1
Quebrada Paso Colorado	1,916	1,282	641	641	0.7
Quebrada de Aguadulce	1,881	71,571	35,786	35,786	38.0
Quebrada Yomasa	1,343	188,120	94,060	94,060	140.1
Total	***44,229***	***297,737***	***148,882***	***148,855***	***6.7***

Source: IDOM and DANE 2018.

4.4. Synthesis for climate-informed prioritization

The prioritization of landscapes and watersheds also directly addresses the barriers and implementation gaps identified in Chapter 3. By selecting areas that combine high climate relevance with strong hydrological functionality and implementation feasibility, the project reduces risks associated with institutional fragmentation, weak capacity, and financial constraints.

The dual approach of conservation and production-focused interventions responds simultaneously to environmental degradation, livelihood constraints, and governance challenges. In addition, the focus on landscapes with existing institutional engagement helps overcome coordination barriers and facilitates the development of scalable financing mechanisms and monitoring systems.

The prioritization strategy reflects a clear climate rationale: water security in the Bogotá Region depends not only on infrastructure, but on the condition of upstream ecosystems, the management of productive landscapes, and the ability of institutions and communities to respond to climate variability.

Accordingly, the selected landscapes and watersheds provide the optimal combination of:

- High relevance for water regulation and supply
- Significant climate risk exposure
- Opportunities for ecosystem restoration and productive transformation
- Feasible implementation conditions
- Potential for scaling and replication

These elements align with the key adaptation needs identified previously, including ecosystem restoration, climate-resilient production, improved water system resilience, strengthened institutional capacity, and the development of sustainable financing mechanisms (IDEAM, 2025; IPCC, 2022).

The climate-informed prioritization of intervention landscapes and watersheds ensures that project investments are strategically targeted to areas where they can generate the greatest impact on water security under climate change. By integrating climate risk, hydrological importance, socioeconomic dynamics, and implementation feasibility, the selection approach provides a robust foundation for effective, scalable, and sustainable adaptation interventions in the Bogotá Region.

Table 23. Summary of variables used for prioritization.

Criterion	Indicator	Unit	Purpose in selection	Data source
Climate Risk (CCVA)	Integrated climate risk index (hazard + exposure + vulnerability)	Index (0–1 or categorical)	Identifies high-risk hotspots where interventions reduce climate impacts most	IDEAM (2025); CCVA
	Frequency of extreme events (floods, landslides, droughts, fires)	Number of events / decade	Prioritizes areas with recurrent climate shocks	DesInventar (2026); IDEAM
	Population exposed to climate risk	Number of people	Links climate risk to human vulnerability	DANE (2025)
Hydrological Relevance	Contribution to Bogotá water supply system	% of total supply or qualitative ranking	Ensures prioritization of strategic water-regulating basins	EAAB (2025)
	Baseflow regulation capacity	Qualitative or modeled index	Identifies areas critical for dry-season water stability	IDEAM; hydrological models
	Runoff reduction potential	% change in runoff (modeled)	Targets areas where interventions reduce flood peaks and erosion	Project hydrological assessment
Environmental Condition	Ecosystem integrity (páramo, Andean forest)	% conserved / degraded	Prioritizes degraded but recoverable ecosystems	IDEAM (2022); Humboldt Institute
	Soil condition (organic carbon, moisture)	% low/medium/high	Identifies areas with limited water retention capacity	BID (2022b)
	Land-use conflict index	Qualitative or categorical	Targets areas where land use undermines water regulation	IDEAM (2022)
Socioeconomic & Institutional Feasibility	Municipal investment capacity	% own investment resources	Assesses ability to co-finance and sustain interventions	DANE (2025)
	Institutional presence and partnerships	Yes/No or qualitative score	Prioritizes areas with implementation readiness	Project analysis
	Access to basic services (water, sanitation, connectivity)	% coverage	Measures enabling conditions for implementation	DANE (2025)
Level 2 – Watershed Prioritization	Conservation priority score (FC)	Weighted index	Identifies areas for restoration and protection	Project methodology

Criterion	Indicator	Unit	Purpose in selection	Data source
	Production transformation potential (FP)	Weighted index	Identifies areas where sustainable production is viable	Project methodology
	Climate vulnerability index at micro-watershed level	Index	Refines targeting within landscapes	CCVA downscaled
Implementation readiness (cross-cutting)	Stakeholder engagement level	Qualitative (low–high)	Ensures social feasibility and adoption	Project consultations

Source: IDOM, 2026.

The prioritization of intervention landscapes and watersheds is supported by a structured set of quantitative and qualitative indicators that translate the selection criteria into measurable variables. These indicators ensure that decision-making is evidence-based, transparent, and replicable. Climate risk indicators identify where impacts are most severe; hydrological indicators ensure that selected areas are critical for water regulation; environmental indicators capture ecosystem condition and restoration potential; and socioeconomic and institutional indicators assess feasibility and sustainability. At the watershed level, additional indicators differentiate between conservation and production priorities, ensuring that interventions are aligned with local ecological and livelihood conditions. Together, this indicator framework operationalizes the multi-criteria approach and strengthens the robustness and credibility of the prioritization process.

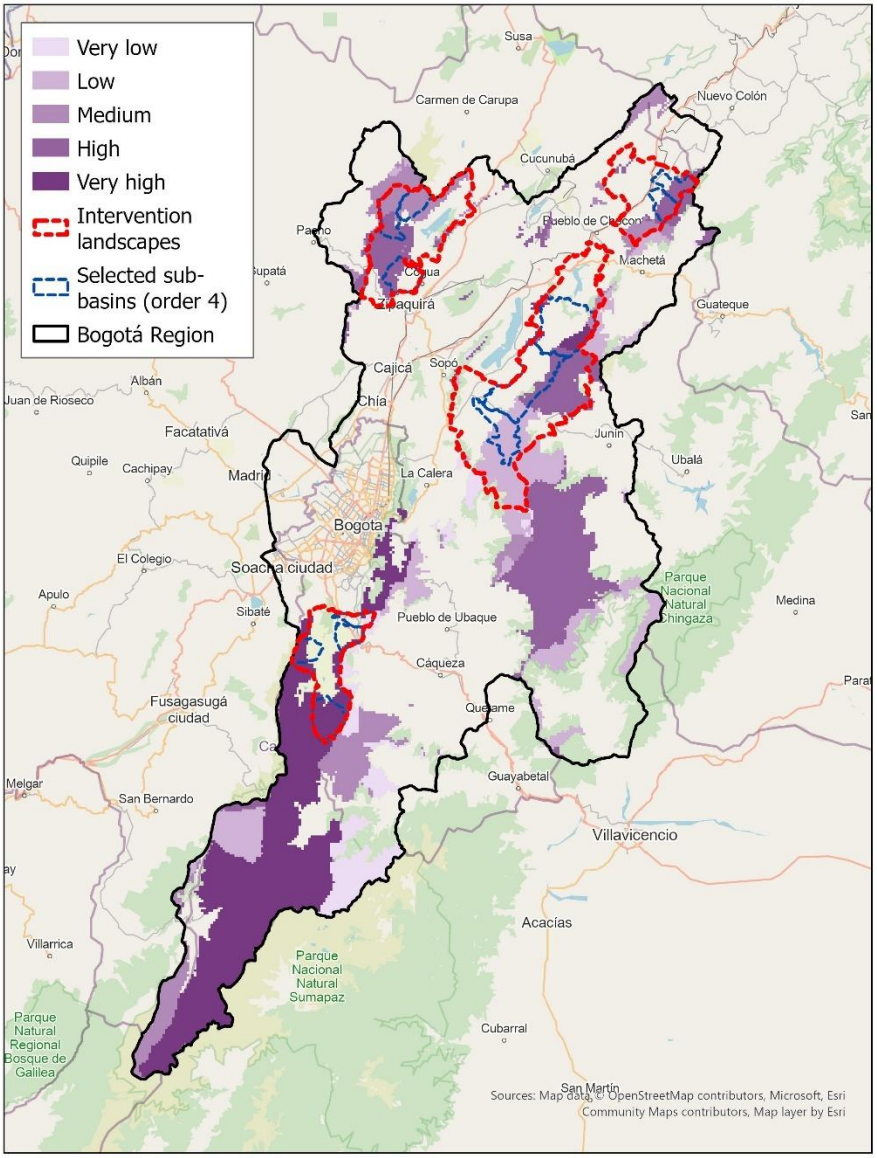


Figure 40. Integrated climate risk (See Chapter 3) with intervention landscapes.
Source: IDOM, 2026.

Overall, the selected intervention landscapes represent the areas where climate risk, hydrological importance, ecosystem degradation, and implementation feasibility converge most strongly (See Figure 40). This ensures that project resources are focused where they can generate the highest impact on water security, while also enabling the testing and scaling of integrated adaptation approaches. The selection is therefore not only technically robust but strategically aligned with the project's objective of demonstrating scalable, watershed-based climate resilience solutions in the Bogotá Region.

While this chapter defines where interventions should be implemented, Chapter 5 evaluates which types of interventions are most effective within these prioritized landscapes.

5. Option Analysis: selecting the highest-impact interventions for water resilience

This chapter presents the methodological approach and results of the assessment of alternative intervention options to address the climate-driven water security challenges in the Bogotá Region. The analysis builds directly on the climate risk assessment (Chapter 2), the identification of gaps and barriers (Chapter 3), and the prioritization of intervention landscapes (Chapter 4), to evaluate which combinations of interventions offer the highest impact, feasibility, and efficiency.

The purpose of this chapter is twofold:

- To demonstrate that the selected interventions are the most effective and efficient options among the feasible alternatives; and
- To justify the use of concessional climate finance by showing that barriers prevent the adoption and scaling of these options under business-as-usual conditions.

The analysis follows a multi-criteria evaluation approach, combining economic, social, environmental, institutional, and equity dimensions, consistent with international best practices and GCF expectations.

This chapter demonstrates that the selected interventions represent the most effective, efficient, and scalable options among all feasible alternatives, thereby justifying the use of concessional GCF finance. The analysis compares a range of solutions to Bogotá's water security challenges based on their economic, social, environmental, institutional, and equity performance, in line with both GCF investment criteria and national public investment standards.

The results show that nature-based, watershed-scale interventions offer the highest impact potential to address the identified climate risks while delivering multiple co-benefits. Critically, the analysis also demonstrates that these interventions enable a paradigm shift from reactive, infrastructure-heavy water management toward preventive, ecosystem-based and financially sustainable approaches. This evidence directly informs the design of the project, leading to the adoption of an integrated two-component structure combining (i) ecological restoration and climate-resilient production activities and (ii) long-term financial mechanisms to ensure sustainability and scalability beyond the lifetime of GCF support.

5.1. Methodological approach used in the options analysis

The options analysis is a structured, quantitative evaluation that compares alternative solutions to Bogotá's water-security challenge on their economic, social and environmental merits. It also responds to a fiduciary requirement of concessional climate finance: because GCF resources are catalytic and scarce, their use must be justified against the best available alternatives. The assessment was therefore designed to provide transparent, defensible justification for the selected interventions and to align explicitly with the Green Climate Fund's six investment criteria (GCF, 2019) and with Colombia's national public-investment standards.

Colombia's National Planning Department (DNP) defines two pathways for comparing alternatives at the pre-investment stage: an economic-viability analysis based on quantitative indicators such as the Economic Internal Rate of Return (EIRR) and Economic Net Present Value (ENPV) using shadow prices, and a multi-criteria analysis (MCA) applying the Analytic Hierarchy Process (AHP) (Departamento Nacional de Planeación, 2014). The team selected the MCA/AHP pathway because the interventions

generate a portfolio of benefits that markets do not fully capture (biodiversity, ecosystem resilience, social equity, governance and Indigenous rights) and because it allows economic efficiency, climate-adaptation impact, environmental co-benefits, social equity and institutional feasibility to be weighed simultaneously, consistent with both GCF criteria and DNP standards.

To ensure a consistent basis for comparison, all candidate measures were first classified by an intervention-typology analysis as grey (engineered assets), green (nature-based) or hybrid infrastructure. Six representative interventions were then selected to span this range and evaluated under a common rubric: two grey (dams/reservoirs and levees/floodwalls), two green (páramo conservation and restoration, and natural stormwater drainage), and two hybrids (rainwater harvesting and managed aquifer recharge) (Table 24).

Each intervention was scored against five weighted categories: Economic (25), Social (25), Environmental (25), Political-Institutional (15) and Gender & Equity (10), summing to 100 points. Each category contains between two and four indicators, scored on qualitative anchors: High (3 points), Medium (2) or Low (1), to allow comparability across diverse project types; category scores are the weight multiplied by the ratio of points obtained to the maximum possible, and all criteria are mapped to the GCF's six investment criteria. The resulting scores support a direct, visual comparison of the interventions. The detailed evaluation rubric, indicator definitions, weighting scheme and full scoring matrices are presented in Appendix IV.

Table 24. List of interventions to increase water availability and reduce flood potential in Bogotá.

Scale	Grey Infrastructure	Green–Grey Hybrid Infrastructure	Green Infrastructure (Ecosystem-Based Adaptation)
Neighborhoods & Slopes	**Retention Basins** to control flash floods and landslides.	· **Slope Stabilization** combining grey retaining walls with bioengineering (vegetation). · **Wetland–Drainage Integration** restoring small wetlands linked to stormwater collectors.	Pocket Parks with Infiltration Features in high-density neighborhoods. **Streamside Buffers** along quebradas (local streams) for filtration and stabilization.
Peri-Urban Transition (Urban Edge & Agricultural Belt)	**Levees and Floodwalls** along vulnerable stretches of the Bogota River.	· **Floodplain Reconnection** through levee setbacks to restore water retention. · **Agro-Wetlands** combining irrigation canals with ecological treatment. · **Slope stabilization and improvement of shallow aquifer recharge** through the construction of cultivation terraces and perimeter drainage systems (amunas).	**Agroforestry & Soil Conservation** in dairy and potato farming zones (eliminating hillside crops, promoting living fences). · Improved livestock practices and reforestation with species that retain soil. **Sustainable Agriculture** improving farming practices, using efficient irrigation and reducing harmful inputs (such as agrochemicals and pesticides).
River Basin (Bogota River & Tributaries)	**Canals, little reservoirs & acueductos veredales** distributing water for irrigation and supply. · Sewerage systems and wastewater	**Riparian Forest Restoration with Structural Embankments** combining ecological and protective functions. Improving water quality through rural sanitation systems that combine	**Floodplain Restoration** to absorb floods and recharge aquifers.

Scale	Grey Infrastructure	Green–Grey Hybrid Infrastructure	Green Infrastructure (Ecosystem-Based Adaptation)
	treatment plants for urban centers.	sewer infrastructure and natural effluent treatment. . **Managed Aquifer Recharge** using engineered wells to complement páramo storage	**Riparian Buffers** enhancing connectivity and biodiversity corridors.
Páramo Ecosystems (Chingaza, Sumapaz, Guerrero, Guacheneque)	**Dams & Reservoirs** (Chingaza, San Rafael, Tominé) securing Bogota's water supply.	Paramo Restoration with Structural Embankments combining ecological and protective functions.	**Páramo Grassland & Wetland Conservation** maintaining water regulation and storage. Reforestation of Degraded Highland Slopes to stabilize soils and regulate flows.

Source: IDOM, 2026.

The application of this structured methodology ensures that the selection of interventions is grounded in a transparent and robust comparison of alternatives. It enables the identification of those activities that not only perform best across multiple criteria but also respond most effectively to the climate risks, address key implementation barriers, and maximize the catalytic use of concessional finance. The following section presents the main findings of this comparative analysis and explains how they inform the prioritization of interventions and the overall project design.

5.2. Main findings: what the options analysis demonstrates

The comparative evaluation leads to three central findings and one clear conclusion:

1. The analysis consistently prioritizes interventions that address the hydrological functions of the supplying watersheds rather than downstream symptoms alone. This is evident in the emphasis placed throughout the document on ecosystem conservation and restoration, climate-resilient productive transformation, and green interventions for páramo and upper-watershed protection. The underlying logic is explicit: Bogotá's water security depends on the ecological and productive condition of the source watersheds, and climate adaptation must therefore act on infiltration, soil-water retention, erosion control, vegetation cover, and baseflow regulation.
2. The analysis shows that the most effective territorial package is integrated rather than sectorally isolated. The preferred package combines conservation and restoration in Conservation Focus (FC) plots, transformation practices (productive reconversion) in Production Focus (FP) plots, and improvements in community-run water systems that make rural water security more resilient to variable supply, pollution, and ecosystem degradation.
3. The analysis concludes that territorial interventions alone are insufficient if they remain dependent on one-off project funding. The preferred package therefore includes not only on-the-ground activities but also a financing strategy capable of absorbing, replicating, and scaling the same intervention model after the grant period.

Beyond comparative performance, the analysis highlights that the preferred interventions introduce systemic changes in how water security is managed in the Bogotá Region. By shifting the focus from downstream control measures toward upstream ecosystem management, integrating productive systems with conservation objectives, and linking verified hydrological outcomes with long-term financing mechanisms, these interventions fundamentally transform the prevailing water management model. This shift aligns with the GCF definition of paradigm shift, as it enables replication, scaling, and sustained impact beyond the boundaries and duration of the project.

Conclusion: nature-based solutions outperform grey-infrastructure and hybrid alternatives for advancing Bogotá's water security and climate resilience. Across a structured comparison of six representative interventions, páramo conservation and restoration ranked highest overall, followed by natural stormwater drainage; conventional grey options (dams/reservoirs, levees/floodwalls) and hybrids (rainwater harvesting, managed aquifer recharge) trailed on most dimensions. Grey infrastructure can deliver predictable yield increases and acute flood control, but at high upfront capital cost, with lengthy permitting and consultation, ecosystem disruption, and operational rigidity if climate conditions diverge from design assumptions. Nature-based solutions, by contrast, deliver cost-effective, multi-benefit adaptation that becomes more valuable as ecosystems recover, and they align most strongly with the GCF investment criteria. This finding is the basis for the project's intervention package.

Importantly, this conclusion is not only based on relative performance across evaluation criteria, but also on the capacity of these interventions to address structural barriers, deliver long-term resilience, and catalyze sustained investment. As such, the selected activities represent the highest-impact and most efficient use of GCF resources among all considered alternatives.

5.3. Comparative findings

The six interventions were compared using a multi-criteria assessment aligned with the GCF's six investment criteria and Colombia's DNP project-evaluation standards, across five weighted categories: economic, social, environmental, political-institutional, and gender & equity.

The widest gap appears on environmental and social performance. Páramo conservation and restoration achieved the maximum score in both dimensions, reflecting superior land-use and biodiversity outcomes, water-quality improvement at source, broad beneficiary reach across rural and metropolitan populations, and Payment-for-Conservation income for vulnerable households; natural stormwater drainage was the next-strongest environmental performer.

On economic performance, grey dams scored highest, but páramo restoration reached near-parity while avoiding the massive capital outlays, long construction timelines and operational rigidity of large dams; a fuller comparison is provided in the Economic and Financial Analysis (Annex 3). On political-institutional alignment, both green options reached the maximum score, reflecting strong embedding in Colombia's National Adaptation Plan, the Green Taxonomy, watershed management plans (POMCAs) and territorial plans (POTs) — the enabling conditions for scaling and replication. On gender and equity, páramo restoration again led, prioritizing women's participation and income and integrating Indigenous knowledge.

Taken together, the comparison shows that nature-based solutions are not only environmentally superior but also socially and institutionally stronger, with economic performance competitive with grey alternatives once co-benefits and avoided costs are considered.

5.4. The preferred intervention package

Building on this finding, the project adopts a green, watershed-scale intervention package, screened for what can be delivered within a four-year horizon under current regulations.

The preferred intervention package is directly informed by the gaps and structural barriers identified in Chapter 3. Specifically, ecological restoration and conservation activities address the degradation of water-regulating ecosystems and the misalignment between land use and hydrological sustainability.

Climate-resilient productive transformation responds to persistent pressures from unsustainable agricultural practices and associated market and livelihood gaps. Strengthening community-run and municipal water systems addresses the uneven institutional capacity and vulnerability observed in upstream territories. Finally, the development of a watershed finance and monitoring architecture responds to the core financial and technical barriers, including fragmented investment, limited private participation, and the absence of operational systems to translate hydrological outcomes into sustained financing.

By explicitly linking each component of the intervention package to the prioritized gaps and barriers, the project ensures that activities are not only technically sound but also structurally targeted at the root causes that have historically prevented climate-resilient water management in the Bogotá Region.

Ecological foundation (generates hydrological evidence)

- Conserve high-Andean ecosystems through voluntary agreements (aligned with Ley 1930 de 2018);
- Restore degraded high-Andean ecosystems through passive and active restoration (building on the executing partner's 10+ years of páramo restoration experience);
- Implement climate-resilient production systems at farm level (silvopastoral systems, agroecological potato production, reduced agrochemical use);
- Develop commercialization and market access for water-regulating rural products;
- Improve water-use efficiency in community-run systems / *acueductos veredales* (aligned with Ley 373 de 1997).

Finance mobilization and exit strategy

- Incorporate an environmental investment component into EAAB's water tariff (political commitment publicly announced by Mayor Galán at the November 2024 launch);
- Operationalize a long-term financial mechanism for private investment.

Crucially, Ecological foundation activities were selected because they generate hydrological evidence, verified Volumetric Water Benefits (VWBs), that demonstrates impact and de-risks investment, while Finance mobilization converts that evidence into durable public and private finance. The two are mutually dependent: the first produces the proof of concept, and the second mobilizes the finance to sustain and scale it beyond GCF support.

These are the most effective, feasible and scalable options, because:

- Effective. It is ranked highest in comparative assessment and delivers integrated water, biodiversity, climate-mitigation and livelihood benefits, measured hydrological outcomes through verified VWBs rather than activity counts.
- Feasible. Every selected activity can be implemented within four years under existing law — without legislative reform, protected-area expansion or population relocation — and builds on the executing partner's proven restoration experience and on the political commitment already secured for the tariff mechanism.
- Scalable. By pairing verified VWBs with a financing facility, the package establishes a replicable, financially self-sustaining model that can crowd in domestic and private finance and be transferred to other Colombian watersheds and the broader tropical Andes — the paradigm shift the GCF investment framework seeks.

In summary, the option analysis confirms that the selected intervention package represents the most effective and efficient response to the identified climate risks affecting Bogotá's water security. The combination of ecological restoration, climate-resilient production systems, and financial mechanisms was selected because it maximizes impact across economic, social, and environmental dimensions while remaining feasible within current institutional and regulatory frameworks.

The analysis clearly demonstrates that alternative approaches, particularly grey infrastructure solutions, are either less effective in addressing root causes, less flexible under climate uncertainty, or less capable of generating co-benefits and scalable impact. By contrast, the proposed activities not only deliver immediate adaptation benefits but also establish the conditions for long-term transformation, making them the most appropriate and justified use of concessional GCF resources.

6. Design selection and theory of change

This chapter translates the evidence and analyses presented in previous chapters into the project's design logic and transformational pathway. It explains how the selected intervention package responds to the climate problem, addresses the key gaps and structural barriers, and delivers a scalable solution for climate-resilient water security in the Bogotá Region.

At the core of the project is a watershed transformation model that integrates ecosystem restoration, climate-resilient production systems, and sustainable financing into a single, performance-based approach. This model is designed to generate measurable hydrological outcomes, expressed as Volumetric Water Benefits (VWB), and to convert these outcomes into sustained public and private investment, overcoming the structural constraints that have historically limited the scale and continuity of watershed-based adaptation.

The project design is structured around two complementary and mutually reinforcing components. Component 1 generates verifiable hydrological evidence through targeted interventions in priority watersheds, while Component 2 establishes the financial architecture required to mobilize, sustain, and scale these interventions over time. Together, these components form a self-reinforcing system in which adaptation outcomes enable finance, and finance enables the expansion and replication of adaptation actions.

Building on this integrated design, the chapter presents the project's theory of change as the logical sequence linking activities, outputs, outcomes, and long-term impact. It also highlights the paradigm-shifting elements of the project, demonstrating how it moves beyond business-as-usual approaches toward a scalable, financially sustainable model for climate adaptation in water systems.

6.1. Theory of Change

The theory of change is grounded in the project methodology. The climate vulnerability assessment defines the key risks and strategic landscapes affecting water security, while the gaps and barriers analysis, together with the assessment of implementation gaps and risks, clarifies why these challenges persist and which design features are needed to address them. The options analysis identifies the preferred package of interventions, and the feasibility assessment confirms its viability and potential for scale. Together, these inputs connect integrated watershed actions with verified hydrological outcomes, barrier reduction, finance mobilization and long-term resilience, translating the analytical diagnosis into the project's transformational pathway.

The project's Theory of Change follows a single investment logic that brings together watershed restoration, rural livelihoods and sustainable financing for water resilience in Bogotá and the Region as a watershed transformation model. It builds on the existing regulatory framework and growing corporate water-stewardship commitments to show how ecosystem-based adaptation and productive transformation measures can generate verifiable hydrological results and livelihood benefits. By demonstrating these outcomes as credible and quantified and verified, the project serves as a proof of concept for mobilizing and scaling public and private resources for upstream watershed resilience beyond the GCF's initial grant support.

*IF watershed interventions are designed and implemented to generate verifiable hydrological results, together with improved rural livelihoods, **THEN** public and private financing solutions for water resilience in Bogotá and the Region will be unlocked and scaled, **BECAUSE** water utilities, municipalities and private companies will have a tested proof of concept with verifiable, hydrological benefits in ecosystem-based adaptation and productive transformation, leading to sustained hydrological improvements in the supplying watersheds.*

This logic reflects a paradigm shift in water-resilience investment. Instead of relying on isolated, grant-funded ecosystem interventions or grey infrastructure expansion, the project introduces a performance-based model in which hydrological outcomes are measured, verified, and used to unlock sustained financing, supported by the VWB-based methodological framework, which links project activities to measurable hydrological changes in modifiable inputs such as land management, water management, technical capacity, and access to productive assets or finance. By demonstrating that ecosystem-based adaptation can be translated into quantifiable hydrological outcomes, the project establishes a new model for how water security can be financed and scaled in climate-vulnerable regions.

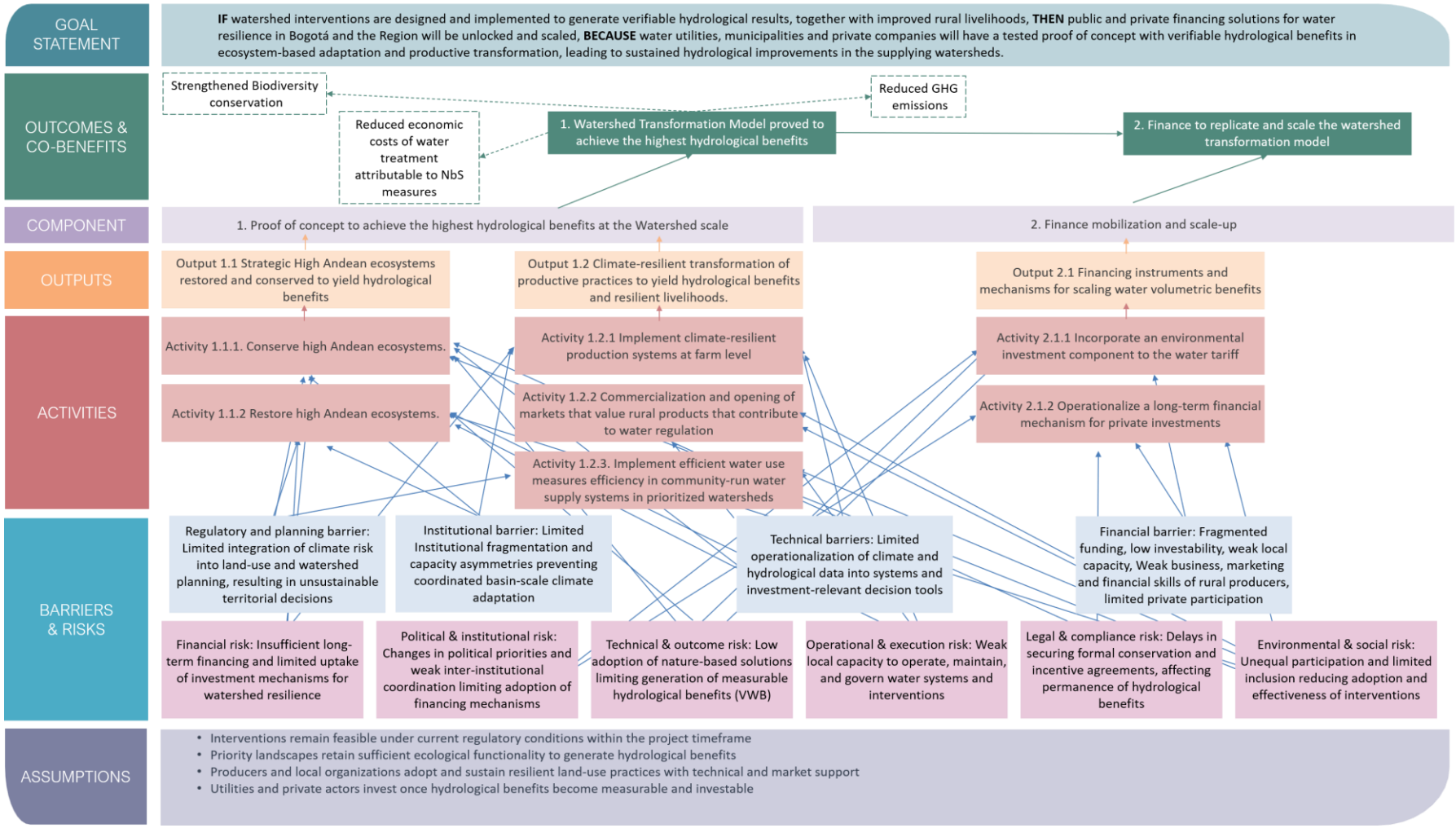


Figure 41. Theory of change diagram.

Operationally, the watershed transformation model links interventions in priority watersheds with the generation of verifiable hydrological outcomes and with the financial mechanisms required to sustain and scale those interventions over time.

Component 1 generates the physical and ecological conditions required for improved water regulation through conservation, restoration, and productive transformation (watershed transformation model), while simultaneously producing measurable hydrological outcomes. Component 2 builds on this evidence to establish the financial architecture needed to sustain and replicate the watershed transformation model, including the integration of environmental investment into the water tariff and the mobilization of long-term private capital.

The interaction between these components is mutually reinforcing: hydrological evidence reduces investment risk and enables financing, while sustained financing ensures the continuity and scaling of watershed interventions. This model represents a shift from fragmented, project-based approaches toward a systemic, performance-based approach to watershed management, where adaptation outcomes are measurable, financeable, and replicable across territories.

For consistency with Chapter 3, the theory of change distinguishes between structural barriers and their operational manifestation in the form of implementation gaps and adoption risks. The project responds directly to the four barrier groups previously identified (financial, regulatory and planning, institutional, and technical) while also addressing the site-specific conditions and operational constraints that derive from them. In this chapter, ecosystem degradation, low adoption incentives, weak local capacities, and inefficient community water systems are therefore treated as implementation gaps or operational constraints, rather than as standalone structural barriers. The project activities are derived from:

- Climate Vulnerability Assessment (Ch. 2) identified the climate problems: sustained warming, more irregular and extreme precipitation, prolonged drought, rising wildfire and frost, ENSO modulation, and the watersheds where they most threaten Bogotá's supply. This climate problem affects a regional water system that is operationally dependent on high-mountain ecosystems.
- Gaps and barriers (Ch. 3) explained why adaptation has not scaled despite an enabling regulatory architecture: fragmented and insufficient long-term financing for watershed resilience, weak integration of land-use and watershed planning, fragmented governance and uneven local capacity, and the absence of an operational hydrological MRV/evidence system capable of translating adaptation outcomes into investment decisions.
- Intervention landscapes (Ch. 4) demonstrate that intervention landscapes and watersheds were prioritized based on climate risk, vulnerability, and hydrological relevance for Bogotá's water supply system and the Region.
- Options Analysis (Ch. 5) compared grey, green and hybrid solutions through a multi-criteria assessment aligned with the GCF investment criteria and Colombia's DNP standards. This chapter concludes that the most effective response is an integrated package of nature-based and productive measures acting on the hydrological functions of the supplying watersheds.
- Feasibility screening retained only what can be delivered within four years under current regulations (no legislative reform, no protected-area expansion, no relocation).

Within the watershed transformation model, each activity plays a distinct function. Conservation and restoration improve ecological regulation and generate hydrological benefits at source; climate-resilient production and market access reduce pressure on regulating ecosystems while improving rural livelihoods and adoption incentives; improvements in community-run water systems strengthen local resilience to drought and variability; and the tariff-based environmental investment component together

with the long-term private financing mechanism convert verified results into sustained finance for replication and scale.

The traceability table below carries each CVA-defined problem through to the barrier it creates, the activity that responds, the deliverable and the indicator.

Table 25. CVA defined problem and its responding activity.

CVA-defined problem	Structural barrier / derived implementation gap	Responding activity (LogFrame)
Sustained warming (≈0.2 °C/decade; up to +3.0–3.5 °C under SSP5-8.5) raises evapotranspiration and stresses páramo and high-Andean forest regulation	Regulatory and planning barrier: misalignment between land use and watershed-protection objectives, resulting in degradation of strategic regulating ecosystems; Technical barrier: absence of an operational hydrological MRV/evidence system capable of translating adaptation outcomes into investment decisions	1.1.1 Conserve; 1.1.2 Restore high-Andean ecosystems
More irregular and extreme precipitation (Rx1day, R95pTOT); floods the most frequent hazard, increasing surface runoff and erosion	Regulatory and planning barrier: land-use dynamics that undermine infiltration and runoff regulation in supplying watersheds; Derived implementation gap: limited incentives and low adoption of climate-resilient production practices	1.1.2 Restore; 1.2.1 Climate-resilient production
Prolonged drought (CDD, SPI-12), aggravated in warm-ENSO phases, reduces dry-season baseflow and water availability	Institutional barrier: weak local implementation capacity in upstream territories and community-run water systems; Derived implementation gap: inefficient and climate-vulnerable operation of community-run water systems	1.2.3 Efficient water use in acueductos veredales
Higher temperatures and dry conditions increase wildfire and non-seasonal frost, degrading natural cover	Regulatory and planning barrier: continued land-use pressures on regulating ecosystems; Derived implementation gap: limited producer capacities and market access for resilient livelihood transition	1.1.1 Control and surveillance / 1.1.2 Restore; 1.2.2 Market access
Escalating climate-driven hydrological risk to Bogotá's supply that grey infrastructure and emergency response cannot resolve alone	Financial barrier: fragmented and insufficient long-term financing for watershed resilience; Institutional barrier: fragmented multi-level governance across upstream and downstream territories	2.1.1 Environmental fee in tariff; 2.1.2 long-term private mechanism

Source: IDOM, 2026.

This logic is operationalized through two complementary component-level activity sets: Component 1 focuses on conservation, restoration, climate-resilient production, market access, and community water-system efficiency; Component 2 focuses on the tariff-based environmental investment component and the long-term private financing mechanism.

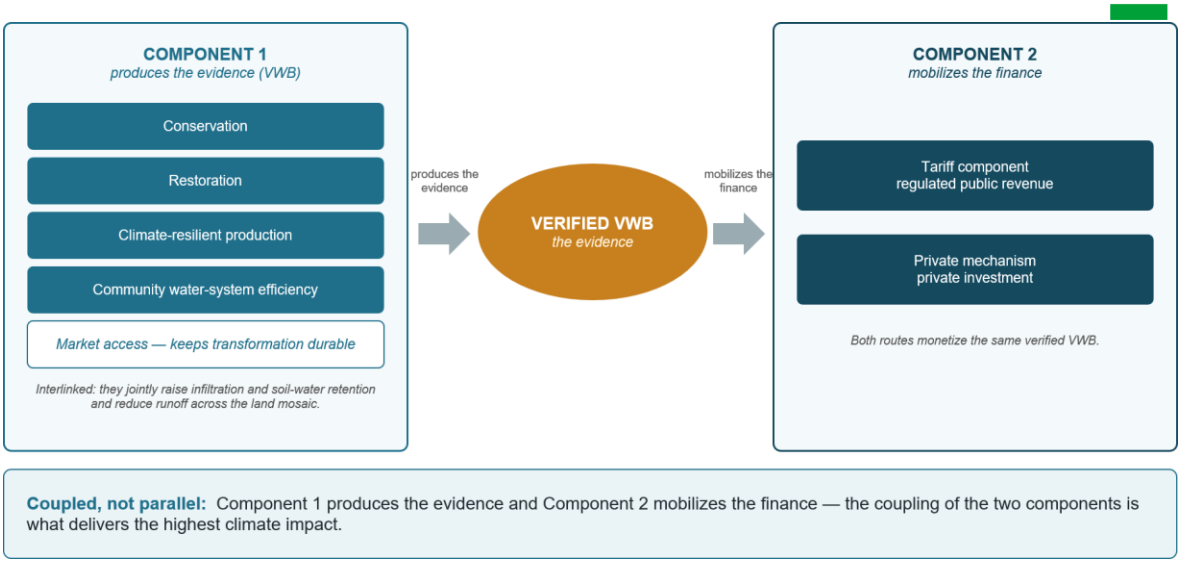


Figure 42. How the components interlink to maximize climate impact.
Source: IDOM, 2026.

Each structural barrier, together with its derived implementation gap or adoption risk, is paired with the activity that removes or mitigates it, so the obstacle cannot block the pathway; where a barrier lacks a current activity, one is added by design.

Table 26. Structural barriers and derived implementation gaps addressed by project outputs.

Structural barrier (Chapter 3) / derived implementation gap	Linked output that removes or mitigates it
Regulatory and planning barrier: ecosystem degradation driven by land-use misalignment; Institutional barrier: weak local implementation capacity in upstream territories	Active/passive restoration and conservation agreements with technical assistance (Output 1.1)
Derived implementation gap: low adoption incentives for climate-resilient land-use change among smallholders	Climate-resilient production (1.2.1) plus market access and price premiums (1.2.2) and Payments for Conservation, providing near-term income
Technical barrier: absence of an operational hydrological MRV/evidence system capable of making adaptation outcomes measurable and reportable.	VWB measurement and reporting established through Component 1 proof of concept
Financial barrier: fragmented and insufficient long-term financing for watershed resilience	Environmental investment component in the tariff and long-term private mechanism (Output 2.1)
Financial barrier: weak private participation in structured, long-term watershed-resilience financing	Environmental investment component in the tariff and long-term private mechanism (Output 2.1)

Source: IDOM, 2026.

The results to be achieved with the activities of this project can be summarized as follows:

Table 27. Indicators of project outcomes.

Result	Deliverable	Indicator
Outcome 1 (Component 1): watershed transformation model proven to achieve the highest VWB	Hectares conserved and effectively monitored; hectares restored per approved design; hectares under resilient practice; water-friendly	VWB (m^3/yr modeled, preliminary) Hectares intervened

	products placed in Bogotá markets; acueductos veredales upgraded	Water-saved indicators
Outcome 2 (Component 2): finance mobilized to replicate and scale the model	Environmental investment component operational in EAAB's tariff with regulator-accepted reporting; long-term private mechanism structured and capitalized	Public and private finance mobilized (USD) Hectares financed at scale
Impact: strengthened, financially self-sustaining water resilience for the Bogotá Region	Delivered jointly by Outcomes 1 and 2	Beneficiaries with improved water security (GCF core adaptation indicator)

Source: IDOM, 2026.

VWB serves to quantify direct hydrological outcomes, . The objective is the watershed transformation model plus the financial structure that mobilizes the private sector: Component 1 delivers the highest water benefit, Component 2 establishes the financial mechanism.

The VWB framework applied in the project is aligned with internationally recognized Volumetric Water Benefit Accounting (VWBA) approaches, which define volumetric water benefits as the volume of water resulting from water stewardship activities that positively modify hydrological conditions and contribute to reducing shared water challenges.

This approach provides a standardized methodology to quantify and communicate hydrological outcomes, while also incorporating complementary indicators to capture non-volumetric outputs and broader water stewardship effects

7. Feasibility assessment of interventions to achieve the highest impact

This chapter demonstrates that the proposed interventions (see proposed interventions in the Chapter 6 in the Theory of Change diagram, and detailed descriptions in Chapter 8) are not only technically sound, but also implementable, scalable, and capable of delivering the intended adaptation outcomes within the project horizon. Building on the climate vulnerability assessment, the analysis of barriers and gaps, the options analysis, and the project design, it assesses whether each component and activity can realistically produce the expected results under current territorial, institutional, and regulatory conditions in the Bogotá Region.

The assessment is grounded in three complementary elements:

- Biophysical and hydrological evidence, demonstrating the causal link between ecosystem condition, land-use practices, and water regulation
- Empirical studies and baseline analysis, showing how similar interventions influence hydrological performance in comparable contexts
- Consistency with the Economic and Financial Analysis (EFA), ensuring that the projected benefits (e.g. reduced sedimentation, improved regulation, carbon sequestration) are supported by observable processes

Within this framework, feasibility is not treated as a theoretical assumption, but as an evidence-based verification of the functional relationship between interventions and outcomes, particularly in terms of water availability, regulation, and resilience to hydro-climatic variability.

To ensure consistency and clarity, the chapter applies a standardized structure for each activity, including:

- Intervention description
- Mechanism of change (biophysical pathway)
- Evidence of effectiveness
- Expected results and contribution to water security
- Link to EFA results
- Key assumptions and limitations

This structure allows the analysis to move from general principles to activity-specific evidence, ensuring that each intervention is explicitly linked to the expected impacts described in the theory of change.

7.1. Component 1: Hydrological feasibility and VWB potential

Component 1 is feasible because it combines interventions whose territorial relevance, hydrological rationale, and implementation conditions have already been established through the project's previous analyses. The Climate Vulnerability Assessment identified the watersheds where warming, drought, irregular precipitation, runoff intensification, wildfire, and ecosystem degradation most threaten water security. The prioritization analysis identified where interventions can generate the greatest water-regulation value. The options analysis confirmed that nature-based and watershed-scale interventions are the most effective and feasible choices relative to grey and hybrid alternatives.

On that basis, the feasibility assessment confirms that Component 1 interventions can generate measurable hydrological benefits at watershed scale, expressed as Volumetric Water Benefits (VWBs), while also strengthening ecosystem condition, rural livelihoods, and local water resilience. Importantly, the component does not depend on a single activity to produce impact. Its feasibility lies in the complementarity of conservation, restoration, productive transformation, commercialization support, and community water-system improvements. Together, these activities address both the biophysical drivers of declining water regulation and the socioeconomic conditions that determine whether change can be sustained over time.

This is a strong feasibility case because it demonstrates that the project is not proposing isolated pilots. It is testing an integrated watershed transformation model in which land-use change, hydrological improvement, and social adoption are mutually reinforcing.

7.1.1. Activity 1.1.1 – Conserve high-Andean ecosystems

A. Intervention description

This activity focuses on the protection and long-term conservation of páramo and high-Andean forest ecosystems located in strategic headwater areas within prioritized watersheds of the Bogotá Region. Interventions include: conservation agreements with landowners; restrictions on land-use change (e.g. prevention of conversion to cultivation, pasture or tree plantations); protection of high-altitude wetlands and recharge zones; and strengthening of local governance and monitoring mechanisms to safeguard ecosystem integrity over time.

Within the Volumetric Water Benefit (VWB) framework, this activity is designed to generate quantifiable hydrological improvements—primarily reduced runoff and erosion, enhanced infiltration, and more stable baseflows—that are measured as changes in water balance components relative to a business-as-usual land-use trajectory (Gray et al., 2019; WRI, 2025). In other words, conserving high-Andean ecosystems keeps the land-use input in a “conserved páramo/forest” state instead of shifting to “pasture/cropland/plantation,” and the VWB methodology translates the resulting differences in runoff volume, sediment load and baseflow into volumetric water benefits at plot and watershed scale (Gray et al., 2019; WRI, 2025).

B. Mechanism of change

High-mountain páramo ecosystems act as natural water regulation infrastructure, with grasslands and organic-rich soils providing high infiltration and large internal water storage that buffer both wet and dry conditions (Mosquera et al., 2022). Under conserved conditions, approximately 50% of water inputs in páramo grasslands return to the atmosphere via evapotranspiration, while the remaining fraction is stored in deep soils and organic matter, reducing rapid surface runoff and favoring subsurface and baseflow contributions (Mosquera et al., 2022). In southern Ecuadorian páramo catchments, passive catchment storage has been quantified in the range of 313–617 mm of water (equivalent to 313–617 liters of water per square meter of catchment area), largely controlled by the proportion of Histosol soils and wetland vegetation, with dynamic storage of 29–35 mm and only 6–10% of mixing storage hydrologically active at any given time, evidencing strong buffering capacity and year-round flow regulation (Lazo, Mosquera, McDonnell, & Crespo, 2019).

Land-use change studies show that when páramo and montane forest are converted to cultivation, pasture or tree plantations, runoff peaks increase and baseflows diminish, while catchment residence

times shorten and regulation capacity declines (Buytaert et al., 2004; Crespo et al., 2009; Ochoa-Tocachi et al., 2016). In undisturbed wet páramo basins, mean baseflow residence times of around 360 hours have been observed, compared to 175 hours in cultivated basins, meaning that degraded catchments release water ~40% faster and lose dry-season regulation much more quickly (Buytaert et al., 2004). For the VWB method, this difference in hydrological behavior is captured by comparing scenarios: conserving high-Andean ecosystems keeps the catchment in a high-storage, slow-release regime, thereby reducing volumetric runoff (especially peak flows) and increasing volumetric baseflow relative to the degraded baseline; these differences are accounted for as VWBs linked to avoided runoff, erosion and water-quality deterioration (Gray et al., 2019; WRI, 2025).

Recent syntheses on páramo water resources also highlight that these ecosystems capture vertical rainfall and horizontal inputs such as fog and cloud interception, regulate runoff, and provide critical hydrological services for urban water-supply systems (Mosquera et al., 2022; Muñoz-Pérez et al., 2023; Schellekens et al., 2010; Ochoa-Tocachi et al., 2015). In basins supplying major cities such as Bogotá, páramos contribute a substantial share of annual water yield, and their ecological integrity is directly linked to reliability of supply under increasing climate variability (Buytaert et al., 2009; Ochoa-Tocachi et al., 2015). Conserving these ecosystems in the Bogotá Region, therefore, directly affects the hydrological inputs to the VWB accounting: instead of a trajectory of increased runoff ratios, higher sediment export and reduced baseflows, the conservation scenario maintains lower runoff coefficients, higher soil-water storage and more stable flows, which are quantified as positive volumetric water benefits under the VWBA guidance (Gray et al., 2019; WRI, 2025).

C. Evidence of effectiveness

Empirical evidence from Andean catchments and rainfall-simulation experiments confirms that conserving páramo and high-Andean forests is an effective way to modify hydrological inputs—runoff, baseflow, sediment—via land-use management. Paired catchment studies in wet páramo ecosystems show that conversion from natural páramo and forest to cultivation or pine plantations leads to large increases in peak flows, reductions in baseflows and decreases in annual water yield, whereas conserved basins retain greater regulation capacity (Crespo et al., 2009; Ochoa-Tocachi et al., 2016; Buytaert et al., 2009). In perennially humid páramos, headwater basins dominated by native grasslands and montane forest exhibit high specific discharge and sustained baseflows, while more intensively used basins in Puna and Jalca display highly seasonal, flashy regimes with reduced low flows and increased variability (Ochoa-Tocachi et al., 2016).

Rainfall-simulation studies on Andisols from Ecuadorian páramos provide quantitative evidence of how soil and vegetation degradation intensifies runoff and erosion. On undisturbed páramo plots, infiltration rates are very high and sediment loss is very low, whereas tilled and burned plots show runoff coefficients roughly three times higher and total erosion increasing from about 80 g m^{-2} to approximately 1200 g m^{-2} under similar rainfall events (Harden, 2001). Synthesis reviews of páramo soil hydro-physical properties confirm that native vegetation and intact soils maintain high organic matter content, water-retention capacity and porosity, while agriculture, burning, grazing and afforestation increase bulk density, promote hydrophobic aggregates, reduce water retention and enhance erosion and runoff (Bonnesoeur et al., 2021; Mosquera et al., 2022). These findings support the design assumption that Activity 1.1.1, by preventing land-use change and conserving soil and vegetation, will reduce volumetric runoff and sediment generation relative to the counterfactual degraded scenario, and thus generate positive VWBs in terms of avoided runoff and avoided sediment delivery.

D. Expected results and contribution to water security

Within the project's VWB-based results framework, conserving high-Andean ecosystems under Activity 1.1.1 is expected to deliver hydrological and water-system outcomes that can be quantified volumetrically and attributed to the intervention. At catchment scale, undisturbed wet páramo basins function as slow-release reservoirs, with long residence times and high storage, while degraded basins release water faster and show reduced baseflows (Buytaert et al., 2004). Monitoring across 25 tropical Andean headwater catchments indicates that cultivation, afforestation and grazing consistently increase streamflow variability and significantly reduce regulation capacity and water yield, particularly at low flows (Ochoa-Tocachi et al., 2016; Ochoa-Tocachi et al., 2018).

For the Bogotá Region, the conservation of páramo and high-Andean forests in strategic headwaters is therefore expected to:

- Increase stability of water availability, especially during dry periods, by sustaining baseflows and catchment storage (Buytaert et al., 2004; Hussain et al., 2023).
- Reduce runoff variability and peak flows during extreme rainfall events, lowering downstream flood risk and stress on reservoirs and treatment plants (Crespo et al., 2009; Ochoa-Tocachi et al., 2016).
- Decrease erosion and sediment transport, reducing sedimentation rates in reservoirs and improving raw water quality (Harden, 2001; Bonnesoeur et al., 2021).

These changes are translated into VWBs by comparing hydrological indicators (runoff volume, sediment yield, baseflow) between the conserved scenario and a land-use change baseline, thus allowing the project to report volumetric water benefits in line with VWBA guidance and link them directly to water security outcomes for Bogotá (Gray et al., 2019; WRI, 2025; Conservation International Colombia & EAAB, 2025).

E. Link to economic and financial analysis (Annex 3)

The hydrological improvements generated by Activity 1.1.1 are directly incorporated into the Economic and Financial Analysis (EFA) through the VWB-based valuation of avoided costs and co-benefits. The natural infrastructure analysis for the upper Bogotá River and Tibitoc shows that reducing sediment and nutrient loads at intakes, via conservation and restoration of high-Andean ecosystems, lowers treatment costs for chemicals and sludge management and can extend infrastructure lifespan by reducing sedimentation pressure (Conservation International Colombia & EAAB, 2025; WRI, 2023). These avoided costs are linked to volumetric reductions in sediment-laden runoff, which the VWBA method treats as quantifiable VWBs supporting economic and financial justification (Gray et al., 2019; WRI, 2025).

Similarly, enhanced infiltration and baseflow regulation contribute to more reliable water supply and fewer shortages; paired catchment studies indicate that degraded basins lose dry-season regulation much faster, implying higher risk of deficit under climate stress (Buytaert et al., 2004; Ochoa-Tocachi et al., 2016). In the EFA, these hydrological VWBs (e.g. avoided deficit volumes) underpin estimates of avoided economic losses from water shortages and resilience benefits for users. In addition, maintaining ecosystem integrity sustains carbon storage and sequestration in páramo soils and peatlands, with field measurements in Colombian páramos reporting soil organic carbon stocks from ~120 tC ha^{-1} at 30 cm to >800 tC ha^{-1} in deep peat profiles (Benavides et al., 2017; Rodríguez-Buitrago et al., 2025). These carbon-related benefits support inclusion of mitigation co-benefits in the project, aligning Activity 1.1.1 with both adaptation and mitigation objectives (USAID, 2023; Conservation International Colombia & EAAB, 2025).

F. Key assumptions and limitations

The magnitude and consistency of VWBs expected from conserving high-Andean ecosystems depend on several assumptions. First, hydrological regulation effects are strongest when conservation is implemented at sufficient scale and with spatial continuity; fragmented or small patches may not replicate the storage and buffering documented in larger conserved catchments (Buytaert et al., 2009; Mosquera et al., 2022). Second, baseline ecosystem condition matters: severely degraded areas require complementary restoration to recover infiltration, soil-water storage and erosion control, and VWBs will materialize gradually as these functions are restored (Mosquera et al., 2022; Crespo et al., 2009). Third, while conservation enhances buffering capacity, it does not eliminate extreme events or large-scale climate anomalies; VWBs are therefore estimated under conservative assumptions about climate variability and should be interpreted as reductions in risk and severity rather than elimination of extremes (Buytaert et al., 2009; Correa et al., 2020). Finally, institutional and governance effectiveness is critical to sustain the land-use input (conserved ecosystem condition) over time; without enforcement of agreements and land-use restrictions, the hydrological and economic benefits underpinning VWBs would erode (Ochoa-Tocachi et al., 2016; Buytaert et al., 2009)

7.1.2. Activity 1.1.2 – Restore high Andean ecosystems.

A. Intervention description

This activity focuses on the passive and active restoration of degraded páramo and high-Andean forest ecosystems in strategic headwater areas of prioritized watersheds in the Bogotá Region. Restoration actions include: exclusion of degrading uses (e.g. intensive grazing, cultivation on fragile slopes), assisted natural regeneration, enrichment planting with native species, stabilization of eroded slopes and gullies, and reconnection of degraded patches to conserved areas under Activity 1.1.1, to enhance ecological and hydrological continuity.

Within the Volumetric Water Benefit (VWB) framework, Activity 1.1.2 explicitly changes the land-use input from “degraded pasture/cropland/abandoned land” to “restoring high-Andean ecosystem,” and tracks how this transition modifies key hydrological indicators—runoff volumes, baseflow, sediment loads—over time, relative to a business-as-usual degraded baseline (Gray et al., 2019; WRI, 2025).

B. Mechanism of change

Section 7.1.1. established that conserved páramo and high-Andean forests maintain high infiltration, large soil-water storage and slow-release baseflows, whereas land-use conversion to cultivation, pasture or plantations leads to faster runoff, shorter residence times and higher erosion (Buytaert et al., 2004; Crespo et al., 2009; Ochoa-Tocachi et al., 2016; Mosquera et al., 2022). Activity 1.1.2 operates on those already degraded areas to shift their hydrological behavior back towards the conserved regime documented under 1.1.1.

Degraded páramo soils typically present reduced organic matter, increased bulk density and loss of structure, which lower infiltration and water-retention capacity and increase runoff and erosion (Harden, 2001; Bonnesoeur et al., 2021). Restoration interventions rebuild vegetation cover and soil structure, increase organic matter content and porosity, and re-establish root networks, which together enhance infiltration and internal storage (Bonnesoeur et al., 2021; Mosquera et al., 2022). Under VWB, this translates into a progressive reduction in volumetric surface runoff and sediment generation, and an

increase in volumetric subsurface and baseflow contributions, as plots move from degraded towards restored conditions over the project period.

C. Evidence of effectiveness

Evidence on land-use impacts in wet Andean páramo shows the magnitude of hydrological deterioration that restoration aims to reverse. In paired catchments, conversion from natural páramo and forest to cultivation and intensive drainage reduces soil-water storage and catchment retention times, increases peak flows, and diminishes baseflows; cultivated catchments release water about 40% faster than undisturbed ones (Buytaert et al., 2004; Crespo et al., 2009; Ochoa-Tocachi et al., 2016). These quantified differences define the degraded baseline against which Activity 1.1.2 can measure hydrological recovery and associated VWBs.

Experimental rainfall-simulation on Andisols in Ecuadorian páramo confirms that disturbance sharply increases runoff and erosion: on undisturbed plots, sediment loss is ~80 g m−2, while tilled and burned plots reach ~1200 g m−2 under comparable rainfall, a more than tenfold increase (Harden, 2001). Reviews on hydro-physical soil properties indicate that improved management and revegetation can restore infiltration rates and water-retention capacity and reduce bulk density, moving soils back towards the low-runoff, low-erosion behavior observed under conservation (Bonnesoeur et al., 2021; Mosquera et al., 2022). Taken together, these results support the assumption that restoration of degraded patches, especially when connected to conserved areas under 1.1.1, will generate incremental VWBs by closing part of the gap between degraded and conserved hydrological performance.

D. Expected results and contribution to water security

Whereas Activity 1.1.1 maintains existing regulation capacity in conserved areas, Activity 1.1.2 recovers lost regulation capacity in already degraded headwaters. As vegetation and soils regenerate, restored areas are expected to:

- Increase infiltration and soil-water storage relative to the degraded baseline, reducing storm runoff volumes and peak discharges.
- Enhance baseflow contributions from previously flashy and erosive patches, improving low-flow conditions and dry-season water availability.
- Reduce erosion and sediment export from critical slopes and headwater zones, lowering turbidity and sedimentation pressures downstream.

In the VWBA framework, these changes are expressed as volumetric water benefits by comparing hydrological indicators for restored areas against a “no-restoration” scenario: m3 of runoff avoided, tonnes of sediment avoided, and m3 of baseflow gained over time (Gray et al., 2019; WRI, 2025). At watershed scale, restoring degraded areas adjacent to conserved corridors under 1.1.1 increases total regulated area and strengthens the cumulative buffering effect documented for intact wet páramo catchments, thereby enhancing the reliability and quality of inflows to Bogotá’s supply systems (Buytaert et al., 2004; Buytaert et al., 2009; Conservation International Colombia & EAAB, 2025).

E. Link to economic and financial analysis (Annex 3)

The incremental VWBs generated by Activity 1.1.2 are incorporated into the Economic and Financial Analysis as additional avoided costs and co-benefits beyond those achieved by conservation alone. By reducing sediment loads and peak flows originating from degraded areas, restoration lowers sedimentation rates in reservoirs and conveyance infrastructure, reduces treatment costs (chemicals, sludge handling) and helps extend asset lifespan, complementing the benefits documented for

conserving intact páramo under 1.1.1 (Conservation International Colombia & EAAB, 2025; WRI, 2023). These avoided costs are linked to quantified reductions in sediment-laden runoff from restored patches and are compatible with VWBA-based valuation.

Additionally, restoration in critical headwaters improves drought-period reliability by increasing baseflow contributions from areas that previously contributed little to low flows. Paired catchment evidence on residence times and low-flow sensitivity (Buytaert et al., 2004; Ochoa-Tocachi et al., 2016) supports the use of changes in low-flow volumes and variability as VWBs representing avoided economic losses from shortages and emergency responses. Restoration also increases biomass and soil carbon stocks relative to degraded baselines, adding mitigation co-benefits that can be valued using Colombian páramo carbon data (Benavides et al., 2017; Rodríguez-Buitrago et al., 2025; USAID, 2023). These carbon-related VWBs complement those from conservation, strengthening the overall investment case in the EFA.

F. Key assumptions and limitations

For Activity 1.1.2, key assumptions relate to pace and scale of hydrological recovery. Short-term restoration studies suggest that more than two years are needed to observe substantial improvements in infiltration, soil-water storage and erosion reduction, implying that VWBs from restoration will grow over time and may be partially realized within the project period (Mosquera et al., 2022). The magnitude of benefits also depends on the area restored and its connectivity with conserved ecosystems under 1.1.1; small, isolated patches generate local gains but may have limited impact on overall watershed regulation unless they target hydrologically critical zones (Buytaert et al., 2009).

Climate variability adds uncertainty: while restoration enhances buffering, it cannot fully offset extreme events or long-term climatic shifts, so VWBs are estimated under conservative climate assumptions and interpreted as reductions in risk and damage, not elimination of extremes (Buytaert et al., 2009; Correa et al., 2020). Finally, governance and land-use control are essential to prevent re-degradation of restored areas; without enforcement and incentives, hydrological gains and associated VWBs could erode, reducing both environmental and economic returns (Ochoa-Tocachi et al., 2016; Buytaert et al., 2009). These limitations are complementary to those already identified for conservation in 1.1.1 and confirm that restoration is most effective when implemented jointly with long-term protection and monitoring

7.1.3. Activity 1.2.1 – Implement climate-resilient production systems at farm level

A. Intervention description

These activities promote climate-resilient production systems at farm level in prioritized high-Andean watersheds, including: (i) conversion from conventional dairy on open pasture to silvopastoral systems with trees and shrubs integrated into grazing areas; (ii) transition from conventional potato production with bare soils and high input use to agroecological practices with cover crops, contour planting and reduced tillage; and (iii) farm-level water-saving and soil-conservation measures (e.g. live barriers, micro-terracing, organic amendments).

Within the Volumetric Water Benefit (VWB) framework, these interventions change the land-use and management input at plot scale from “conventional pasture/cropland” to “climate-resilient system,” and track how this modifies runoff, infiltration, erosion and water-use efficiency relative to a business-as-usual scenario. VWBs are calculated as volumetric reductions in runoff and erosion, and improvements in

soil-water storage and on-farm water use that can be aggregated to the watershed level (Gray et al., 2019; WRI, 2025).

B. Mechanism of change

Conventional hillside agriculture and open pasture in Andean landscapes often leave soils exposed, compacted and low in organic matter, leading to high runoff, low infiltration and elevated erosion, particularly on steep slopes (FAO, 2019; Obando-Moncayo, 2004). Silvopastoral systems and agroecological practices modify this by increasing vegetation cover, root density and soil organic matter, improving soil structure and macro-porosity, and stabilizing slopes through tree and shrub roots (Murgueitio et al., 2011; FAO, 2019).

Silvopastoral systems have been shown to reduce overland flow and erosion compared to treeless pastures, as trees and shrubs intercept rainfall, promote infiltration and protect soil from raindrop impact (Murgueitio et al., 2011; Ibrahim et al., 2013). Agroecological practices such as live barriers, contour hedges and cover crops in Andean hillsides significantly reduce downslope runoff and soil loss by breaking slope length, trapping sediments and enhancing infiltration; studies in Ecuadorian Andes report that hedgerows and organic amendments can cut erosion rates and improve crop productivity in degraded hillsides (Kessler et al., 2016). Under VWB, these plot-scale changes are translated into avoided runoff and avoided erosion volumes compared to conventional practice, representing measurable VWBs linked to land-management change.

C. Evidence of effectiveness

Evidence from Latin America confirms that silvopastoral systems provide erosion control and watershed protection relative to traditional grazing systems. Case studies compiled by the World Bank and regional initiatives document that trees associated with pastures reduce erosion through root stabilization, canopy interception and improved ground cover, and that intensive silvopastoral systems can substantially lower sediment export from grazed hillsides (Murgueitio et al., 2011; Ibrahim et al., 2013; World Bank, 2002). Similarly, studies in hillside agricultural systems of the Andean valleys show that implementing live barriers and leguminous cover crops reduces soil erosion and improves soil fertility, increasing productivity and reducing poverty in semi-arid inter-Andean zones (FAO, 2019).

Experimental work in the Ecuadorian Andes indicates that live barriers and associated organic amendments mitigate land degradation and improve crop productivity, while reducing land-surface runoff and soil loss on steep agricultural lands (Kessler et al., 2016). Management trials in the Central Andes of Colombia show that contour hedges and conservation tillage can markedly lower rill erosion and runoff on potato fields compared to conventional bare-soil planting (Obando-Moncayo, 2004). These results support the assumption that farm-level interventions in 1.2.x will generate VWBs by reducing plot-scale runoff and erosion, improving soil-water storage and lowering on-farm water demand relative to conventional systems.

D. Expected results and contribution to water security

While Activities 1.1.1 and 1.1.2 act primarily on ecosystem condition and land cover in headwaters, farm-level activities 1.2.x act on managed agricultural land to reduce hydrological pressure on upstream ecosystems and downstream infrastructure. By lowering plot-scale runoff and erosion, increasing infiltration and improving soil-water storage, these interventions are expected to:

- Reduce volumetric runoff contributions from agricultural slopes into streams, helping flatten hydrographs and limit event-scale peaks at sub-catchment outlets.

- Decrease sediment and nutrient loads mobilized from farms, improving water quality and reducing sedimentation and treatment burdens downstream.
- Enhance on-farm water-use efficiency, freeing water resources and decreasing the probability of local shortages in community-run systems.

In the VWBA framework, these changes are expressed as VWBs through plot- and micro-catchment-level quantification of avoided runoff, avoided sediment and improved water-use volumes, then aggregated across participating farms. Combined with ecosystem VWBs from Activities 1.1.1 and 1.1.2, farm-level VWBs strengthen watershed-scale regulation and water security outcomes for the Bogotá Region (Gray et al., 2019; WRI, 2025; Conservation International Colombia, 2026).

E. Link to economic and financial analysis (Annex 3)

Farm-level VWBs translate into economic and financial benefits by reducing the externalities of agriculture on water infrastructure and by increasing productivity and resilience. Lower sediment and nutrient loads from agricultural land mean less frequent and less intense turbidity events, fewer sediment pulses in reservoirs and canals, and reduced treatment costs, complementing the avoided costs from ecosystem conservation and restoration (World Bank, 2002; Conservation International Colombia & EAAB, 2025). Improved soil structure and fertility from agroecological practices can raise yields and reduce input costs, enhancing household resilience and increasing willingness and capacity to maintain conservation agreements, which supports long-term sustainability of VWBs (FAO, 2019; Kessler et al., 2016).

In the EFA, VWBs from farm-level activities are valued as: avoided sedimentation and treatment costs; avoided or reduced losses from water-related crop failures; and co-benefits in terms of improved livelihoods and reduced land-use pressure on strategic ecosystems. This complements the valuation of VWBs from Activities 1.1.1 and 1.1.2, reinforcing the overall economic case for integrated watershed management.

F. Key assumptions and limitations

Key assumptions for VWBs from farm-level activities include adoption rates, maintenance of practices, and spatial targeting. Hydrological and erosion benefits depend on sustained implementation of silvopastoral and agroecological practices; if farmers revert to conventional systems, VWBs will decline. Effectiveness also varies with slope, soil type and rainfall intensity; most evidence comes from steep hillside systems where erosion and runoff problems are acute (Obando-Moncayo, 2004; FAO, 2019).

Moreover, while plot-scale benefits are clear, their impact at watershed scale depends on the proportion of agricultural land under improved management and its location relative to drainage networks and strategic ecosystems. VWBs are therefore estimated assuming realistic adoption scenarios and conservative transfer of plot-level reductions to sub-catchment hydrological behavior. Finally, governance and extension support are needed to ensure that technical assistance, incentives and monitoring sustain practice changes and associated VWBs over time. These limitations complement those identified for ecosystem-based activities and highlight the need for integrated management across land uses.

7.1.4. Activity 1.2.2 – Commercialization and opening of markets that value rural products that contribute to water regulation

A. Intervention description

This activity supports producer associations and local organizations in developing business models, commercialization channels and market access for rural products generated under climate-resilient production systems that contribute to water regulation in prioritized watersheds of the Bogotá Region. Interventions include product differentiation, traceability, branding linked to watershed stewardship, strengthening of producer organizations, market intelligence, buyer engagement and commercialization agreements for products associated with improved land and water management.

Within the Volumetric Water Benefit (VWB) framework, the activity does not directly modify runoff, sediment or baseflow at plot scale. Its role is to create the economic conditions needed for producers to adopt and maintain the land-use and land-management changes introduced under Activities 1.1.1, 1.1.2 and 1.2.1, thereby increasing the permanence, scale and financial viability of the interventions that generate VWBs

B. Mechanism of change

Activities 1.1.1, 1.1.2 and 1.2.1 generate hydrological benefits through conservation, restoration and improved farm management. Activity 1.2.2 addresses a different barrier: producers may not sustain these practices if they remain economically less attractive than conventional land uses that generate faster short-term returns.

The mechanism of change is therefore economic and institutional. By creating market value for products associated with watershed stewardship, the activity raises the expected return to conservation-compatible and agroecological practices, improving adoption, retention and expansion over time. Evidence from PES and water-fund experiences in the tropical Andes shows that upstream land managers respond more durably when environmental incentives are combined with productive support, market opportunities and livelihood gains, rather than relying on compensation alone. Under the VWB approach, this activity helps secure the continuity of the land-use changes that generate avoided runoff, reduced sediment and improved baseflows, converting short-term interventions into persistent hydrological benefits.

C. Evidence of effectiveness

Evidence from the tropical Andes shows that incentive-based mechanisms, including PES schemes and water funds, can mobilize significant upstream land-use change and support conservation and improved management at scale, although their effectiveness depends on design and governance. A survey of 39 active PES programs across the Tropical Andes found that the majority target watershed services and work directly with smallholder land managers, illustrating the widespread use of incentives to influence upstream land-use decisions (Bremer et al., 2021). In Colombia and neighboring countries, conservation-oriented water funds have collectively helped conserve or improve management across tens of thousands of hectares and benefit millions of downstream users: early assessments report that established funds in Latin America were linked to over 58 million ha under some form of conservation or sustainable management and a consolidated beneficiary population exceeding 9 million people (TNC, 2011).

More detailed case studies underline both the potential and challenges. In a silvopastoral PES programme in the Colombian Andes, less than half of participating farmers stated they would continue silvopastoral measures once payments ended, and only 13% understood that their contractual commitment included forest conservation, suggesting that purely monetary incentives may not be sufficient to secure long-term behavioral change without stronger links to livelihoods and local priorities (Kosoy et al., 2012). Reviews of watershed PES in Latin America show that schemes often achieve additional conservation or improved management on upstream lands, for example, enrolling hundreds to thousands of hectares in conservation agreements in individual basins, but that the durability of these changes is greater when programs are embedded in broader livelihood strategies and provide non-financial benefits such as technical support, market access or social recognition (Porras et al., 2008; Ferraro, 2009).

For Activity 1.2.2, these numbers support the use of market-based incentives, via commercialization and value-added markets, as complementary tools to sustain and scale the land-use changes already proven effective for water regulation under Activities 1.1.1, 1.1.2 and 1.2.1. By tying producer income growth to water-regulating production systems, the project increases the likelihood that the hundreds or thousands of hectares targeted under its conservation, restoration and farm-level interventions remain under practices that generate VWBs over the long term, rather than reverting to higher-impact land uses once project funding ends (Bremer et al., 2021; TNC, 2011).

D. Expected results and contribution to water security

This activity is expected to increase the adoption and persistence of climate-resilient and watershed-friendly practices promoted under the project, reduce the risk of reversion to higher-impact land uses, and expand the area under conservation-compatible and agroecological production over time. Its contribution to water security is therefore indirect but strategic: it strengthens the permanence and scalability of the practices that generate primary hydrological benefits in the watershed.

Within the VWB framework, this contribution can be interpreted as enabling additionality and permanence. By improving profitability and market access for products associated with water-regulating land management, the activity increases the number of producers and hectares that remain under practices generating avoided runoff, reduced sediment and improved baseflows. In this sense, commercialization functions as a durability and scaling mechanism for VWBs, linking producer incentives with longer-term watershed performance and reduced water-security risks in the Bogotá Region.

E. Link to economic and financial analysis

From an economic and financial perspective, this activity strengthens the feasibility and durability of the project's investment case. The Economic and Financial Analysis values avoided sedimentation, improved water regulation and related resilience benefits, but those benefits depend on whether producers maintain the land-use and management changes that generate them. By increasing revenues and market opportunities for rural products associated with improved watershed stewardship, Activity 1.2.2 lowers the risk that producers abandon or underperform those practices, thereby protecting the expected flow of VWBs over time.

The activity also improves broader economic resilience by strengthening producer organizations and reducing dependence on environmentally degrading production pathways. Experience from PES and water-fund programs shows that long-term sustainability is stronger when environmental objectives are aligned with viable economic opportunities for upstream communities. Commercialization and market access should therefore be understood in the project as a risk-reduction and sustainability measure that

helps preserve the hydrological and financial returns generated by ecosystem and farm-level interventions.

F. Key assumptions and limitations

The expected contribution of this activity depends on several assumptions. Differentiated products, commercialization channels and business models must generate sufficient and reasonably stable value to influence producer behavior; if price premiums, buyer commitments or market access remain weak, long-term land-management decisions may not change substantially. In addition, commercialization must be linked to credible environmental criteria and traceability; otherwise, improved incomes may not translate into sustained water-regulating practices.

Evidence from PES and watershed incentive programs also indicates that financial incentives alone are rarely sufficient. Institutional trust, collective organization, technical support and governance quality strongly shape participation and permanence, and this activity does not independently generate immediate hydrological outcomes. Its contribution to VWBs is therefore conditional on the successful implementation of Activities 1.1.1, 1.1.2 and 1.2.1. Even so, it addresses a critical barrier to scale and permanence and is thus essential for turning project-funded land-use change into durable watershed benefits and long-term water security outcomes.

7.1.5. Activity 1.2.3 – Implement efficient water use measures efficiency in community-run water supply systems in prioritized watersheds

A. Intervention description

This activity targets community-run rural water-supply systems in prioritized watersheds of the Bogotá Region and focuses on improving technical efficiency, reducing physical and administrative losses, and strengthening operational management. Measures include macro-metering at system inlets, upgrading distribution networks to reduce leakages, installing control valves and simple pressure-management devices, improving household metering where feasible, and promoting efficient water use through community-based training and operational support.

Within the Volumetric Water Benefit (VWB) framework, these measures act on the conveyance and end-use side of the water cycle. Their purpose is to reduce non-revenue water and unnecessary abstractions from streams and springs by improving how available water is distributed and used; VWBs are therefore captured as volumetric reductions in losses and demand relative to a business-as-usual scenario of inefficient, weakly monitored community systems (Gray et al., 2019; WRI, 2025).

B. Mechanism of change

Unlike Activities 1.1.1, 1.1.2 and 1.2.1, which improve water regulation at source through ecosystem conservation, restoration and land management, Activity 1.2.3 acts downstream in the service chain by reducing wastage between abstraction and final use. This is important because water security in rural systems depends not only on how much water is regulated in the catchment, but also on how efficiently that water is captured, conveyed and managed once it enters the community supply network.

The mechanism of change combines technical and behavioral improvements. At regional level, World Bank assessments estimate that around 45% of water supplied by utilities in Latin America is lost as non-revenue water due to leakage, illegal connections and operational inefficiencies (World Bank, 2013). In community systems, macro-metering and leakage control improve the ability to detect and reduce physical losses; network and pressure management reduce chronic leakage and system failures; and

user-level metering and awareness measures help curb avoidable consumption. Under the VWB lens, the result is that less water needs to be abstracted from source waters to provide the same service level, reducing pressure on high-Andean water sources and improving supply reliability during climatic stress.

C. Evidence of effectiveness

Evidence from Latin America shows that water-efficiency measures can generate substantial water savings and operational improvements. According to the World Bank, targeted efficiency programs can reduce non-revenue water from levels above 70% to around 20–30%; in one documented case, Uruguay's Obras Sanitarias del Estado reduced non-revenue water in Ayuí, Artigas, from 73% to 21%, saving approximately 382,000 m^3 of water per year and about US$156,000 annually in associated costs (World Bank, 2013). Although this example refers to a larger utility, it demonstrates the scale of savings that can be unlocked when losses are identified and managed systematically.

Evidence from smaller and rural systems supports the relevance of these measures for community-run schemes. Studies on proportional macro-metering in Latin American contexts show that bulk metering can significantly improve operational control by enabling local operators to identify abnormal consumption patterns and system losses (Montoya et al., 2009). In rural Andean settings, integrated interventions combining infrastructure improvements with community training have strengthened operation and maintenance capacity and improved long-term service functioning (Moriarty et al., 2007). Taken together, this evidence supports the assumption that Activity 1.2.3 can generate measurable VWBs in the form of reduced non-revenue water and lower abstraction needs, especially where baseline inefficiencies are high.

D. Expected results and contribution to water security (VWBs from efficiency)

The direct result of this activity is not increased runoff regulation at source, but more efficient and reliable use of the water already captured by community systems. Expected outcomes include lower system losses, reduced unnecessary abstractions, and more stable service delivery for rural users in prioritized watersheds. These improvements are particularly relevant in small systems that are vulnerable to dry-season shortages and operational disruptions.

Within the VWBA framework, the main VWBs associated with Activity 1.2.3 are quantified as: (i) m3 of non-revenue water reduced through lower physical and apparent losses, and (ii) m3 of abstraction avoided or demand reduced for a given level of service. When aggregated across participating systems, these savings reduce cumulative pressure on upstream ecosystems and complement the source-side VWBs generated under Activities 1.1.1, 1.1.2 and 1.2.1, thereby strengthening water security for vulnerable rural users in the Bogotá Region (IDB, 2013; Gray et al., 2019).

E. Link to economic and financial analysis

The justification for this activity extends beyond water savings because service reliability and continuity are strongly linked to health outcomes. Evidence from small-community water supply interventions shows that the incidence rate ratio for diarrhea after installation of improved community water systems was 0.43 relative to a control community, equivalent to a 57% reduction in diarrheal disease, and the more reliable system performed significantly better than the less reliable one (Hunter, Zmirou-Navier, & Hartemann, 2010). This indicates that improving how community systems function can translate directly into reduced exposure to water-related disease.

Broader evidence supports the same conclusion. A systematic review and meta-analysis found that water supply interventions with higher service levels and better continuity are associated with significant

reductions in childhood diarrhea, and an updated meta-analysis reported that piped water of higher quality and continuous availability reduced diarrhea risk by 36% relative to unimproved drinking water (Wolf et al., 2022; Wolf et al., 2018). In the Bogotá Region, efficiency measures such as leak reduction, macro-metering and operational control can reduce interruptions, stabilize supply and lower the need for unsafe coping practices such as prolonged household water storage or switching to lower-quality alternative sources. This makes Activity 1.2.3 a public-health measure as well as a water-security intervention, with benefits that are directly experienced at household level.

F. Key assumptions and limitations

The expected benefits of Activity 1.2.3 depend on whether efficiency gains translate into reliable service rather than only lower technical losses. Evidence from rural small-community systems shows that reliability is critical: when upgraded systems were operational, 72% of households met the minimum service benchmarks for distance and water quantity, but during non-operational periods daily per-capita water consumption fell by 5.19 liters and distances to water sources increased by 639 meters (Majuru et al., 2013). This means that the health and water-security benefits of the activity depend not only on infrastructure improvements, but on keeping systems functional over time.

A second limitation is institutional. Studies on rural water sustainability show that local governance quality, financing arrangements and operation-and-maintenance capacity are central to long-term performance; without these conditions, metering, leakage control and network improvements may deteriorate rapidly and fail to deliver sustained benefits (World Bank, 2017; Carter, 2009). Behavioral responses also matter: water supply community-run systems must accept measures such as metering or revised allocation rules, and local operators must be able to use system information effectively. Finally, improved efficiency alone does not guarantee safe water at the point of use, since household storage and handling can still lead to contamination even when source water is potable (Majuru et al., 2013). For these reasons, the activity's benefits should be understood as conditional on reliable operation, adequate maintenance and complementary community practices that preserve water quality after collection.

7.1.6. Why Component 1 is credible as a proof of concept: Volumetric Water Benefits (VWB) conceptual framework

Component 1 constitutes a credible proof of concept by applying a spatially targeted, integrated, and results-oriented package of interventions aligned with established hydrological evidence and with the project's sizing of conservation, restoration, and farm-level actions across priority landscapes. The intervention focuses on headwater systems that are widely recognized as critical for Bogotá's water security and climate risk management. The Guacheneque páramo, where the Bogotá River originates, extends over approximately 10,000 hectares and sustains more than 50 rural aqueducts while contributing to downstream water availability across a basin influencing up to 10–12 million people (CAR, 2020). This natural infrastructure is complemented by the Guandoque–Tominé system, whose reservoir (estimated at approximately 690 million m³) represents the largest surface water storage in the Sabana de Bogotá and plays a central role in environmental flow regulation, flood control, irrigation, and potable water supply through the Tibitoc treatment plant (CAR, 2020; EAAB, n.d.). In the southern basin, the upper Tunjuelo River supports the ecological and hydrological functioning of Bogotá's urban–periurban interface and is recognized as a key system for managing water security under increasing hydroclimatic variability (Osorio, 2008; Sánchez-Calderón, 2018).

These interconnected systems operate as a coupled natural–built infrastructure network that regulates hydrological flows, buffers extreme precipitation, and sustains dry-season baseflows, thereby reducing flood and water scarcity risks for both rural and urban users. Their conservation and restoration are

therefore central to achieving climate adaptation outcomes, including improved reliability of water supply, reduced vulnerability of users, and strengthened ecosystem-based disaster risk reduction across the basin. Evidence indicates that the upper Bogotá River and Tunjuelo sub-basins contribute significantly to inflows to key supply systems such as Tibitoc, while also being subject to high land-use pressure, which increases sediment loads and degrades raw-water quality (JICA, 2010). Targeting these hydrologically sensitive areas enhances both feasibility and impact by directing resources to locations where interventions can generate the greatest measurable benefits.

The design of Component 1 reflects the multi-driver nature of hydrological change in tropical Andean catchments. Land-use transformations in páramo ecosystems, high-Andean forests, and agricultural slopes have been shown to jointly increase streamflow variability and reduce regulation capacity and water yield (Ochoa-Tocachi et al., 2016). By simultaneously addressing ecosystem integrity, agricultural practices, and local water-system performance within the same priority watersheds, the component aligns with this evidence and strengthens its validity as a watershed-scale adaptation model.

Crucially, the component is structured around measurable hydrological outcomes rather than activity-based reporting. It adopts the Volumetric Water Benefit (VWB) approach to quantify the effects of land-use and management changes in terms of avoided runoff, reduced sediment loads, enhanced baseflows, and improved efficiency in water systems. This approach is consistent with methodologies applied in the Andean headwater monitoring network, which has demonstrated how interventions in small, instrumented catchments can generate robust evidence on hydrological responses to land-use change (Ochoa-Tocachi et al., 2018). In the Bogotá context, existing analyses already show that managing strategic high-Andean ecosystems can reduce pollutant loads reaching intake points and lower treatment costs, providing a clear baseline from which to measure incremental change.

The project adopts the Volumetric Water Benefit (VWB) methodology as a robust, outcome-oriented framework to quantify hydrological improvements derived from ecosystem conservation, restoration, and water-management interventions. VWB translates biophysical changes into standardized volumetric metrics, enabling the measurement of how interventions improve water availability, regulation, and efficiency at watershed scale. This approach is particularly suited to high-Andean systems, where hydrological responses to land-use change are significant but spatially heterogeneous (Ochoa-Tocachi et al., 2018).

Volumetric water benefits (VWBs) are the volume of water resulting from water stewardship activities, relative to a unit of time, that modify the hydrology in a beneficial way and/or help reduce shared water challenges, improve water stewardship outcomes, and meet the targets of Sustainable Development Goal 6. Volumetric water benefit accounting (VWBA) provides corporate water stewardship practitioners with a standardized approach and set of indicators to quantify and communicate the volumetric water benefits, complementary indicators to measure nonvolumetric outputs, and elements of effective water stewardship activities that increase the likelihood of generating social, economic, and environmental benefits and solving shared water challenges. The VWBA includes recommended indicators and calculation methods for different water stewardship activities, including the ones being proposed by this GCF project.

Because providing a volume of water alone does not guarantee that shared water challenges are reduced, CI uses additional water benefits of effective water stewardship activities that reflect the generation of social, economic, and environmental benefits of investments.

VWBA helps calculate and communicate volumetric water benefits of activities that contribute to meeting water stewardship outcomes and SDG targets and help solve shared water challenges

Therefore, VWB and additional water benefits measure the incremental water-related benefits generated by interventions relative to a baseline scenario. These benefits are expressed in volumetric terms (m^3/year) and reflect four main hydrological performance dimensions:

- Avoided runoff (improved infiltration and retention)
- Enhanced baseflows (increased dry-season water availability)
- Reduced sediment and pollutant loads (improved water quality)
- Water savings and efficiency gains (reduced non-revenue water and losses)

By quantifying these effects, VWBs provides a common metric that links ecosystem processes, built infrastructure, and service delivery outcomes.

A. Methodological Steps

Step 1: Baseline Characterization.

A hydrological baseline is established for each priority watershed using:

- Existing monitoring data (streamflow, precipitation, sediment loads)
- Land-use and land-cover maps
- Water system performance indicators (e.g., leakage, treatment costs)

This baseline reflects current conditions of:

- Flow variability and regulation capacity
- Seasonal water availability
- Sediment and nutrient loads
- Efficiency of water supply systems

Where direct data is limited, values are triangulated using regional studies and Andean monitoring networks (Ochoa-Tocachi et al., 2018).

Step 2: Intervention Mapping and Attribution

Each intervention under Component 1 is spatially linked to hydrologically sensitive areas, runoff-based VWBs are used as the primary hydrological proxy across the project, while additional VWBs related to sediment reduction, enhanced baseflow and volumetric water savings in community systems are derived consistently from the same watershed-scale volumetric framework, including:

Intervention Type	Hydrological Effect	VWBA indicators under WRI methodology	Additional water benefits for the project
Páramo conservation (Act. 1.1.1)	Maintains soil storage and infiltration	Avoided runoff	Avoided sediment export
Ecosystem restoration (Act. 1.1.2)	Improves retention capacity and reduces erosion	Avoided runoff	Sediment reduction; enhanced baseflow volumes
Transformation of productive systems (Act. 1.2.1)	Reduces runoff and soil loss	Reduced runoff	Sediment reduction
Water system improvements (Act. 1.2.3)	Reduces losses and inefficiencies; potable household water, new water supply for domestic use	Reduced withdrawal, Volume provided - *not*	Reduced Non-Revenue Water - *not*

	quantified at project design phase	*quantified at project design phase*

Step 3: Hydrological Response Functions

The relationship between land-use change and hydrological outcomes is represented through response functions, derived from:

- Paired catchment studies
- Monitoring networks (<20 km² catchments)
- Regional hydrological models

These functions estimate how specific interventions influence:

- Infiltration rates
- Peak flow attenuation
- Baseflow persistence
- Sediment export

This step ensures that VWB quantification is grounded in observed, not assumed, hydrological behavior.

Step 4: Quantification of Water Benefits

For each intervention landscape, VWB is calculated as:

$$VWB = \Delta WR + \Delta BF + \Delta WQ + \Delta WS$$

Where:
ΔWR = Change in water retention (avoided runoff / increased infiltration)
ΔBF = Change in baseflow (dry-season water availability)
ΔWQ = Water-quality-related benefits (linked to sediment reduction)
ΔWS = Water savings (efficiency improvements in systems)

As illustrated in the Figure 43, volumetric water benefits are generated through the interaction of climate, land use and ecosystem condition, soil properties, management practices, and watershed characteristics, which together determine key hydrological processes such as evapotranspiration, infiltration, soil water storage, runoff generation, baseflow regulation, sediment reduction, and water quality. Within this framework, the project targets the variable most directly influenced by intervention activities: land use and ecosystem condition, while also improving management practices that affect how water moves through the landscape. Changes in these inputs are expected to modify infiltration, runoff, and erosion processes, thereby improving dry-season flows, reducing sediment transport, and enhancing overall water regulation. The resulting hydrological gains are then expressed as Volumetric Water Benefits (VWB), providing a measurable estimate of the water-related adaptation value created by the proposed interventions.

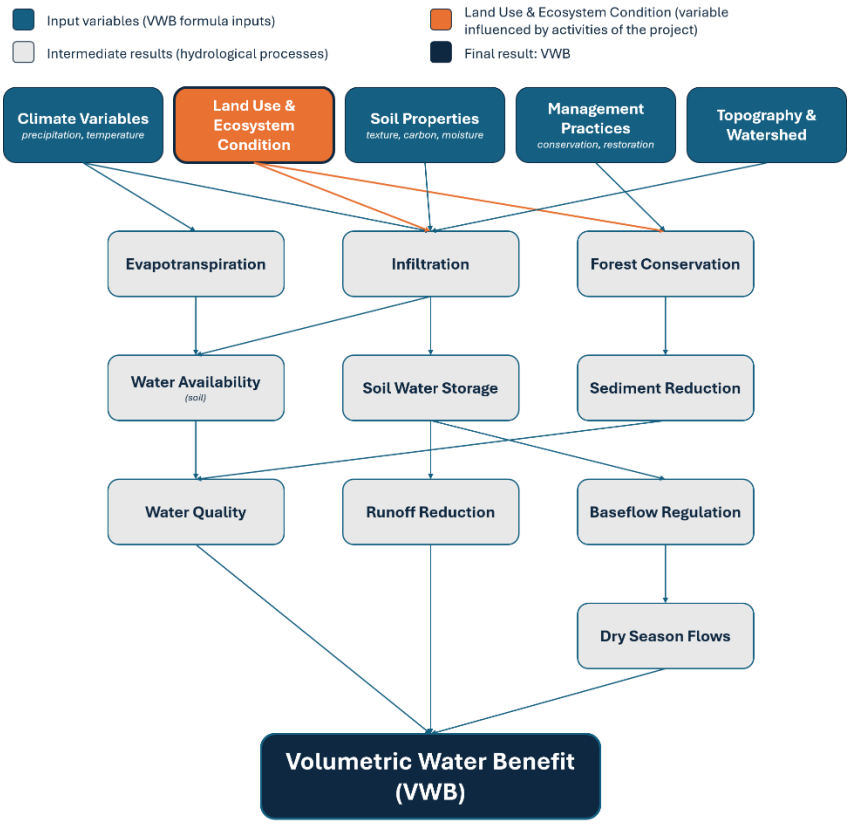


Figure 43. VWB quantification model.
Source: IDOM, 2026.

To quantify these benefits, the Curve Number (CN) runoff method was applied following the approach outlined in Volumetric Water Benefit Accounting 2.0 (WRI et al., 2025). The methodology estimates the reduction in surface runoff generated by water stewardship activities planned for the Bogotá region by comparing two scenarios: (i) a baseline scenario, reflecting current land-use conditions, and (ii) a with-project scenario, representing expected ecosystem recovery and improved land management at full project maturity. The difference in runoff between these two scenarios is treated as the VWB, and results are expressed as a VWB rate in megaliters per hectare per year (ML/ha/yr) for each intervention landscape and proposed activity. In this way, the methodology directly links intervention-induced changes in land cover and management to quantifiable hydrological outcomes (See appendix V for detailed calculations).

Table 28. VWB quantification for the prioritized watersheds of the project.

Intervention landscape	Watersheds	Sub-Activity 1.1.1.2. Conservation (ML/ha/yr)	Activity 1.1.2. Restoration (active+passive) (ML/ha/yr)	Activity 1.2.1. Transformation of productive systems (ML/ha/yr)
1.Guandoque	Río Salitre	0.26	0.53	0.5
1.Guandoque	Río Guandoque	0.3	0.55	0.52
1.Guandoque	Río Susagua	0.25	0.39	0.32
2. Villapinzón	Río Bogotá Parte Alta	0.32	0.555	0.46
2. Villapinzón	Quebrada Quincha	0.36	0.565	0.49

Intervention landscape	Watersheds	Sub-Activity 1.1.1.2. Conservation (ML/ha/yr)	Activity 1.1.2. Restoration (active+passive) (ML/ha/yr)	Activity 1.2.1. Transformation of productive systems (ML/ha/yr)
3. Tominé	Río San Francisco	0.2	0.43	0.31
3. Tominé	Río Aves	0.19	0.415	0.32
3. Tominé	Río Chipatá	0.24	0.49	0.41
4. Tunjuelo	Río Curubital	0.46	0.47	0.48
4. Tunjuelo	Quebrada Yomasa	0.22	0.34	0.32
4. Tunjuelo	Quebrada de Aguadulce	0.25	0.36	0.33
4. Tunjuelo	Quebrada Paso Colorado	0.23	0.365	0.3

Disclaimer for VWB estimations:

- The guidelines used to quantify Volumetric Water Benefits (VWBs) for the activities proposed under this project are based on a modeling approach. As such, they are subject to inherent limitations in fully representing real-world hydrological conditions and outcomes.
- The VWB estimates presented at this proposal development stage are preliminary and are intended solely to provide an indicative range of potential benefits for the region of analysis. These estimates should be interpreted as illustrative rather than definitive.
- If the defined area of interest or underlying assumptions change, the estimated range of potential VWBs is also likely to change. Credible and realistic VWB estimations can only be generated once specific activities are implemented at clearly defined locations, using site-specific data. During project implementation, VWBs will be re-estimated to reflect actual implementation conditions.
- In addition, more precise and reliable VWB estimates can only be obtained through the deployment of hydrology-specific monitoring plots and field-based measurements, which allow modeled results to be validated and refined based on observed data. Conditional to dedicated investment on monitoring, VWBs can therefore be re-estimated once monitoring systems are in place.

VWB are calculated only for ha under payment-for-conservation schemes. VWBs for the conservation activities associated with the whole Protected Areas and RNSC will be calculated during project implementation when enough data is generated to quantify avoided runoff benefits. Short Guidance on Verification of CI's VWB's:

- In line with standard industry practice, VWBs generated through this project implementation should be independently verified by a qualified third party. Responsibility for securing and contracting this independent verification rests with the company claiming the water benefits. This includes verification of the VWB estimates produced by CI.
- Key requirements for VWB claims: The process of claiming VWBs typically involves several contractual, technical, and procedural elements, including:
  - Identification and engagement of an independent third-party validator
  - Definition of the claiming period, which is generally aligned with the duration over which project outcomes are monitored and/or funded by the company
  - Establishment of a clear attribution framework to determine how benefits are allocated and claimed
- Conservation International can support companies throughout the verification. This support typically includes providing relevant technical documentation, data, and methodological clarification directly to the third-party verifier upon request. The duration of Conservation International's engagement with the third-party verifier will align with the period during which the company intends to claim VWBs, provided that the company continues to invest in the maintenance and monitoring of the implemented activities generating those benefits, and that such support is included within the agreed scope of work.

Source: Freshwater Science Team at the Moore Center for Science and Solutions from CI in accordance with the VWBA guidelines (WRI, Limnotech, Bluerisk & Bonneville Environmental Foundation, 2025), 2026

The runoff simulations were performed using the Curve Number method as implemented in the Soil and Water Assessment Tool (SWAT) (Neitsch et al., 2009), with daily surface runoff estimated for the period 2018–2024. A daily variation in the soil retention parameter was assumed in order to capture the effect of vegetation dynamics on runoff response. Because evapotranspiration is one of the key intermediate processes shown in the diagram, the Hamon method was used to estimate daily potential evapotranspiration (PET) from daily average air temperature and latitude. This allowed the model to reflect the role of plant water use in modifying soil moisture conditions and runoff generation over time.

The preliminary calculations draw on multiple biophysical inputs consistent with the structure of the diagram. Precipitation, a core climate driver, was derived from rainfall station records and complemented with bias-corrected CHIRPS v2 data where gaps existed, ensuring spatially and temporally coherent rainfall estimates for runoff modelling (Funk et al., 2015; Valencia et al., 2023). Air temperature data were used to estimate PET and were supplemented using bias-corrected ERA5-Land reanalysis data where station records were incomplete (Muñoz-Sabater et al., 2021). Soil properties, represented through Hydrological Soil Group (HSG) classes, were derived from the Bogotá River basin POMCA soil mapping and reclassified according to infiltration capacity, runoff potential, and drainage characteristics (CAR et al., 2014; IGAC & Gobernación de Cundinamarca, 2000). Topography, another key driver in the diagram, was characterized using watershed mean slope derived from the NASADEM digital elevation model (NASA Jet Propulsion Laboratory, 2020). Finally, Curve Number values were assigned using the standardized SCS (1986) tables based on site-specific combinations of land use / land cover and soil group, allowing CN values to vary across watersheds according to local hydrological conditions under both baseline and with-project scenarios.

The with-project scenario was defined to represent full project maturity, incorporating the expected improvements in vegetation structure, soil cover, and hydrological function resulting from restoration, conservation, and improved management practices. In terms of the diagram, this means that project interventions first alter land use and ecosystem condition and management practices, which in turn affect infiltration, soil water storage, runoff reduction, forest conservation effects, and ultimately downstream variables such as sediment reduction, baseflow regulation, dry season flows, and water quality. By framing runoff reduction as the first measurable hydrological response and translating it into VWB, the methodology provides an operational entry point for quantifying adaptation benefits while remaining consistent with a broader systems understanding of watershed function.

This approach is strategically important for Component 1 because it converts landscape interventions into a standardized and verifiable water metric that can be compared across intervention types and locations. Rather than reporting only hectares restored or practices adopted, the project can demonstrate how these actions generate measurable hydrological improvements in terms of reduced runoff, enhanced regulation, and, in subsequent analytical stages, potentially improved baseflows and reduced sediment delivery. As such, the VWB methodology serves not only as a monitoring tool, but also as a bridge between ecosystem restoration, climate adaptation outcomes, and future economic or financial valuation of watershed services.

Step 5: Aggregation at Watershed Scale

- Individual VWB estimates are aggregated across:
- Sub-basins (Guacheneque, Villapinzón, Tominé, Tunjuelo)
- Intervention types
- Time horizons (annual and cumulative impacts)

This provides a basin-scale picture of hydrological improvement, directly linked to priority water systems such as Tibitoc.

The combination of passive restoration, active restoration, conservation, and transformation of productive systems constitutes the core intervention package under Outcome 1, generating positive and quantifiable Volumetric Water Benefits (VWBs) across all targeted watersheds. These interventions act directly on land use and ecosystem condition and management practices, modifying hydrological processes such as infiltration, runoff generation, and soil water storage. As a result, they provide a robust, model-based basis for estimating watershed-scale improvements in water regulation and retention. While these

estimates are preliminary and will be refined through the project's monitoring system, they already offer a defensible quantitative foundation for assessing adaptation benefits and informing future water-related investment decisions.

resents the aggregated VWB results at watershed level. VWB coefficients are first calculated at the intervention scale and expressed as megaliters per hectare per year (ML/ha/year). These values are then converted into cubic meters per year (m^3/year) and scaled by multiplying by the total area under intervention, covering conservation, restoration, and productive reconversion (FC + FP) (see section 4.2), within each watershed. The resulting volumetric estimates are subsequently aggregated across all priority watersheds to derive total annual VWBs. These values represent the annual volume of water whose hydrological behavior is improved, specifically through reduced rapid surface runoff and enhanced retention, once the project reaches full implementation maturity.

Table 29 resents the aggregated VWB results at watershed level. VWB coefficients are first calculated at the intervention scale and expressed as megaliters per hectare per year (ML/ha/year). These values are then converted into cubic meters per year (m^3/year) and scaled by multiplying by the total area under intervention, covering conservation, restoration, and productive reconversion (FC + FP) (see section 4.2), within each watershed. The resulting volumetric estimates are subsequently aggregated across all priority watersheds to derive total annual VWBs. These values represent the annual volume of water whose hydrological behavior is improved, specifically through reduced rapid surface runoff and enhanced retention, once the project reaches full implementation maturity.

Table 29. Volumetric Water Benefits for the watersheds of the project.

Intervention landscape	Watersheds	Total VWB m3/yr for the watersheds with interventions
1.Guandoque	Río Salitre	118,765
1.Guandoque	Río Guandoque	323,555
1.Guandoque	Río Susagua	441,133
2. Villapinzón	Río Bogota Parte Alta	197,440
2. Villapinzón	Quebrada Quincha	123,030
3. Tominé	Río San Francisco	667,140
3. Tominé	Río Aves	510,333
3. Tominé	Río Chipatá	118,900
4. Tunjuelo	Río Curubital	281,310
4. Tunjuelo	Quebrada Yomasa	51,646
4. Tunjuelo	Quebrada de Aguadulce	54,720
4. Tunjuelo	Quebrada Paso Colorado	52,613

Source: Freshwater Science Team at the Moore Center for Science and Solutions from CI in accordance with the VWBA guidelines (WRI, Limnotech, Bluerisk & Bonneville Environmental Foundation, 2025), 2026.

Full implementation maturity refers to the stage at which all planned conservation, restoration, and transformation of productive systems (Activities 1.1.1, 1.1.2 and 1.2.1) have been completed and are functioning as intended, with stabilized vegetation cover, improved soil hydrological properties and consistent management practices. Short-term restoration studies in high-elevation Andean grasslands indicate that more than two years are necessary to recover the hydrological function of degraded grasslands, especially infiltration, soil-water storage and erosion control, and therefore medium-term horizons are required to capture efficient restoration periods (Mosquera et al., 2022; Bonnesoeur et al.,

2021). In this project, this condition is expected to be reached toward the final phase of implementation (approximately year 4–5), by which time vegetation and soil functions have had sufficient time to recover and management practices have been consolidated. At that point, the hydrological responses simulated in the 'with-project' scenario—particularly reductions in runoff and increases in water retention—can reasonably be considered representative of steady-state annual VWB generation at the scale of instrumented catchments, consistent with the 1–5 year monitoring windows used in tropical Andean paired-catchment studies to assess land-use impacts on hydrological regulation (Ochoa-Tocachi et al., 2016).

These results demonstrate that the measures under Outcome 1 generate measurable improvements in runoff regulation and water retention at watershed scale, consistent with the project's freshwater pathways of change. By capturing early hydrological responses, particularly reductions in overland flow and associated erosion, the VWB estimates provide a credible proxy for broader system impacts, including enhanced baseflow regulation, improved water quality, and increased reliability of water supply. At the same time, the quantified VWBs establish a clear volumetric basis for linking ecosystem interventions to economic and financial value, supporting the development of environmental investment mechanisms and the potential mobilization of private finance in subsequent components of the project.

Step 6: Verification and Monitoring

The project integrates a monitoring system combining (See under Act 2.1.2):

- Field instrumentation (flow gauges, sediment sampling)
- Remote sensing (land cover, vegetation recovery)
- Utility data (water production, treatment costs, losses)

This allows periodic validation of VWB estimates and supports adaptive management.

B. Link to Climate Adaptation Outcomes

The VWB methodology directly supports the measurement of climate resilience benefits, translating hydrological improvements into adaptation outcomes:

Table 30. Adaptation outcome for each hydrological change.

Hydrological Change	Adaptation Outcome
Increased baseflow (including avoided and reduced runoff)	Reduced drought vulnerability
Reduced peak flows	Lower flood risk
Improved water quality	Reduced treatment costs and system stress
Reduced water losses	Increased supply reliability

By expressing these effects in volumetric terms, VWB enables:

- Quantification of avoided climate impacts
- Assessment of system reliability under climate variability
- Comparison of intervention efficiency across locations

C. Financial and Scaling Relevance

A key strength of the VWB approach is its ability to link hydrological performance with economic value and financing mechanisms:

- Reduced sediment loads → lower treatment costs at Tibitoc
- Increased water availability → avoided infrastructure expansion
- Improved efficiency → reduced operational costs

D. Strategic Role within Component 1

Within the project, VWB serves as:

- A measurement tool → tracking hydrological outcomes
- A decision-support framework → prioritizing interventions
- A finance-enabling mechanism → linking benefits to costs
- A scaling instrument → generating comparable evidence across watersheds

This positions Component 1 not only as an implementation effort, but as a replicable model for basin-scale adaptation, capable of generating verifiable evidence to inform broader water governance and investment strategies in Bogotá and beyond.

Additionally, and to further proof the results modeled with the VWB methodology, the intervention landscapes selected and the activities where modelled in InVEST through Seasonal Water Yield, confirming the direction and magnitude of the changes identified through VWB calculation, particularly in relation to runoff reduction (for more detail see Appendix V).

7.2. Component 2: Feasibility of mobilizing and scaling finance

Component 2 is feasible because it is anchored in financing channels that already exist in Colombia's regulatory and institutional framework and can be activated within the project period once Component 1 delivers verified hydrological results. Rather than adding new conservation activities, this component addresses the next barrier in the theory of change: the absence of durable financing mechanisms capable of converting verified Volumetric Water Benefits (VWBs) into recurrent public and private investment.

Its role is therefore distinct from Component 1. While Component 1 proves that watershed transformation model can generate measurable water-resilience outcomes, Component 2 tests whether those results are strong enough to support financing decisions under existing rules for water tariffs, corporate environmental action and strategic environmental investment. This makes Component 2 the project's scale pathway, not an additional implementation package.

The feasibility is backed by the fact that the project operates within a water system where resilience investments are already demonstrably material to urban water security. During the 2024 supply crisis, the contribution of the Northern Bogotá system, the Tibitoc drinking water treatment plant and associated infrastructure (Tominé and other reservoirs of the Northern Bogotá River) increased significantly its contribution, rising from its historical share of approximately 26% to around 46% of the city's water consumption, thereby alleviating pressure on the Chingaza system (EAAB, 2024). This shift underscores the strategic importance of diversified and well-regulated water sources under conditions of hydroclimatic stress. In this context, mechanisms designed to sustain upstream investments in source protection, water quality, and flow reliability are not experimental, but rather represent a financially and institutionally relevant extension of an already critical system function.

7.2.1. Activity 2.1.1 – Incorporate an environmental investment component to the water tariff

A. Intervention description

This activity supports EAAB (the Bogotá water utility) in structuring environmental investments that could be recognized through the water tariff, based on demonstrated benefits for continuity, quality and climate resilience of the water service. In addition to hydrological and environmental performance metrics, the technical studies under Activity 2.1.1 will incorporate explicit socioeconomic and affordability dimensions, including analysis of distributional impacts by socioeconomic stratum and assessment of tariff-design options that maintain or strengthen protection for vulnerable user groups within the existing regulatory framework. The activity includes three functions: defining and validating indicators and methodologies to demonstrate the cost-effectiveness of water-resilience investments; establishing systematic reporting for regulatory and supervisory authorities; and preparing replication models for other water utilities.

Unlike Component 1 activities, Activity 2.1.1 does not generate VWBs directly. Its purpose is to convert already verified hydrological results into a tariff-compatible investment rationale so that watershed measures can be financed as part of service protection, rather than remaining dependent on one-off project grants.

B. Mechanism of change

The mechanism of change is regulatory rather than biophysical. Resolution CRA 1032 of 2026 allows water utilities to incorporate additional environmental investments into the tariff when these investments contribute to protecting water sources, reducing the risk of supply shortages and improving medium- and long-term service conditions. The CRA has explicitly stated that this regulation aims to improve continuity and water quality by protecting the water resource needed to meet current and future demand under climate change.

The project creates the evidence needed to operationalize that possibility. Component 1 generates quantified hydrological outcomes, while Activity 2.1.1 organizes those results into the technical, economic and reporting package required for tariff recognition. In this sense, the activity is a bridge between proof of impact and regulatory uptake.

C. Evidence of effectiveness

The main evidence supporting feasibility is that the tariff instrument is already established and specifies the kinds of investments that may be recognized. According to the CRA, eligible categories include land purchase and isolation, aquifer recharge projects, restoration, protection and recovery of supplying watersheds and riparian areas, water-resource monitoring, and payments for hydrological regulation and water-quality services. These categories align closely with the project's intervention mix under Component 1, which means the project is not trying to fit watershed investments into an unrelated tariff mechanism; it is using a regulation designed precisely for this type of environmental expenditure.

D. Expected results and contribution to water security

The expected result is not a hydrological change in itself, but an institutional financing pathway through which verified watershed benefits can be incorporated into utility decision-making and cost recovery. This would allow EAAB to move from discretionary or project-specific environmental spending toward a more structured model in which source-protection investments are supported by recognized tariff logic and formal reporting.

Its contribution to water security is therefore enabling and long-term. By creating a recurrent source of finance for interventions that improve source condition and water reliability, the activity increases the probability that upstream adaptation measures continue beyond the GCF period and can be replicated in other supplying systems.

E. Link to economic and financial analysis

Activity 2.1.1 is linked to the Economic and Financial Analysis by translating hydrological and service-delivery benefits into a tariff-based mechanism that users are willing to support. In Bogotá (Colombia), natural-infrastructure investments generate measurable economic value through reduced sediment and nutrient loads, lower treatment and energy costs, and increased resilience of drinking water systems. When these benefits are evaluated through willingness-to-pay (WTP) approaches, they reveal that users attribute monetary value to improvements in service quality and reliability. Evidence from international contexts, including Belgium and France (Europe) and Uganda (Africa), shows that households are typically willing to pay between 5% and 20% above current tariffs for enhanced water quality or watershed restoration, with annual contributions ranging from US$10 to US$40 depending on income and perceived risk (Bruffaerts & De Jaeger, 2010; Reynaud, 2003; Komakech et al., 2008).

Further evidence from watershed governance mechanisms reinforces the viability of tariff-based financing. In China, more than half of surveyed urban residents expressed willingness to contribute to ecological compensation schemes, with a significant share preferring to channel payments directly through water tariffs, confirming their acceptability as a financing vehicle when benefits and governance are clear (Zhang et al., 2022). Similar experiences in Costa Rica and Mexico demonstrate that structured payment schemes can mobilize local revenue to co-finance watershed protection when fees remain modest and linked to tangible improvements in water services (Camacho et al., 2016). Building on this evidence, Activity 2.1.1 positions a regulated environmental investment component to the tariff, transparent, evidence-based, and linked to measurable VWB outcomes, as a mechanism to internalize the economic value of watershed interventions, enabling cost recovery within existing tariff structures and supporting scalable, performance-linked financing for long-term water security.

F. Key assumptions and limitations

The main assumption is that the hydrological and economic evidence generated by the project will be sufficiently robust for tariff incorporation and regulatory review. The applicable tariff framework (Resolution CRA 1032 of 2026) requires technical support, articulation with environmental planning instruments, and safeguards to prevent double charging for investments already mandated by environmental authorities. This means the activity depends not only on strong evidence, but also on careful documentation and institutional coordination.

A second limitation is that tariff uptake is ultimately a governance and decision process within the utility and its regulators. The activity is feasible under the current framework, but implementation may be slowed by internal priorities, evidentiary thresholds or administrative caution. Its success therefore depends on regulatory compliance, strong reporting and a clear demonstration that watershed investments improve service resilience in ways relevant to users.

7.2.2. Activity 2.1.2 – Operationalize a long-term financial mechanism for private investments

A. Intervention description

Activity 2.1.2 establishes a structured mechanism to channel private-sector finance into prioritized watershed interventions that generate measurable hydrological outcomes verifiable through Volumetric Water Benefits (VWBs) Accounting. It includes the development of spatial prioritization tools, monitoring and VWB quantification systems, as well as the creation of the administrative, operational, and financial architecture required to mobilize and deploy private investment toward water-resilience outcomes.

Its distinct role within the project is to attract additional resources for the continued implementation, maintenance and expansion of watershed resilience activities. While Activity 2.1.1 is anchored in regulated public utility finance, this activity is designed to aggregate voluntary and compliance-related private capital into a coordinated portfolio of watershed interventions with quantified and verifiable results.

B. Mechanism of change

The mechanism of change is based on aligning private-sector environmental obligations and corporate water-stewardship goals with a credible, performance-based investment vehicle. In Colombia, Law 2173 of 2021 established the "Áreas de Vida" framework to promote ecological restoration through corporate participation, including obligations for medium and large companies to contribute to restoration efforts (Congreso de la República de Colombia, 2021). This framework was further operationalized through Resolution 1491 of 2025, which clarified that corporate programs must include not only tree planting, but also maintenance, monitoring, and follow-up during the initial implementation period, and must prioritize strategic ecosystems such as páramos, wetlands, and other degraded areas (Ministerio de Ambiente y Desarrollo Sostenible, 2025).

Building on this regulatory context, Activity 2.1.2 shifts corporate engagement from fragmented planting initiatives toward a watershed-scale investment model linked to measurable hydrological outcomes. By providing spatial targeting tools, quantified VWBs, and a transparent governance structure for fund management, the mechanism enables companies to invest in the water transformation model that are strategic, traceable, and aligned with both compliance requirements and sustainability commitments.

C. Evidence of effectiveness

The feasibility of this activity is supported by the existence of an established and expanding regulatory framework for corporate restoration in Colombia. Resolution 1491 of 2025 requires that restoration actions include maintenance, monitoring, and traceability, and that interventions be directed toward priority ecosystems. This creates tangible demand for structured implementation platforms capable of delivering environmental results with technical credibility (Ministerio de Ambiente y Desarrollo Sostenible, 2025).

A second key factor is the scale of potential corporate demand generated under Law 2173 of 2021, which requires medium and large companies to support ecological restoration actions, including tree planting linked to workforce size (Congreso de la República de Colombia, 2021). This creates a recurring need for implementation mechanisms able to absorb and effectively deploy restoration investments. By linking this demand to geographically prioritized watersheds and measurable water outcomes, the proposed mechanism improves the environmental effectiveness and accountability of corporate contributions,

making it attractive to both compliance-driven actors and companies with broader ESG and water-stewardship goals.

D. Expected results and contribution to water security

The expected result is the establishment of a functional investment vehicle capable of mobilizing and directing private finance toward the same priority landscapes where Component 1 demonstrates hydrological outcomes. This creates continuity beyond the project lifecycle and enables the scaling of watershed interventions without relying exclusively on public funding.

Its contribution to water security is systemic. By extending investment into upstream conservation, restoration, and climate-resilient production systems, the mechanism reinforces the hydrological functions that underpin reduced runoff, improved water quality, and increased supply reliability. In this way, Activity 2.1.2 supports the long-term sustainability of water-resilience outcomes while allowing private sector to report VWBs and sustain corporate participation overtime.

E. Link to economic and financial analysis

Activity 2.1.2 is linked to the EFA by translating demonstrated hydrological benefits into an investment proposition aligned with corporate water stewardship compliance. This activity creates a mechanism through which companies can allocate capital in ways that meet both regulatory obligations ("Areas de Vida") and broader stewardship commitments linked to ESG standards and water-risk management. By expressing impacts through verifiable Volumetric Water Benefits (VWBs), the mechanism provides a standardized, auditable metric that supports corporate reporting and aligns with recognized approaches for water stewardship accounting (World Resources Institute et al., 2025).

From a financial perspective, firms require traceability, governance, and measurable outcomes to justify environmental investments. Activity 2.1.2 addresses these requirements by offering a structured vehicle with transparent fund management and monitored results through VWB, thereby reducing transaction costs and uncertainty compared to fragmented compliance actions. This enables companies to treat watershed investments not only as compliance expenditures but as part of strategic risk mitigation and operational resilience, particularly in water-dependent sectors. By linking quantified VWBs to corporate compliance and disclosure needs, the mechanism helps to systematically quantify and verify the hydrological outcomes of upstream interventions within private decision-making, attracting sustained investment.

F. Key assumptions and limitations

The primary assumption is that companies will recognize quantified VWBs and watershed transformation model outcomes as relevant to their regulatory, reputational, and stewardship objectives. The Colombian regulatory framework, particularly the operationalization of the "Áreas de Vida" program, supports this assumption, although participation will depend on transaction costs, governance quality, and confidence in monitoring systems.

A second limitation relates to implementation complexity. Private financing mechanisms require strong institutional design, including transparent governance, credible verification systems, and efficient fund deployment. Without these elements, companies may revert to simpler compliance options with lower environmental impact. Therefore, the effectiveness of the mechanism depends not only on regulatory alignment but also on operational credibility and accountability.

7.2.3. Why Component 2 is credible as a scaling mechanism

Component 2 is credible because it leverages existing regulatory instruments to translate verified hydrological benefits into sustained investment decisions. It does not depend on new legislation: tariff-based financing pathways are already supported under CRA Resolution 1032 of 2026, Article 111 of Law 99 of 1993 has been reinforced through Law 2320 of 2023 to prioritize nature-based solutions in strategic water areas, and the corporate restoration pathway under Law 2173 of 2021 has been operationalized through Resolution 1491 of 2025 (Congreso de la República de Colombia, 1993, 2021, 2023; CRA, 2026; Ministerio de Ambiente y Desarrollo Sostenible, 2025).

Its credibility also derives from its sequencing. Component 2 builds directly on the verified hydrological outcomes generated under Component 1, ensuring that investment mechanisms are tied to demonstrated performance rather than unproven assumptions. This approach aligns with the project's exit strategy, where grant financing is justified by its role in establishing self-sustaining financial flows.

Finally, the component addresses the importance of the diversification of funding sources. By combining public, tariff-based financing with private, corporate-driven investment, it reduces reliance on a single channel and creates a more resilient and scalable financial architecture. This dual pathway reflects existing institutional mandates and aligns with measurable water-resilience outcomes, providing a credible foundation for replication and scaling in the Bogotá region.

7.3. Key assumptions underpinning feasibility

The feasibility assessment is grounded in a set of explicit assumptions that have been actively considered and addressed in the design of the project, rather than treated as implicit or uncertain conditions. From the outset, the intervention has been structured to respond to these realities, ensuring that delivery is aligned with how local systems operate and how change actually unfolds in practice. This approach is important because reduces uncertainty and builds on conditions that are already understood and manageable within the project context.

For Component 1, the project assumes that landholders will adopt and sustain improved practices when incentives, technical support, and market opportunities are effectively combined, an approach that is directly embedded in the intervention strategy. It also assumes that hydrological modelling results will be progressively validated through field-level monitoring and reporting systems, which are already integrated into the VWB framework. In addition, the design recognizes that local actors, including community-managed water systems, require a minimum level of institutional support to absorb technical assistance; this is addressed through dedicated capacity-building and ongoing accompaniment.

For Component 2, the project builds on the assumption that existing regulatory frameworks remain stable and operational, providing the foundation for financing mechanisms already incorporated into the project architecture. It also assumes continued engagement from public institutions responsible for water tariffs and watershed governance, as well as a positive response from private-sector actors when presented with credible, measurable, and reportable hydrological outcomes. These conditions are not taken for granted; they are explicitly reflected in the design of governance arrangements, monitoring systems, and investment mechanisms.

Making these assumptions demonstrates that the project has been designed with a clear understanding of the institutional, behavioral, and technical factors that determine success. As a result, transformational

adaptation is framed not as an abstract ambition, but as a realistic and achievable pathway grounded in practical conditions and supported by targeted design choices.

7.5. Conclusion

The feasibility assessment shows that the proposed intervention package can be implemented under current territorial, institutional and regulatory conditions in the Bogotá Region and can deliver the intended adaptation outcomes within the project period. As presented in Figure 44, the project operates through a causal chain in which land-use and management changes under Component 1 modify hydrological processes and are measured as Volumetric Water Benefits (VWBs), while Component 2 converts those VWBs into financing decisions through tariff instruments and private mechanisms.

The analysis confirms that this causal chain is consistent with observed biophysical evidence, empirical studies in comparable Andean contexts, and the Economic and Financial Analysis, which values reduced sedimentation, improved regulation and carbon sequestration. It also shows that feasibility depends on the interaction of hydrological, territorial, institutional and financial elements: watershed interventions generate measurable VWBs, and existing regulations provide channels through which these results can inform public and private investment.

Overall, the chapter validates the project as a proof of concept for a watershed transformation model in high-Andean systems. It demonstrates that nature-based interventions can produce verifiable water-resilience benefits and that these benefits can be linked to concrete financing pathways, providing a basis for replication and scale-up of water-security investments in the Bogotá Region

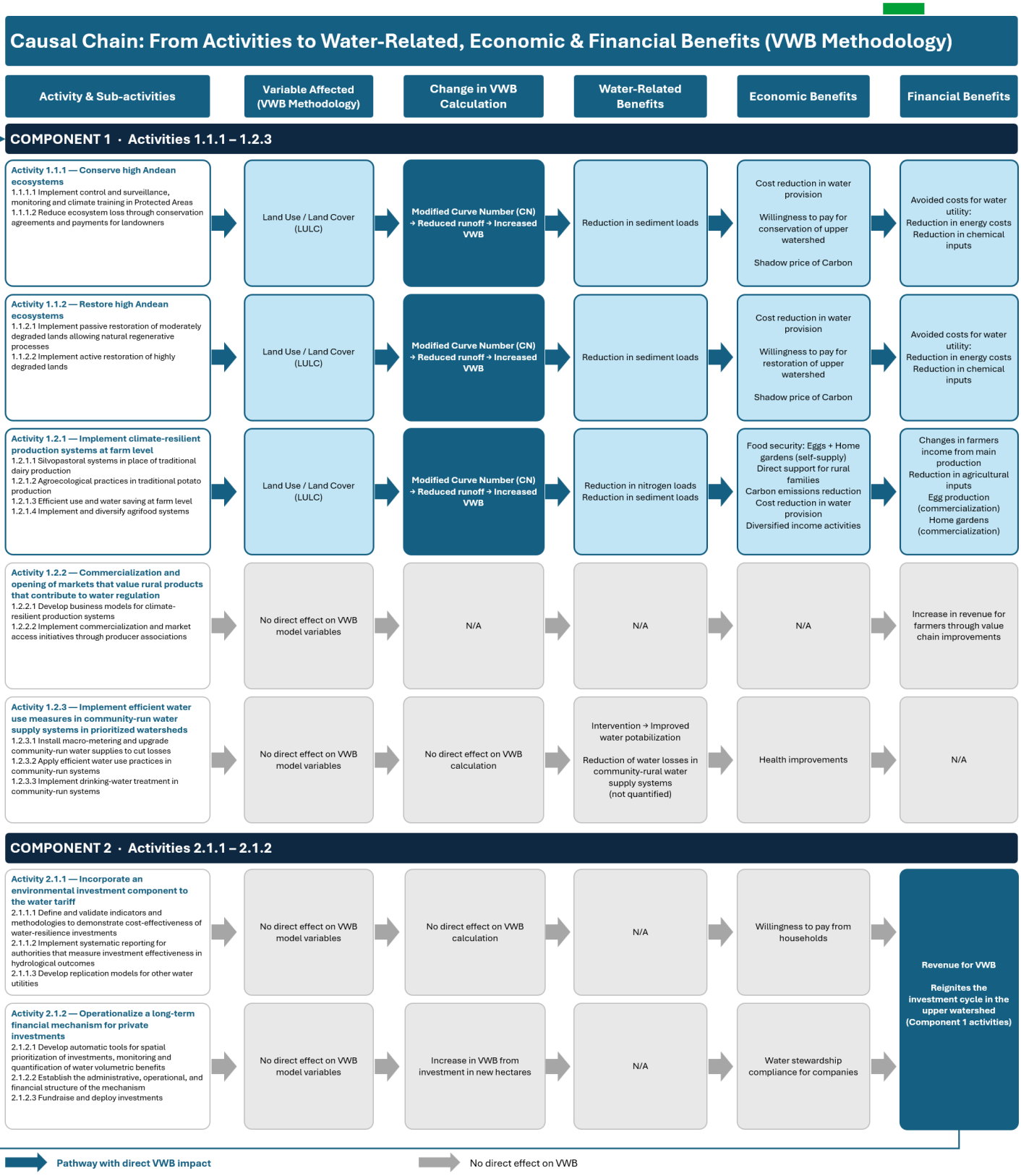


Figure 44. Causal chain from activities to water-related, economic & financial benefits (VWB Methodology).
Source: IDOM, 2026.

PART III. Project description

8. Description of activities

This chapter describes the project's activities designed to deliver integrated environmental, social, and hydrological outcomes across intervention landscapes. These activities are grounded in a coordinated, multi-level implementation approach that ensures coherence between site-specific interventions and watershed-scale impacts. The design of activities responds to the diverse ecological, institutional, and socio-economic conditions of the Bogotá Region (See Part I), while ensuring consistent application of technical, social, and monitoring standards across all project components.

The implementation responsibilities of the Executing Entities and implementing partners, together with the justification of their institutional capacities and comparative advantages for each project activity and sub-activity, are presented in Appendix I.

8.1. Outcome 1. Watershed Transformation Model proved to achieve the highest hydrological benefits

Outcome 1 focuses on generating measurable improvements in water resilience in the Bogotá Region by restoring and conserving high-Andean ecosystems and transforming productive systems at the farm and community levels. The outcome seeks to address the root causes of hydrological degradation, namely land-use change, ecosystem conversion, and unsustainable agricultural practices; by implementing integrated interventions that enhance infiltration, soil-water retention, and baseflow regulation. Through this approach, the project aims to deliver verifiable Volumetric Water Benefits (VWBs) while strengthening the adaptive capacity and livelihoods of rural communities in priority watersheds.

To achieve this, the project is structured around the following key implementation elements on the ground:

- ✓ **The coordination Team.** The operational implementation strategy is structured around a multidisciplinary coordination team within CI-Colombia. This Coordination Team comprises specialists in operations, conservation, restoration, social engagement, sustainable productive landscapes, and monitoring and evaluation (M&E). The team ensures a cohesive implementation approach across all intervention landscapes, as well as seamless articulation of activities on the ground. This includes integrated planning and implementation, spatial and biophysical data analysis, community and institutional engagement, monitoring of social, environmental, and hydrological impacts, and rigorous oversight of contracts and partnership agreements.
- ✓ **Ground Teams.** The Project will also have a multidisciplinary team on the ground for each of the intervention landscapes with guidance and supervision by the Coordination Team. The Ground Teams will lead project implementation of all activities of Component 1 at watersheds and farm levels, based on direct and trust relationships with local authorities, beneficiaries and local organizations. An additional team of Extensionists will maintain constant contact with farm landowners and families to support farm implementation activities, provide farm (landowner and family) technical support and project MRV at farm level.

- ✓ **Climate Resilient Farm Plans.** The minimum field implementation unit of the project will be the farm and beneficiaries of project ground activities will be smallholder family farms. To maximize beneficiary impact and long-term sustainability, project conservation, restoration, and climate resilient production activities will be combined on the same farms when possible. As part of the strategy, and before any intervention, a Climate Resilient Farm Plan will be formulated for each beneficiary farm following a locally led climate adaptation approach. The Farm Plan will be codesigned by CI team and each family to define production and conservation areas as well as the climate resilient strategy of the farm. Farm plans will guide the consistency and complementarity of interventions on the same farm but, most importantly, they will ensure family ownership.
- ✓ **Watershed Vision.** The project will construct a participatory watershed vision, following a locally led climate adaptation approach, for the project selected watersheds led by the project ground teams and engaging local leaders, organizations, and community. These watershed visions will define the headwaters and key riparian structure as target project conservation and restoration areas as well as priority production areas to be intervened for watershed environmental and hydrological service protection.
- ✓ **Watershed Transformation Model.** The alignment of the Climate Resilient Farm Plans with the Watershed Visions to guide conservation, restoration and climate-resilient production interventions is the key to generating verifiable hydrological results on the watershed scale. The integrality of Component 1 of the Project combines these verifiable hydrological results at watershed scale with water resilience at farm and community levels and with commercialization and market access of local products for local climate change adaptation and improvement of socioeconomic condition. As farm plans and watershed visions materialize, a sense of achievement will grow amongst families and the community encouraging them to protect the progress.
- ✓ **Payments for Conservation.** Conservation Payments and Agreements are conditional commitments for preservation of strategic ecosystems, linking economic incentives in the form of "payments for conservation" to verified actions that maintain or generate environmental services agreed under "Conservation Agreements". This instrument is particularly suitable for high mountain ecosystems where water regulation depends on preventing land use pressures that degrade páramo functioning and diminish water yield and regulation capacity.

Within this framework, **Output 1.1 Strategic High Andean ecosystems restored and conserved to yield hydrological benefits** contributes to this outcome by restoring and conserving strategic high-Andean ecosystems, including páramos, high-Andean forests, and riparian corridors, which are critical for water regulation and supply. By combining conservation measures to prevent further degradation with targeted restoration interventions in degraded areas, this output seeks to recover ecosystem functionality and stabilize hydrological processes at both the plot and watershed scales. The following activities describe how these interventions will be implemented to generate coordinated environmental and socio-economic benefits across the intervention landscapes.

8.1.1. Activity 1.1.1 Conserve high Andean ecosystems

Activity 1.1.1 will conserve 26,071 ha of native high-Andean ecosystems (páramos, high-Andean forests and riparian corridors) represent 4% of the intervention landscapes. The maintenance of these ecosystems is essential to the provision of water to downstream populations. as high-Andean ecosystems such as páramos can regulate and supply water for the majority of Andean urban centers by acting as natural water storage and regulation systems. In the project landscapes, 34% of the native ecosystems are in protected areas, and less than 1% are in private protected lands. Under each form of land tenure,

these ecosystems are threatened with conversion to other land use: multitemporal analyses in the upper Bogotá River basin show that, between 1977 and 2015, more than 40% of high Andean natural covers were transformed into agricultural, livestock and urban uses, with a marked expansion of cultivation towards the headwaters and páramo zones (Departamento Administrativo de Planeación Distrital, 2018; Correa Metrio et al., 2018).

Conservation of natural ecosystems to other land uses will result in the reduction of the watershed capacity to regulate water and retain sediments, by conserving these 26,071 has the project will also be generating an average of 0.27 ML/ha/years of VWB.

Through Activity 1.1.1 the project will implement actions to avoid the conversion of these lands and preserve these ecosystems thereby maintaining the ecohydrological functioning in the priority watersheds. Activity 1.1.1 contributes directly to the project's proof of concept under Component 1, that integrated watershed interventions, combining the conservation and restoration of strategic high-Andean ecosystems with climate-resilient productive transformation, can generate verifiable hydrological results while strengthening climate change adaptation in the supplying watersheds. Within this logic, conservation is the intervention that prevents the degradation of páramos, high-Andean forests and riparian corridors, sustaining the infiltration, soil-water retention and baseflow regulation on which downstream water security depends.

To prevent and avoid degradation of natural ecosystems, the Activity is organized into two Sub-activities that respond to different land-tenure contexts and needs where these ecosystems, people and institutions converge: Sub-activity 1.1.1.1 prevents degradation of natural ecosystems in protected areas administered by the Regional Environmental Authorities through surveillance and control of human activities inside the areas and the buffer zones, monitoring the evolution of vegetation cover within the protected area as well as the environmental conditions and climate training of the staff and communities; and Sub-activity 1.1.1.2 reduces ecosystem loss on private lands, through economic incentives, specifically, conservation agreements and payments to landowners, because in these areas conservation measures coexists with agricultural and livestock production. Sub activity 1.1.1.1 addresses the main causes of degradation inside protected areas in the region, including habitat destruction by visitors and by neighbor farmers and communities while Sub activity 1.1.1.2 addresses the threat of incorporating for agriculture the remaining forested areas in private land by providing financial incentives for conservation and supporting private conservation efforts. These differentiated interventions ensure that both regulatory and incentive-based mechanisms address the distinct drivers of ecosystem degradation across public and private lands.

This Activity addresses critical institutional, economic, and governance barriers that currently limit the effective conservation of high-Andean ecosystems. In protected areas, key gaps include limited capacity for monitoring and enforcement, insufficient resources for systematic ecological monitoring, and weak integration of surrounding communities into conservation efforts, which allow gradual degradation to persist despite formal protection status. On private lands, major barriers relate to the absence of economic incentives for conservation and the strong dependence of households on agricultural and livestock production, which drives the conversion of remaining natural ecosystems. The proposed interventions directly respond to these constraints by strengthening surveillance, monitoring systems, and institutional capacities in protected areas, while introducing financial incentives and conservation agreements that align conservation objectives with local livelihood needs in private lands.

The Activity also incorporates and mitigates the key risks identified in the ESMP, including ecosystem conversion pressures, land tenure conflicts, and potential livelihood impacts associated with land-use restrictions, by applying a participatory and voluntary agreement approach, verifying land tenure

conditions prior to intervention, and integrating monitoring systems to detect unintended land-use changes. This ensures that the Activity not only addresses the underlying drivers of ecosystem degradation but also manages social and environmental risks in line with the project's safeguards framework. The main deliverables for this activity are:

- Control and surveillance reports, monitoring reports and climate training certificates and RNCS registrations to achieve conservation of 26,071 ha.
- Conservation payments made for a minimum of 650 landowners to achieve 4,756 ha conserved.

The following paragraphs will describe each sub activity, the specific interventions, beneficiaries, deliverables, implementing partners, expected impact and indicators.

8.1.1.1. Sub-activity 1.1.1.1 Implement control and surveillance, monitoring and climate training in Protected Areas

This sub-activity will conserve 26,071 ha in existing protected areas and Civil Society Natural Reserves (RNCS) to protect ecological processes by reducing anthropogenic pressures that degrade natural ecosystems and disrupt water regulation in high mountain protected areas and their zones of influence, particularly across the Guandoqué, Villapinzón and Tominé connected landscapes. These activities will be strengthened by additional measures currently being undertaken and financed by the Regional local authorities.

The selected conservation measures included in this sub activity are:

- Control and Surveillance of visitors, agricultural practices and local communities' activities: This will consist of the adoption and implementation of the National Parks Unit Institutional Guidelines for Prevention, Surveillance, and Control (PVC) (Alvis, 2021) across these regional protected areas. Prevention measures include education and awareness for local communities and visitors, zoning and demarcation, and agreements with stakeholders in the buffer zone.
  Surveillance measures include systematic site patrols along designated routes, remote sensing monitoring, monitoring protocols for authorized activities and specific permits, and standardized reporting through the SICO-SMART digital platform. Control measures include on-site admonitions, legal actions, economic sanctions, and police interventions. Each Protected Area will adapt these guidelines to the local context and implement them accordingly.
- Training PA personnel and rangers and local communities on adaptive PA management under climate change scenarios: Climate training will transform the ability of protected area teams and local partners to interpret and operationalize climate and hydrological information for on-the-ground decisions on issues like zoning and authorized activities, definition of restauration priorities and strategies, monitoring and response for natural hazards including forest fires, and climate compatible activities in the protected areas buffer zones. This will also benefit and maximize benefit of high mountain programs in the region that are explicitly installing multiple climate and biodiversity monitoring points to inform adaptation and management in prioritized municipalities.
- Monitoring biodiversity and land cover: This will be implemented mainly through the use of satellite imagery, trap cameras, and the formation and consolidation of community monitoring groups. Biodiversity and land cover monitoring will make it possible to track the evolution of the ecological integrity of the protected area, both as a whole and within its different sections, and to assess the effectiveness of management measures. This information will guide decision-making for the management of the area, supporting the protection of ecosystems and ecosystem services, including hydrological services. Freely available satellite imagery will be used to assess

land cover change. Trap cameras will be installed in the Project's protected areas and linked to the Wildlife Insights platform, allowing for the automatic processing of the large volume of captured images and the generation of reports on identified species and individuals over time.
Local community monitoring groups will be trained in local biodiversity, safe field monitoring practices, and monitoring protocols, as well as in the use of citizen science and biodiversity platforms (eBird, Merlin, eButterfly, Wildlife Insights, iNaturalist) and Colombia's Biodiversity Information System (SiB Colombia). Community monitoring groups are highly effective at collecting data, which can be readily made available when uploaded to citizen science platforms. Community involvement in monitoring also strengthens connections with the environmental values of their territory, fostering pride and a sense of achievement. This knowledge is often further applied in support of local tourism activities.

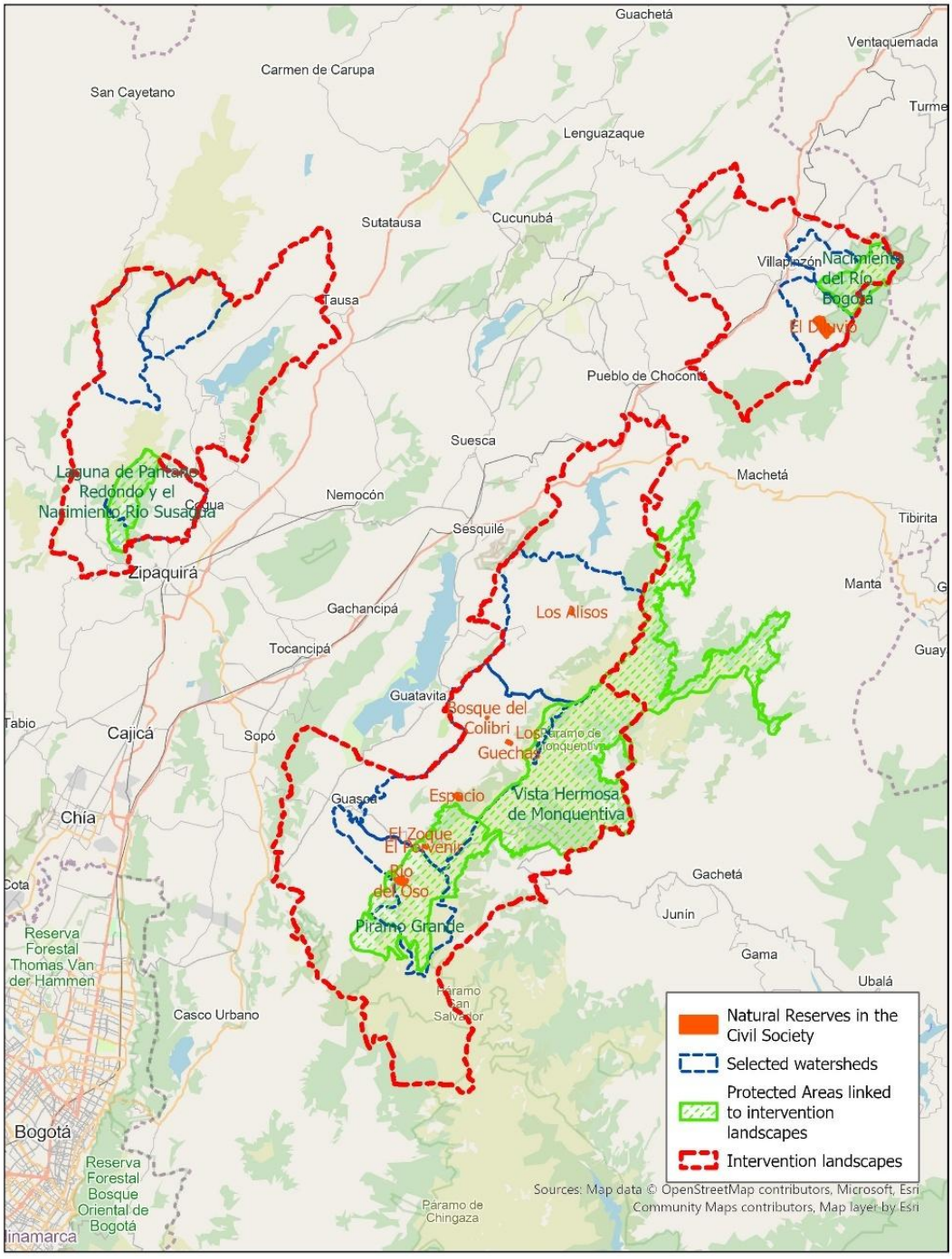
- **Declaration of new Civil Society Nature Reserves (RNSC) and enriching conservation in existing ones:** RNSC is an official category of protected area that allows private landowners to voluntarily designate part of their property for biodiversity conservation. It is the only type of private protected area that can be legally recognized as part of the National System of Protected Areas. Once declared and registered within the National System of Protected Areas, the RNSC owner commits to conservation, and the site gains a level of legal protection that restricts its use for future infrastructure development, including public infrastructure. This condition is binding and is transferred to future landowners.
  The project will promote the declaration of new RNSCs by engaging landowners in selected watersheds whose properties have high conservation value. Key candidates include landowners who have acquired farms as second homes, have an interest in nature, and are often unaware of the RNSC designation. Previous project experience shows that some of these landowners are interested in declaring RNSCs, as well as in assessing the conservation value of their land and receiving guidance on zoning, restoration, and management.
  The project will leverage this interest by supporting landowners in implementing management and restoration activities, conditional upon the formal declaration of the RNSC. Technical and legal assistance will be provided throughout the registration process. Support to existing RNSCs will focus on updating environmental zoning to better guide conservation, restoration, and monitoring interventions.

Sub-activity 1.1.1.1 will take place in 8 Regional Protected Areas and in at least 5 existing and 15 new Civil Society Natural Reserves as shown in **Error! Reference source not found.**. These are protected areas that overlap with the selected watersheds intervened by the Project. In most cases located in the headwaters of the watersheds, they are covered by paramo and high Andean Forest ecosystems in different levels of conservation and are strategic for water regulation and the provision of other hydrological services.

Table 31. Public protected areas and Civil society natural reserves under sub-activity 1.1.1.1.

Public Protected Areas (PA)	Civil Society Natural Reserves (RNSC)
Laguna de Pantano Redondo and Susagúa River Headwaters Protected Forest Reserve	RNSC El Diluvio
Páramo Grande National Protected Forest Reserve	RNSC Los Alisos
Vista Hermosa Monquentiva Regional Natural Park	RNSC El Zoque
Bogota River Headwaters Regional Protected Forest Reserve	RNSC El Porvenir
Sustainable Landscapes Peñas Blancas – Paso Colorado Corridor	RNSC Los Guechas
Sustainable Landscapes Quiba Agropark	RNSC Espacio
Sustainable Landscapes Los Soches Agropark	RNSC Bosque del Colibri
Sustainable Landscapes La Requilina – El Uval Agropark	RNSC Río del Oso

And registering 15 new Private Nature Reserves (RNSC),



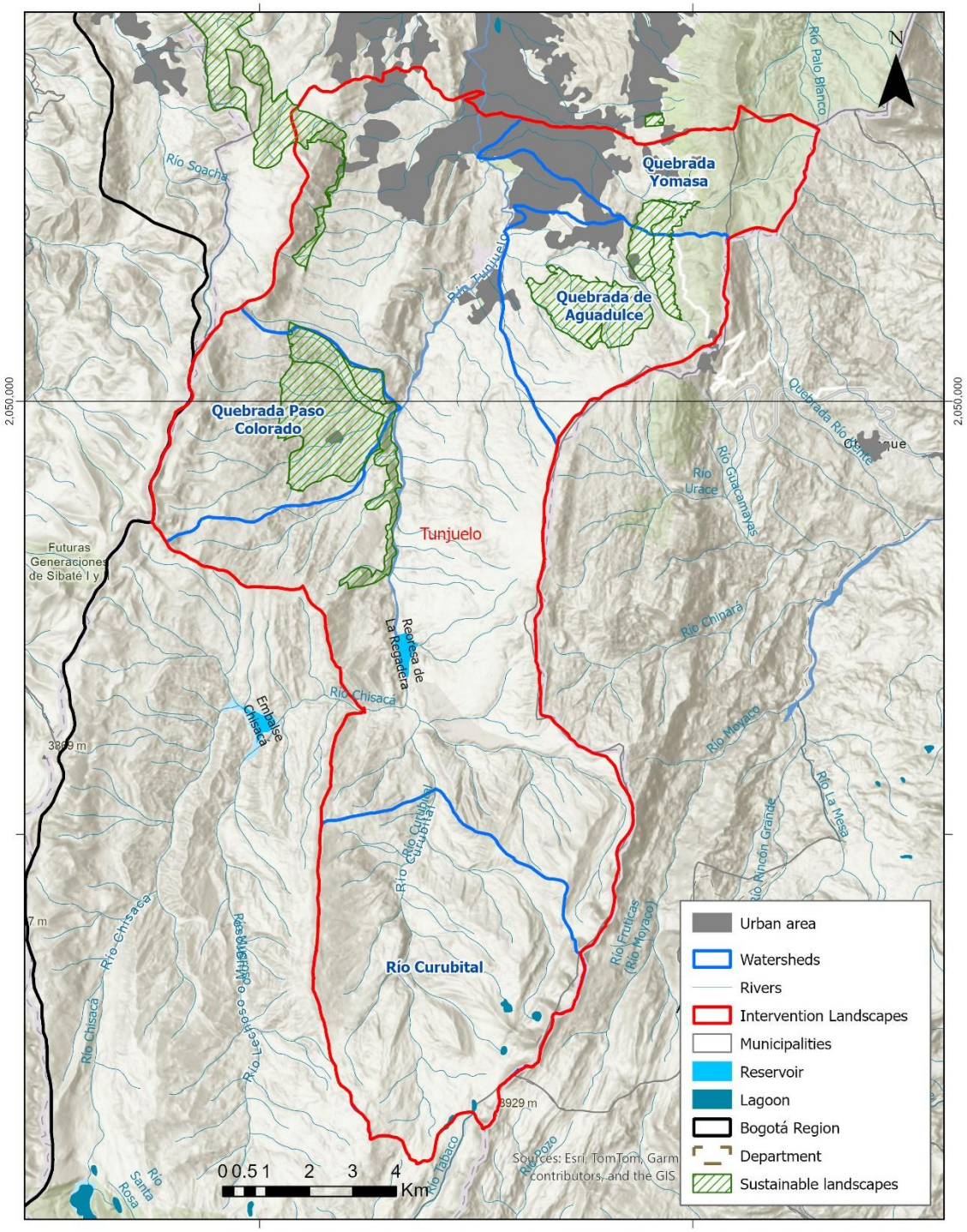


Figure 45. Protected areas and RNSC under sub-activity 1.1.1.1.
Source: IDOM, 2026.

Implementation model and partners

- CI will serve as the executing entity, leading overall coordination, technical supervision, and engagement with regional environmental authorities and local stakeholders. CI will recruit specialized technical staff and individual consultants, embedded within Project field teams and working in continuous coordination across activities.
- The Cundinamarca Regional Autonomous Corporation (CAR) and the Guavio Regional Autonomous Corporation (Corpoguavio) will co-finance and implement control, surveillance, and monitoring activities in protected areas under their jurisdiction. As legally mandated administrators of these areas, both institutions have technical teams and institutional mandates aligned with this sub-activity. Leveraging their existing structures to coordinate with territorial stakeholders and lead monitoring, control, and surveillance avoids duplication of efforts and ensures continuity beyond the project lifecycle. No GCF funds will be transferred to government entities, in line with efficiency and fiduciary prudence criteria. Public co-financing reflects strong national and regional commitment to the project.
- Alexander von Humboldt Institute (IAVH) The Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAVH) will design and deliver a training program to strengthen capacities in climate change adaptation, fire ecology and management, and socio-environmental conflict transformation. CI will formalize this partnership through a Grant Agreement (CI → IAVH). IAVH was selected based on a combination of strategic, technical, and institutional factors:
  - → It has a strong scientific and technical track record in biodiversity management
  - → It is the national authority responsible for the delimitation of páramo areas and for issuing guidelines for protected area planning and Páramo Management Plans
  - → It provides institutional legitimacy and credibility to interventions in these ecosystems

  Moreover, channeling training and capacity-building functions through a single institution capable of covering multiple thematic areas reduces fragmentation, minimizes administrative costs, and ensures coherence and quality. This approach provides a level of integrated technical capacity that would be difficult to achieve through multiple individual consultancies.
- Protected Area management teams, park rangers will support the day-to-day implementation of conservation, control, and surveillance activities.
- Participants include:

  - → Protected area management teams, park rangers, engaged in training and monitoring across four protected areas
  - → Civil Society Natural Reserves (RNSC) owners and networks, implementing biodiversity monitoring, receiving management advisory support, and strengthening ecological connectivity
  - → Local communities and community-based organizations, participating in training, monitoring, governance processes, and socio-environmental conflict transformation in surrounding landscapes

Implementation times[8]

Year 1 – Start-up

- Recruitment of technical staff and GIS expert
- Subgrant agreement signed with IAVH
- Diagnostic studies on stakeholders, governance, and conflicts
- Initial coordination workshop to define institutional agreements

[8] For administrative purposes, Year 1 (6 months effective) is for project start up and Year 6 (6 months effective) is for project close out. For further details see Annex 5. Implementation timetable

- Design of NOOC and training materials

Year 2 – Capacity Building and System Deployment

Humbolt Institute, with support from CI Colombia will delivery 37 thematic workshops (~20 participants each) and one NOOC and stablish biodiversity monitoring systems in four protected areas and participating RNSC. Monitoring systems will be implemented in coordination with SDA, CAR, and Corpoguavio to define work plans and protocols. CI will building capacity of community-based participatory monitoring networks and support integration of data into specialized information platforms.

Years 3–4 Consolidation

- Operation and strengthening monitoring systems and networks
- Reinforcement of local governance
- Advancement of socio-environmental conflict transformation processes

Year 5 – Closure technical activities

- Final monitoring cycles
- Systematization of results and lessons learned
- Evaluation and closure workshops
- Definition of sustainability and continuity pathways with partners

Year 6 – administrative closure

To deliver this activity, the acquisition of monitoring equipment is necessary to evaluate the effectiveness of conservation actions and to support adaptive management of protected areas. Tools such as camera traps, GPS devices, photographic cameras, and biodiversity monitoring equipment will generate information on ecosystem status, changes in vegetation cover, and the presence of indicator species, providing evidence to verify the environmental results of the project. In addition, these instruments will provide capacity to community monitoring groups and will serve decision-making.

Deliverables

Control and surveillance reports, monitoring reports and climate training certificates and RNCS registrations to achieve conservation of 26,071 ha.

8.1.1.2. Sub-activity 1.1.1.2 Reduce ecosystem loss in private land through conservation agreements and payments for landowners

This sub-activity will protect 4,756 has in private land through providing payments for conservation to an estimated 650 landowners in priority watersheds linked to Conservation agreements, In exchange for making specific conservation commitments to protect natural standing forest or recently stablished restauration in their lands landowners will receive an agreed annual payment upon verification of commitments. Considering that most private land in the Project area belongs to vulnerable smallholder families, the remaining natural covered area and recently established restauration is always at risk of

deforestation to increase productive land. Through this economic incentive the project will reduce the pressure for ecosystem loss by aligning lands stewardship with ecohydrological outcomes[9].

As long-term sustainability strategy, the project will have the policy that landowners that allocate land for conservation and/or restoration should also be candidates for productive reconversion to increase the productivity of their land, family income and food security in order to secure family income and wellbeing on the productive section of the farm and not dependent on payments for conservation. This incentive then conceived as a transitional measure until sustainable production practices is stabilized, and commercialization and market access to rural products takes off and provided additional and stable income to farmers (Activity 1.2).

Since investments in conservation and restoration require protection, maintenance and monitoring over some years to maximize long term success, past CI projects show that the most cost-effective approach is through the involvement of the landowners in these activities. Consequently, the payment for conservation incentive will also include the commitment of the landowners to provide support in conservation, maintenance and monitoring activities. Conservation of standing forest agreements may request complementary activities by the landowner, like control of invasive species and replacement of foreign species to enhance conservation.

Conservation agreements of recently established restoration may request complementary maintenance activities by the landowner including caring for young plants, weeding, alerting project staff about dead plants in need of replacement or damages in protective fencing that need repair. In all cases, landowners may also be requested to support monitoring such as support in caring for hydroclimatic or biodiversity monitoring equipment that might be in their land and even collecting data. These tasks incentivize long term land stewardship practices that directly enhance water regulation, reduce sediment loads, and sustain ecosystem services critical for downstream water users (García, et al., 2021).To maximize efficiency and reduce transaction costs, the maintenance of restoration is considered as a conservation treatment and included in the same Conservation Agreement.

Through voluntary Conservation Agreements, beneficiary landowners commit to the following tasks:

- Maintain existing forest cover and avoid land-use change.
- Conduct regular monitoring of standing forest conditions.
- Implement sustainable forest management practices, including the control competing vegetation, establishment of vegetated riparian buffers, and the maintenance of live fences and multifunctional landscape elements.
- Support vegetation establishment through appropriate irrigation and water management when required.
- Monitor plant health and growth and replace trees or seedlings that do not survive.
- Implement and maintain agreed conservation and restoration actions specific for their plot.
- Avoid activities causing environmental degradation.
- Support in the operation of monitoring equipment that might be operating in their land

In addition, landowners must:

- Allow access to the property for monitoring and verification.

[9] Under Colombia's Payments for Conservation framework, agreements formalize conditional commitments for preservation of strategic ecosystems, linking incentive delivery to verified actions that maintain or generate environmental services. This instrument is particularly suitable for high mountain ecosystems where water regulation depends on preventing land use pressures that degrade páramo functioning and diminish water yield and regulation capacity.

- Report any situation affecting compliance.
- Maintain investments, works, and interventions carried out under the Project.

Conservation Agreements and Payments will follow the conditionality principle; whereby conservation payments are made upon verified compliance with agreed commitments. The Agreements clearly specify:

- Incentive value
- Payment modality
- Disbursement schedule
- Conditions for each disbursement
- Responsibilities of the landowner
- Verification mechanisms prior to payment

The incentive will be offered over a three-year period, which is considered sufficient for the supported interventions to become self-sustaining. To participate in the Payment for Conservation scheme, landowners must meet a set of eligibility criteria. These include demonstrating a clear willingness to commit to conservation actions, actively participating in complementary project activities, and formally signing conservation agreements. In addition, participation requires compliance with security screening procedures and verified land tenure rights. Priority will be given to properties located in headwater areas and key riparian zones within the selected watersheds, given their strategic importance for water regulation. In line with the project's commitment to advancing gender equality, at least 30 percent of the incentive budget will be allocated to actions identified as priorities by women, as further detailed in the Gender Action Plan (GAP).

To guide prioritization, a common vision of the watersheds, identifying the target conservation and restoration areas for watershed environmental and hydrological service protection will be used. It will be built through a participatory process with local leaders, organizations, and community, guided by scientific knowledge and led by the project team on the ground. This process will generate local ownership in the process and the adoption of common goals contributing to long term sustainability.

During project preparation, a spatial analysis identified priority plots for conservation and restoration within the selected watersheds (see Chapter 4), establishing the initial pool of candidate areas for Conservation Agreements and Payments for Conservation. Based on this prioritization, an estimated

4,756 hectares have been defined as the target area for intervention under this instrument, as detailed in the section on the prioritization of intervention landscapes and watersheds.

Selected watersheds	Potential FC (ha)
Río Guandoque	1,216
Río Salitre	902
Río Susagua	821
Quebrada Quincha	1,697
Rio Bogota Pte Alta	1,992
Río Aves	3,968
Río Chipata	2,356
Río San Francisco	4,280
Río Curubital	2,217
Quebrada Yomasa	208
Quebrada de Aguadulce	511
Quebrada Paso Colorado	1,374
Total general	**21,542**

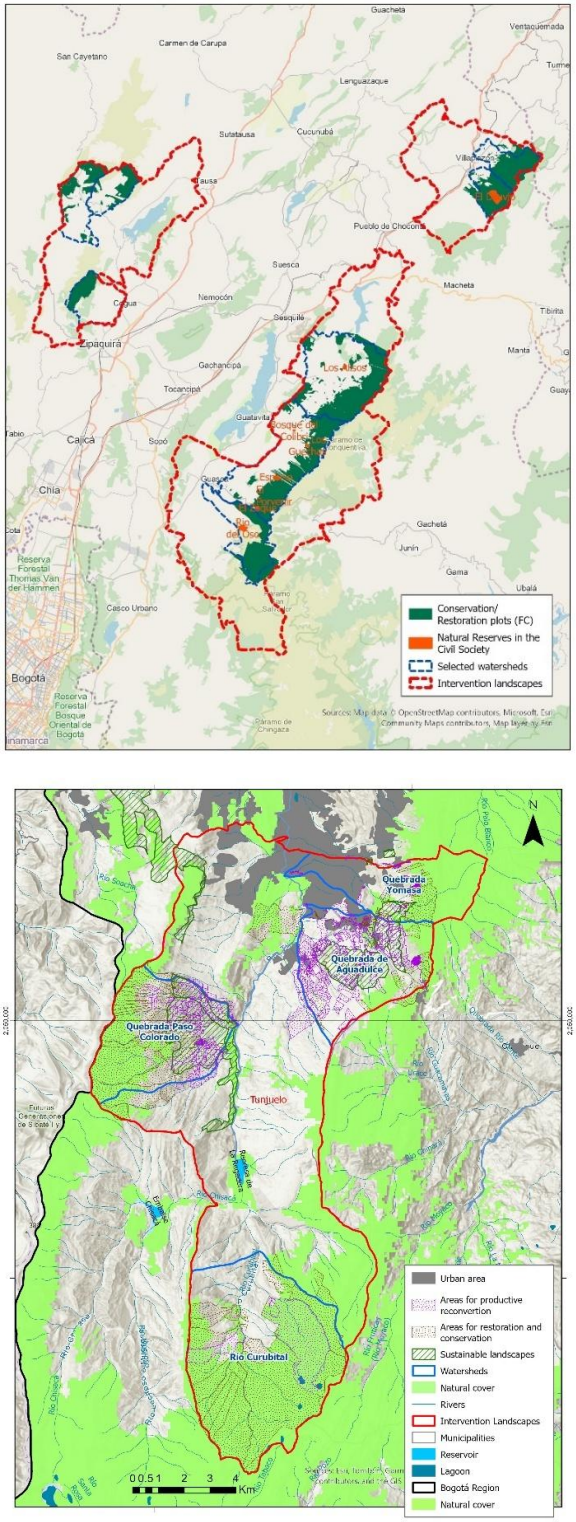


Figure 46. Potential areas for conservation agreements and payments for landowners under sub-activities 1.1.1.2 (Intervention area 1,2, 3 up and 4 down).

Source: IDOM, 2026 with data from Conservation International.

Implementation Model and Partners

Under the sub activity 1.1.1.2. the conservation agreements and payments to private landowners led by Fondo Acción and supported by CI-Colombia through a division of labor that leverages the experience of each and avoids redundant structures which is explain below and in Table 32. **No GCF funds will be used to finance Payments for Conservation, rather all incentives will come from cofinancing sources from the SDA, EAAB and the Government of Cundinamarca.**

The implementation of Conservation Agreements and Payments for Conservation is supported through a co-financing structure in which the economic incentives are fully funded by public entities, while the project provides enabling support to facilitate access and effective implementation. The District Secretariat of Environment (SDA), the Government of Cundinamarca, and the Bogotá Water Utility (EAAB) will provide the financial resources for the Payments for Conservation. The SDA and the Government of Cundinamarca will disburse incentives directly to landowners, while EAAB will channel additional resources through CI-Colombia to complement payments. No GCF funding will be used to finance the economic incentives themselves; instead, GCF resources will support the operational, technical, and institutional conditions required for landowners to access and sustain these benefits, including outreach, eligibility verification, agreement structuring, and monitoring.

Fondo Acción, as Executing Entity, will lead this activity to ensure coherence of payments for conservation in the territory coming from different sources of public funding and its additionality to the rest of activities under outputs 1.1 and 1.2. In addition, FA is responsible for verifying the legal backing of beneficiaries' land tenure rights, a prerequisite for accessing conservation incentives. Additionally, FA will be responsible of integrating and tracking progress against project targets. This role builds on its demonstrated experience in land tenure verification processes and ensures that payments are implemented in a transparent, efficient, and legally compliant manner.

Complementing this structure, **CI-Colombia,** also acting as an Executing Entity, is responsible for the operational implementation of the Payment for Conservation scheme with resources coming from the EAAB, including the management of open calls based on predefined eligibility criteria, the formalization of conservation agreements, defining commitments and performance-based disbursement conditions, and ongoing monitoring. Prior to any payment, CI-Colombia's field teams issue binding technical assessments to verify, validate, and confirm the feasibility of compliance by beneficiaries. These assessments serve as a prerequisite for disbursements and are followed by continuous monitoring to ensure that subsequent payments are triggered based on verified performance. Through this role, the project provides the technical, legal, and fiduciary backbone of the scheme, ensuring that public disbursements are properly substantiated while enhancing the efficiency, transparency, and effectiveness of conservation payments in contributing to the project's proof of concept.

This model generates additional operational efficiencies, as the calls for proposals, farm selection, and agreement processes are shared across conservation (Activity 1.1.1), restoration (Activity 1.1.2), and productive transformation (Activity 1.2.1) activities. As a result, applications, selection, and contracting are conducted once per landowner for the full set of interventions on their property, avoiding duplication and reducing transaction costs. In this integrated approach, Climate-Resilient Farm Agreements remain the primary instrument for farm-level planning and productive transformation, guiding the implementation of conservation, restoration, and livelihood measures in a coordinated manner. The same field teams promote and support the establishment of Civil Society Nature Reserves under Sub-activity 1.1.1.1, ensuring alignment between conservation objectives and farm-level interventions.

The implementation approach for this activity is described below:

Table 32. Implementation approach for sub-activity 1.1.1.2.

Process phase	#	Key activities	SDA	EAAB	GOVT. OF CUNDINAMARCA
Preparation	1	Identify intervention areas in watersheds	CI-Colombia/ SDA	CI-Colombia/EAAB	CI-Col/GC
	2	Outreach, call for applications & engagement	CI-Colombia	CI-Colombia	GC
Assessment	3	Screen land tenure and security	Fondo Acción	Fondo Acción	GC
	4	Visit properties	CI-Colombia	CI-Colombia	
	5	Develop Farm Plan	Ci-Colombia	Ci-Colombia	
Agreement	6	Define actions and payments	CI-Colombia	CI-Colombia	GC
	7	Negotiate conservation agreements in a voluntary way (following steps outlined in the ESMP)			
	8	Formalize agreements	SDA	CI-Colombia	GC
Implementation	9	Implement agreements	CI-Colombia	CI-Colombia	GC
	10	Disburse funds	SDA	CI-Colombia	GC
Tehcnical and financial monitoring	11	Monitor technical results	CI-Colombia	CI-Colombia	GC
	12	Systematization of Info. on Areas (Payments for Conservation)	Fondo Acción	Fondo Acción	Fondo Acción
	13	Close agreements	CI-Colombia / SDA	CI-Colombia / EAAB	GC

Source: IDOM, 2026.

The Payment for Conservation process is implemented through a structured, five-phase cycle that ensures participatory planning, robust eligibility verification, transparent agreement formalization, effective implementation, and continuous monitoring. The process begins with the participatory development of a Watershed Vision for each selected watershed, which identifies priority areas and strategic actions for conservation, restoration, and climate-resilient production. Following this foundation, the process advances through sequential phases (Figure 47):

1. Preparation Intervention areas in watersheds are identified, and outreach activities are conducted to engage potential participants. This includes cartographic analysis, prioritization of target zones, delineation of micro-watersheds, and diagnostic assessments using GIS tools (ArcGIS, QGIS).
2. Assessment Land tenure and security are screened, properties are visited, and farm management plans are developed. Potential plots are identified within prioritized micro-watersheds, and owners, possessors, or occupants submit documentation to validate legal status and eligibility for PES agreements.
3. Agreement Conservation actions and incentive values are defined in line with the national normative, considering opportunity costs of local productive activities.

Voluntary agreements are negotiated and formalized through written contracts specifying property details, incentive value and modality, commitments, responsibilities, duration, and termination clauses.

4. Implementation Agreements are executed with technical assistance, training, and environmental awareness activities to ensure effective conservation actions and strengthen sustainable production practices. Incentive payments are disbursed in accordance with institutional regulations.
5. Monitoring Results are monitored through regular field visits and verification of compliance with conservation commitments. Monitoring goes beyond compliance checks, generating data to evaluate the effectiveness of interventions in maintaining or improving ecosystem services (e.g., water regulation). Information is systematized in PES platforms, and agreements are formally closed once commitments are fulfilled.

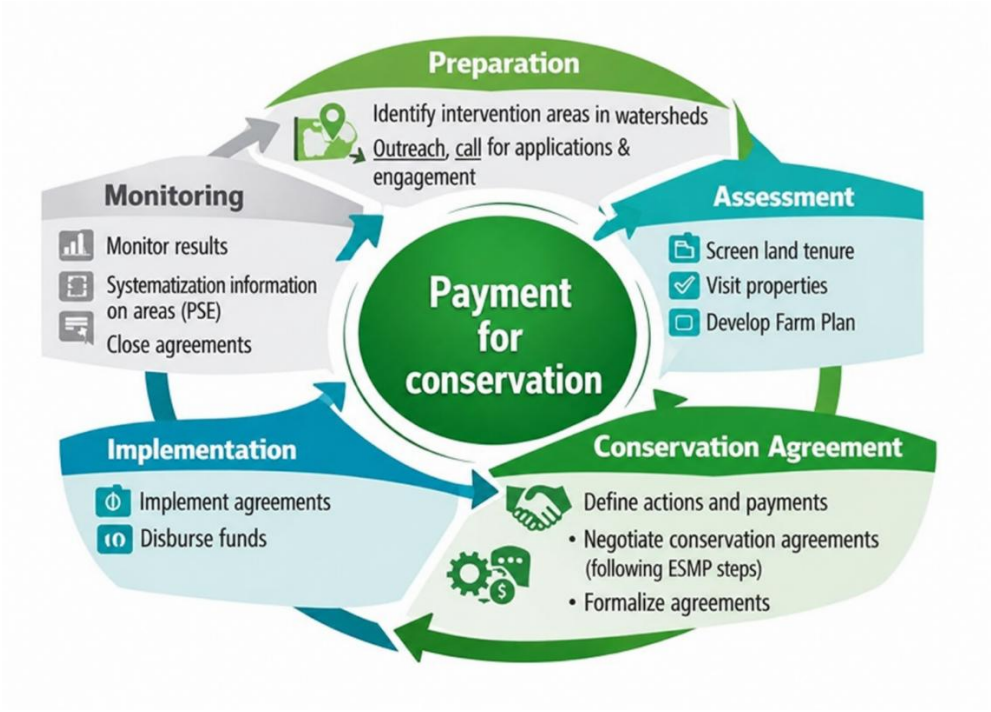


Figure 47. Payment for conservation process.
Source: IDOM, 2026.

Deliverables

Conservation payments made for a minimum of 650 landowners. This sub-activity will preserve 4,756 hectares through Payments for Conservation, verified through Conservation Agreements and final compliance reports. Of this area, 2,724 hectares correspond to standing forests and 2,032 hectares to recently restored ecosystems, ensuring continuity between conservation and restoration efforts. The resulting hydrological benefits, expressed as avoided runoff and improved water regulation, are consistent with the Volumetric Water Benefits (VWB) methodology and assumptions described in Chapter 7, which demonstrates how maintaining vegetation cover enhances infiltration, soil-water retention, and baseflow stability while reducing sediment and agrochemical transport.

Sustainability is reinforced through the selection of institutional partners with long-term mandates over ecosystem management, including CAR, CORPOGUAVIO, and SDA, which anchor interventions within existing public frameworks and ensure continuity beyond the project lifecycle (See Table 33). At the local level, the integration of conservation, restoration, and productive transformation within Climate-Resilient Farm Plans strengthens household ownership and long-term commitment, supported by complementary activities on livelihood diversification and market access that enhance income stability and reinforce conservation incentives. Operationally, the model maximizes efficiency by streamlining field implementation through a single delivery structure, direct disbursement of incentives by public entities, and targeted use of GCF resources for enabling functions only. This integrated approach ensures cost-effectiveness, institutionalization, and scalability, demonstrating a replicable model that generates verified hydrological outcomes and supports long-term financing mechanisms under Component 2.

Table 33. Institutional Partners and Contribution to Sustainability.

Institution	Mandate and Role	Contribution to Sustainability	Post-Project Continuity Mechanism
CAR (Corporación Autónoma Regional)	Regional environmental authority responsible for ecosystem management, protected areas, and watershed regulation	Ensures alignment with regional environmental policies and technical standards; integrates project interventions into official environmental management frameworks	Long-term institutional mandate over watershed management and conservation; continued allocation of public resources and staff
CORPOGUAVIO	Regional environmental authority overseeing ecosystems in its jurisdiction, including high-Andean landscapes and water sources	Strengthens local implementation capacity; ensures interventions are embedded in territorial planning and environmental governance instruments	Permanent institutional presence and regulatory authority ensure replication and scaling of interventions beyond the project
SDA (District Secretariat of Environment)	Environmental authority for Bogotá with responsibilities in conservation, restoration, and PES implementation	Anchors Payment for Conservation within existing public programs; ensures consistency with district-level policies and integration into water and environmental planning	Ongoing PES schemes and public funding streams linked to Bogotá's water system ensure continuity of incentives and conservation actions
IAvH (Instituto Alexander von Humboldt)	National authority providing scientific guidance on biodiversity, páramo delimitation, and ecosystem management	Provides technical credibility and alignment with national standards; guides ecosystem prioritization and intervention approaches	National-level mandate and technical leadership ensure long-term consistency and legitimacy of conservation and restoration strategies

8.1.2. Activity 1.1.2 Restore high Andean ecosystems

Activity 1.1.2 will restore 2,032 ha of native high-Andean ecosystems (páramos, high-Andean forests and riparian corridors) represent 4% of the project landscapes with these ecosystems. These ecosystems exhibit a high-water yield and strong water regulation under low disturbance, while degraded conditions diminish hydrological functioning and service reliability. Through Activity 1.1.2, the project will recover and rehabilitate these lands, thus, reestablishing hydrological functions of capturing, storing, and

gradually releasing water to contribute to a stable supply for downstream communities and ecosystems overtime. In turn, increasing climate resilience and water security for the City of Bogota and the Region.

Project activities under Component 1 are expected to generate measurable VWBs while also improving water quality by reducing sediment and nutrient loads at the watershed scale. Based on the Sediment Delivery Ratio modelled for the project's interventions, the intervention package is associated with an estimated 1,084,600.6 tons of avoided sediment export, equivalent to an average reduction of 30% across all the prioritized basins. In parallel, the Nutrient Delivery Ratio model indicates reductions of 147,214.04 tons of total nitrogen export and 193,315.22 tons of phosphorus export, equivalent to approximately 33% and 53.2%, respectively, when comparing baseline and intervention scenarios. These results confirm that the project not only improves hydrological regulation, through enhanced infiltration, soil-water retention, and reduced runoff, but also significantly limits the transport of sediments, nutrients, and agrochemicals into downstream water bodies. This combined effect on water quantity and quality strengthens the hydrological proof of concept and underpins the project's strategy for scaling and long-term financing based on verifiable ecosystem service outcomes.

Under the same logic as activity 1.1.1., Activity 1.1.2 contributes directly to the project's proof of concept under Component 1. Restoration is the intervention that recovers and rehabilitates areas of páramos, high-Andean forests and riparian corridors that have been already impacted by land use changes and unsustainable productive activities and that require dedicated treatments to reestablishing the infiltration, soil-water retention and baseflow regulation on which downstream water security depends. These treatments will slowly recover hydrological benefits over time.

Ecosystem restoration actions will combine passive and active restoration approaches tailored to the degree of ecosystem degradation, fostering natural regeneration processes, through interventions that stabilize soils, recover infiltration, moisture-retention processes, and reduce erosive losses that undermine baseflow regulation. Sub activity 1.1.2.1 Passive restoration will focus on natural regeneration in moderately degraded páramo slopes, high Andean and grasslands, through grazing exclusion and area isolation. Sub activity 1.1.2.2 Active restoration will target severely degraded sites through the planting of native species, soil stabilization works, and the recovery of degraded areas using different treatments such as high-density revegetation designed to enhance infiltration, reduce runoff, and restore ecological functions (García, et al., 2021).

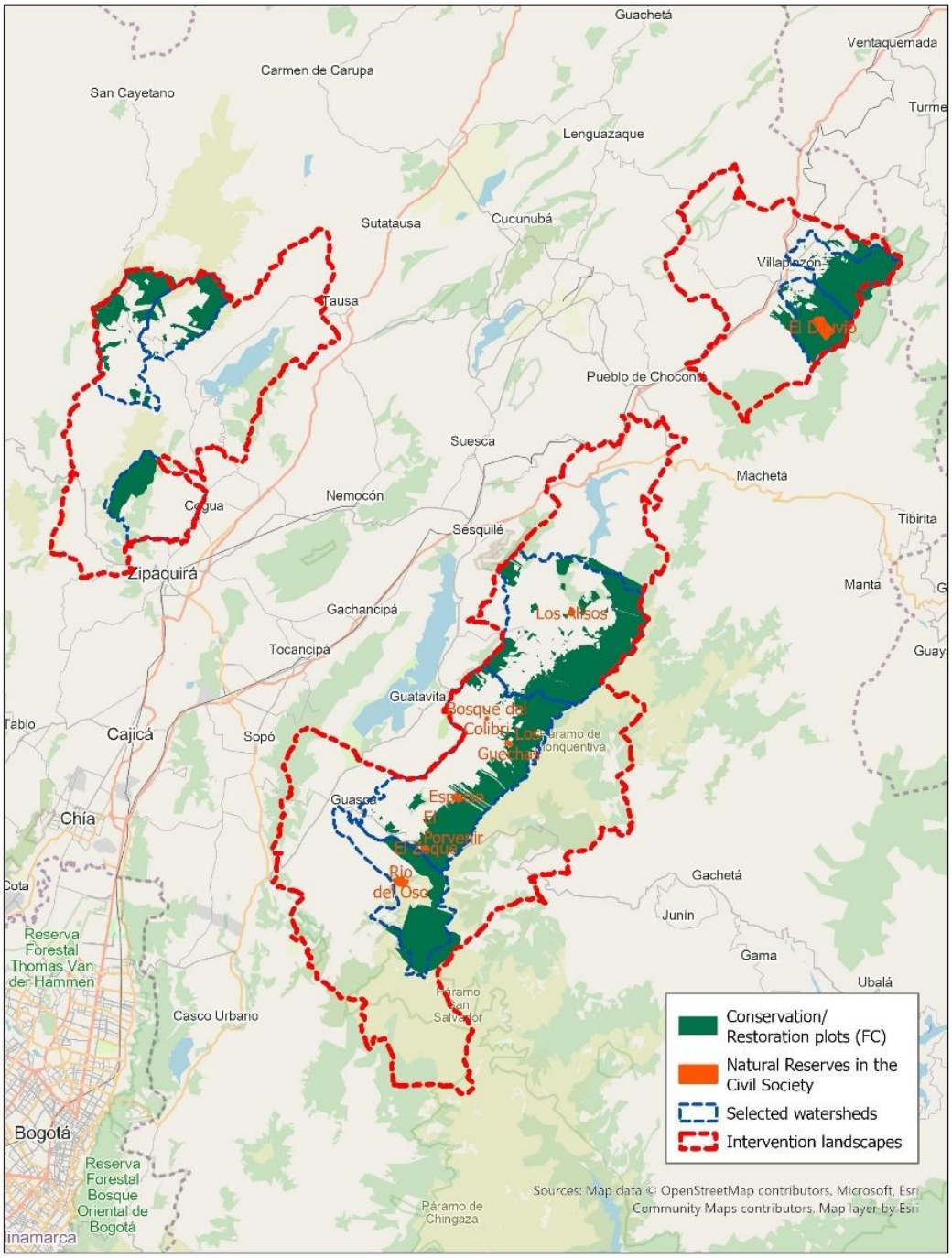
One of the risks associated with the restoration activities in highly sensitive ecosystems such as paramos, is the vulnerability of restoration efforts to extreme weather events, such the "El Niño" and "La Niña" phenomenon, and natural disasters associated with extreme weather events (draught, wildfires, landslides, floods, etc.). The project has identified this risk through its ESIA/ESMP and has developed mitigation measures, such as support to fire brigades, assessment and planning of the restoration activities considering accurate weather predictions, and in cases where extreme weather events partially affect restoration efforts, a small disaster risk management fund.

As with conservation, restoration is carried out in the two land-tenure contexts of the watersheds, private lands and public lands administered by the Regional Environmental Authorities. Implementation will select key sites and landowners across public and private lands using predefined criteria that connect hydrological relevance (headwaters, wetlands, riparian buffers, and reservoir-influence zones) with feasibility of stewardship and long-term compliance (see Chapter 4).

During project preparation, a spatial prioritization exercise identified plots with high restoration potential within the selected watersheds (see Section 4.2), establishing the initial pool of candidate areas for intervention. Based on this analysis, an estimated 2,032 hectares have been defined as the restoration

target. Figure 48 shows the potential areas for active and passive restoration under sub-activities 1.1.2.1 and 1.1.2.2.

To guide prioritization of specific intervention sites, the common vision of the of the watershed will identifying the target conservation and restoration areas for watershed environmental and hydrological service protection will be used.



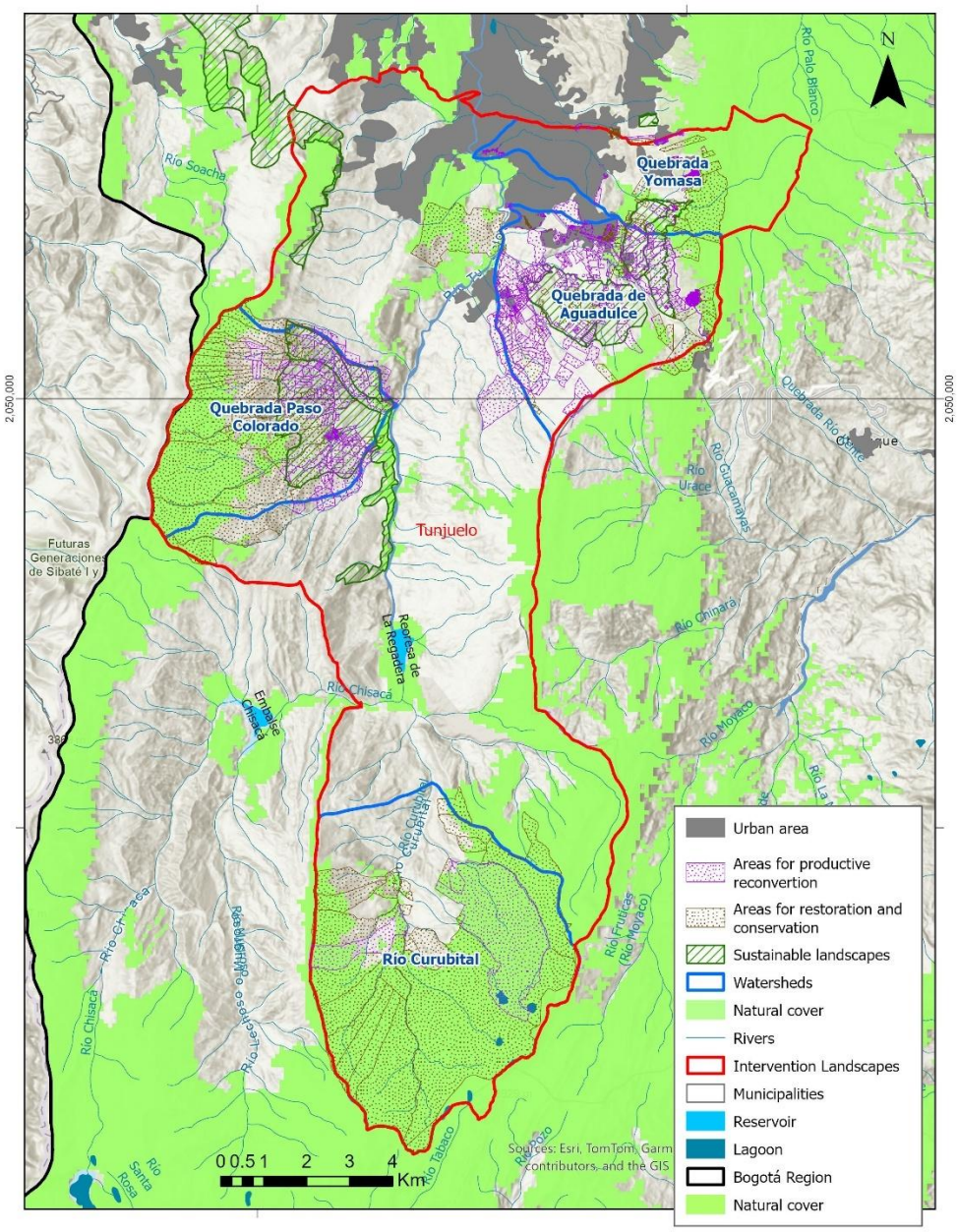


Figure 48. Potential areas for active and passive restoration under sub-activities 1.1.2.1 and 1.1.2.2 (Intervention area 1,2, 3 up and 4 down).
Source: IDOM, 2026.

Implementation model and partners

CI will centralize planning, technical design, supervision, and monitoring within a single technical team, while delegating field implementation to local social organizations through grants and service provider contracts. This approach avoids requiring each partner to replicate processes, thereby reducing duplication and overall costs. GCF resources are strategically reserved for elements essential to reaching

local organizations and landowners, who will sustain project results beyond the GCF funding period. This model ensures both cost-efficiency and long-term impact.

Resolving technical design through a single team ensures rigor, consistency across landscapes, and efficient use of CI-Colombia's in-house restoration expertise. It also substantially reduces transaction costs.

The CI-Colombia team will be headed by a coordinator and supported by consultants leading restoration activities in each landscape, thematic specialist on botanic, monitoring and hydrology. This team will conduct, in a standardized manner across all landscapes: context analysis of each site, assessment of degradation levels, evaluation of regeneration potential and appropriate treatments, definition of restoration objectives at watershed and property scales, specification of input, plant material, and equipment needs.

Local implementation will be supported by 25 extension agents residing in project municipalities. These agents assist landowners in both restoration and productive reconversion activities. Extension agents serve as focal points in project territories, providing technical, social, and operational support to local social organizations. Key activities of extension agents include managing technical visits to prioritized plots, identifying and motivating potential beneficiaries, supporting socio-economic characterization and farm plan preparation, assisting in the consolidation of documents for voluntary agreements, facilitating logistics for delivery and monitoring of inputs, supporting training and community outreach events. This complementary structure ensures that social organizations lead implementation in the field, while extension agents provide the technical backbone needed to guarantee effective, participatory, and sustainable outcomes.

This approach:

- Reduces travel and logistical costs
- Strengthens trust with landowners
- Builds locally embedded capacity that persists beyond project completion
- Avoids duplication, as the same extension agents support Activity 1.2.1

Local Social Organizations will undertake restoration works (e.g., site preparation, planting, fertilization). These organizations (8 in total) will be selected through an open call for proposals with predefined criteria and sign a grant agreement with CI (CI-Colombia → social organizations). Organizations must have operational presence and capacity to implement restoration activities in at least one of the 4 intervention landscapes. Mandatory security screenings will be conducted for all candidate organizations and beneficiaries. Further details on criteria are provided in Annex 26 (Grants Manual). This model strengthens social fabric and local ownership and enhances transparency in resource allocation. Each selected organization will receive the property-level restoration plan (including intervention areas, treatment types, maintenance tasks, and technical guidance) prepared by CI-Colombia, which will guide implementation.

To improve efficiency, the terms of reference, calls for proposals, evaluation, and contracting processes will be conducted once per landscape. The same local organizations, under the same call for proposals, will undertake field under activities 1.1.1 and 1.2.1.

Plant material will be supplied through contracts with local community nurseries, ensuring availability and quality of native species, reduced procurement costs and generation of local income. These nurseries will supply planting material for both restoration and productive transformation activities.

Restoration areas will undergo three years of maintenance, including tree replacement and enclosure upkeep, to consolidate initial investments and ensure lasting results.

AB InBev, Coca-Cola and EAAB will provide additional resources through co-financing agreements with CI-Colombia (flow: co-financiers → CI-Colombia) to scale restoration efforts.

SDA will execute its co-financing directly through an open procurement process, contracting an organization to implement the restoration associated to its co-financing, with no GCF fund transfers. CI-Colombia will coordinate with SDA to ensure that restoration occurs on project-selected properties. Maintenance of SDA-financed restoration will be covered by CI-Colombia using GCF resources to maximize restoration success. Co-financing resources ensure that the project reaches sufficient scale to reverse current degradation trends and generate measurable improvements in hydrological functions.

Restoration areas on private land will receive payments for conservation (PSE) for three years. Restoration within protected areas will be coordinated by Environmental Authorities.

Participants include:

- Local social organizations implementing restoration activities
- Landowners receiving technical support and implementing restoration plans

This structure strengthens local ownership, builds installed capacity, and supports continuity beyond the project.

The implementation approach for this activity is described below:

Process phase	#	Key Activities	Restoration - SDA	Restoration – EAAB, AB InBev/Coca Cola
Preparation	1	Identify intervention areas in watersheds	CI-Colombia/ SDA	CI-Colombia/EAAB
	2	Outreach, call for landowners' applications & engagement	CI-Colombia/SDA	CI-Colombia
Assessment	3	Screen land tenure and security	Fondo Acción	CI-Colombia
	4	Visit properties	CI-Colombia	
	5	Selection of Restoration Plots and definition of restoration approaches	Ci-Colombia/SDA	
Restoration Procurement Process	6	Call for proposals, evaluation and, contracting	SDA	
Implementation	7	Selection of local organizations for restoration support		CI-Colombia
	8	Disburse funds	SDA	CI-Colombia
Monitoring	9	Monitor results	CI-Colombia	CI-Colombia
	10	Systematization of Info. On Project restored Areas	CI-Colombia	CI-Colombia

Phases of the Restoration Process

The restoration process follows a structured sequence, beginning with the participatory development of a Watershed Vision for each of the twelve selected watershed. This process identifies key challenges, opportunities, and priority areas for adaptation, conservation, restoration, and sustainable production, providing the territorial framework that guides all subsequent field interventions. Following this foundation, the process unfolds through five phases.

1. Preparation: Following the construction of the watershed visions, a more detailed multi-criteria cartographic analysis is conducted at the watershed level, evaluating vegetation cover, ecosystems, and management strategy groupings (conservation, ecological restoration, and productive conversion). Potential areas within priority micro-watersheds are identified based on landscape metrics such as ecological connectivity, water supply areas, priority ecosystems, and areas included in key ecological structure layers. A call for participation and outreach to landowners is conducted, explaining the approaches, strategies, and models designed for areas included in voluntary conservation agreements within conservation and ecological restoration areas. A single call for proposals is launched to implement jointly activities 1.1.2 and 1.2.1.

2. Assessment: Legal requirements regarding land tenure and security are examined; a technical visit is conducted to potential areas using a methodology that includes property characterization, cartographic delimitation, and visits to vegetation cover monitoring points, identifying constraints, limitations, the presence of exotic or invasive species, and logistical requirements for the proposed models. The potential for natural regeneration and the natural regeneration index are evaluated in control plots located in ecologically representative areas, based on multi-criteria analyses. The approach, strategy, and intervention model are defined for each prioritized area.
3. Contracting for the Co-Implementation of Ecological Restoration Actions: The contracting process for implementation actions within the SDA's jurisdiction is carried out through a public call for proposals, based on the agency's administrative procedures. CI Colombia carries out this process in accordance with its procurement policies, developing terms of reference for implementation by community associations under a partnership agreement, which includes a matching contribution from the associations.
4. Implementation: The implementation process will utilize planning and monitoring tools for each intervention area, including the approach, strategy, models, goals, materials, responsible parties, and timelines. It will also include digital applications for data collection and action tracking (SMART). Community associations or contractors will receive technical protocols for installing insulation, landscape management tools, planting design templates based on strategy, ecosystems, and vegetation cover, as well as templates for calculating labor, soil amendments, and establishment logistics. Planting will include soil amendment packages based on the soil analysis conducted during the assessment phase, which includes water-retaining agents in areas with water deficits, organic fertilizers, lime, and macronutrients. The plant material to be used comes from ICA-certified nurseries and is selected according to high standards. The planting period is determined based on climate analyses to reduce the risk of drought. In subpáramo or páramo areas with rodent activity, protective netting will be installed around seedling clusters in areas undergoing active restoration.

5. Monitoring: The monitoring protocol includes training professional and technical teams in the establishment of permanent plots and the measurement of dendrometric data. CI Colombia will provide them with pre-formatted databases and forms in KOBO for collecting information in the field. Variables in active restoration approaches include survival, phytosanitary status, dendrometric measurements of diameter and height growth, and subsequent calculations of biomass and carbon accumulation by species. In areas under assisted natural regeneration approaches (passive restoration), protocols include measuring natural regeneration indices, monitoring landscape management tools (perches and refuges), and tracking changes in edaphic variables based on soil samples. The monitoring and verification protocols report indicator results on dashboards that include the unit, monitoring frequency, and method used.

Implementation Timeline[10]

Year 1 – Preparation

- Establishment of the technical restoration team.
- Signing of cooperation agreements with SDA, EAAB, Coca-Cola, and AB InBev to support actions in prioritized micro-watersheds.
- Multicriteria Cartographic Analysis at the Landscape and Micro-Watershed Levels
- Identification of Potential Areas in Priority Micro-Watersheds Based on Landscape Metrics

Year 2 – Planning

Development of implementation protocols based on approaches, strategies, and models
- Training of the technical team and extension agents.
- Ecological assessment of areas based on criteria of ecological and statistical representativeness

- Development of species models based on functional groups, ecosystems, and implementation strategies Project launch with local stakeholders.
- Development of the Watershed Vision Plan, including identification of degraded areas and properties to be restored.
- Formulation of Climate Resilient Farm Agreements.
- Design of the restoration monitoring system.

Signing of partnership agreements with communities and a public call for certified nurseries located within the project's ecosystem range Years 3–4 – Implementation

- Validation of target areas by community associations
- Signing of voluntary agreements with beneficiaries, including a work schedule
- Transportation of materials, supplies, and seedlings to collection points or implementation areas
- Physical isolation of areas with stressors
- Planting of vegetation

Preparation of monitoring reports by micro-watershed. Year 5 – Monitoring

- Consolidation of monitoring reports.
- Completion of maintenance activities.
- Preparation of the final restoration report, including results and lessons learned.

Year 6 – Administrative Closure

[10] For administrative purposes, Year 1 (6 months effective) is for project start up and Year 6 (6 months effective) is for project close out.

When the restoration process described above reaches the implementation phase, the definition of the appropriate restoration approach for each selected restoration site will determine which sites are addressed with passive restoration under Sub-activities 1.1.2.1 or with active restoration under Sub-activity 1.1.2.2, both sub-activities described below:

8.1.2.1. Sub-activity 1.1.2.1 Implement passive restoration of moderately degraded lands allowing natural regenerative processes

This activity will recover and rehabilitate approximately 1,422 ha through passive restoration techniques in moderately degraded sites where the recovery of ecohydrological functioning can be driven primarily by natural regeneration once pressures are removed and access is managed.

Passive restoration is usually a combination of the isolation of the area with complementary treatments. The area is demarcated, and protective fencing is installed when needed to prevent livestock access or other economic activities in the area. Representative interventions are:

- Fencing for natural regeneration: Construction of barriers to exclude livestock and protect native vegetation remnants, enabling natural recovery processes
  Complementary treatments help accelerate the speed and the diversity of species present in the restoration and are selected depending on the particularities of each site. Alternatives of complementary treatments include:
- Bird and bat Perches: Simple structures placed in degraded areas that provide resting points for birds and bats, enhancing seed dispersal in open disturbed zones.
- Mammal Shelters: Brushwood or log piles established in degraded areas to substitute for the absence of natural shelters caused by habitat transformation. Over time, these structures decompose and enrich the soil.
  Fog Traps: Shade-mesh panels extended over posts at approximately 2 m height, designed to capture water particles from fog. The collected water drains by gravity into a channel and is used to moisten soil under restoration treatment.

<u>Deliverables and impact</u>

Restoration plans and monitoring reports to achieve 2032 ha restored.

8.1.2.2. Sub-activity 1.1.2.2 Implement active restoration of highly degraded lands

This activity will restore approximately 610 hectares of native high-Andean ecosystems in highly degraded areas where natural regeneration processes are insufficient, and where targeted interventions are required to re-establish vegetation structure, recover ecosystem functionality, and stabilize soils.

Active restoration will be prioritized in erosion-prone or heavily transformed patches that compromise headwater integrity and sediment-related impacts on downstream systems. Interventions will be designed to rebuild hydrological regulation capacity by restoring native plant cover and enhancing infiltration and water-retention conditions where disturbance has severely altered the soil–vegetation system (Wouter, Iñiguez, & De Biévre, 2007). Active restoration will incorporate complementary nature-based measures such as the establishment of multi-strata live fences, vegetated windbreaks, artificial perches, and soil bioengineering structures (e.g., drainage channels, erosion control barriers) to accelerate ecosystem

recovery, enhance connectivity, and improve microclimatic and hydrological conditions at the plot and micro-watershed levels (García, et al., 2021).

Representative restoration techniques include:

- **Enrichment of remnant native vegetation:** Planting additional native species into existing patches of natural vegetation. By increasing plant diversity and density, it enhances canopy cover and root systems, which improve soil structure, increase water infiltration, reduce surface runoff, and support groundwater recharge.
- **Establishment of multifunctional buffer strips:** These are deliberately planted strips of vegetation, typically along waterways, field edges, or slopes. They slow water flow, trap sediments, and filter pollutants while their roots improve soil porosity. This helps reduce erosion, enhance infiltration, regulate streamflow, and maintain water quality.
- **Installation of live fences (tree lines):** Live fences are rows of trees or shrubs planted along property boundaries or across landscapes. They act as vegetative barriers that reduce wind and water runoff, promote water infiltration through improved soil structure, and help retain soil moisture, contributing to more stable hydrological conditions.
- **Installation of artificial bird perches:** These are simple structures placed in degraded areas to attract birds that disperse seeds. As vegetation regenerates around the perches, increasing plant cover and root systems improve soil stability, enhance infiltration, reduce runoff, and gradually restore water regulation functions.

Deliverables and impact

Restoration plans implemented and monitoring reports to achieve 2032 ha restored.

8.1.3. Activity 1.2.1 Implement climate-resilient production systems at farmer level

Activity 1.2.1 will transform 2,409 hectares of productive land into sustainable production systems that improve infiltration, soil-water retention, and drought buffering at the plot and farm scale. Productive land currently represents a significant share of the intervention landscapes, with a large proportion dedicated to extensive cattle grazing and potato cultivation, which are associated with soil compaction and degradation after decades of intensive use. These practices have reduced infiltration capacity and increased surface runoff, contributing to declining hydrological performance across the watersheds.

The selected interventions are designed to reverse these trends by restoring soil structure, increasing vegetative cover, and improving water regulation functions. As a result, the activity will generate 888,325 cubic meters of VWBs, reflecting improved infiltration, reduced runoff, and enhanced water availability during dry periods, while also contributing to reduced erosion and sediment transport.

This activity will focus on implementing farm-level interventions that combine productivity with improved hydrological performance. Most farms in the Project areas belong to smallholder vulnerable families which depend economically on the production of the farm to a large degree if not fully. The set of interventions selected for each sub-activity was designed considering the vulnerability and economic fragility of the beneficiaries as well as its water-resilience and adaptation potential at the farm level. Interventions in each

farm will respond to a farm plan design with the participation of all the family members which will define productive and conservation areas of the plot as well as food security, living areas, all farms will have a defined use and this activity will contribute to the implementation of the farm plan. Through sub activity 1.2.1.1, CI will work with smallholders to transform traditional dairy production into silvopastoral systems, sub-activity 1.2.1.2 focuses on implementing agroecological practices in small plots of traditional potato productions systems. Sub activity 1.2.1.3 focuses on Implement efficient water use and management at farm level aiming at increasing water security while reducing water waste and water losses at farm level and sub activity 1.2.1.4 will deliver diversify agrifood systems. In combination, these interventions are designed to improve resilience and productivity within the farms while recovering the infiltration capacity of the soil, reducing runoff controlling erosion, reducing sediments and agrochemical contamination of water thus contributing both to the resilience and socioeconomical wellbeing of the farmers and increasing water resilience downstream.

To be eligible for this activity, landowners must comply with the following criteria: Landowners need to express the willingness to commit to transform at least one hectare of its productive land, formulate a climate resilient farm plan led by the Project´s ground team and with the participation of the family, get involved in complementary activities and signing an agreement (Climate resilient farm agreement); security screening and documented land tenure rights is also a requirement. Please refer to Annex 26. Grants Manual for more information on eligibility criteria.

As in the previous activities, the Watershed Visions will guide all activities of the Project. This process will generate local ownership in the process and the adoption of common goals contributing to long term sustainability.

The project will implement sub-activities across at least 1,248 farms distributed throughout the twelve selected watersheds. Selected farms will transform at least one hectare of their productive land, in average two hectares per farm. All farms will have a farm plan and will be part of activities 1.2.1.3 and 1.2.1.4 to improve water management and resilience as well as diversify agrifood systems and food security. In total, at least 1,248 farms and families will have increased water resilience, food security and climate-resilient sustainable productive systems, resulting in an estimated number of 9,984 ha under sustainable management practices at the end of the project (considering an average farm size of 8ha). In addition, within the 1,248 farms at least 2,409 ha of land will be transformed into silvopastoral systems and sustainable potato production increasing soil permeability with a direct contribution to reduction of water runoff.

The multi-criteria prioritization indicates that some watersheds contain a higher concentration of plots suitable for this activity. However, implementation will cover all selected watersheds, as they are characterized by smallholder production systems where productive areas are present across farms.

To maximize impact and efficiency, farms selected under Activities 1.1.1 and 1.1.2 will, where feasible, also be included in Activity 1.2.1, ensuring that the productive component of the same farm is addressed alongside conservation and restoration. This integrated approach enhances productivity, income stability, and climate resilience, reducing reliance on conservation payments by strengthening alternative, sustainable sources of livelihood within the farm system.

Table 34. Areas prioritized as suitable for activity 1.2.1.

Selected watersheds	Potential focus on production FP (ha)
Río Guandoque	176

Río Salitre	0
Río Susagua	1,327
Quebrada Quincha	0
Rio Bogota Pte Alta	126
Río Aves	654
Río Chipata	0
Río San Francisco	1,147
Río Curubital	598
Quebrada Yomasa	35
Quebrada Aguadulce	588
Quebrada Paso Colorado	412
Total general	**5,063**

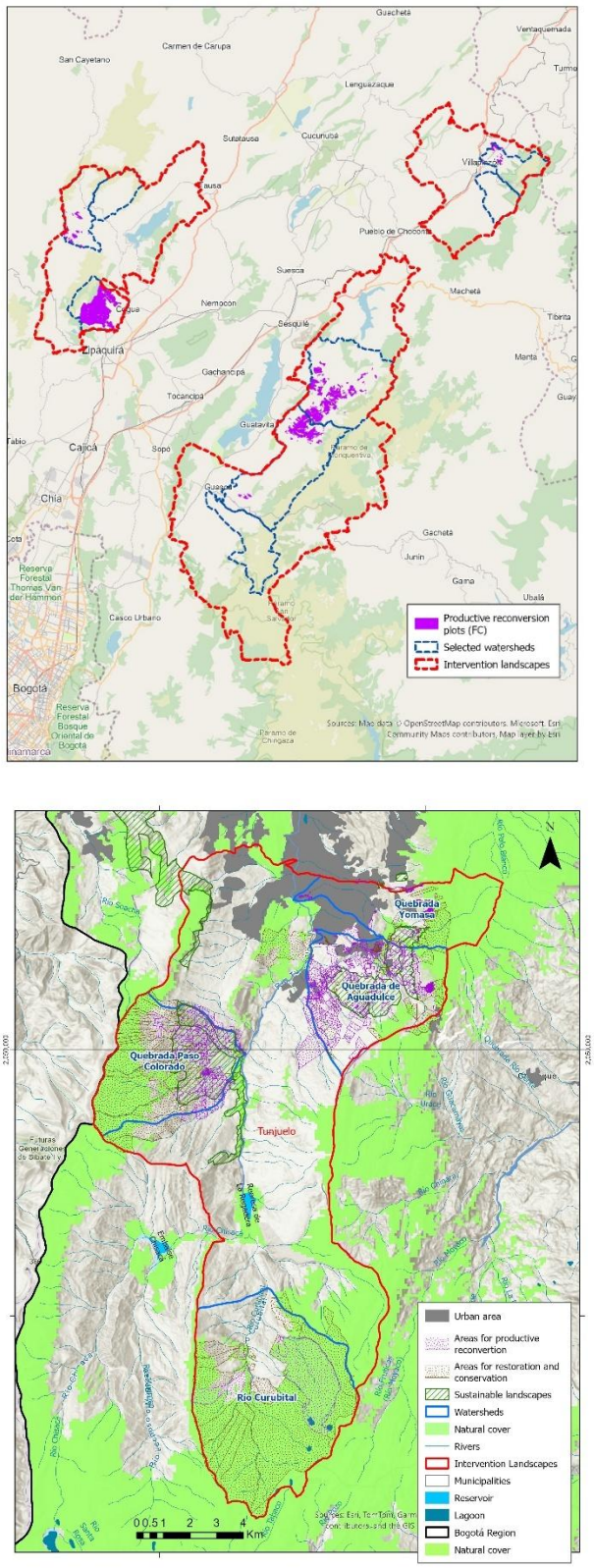


Figure 49. Areas under Activity 1.2.1 (FP).
Source: IDOM, 2026.

Activity 1.2.1 directly addresses the planning, regulatory, and market-and-livelihood barriers identified in Chapter 3 of the feasibility analysis, particularly Section 3.1.2. As described in that chapter, water demand already exceeds sustainable supply in a substantial share of the territory, while prevailing land uses remain poorly aligned with hydrological sustainability. This mismatch is driven by conventional dairy and potato systems that contribute to soil compaction, erosion, sediment transport, and agrochemical contamination in the watersheds supplying Bogotá. By transforming 2,409 ha of productive land currently dominated by cattle pasture and potato production into silvopastoral systems, agroecological potato plots, efficient on-farm water management, and diversified agrifood systems, the activity addresses these underlying pressures and improves infiltration, soil-water retention, and runoff regulation.

The activity also responds to the implementation-capacity gap identified in the feasibility analysis, namely limited technical knowledge among producers and weak organizational capacity at farm level. This is addressed through the Climate-Resilient Farm Plan methodology, sustained technical assistance from the ground teams, and family-level participatory planning. At the same time, the activity helps overcome the market and livelihood barriers that keep smallholders locked into low-productivity and climate-vulnerable systems, even where more sustainable alternatives exist. By linking farm-level transformation with improved productivity, income stability, and the commercialization support provided under Activity 1.2.2, the project makes climate-resilient land use economically viable and reduces the risk that sustainable practices are perceived as an additional burden on vulnerable rural households.

Phases of the transformation productive Process

First, the participatory construction of the Watershed Vision for each of the twelve selected watersheds to identify key challenges, opportunities, and priorities for adaptation, conservation, and sustainable production in each watershed is developed before conservation, restoration and climate resilient production activities take place.

Phase 1. Preparation

Priority intervention areas within the target watersheds are identified based on the watershed visions and following a more detailed environmental and hydrological criteria to select production areas with the highest impact to hydrological services. For each intervention landscape, a dedicated technical team is established to ensure territorial coordination, engagement with local stakeholders, and technical support. The Project conducts outreach activities with communities and local institutions to present its objectives, promote beneficiary participation, and lay the foundations for participatory and transparent implementation. Finally, a call for applications is opened.

Phase 2. Assessment

Beneficiary farms are selected through a voluntary expression of interest and verification of eligibility criteria, , The Climate Resilient Farm Plan is formulated for each selected farm integrating the environmental and productive zoning of the property, characterization of production systems, assessment of climate resilience, and definition of adaptation and productive transformation measures.

Phase 3. Climate Resilient Farm Agreement

Based on the results of the Farm Plan, conservation, restoration, and productive transformation measures are jointly defined, along with the supplies, materials, and equipment required for their implementation. Participation by families is entirely voluntary. The agreed commitments are formalized through the signing of Climate Resilient Farm Agreements, which establish the responsibilities of the parties, the actions to

be undertaken, and the expected results in terms of climate resilience, productive sustainability, monitoring and conservation of natural resources.

Phase 4. Implementation

The measures defined under the Climate Resilient Farm Agreements are implemented with technical assistance from CI-Colombia and by local social organizations. Interventions include sustainable agricultural and livestock practices, agroforestry and silvopastoral systems, water-efficient management measures. These investments aim to strengthen the climate resilience of rural families, improve watershed water regulation, and promote sustainable livelihoods.

Phase 5. Monitoring

Progress of the interventions is assessed through climate resilience and sustainability indicators defined during farm-level planning. Monitoring verifies the implementation of agreed measures, evaluates their environmental, productive, and climate adaptation outcomes, and documents the progress achieved by participating families. The results form the basis for the formal closure of agreements and for evaluating the sustainability of the implemented actions.

The implementation of the activity is as follows:

Process Phase	#	Key Activities	GCF funding	EAAB	Coca-Cola	ABInBev
Preparation	1	Identify intervention areas in watersheds	CI-Colombia	CI-Colombia /EAAB	CI-Col / CC	Ci-Col/ABI
	2	Outreach, call for applications & engagement	CI-Colombia	CI-Colombia	CI-Colombia	CI-Colombia
Assessment	3	Screen land tenure and security	CI-Colombia	CI-Colombia	CI-Colombia	CI-Colombia
	4	Visit properties				
	5	Develop the watershed's vision and farm Plan				
Resilient-Climate Farm agreement	6	Assess supply and equipment needs.	CI-Colombia	CI-Colombia	CI-Colombia	CI-Colombia
	7	Negotiate Climate Resilient Farm agreements in a voluntary way				
	8	Formalize agreements				
Implementation	9	Implement agreements	CI-Colombia SO/BEN	CI-Colombia SO/BEN	CI-Colombia SO/BEN	CI-Colombia SO/BEN
	10	Signing of In-Kind Grants	CI-Colombia/BEN	CI-Colombia/BEN	CI-Colombia/BEN	CI-Colombia/BEN
Monitoring	11	Monitor results	CI-Colombia	CI-Colombia	CI-Colombia	CI-Colombia

	12	Close Agreement	CI-Colombia	CI-Colombia	CI-Colombia	CI-Colombia

Legend: CI-Colombia = Conservation International Colombia. SO = Local social organizations. BEN = Beneficiaries / Landowners. EAAB = Bogotá Water and Sewerage Company.CC = Coca-Cola. ABI = AB InBev. SDA = Bogotá Environmental Secretariat



Figure 50. Productive Transformation Process.

Source: IDOM, 2026.

Ecohydrological Modeling, in the prioritized micro-watersheds for impact assessment and calibration of modeling parameters

Runoff plots will be installed across all land-use types so that differences in runoff generation mechanisms can be characterized due to differences in land cover, slope, soil compaction, and management. Standardized runoff plots will be placed within each land-use type ensures that measurements reflect this heterogeneity and that estimated avoided or reduced runoff is representative at the landscape scale.

Runoff plots provide controlled, comparable measurements by isolating specific land-use responses to the same rainfall inputs. Rainfall and plot-level runoff will be measured simultaneously to enable direct calculation of runoff coefficients and event-based reductions attributable to land management. Runoff plots will be distributed strategically across land-use types and conditions to generate robust datasets to validate estimates, inform scaling assumptions, and support credible aggregation of runoff reduction benefits at the watershed scale.

Reliable discharge data are essential for calibrating a hydrological model because models must reproduce observed streamflow magnitude, timing, and variability to be credible. Calibration uses observed discharge to adjust model parameters (e.g., soil storage, runoff generation, routing) so simulated flows match reality across low, average, and high-flow conditions. Without discharge data, models may fit precipitation or evapotranspiration patterns but still produce biased flows, leading to large uncertainties in water balance estimates, flood risk, and ecological flow assessments.

Continuous discharge data will be collected to calibrate the hydrological model against full hydrographs, which improves parameter identifiability, and supports independent validation periods—critical for confidence in model predictions under changing climate or land use. Continuous discharge data will be collected using pressure transducers across all 8 prioritized micro-watersheds. A pressure transducer

(water level logger) will be installed in a stable stream cross-section to record water level (stage) at regular intervals (e.g., 5–15 minutes). Periodic manual discharge measurements will be taken across a range of flow conditions using a current meter or acoustic device. These paired stage–discharge measurements will be used to develop a rating curve that converts continuous stage records into continuous discharge.

Validation of estimations of volumetric water benefits

Field data are critical to validating estimates of avoided and reduced runoff because model–based estimates rely on assumptions about soils, vegetation, management practices, and rainfall–runoff processes. Without field measurements, reductions attributed to interventions (e.g., restoration, improved land management) cannot be confidently distinguished from natural variability in rainfall or antecedent conditions. Empirical runoff data provides an objective benchmark to test whether estimated changes are realistic, defensible, and attributable to the intervention rather than model bias or parameter uncertainty.

Collecting field data strengthens credibility and comparability by capturing real-world hydrologic responses across events and seasons. Continuous or event-based runoff measurements allow validation across different magnitudes of rainfall, antecedent moisture states, and land-use conditions, improving confidence in reported outcomes for reporting, financing, and adaptive management. Field validation also helps refine models, reduce uncertainty bounds, and support transparent claims of impact.

Implementation model and partners

As stated above CI Colombia will have coordinated teams on the ground that will lead the implementation of the Project activities, this activity in particular will have a coordinator supported by a consultant in each of the intervention landscapes. The coordinator will work closely with the coordinators of the other activities while in each intervention landscape consultants will also work closely and support each other. Local implementation will be supported by the extension agents residing in project municipalities. These agents assist landowners in both restoration and productive reconversion activities.

All interventions of this activity will be developed within the framework of the Climate Resilient Farm Plans, which serve as the farm level planning instrument to identify vulnerabilities, adaptation opportunities, and priority measures for productive transformation, conservation and restoration. These plans will be formulated following the methodology developed by CI-Colombia during the GEF project[11] that creates an open space and has specific strategies to assure the participation of all members of the familiy. Farm Plans will allow to define which elements of sub-activities 1.2.1.1, 1.2.1.2, 1.2.1.3, 1.2.1.4 will be implemented in each selected farm and consequently be included in the Climate resilient farm agreements to be signed by beneficiaries.

Implementation will focus on priority dairy and potato production systems within the Guandoqué–Villapinzón–Tominé–Tunjuelo intervention landscapes. The same local social organizations engaged under Activity 1.1.2 will implement this activity through grant agreements with CI-Colombia, following a delivery model structured as CI-Colombia → local organizations, supported by continuous technical assistance from the project team.

[11] "Conservation and Sustainable Use of Biodiversity in High Mountain Ecosystems of the Colombian Andes (Páramos)", implemented with support from the Global Environment Facility (GEF), the Government of Colombia, and partners including Conservation International Colombia.

Using the same organizations streamlines calls and selection processes across restoration and productive transformation activities, reducing costs while strengthening local ownership. These organizations will submit periodic technical and financial reports, and all transfers of goods and inputs to beneficiaries will be documented through delivery records, ensuring traceability and fiduciary control.

Measurement and modeling of hydrological impacts—the core of the project's proof of concept—will be implemented through a coordinated technical structure. CI Colombia's hydrology and GIS team will model watershed-scale effects using the SWAT model, calibrated with monitoring data, while the Freshwater team will calculate Volumetric Water Benefits (VWBs) at farm, watershed, and project levels. This integrated approach ensures rigorous quantification of runoff reduction and attribution of results across interventions.

In terms of financial flows, GCF resources will finance productive transformation actions through local organizations and the contracting of specialized monitoring services, while hydrology, GIS, and freshwater functions operate within CI Colombia's institutional structure. Private co-financing will support restoration and production activities, with VWBs calculated to ensure transparency and attribution of results. This arrangement mobilizes additional resources without creating parallel systems and directs investments toward demonstrating the project's proof of concept.

Overall, the implementation model maximizes impact at low cost by relying on a single coordinated team, shared partnerships, and integrated planning under a common watershed vision. Activity 1.2.1 serves as a key convergence point between productive transformation and hydrological monitoring, generating the evidence required to demonstrate that integrated land-use interventions improve water regulation and availability. These results underpin the development of long-term financing mechanisms under Component 2 and support the scaling of the project model.

Local Social Organizations. These organizations (8 in total) will be selected through an open call for proposals with predefined criteria and sign a grant agreement with CI (CI-Colombia → social organizations). Organizations must have operational presence and capacity to implement xx activities in at least one of the 4 intervention landscapes. Mandatory security screenings will be conducted for all candidate organizations and beneficiaries. Further details on criteria are provided in Annex 26 (Grants Manual). This model strengthens social fabric and local ownership and enhances transparency in resource allocation. Each selected organization will receive technical guidance prepared by CI-Colombia, which will guide implementation.

To improve efficiency, the preparation of terms of reference, calls for proposals, evaluation, and contracting processes will be carried out once per intervention landscape. Under a single call for proposals, the same local organizations will implement activities across conservation and productive transformation (Activities 1.1.1 and 1.2.1), streamlining engagement and avoiding duplication of selection processes. Detailed eligibility criteria and selection procedures for these organizations are provided in Annex 26 (Grants Manual). Materials, inputs, and equipment required for implementation will be supplied in accordance with project procurement procedures and fiduciary control standards.

AB InBev, Coca-Cola and EAAB will provide additional resources through co-financing agreements with CI-Colombia (flow: co-financiers → CI-Colombia).

Implementation Timeline[12]

Year 1 – Preparation

- Recruitment of the farm-level water management coordination team and the field team for on-farm water management.

Year 2 – Assessment and Resilient-Climate Farm Agreement

- Training of the farm-level climate-resilient production systems team and local extension agents.
- Project launch with local stakeholders.
- Initiation of workshops to develop Watershed Visions.
- Design of a farm-level water management monitoring system.
- Launch of a Call for Proposals for Community Organizations to implement Climate Resilient Farm Agreements in collaboration with landowners.
- Signing of Climate Resilient Farm Agreements at the farm level between CI and landowners.
- Award of grants to Community Organizations to implement Climate Resilient Farm Agreements in collaboration with landowners.

Years 3–4 – Implementation

- Implementation of climate-resilient production measures at the farm level by Community Organizations.
- Provision of goods, inputs, and technical assistance.
- Signing of in-kind grants from CI to landowners.
- Monitoring of productive transformation measures.
- Preparation of the Implementation Report on farm-level water management measures.

Year 5 – Monitoring and Technical Closure

- Completion of the implementation of climate-resilient production system measures at the farm level.
- Preparation of the final report, including results and lessons learned.

Year 6 – Administrative Closure

- Completion of administrative closure activities.

Deliverables and impact

- Land-use transformation: 2,409 ha of productive land transitioned to sustainable management systems across prioritized micro-watersheds
- Beneficiaries: 1,248 vulnerable smallholder family farms engaged and supported
- Climate-Resilient Farm Agreements, Plans and monitoring reports to achieve 1248 farms under silvopastoral systems.
- Climate-Resilient Farm Agreements, Plans and monitoring reports to achieve 1248 farms incorporating agroecological practices in their productive systems.

[12] For administrative purposes, Year 1 (6 months effective) is for project start up and Year 6 (6 months effective) is for project close out.

- Climate-Resilient Farm Agreements, Plans and monitoring reports to achieve 1248 farms incorporating efficient use and water saving measures.
- Climate-Resilient Farm Agreements, Plans and monitoring reports to achieve 1248 farms under climate resilient production systems implementing measures to diversify their production systems.

8.1.3.1. Sub-activity 1.2.1.1 Implement silvopastoral systems in place of traditional dairy production

Silvopastoral systems will be introduced to replace conventional dairy production practices where pasture simplification and soil degradation reduce water regulation capacity, particularly on sloping highland farms vulnerable to compaction and runoff. By integrating trees, shrubs and managed pastures, silvopastoral systems can rehabilitate degraded lands and generate ecosystem services, including improvements in water quality and permeability, while sustaining livestock production (Murgueitio, et al., 2015). Evidence syntheses for Latin America describe silvopastoral systems as supporting resource-use efficiency and multiple environmental co-benefits at farm and landscape scale. These systems are therefore framed as ecohydrological interventions that increase infiltration, reduce erosive energy of rainfall via canopy structure, and stabilize water flows through improved soil cover and root networks.

Implementation will focus on priority dairy farms in the Guandoqué–Villapinzón–Tominé ecosystems where tree-based paddock structures (e.g., live fences, forage shrubs, dispersed trees) can be integrated with rotational grazing and protected watering points. Technical packages will follow established guidance on silvopastoral design and management, emphasizing species selection and spatial arrangements that match local climate and soils to sustain productivity while improving soil organic matter and erosion control (Zapata Cadavid & Silva Tapasco, 2020). Adoption will be supported through CSA-oriented extension and farm planning that explicitly manages trade-offs between productivity and ecosystem outcomes. Monitoring will track changes in ground cover, soil condition, and on-farm water availability as proximate indicators of improved ecohydrological performance.

Representative eligible measures on agroecological potato production systems are measures to minimize tillage, incorporate green manures and crop rotations, protect springs and riparian buffers, reduce synthetic fertilizer use, and apply integrated pest management with biological controls.

8.1.3.2. Sub-activity 1.2.1.2 Implement agroecological practices in traditional potato production systems

Agroecological practices will be implemented in potato systems to reduce soil degradation pathways that undermine water regulation in high-Andean landscapes, including loss of soil quality linked to intensive cropping in páramo-adjacent zones (Farfán, Forero, & Avellaneda-Torres, 2020). Evidence from Colombian high-Andean páramo soils shows that potato cultivation can significantly alter key soil quality attributes (e.g., moisture, bulk density, organic carbon and enzymatic activity), which are foundational for infiltration and moisture retention (Dagunga, et al., 2023). Therefore, agroecological transition measures will focus on rebuilding soil function through reduced disturbance, improved organic matter management, and landscape-protective practices that strengthen social-ecological resilience in potato landscapes. This strategy is consistent with FAO agroecology frameworks that emphasize diversity, synergy, and nutrient cycling as resilience-enhancing principles.

Agroecological practices will include diversified crop rotations, reduced soil disturbance, organic matter management, contour planting and vegetated barriers. These practices contribute to soil moisture retention, erosion control and reduced agrochemical runoff, improving hydrological performance while increasing the resilience of potato-based livelihoods to climate variability.

Implementation will prioritize farms in Guand Villapinzón and the Tominé landscape where water-saving can be achieved through improved irrigation management, storage and distribution practices that stabilize water availability across seasons.

Representative eligible interventions include: minimum tillage to prevent soil degradation, green manures, reduced synthetic fertilizer use, crop rotation (pastures, legumes, vegetables) and integrated pest management (biological control)[13].

8.1.3.3. Sub-activity 1.2.1.3 Implement efficient use and water saving at farm level

Water-saving measures will be implemented to increase the productivity of water use and to reduce vulnerability to water stress, recognizing that irrigated agriculture must become more efficient, equitable and sustainable under increasing scarcity. Farm-level actions will follow established irrigation water management guidance that distinguishes among surface, sprinkler and drip methods and provides operational principles for application timing and system performance (FAO, 2020). Because improved irrigation technology does not automatically translate into real water savings without governance and management, the activity will couple hardware choices with scheduling, measurement and behavioral practices. These measures align with CSA water-management options that explicitly address climate impacts on water availability and propose adaptation responses for agriculture.

Representative interventions of efficient water-use measures at farm level will include rainwater harvesting systems using low-impact storage equipment, on-farm sprinkler irrigation systems for greenhouses, alternative livestock watering systems, on-farm sprinkler irrigation for greenhouses, alternative livestock watering systems.

8.1.3.4. Sub-activity 1.2.1.4 Implement and diversify agrifood systems.

Agrifood diversification will be used as a resilience strategy to reduce dependence on single commodities and to distribute climate and market risks across multiple products, practices and value-chain options. This framing is consistent with evidence-based pathways for resilient food systems that emphasize diversification of socio-ecological systems and bouncing forward through transformative change rather than returning to fragile pre-shock conditions. At farm level, diversification will support ecohydrological resilience by increasing functional diversity in fields and farms, which can buffer yields under variable rainfall and temperature regimes. Diversification will also be aligned with agroecology principles that strengthen resilience through diversity, synergy and circularity in resource use (Teng & Craigen, 2025).

Agrifood diversification will reduce dependence on single climate-sensitive commodities, distribute water demand more evenly across seasons and strengthen household food security. Functional diversity at farm level enhances system resilience while supporting hydrological stability in productive landscapes.

Diversification will focus on poultry coops for the production of poultry meet and eggs, rabbit rising, greenhouse production of high value vegetable crops apiary management and harvesting. Beneficiary farms will be provided with materials and support to build simple removable climate resilient design wood infrastructure following the farm plans, including poultry coops, rabbitries, small greenhouses, apiary infrastructure.

[13] Any pesticide or fertilizer used under project-supported activities will be subject to the restrictions, exclusion criteria, and management measures established in the ESMP, including the promotion of Integrated Pest Management (IPM) and the reduction of synthetic agricultural inputs.

8.1.4. Activity 1.2.2 Commercialization and opening of markets that value rural products that contribute to water regulation.

The ultimate objective of this activity is to increase family income and stability from the commercialization of their products. Taking the advantage that there is an ecosystem of associativity in the region ranging from producer association, women associations and associative organizations to transform milk into dairy products and even commercialization associations, the project will implement this activity through a grants strategy to support of these associations. Farmers and associate producers will increase sales value by 16% in the year following grants implementation. Compliance with this indicator is assessed by comparing sales volume at the start of the grant implementation period with the results from the first year; the unit is a percentage, since it depends on the type of product being analyzed (e.g., liters, units, kilograms). At least 20 supply contracts with new clients will be formalized as part of the strategy to increase income.

This responds to the fact that long-term adoption of sustainable land-use practices depends not only on technical feasibility, but also on being able to access markets that reward producers that contribute to regional water regulation, climate adaptation, and sustainability.

Activity 1.2.2 addresses a critical condition for sustaining Volumetric Water Benefits (VWBs) benefits from farm project activities over time, ensuring that producers obtain sufficient and profitable economic returns to maintain the land-use practices that generate water regulation services. By addressing commercialization income, stability and profitability of farms participating in the watershed transformation process, the activity supports the permanence of the interventions that contribute to reduced runoff, increased infiltration, and more stable hydrological conditions in priority watersheds.

The activity is organized into two sub-activities. Sub-activity 1.2.2.1 to develop business models at producers' associations and associative organizations for, including the identification of local and regional market opportunities, value propositions, and organizational arrangements to overcome gaps and barriers to reach those markets. Sub-activity 1.2.2.2 focuses on the implementation of key elements of the developed business models focusing on commercialization and value-added initiatives including market access strategies, commercial partnerships, and grant-supported investments that facilitate participation in selected value chains.

The activity addresses several barriers identified in feasibility and economic analysis. Rural producers often face limited access to profitable markets, fragmented value chains, insufficient market information, and restricted access to investment capital required to participate in higher-value markets. These constraints discourage climate-resilient production systems and may challenge the permanence of watershed interventions once project support ends. The activity reduces these barriers by creating commercially viable pathways for producers, facilitating collective action through producer organizations, and supporting investments that connect producers with buyers capable of recognizing the value of products generated under water-sensitive production systems. Risks associated with weak market demand, limited organizational capacity, and price volatility will be managed through market assessments, diversification of commercialization channels, phased implementation, and continuous technical support.

Implementation model and partners

Fondo Acción will lead the implementation of this activity by contracting a team of market access consultants to provide direct support to producer's associations and organizations in intervention landscapes and develop business models.

FA will also launch a competitive call for the selection of targeted organizations, the award of grants, and the implementation of commercialization and access to market initiatives based on the business models developed during the previous phase. Grant resources may support activities such as product aggregation, processing, packaging, quality control, certification processes, commercialization infrastructure, market access activities, participation in commercial events, buyer engagement, and implementation of commercialization strategies. Technical assistance with the hired team of consultants will accompany grant implementation to facilitate compliance with market requirements and commercial objectives. Implementation will take place across the 12 prioritized watersheds areas of intervention of the project.

Beneficiary organizations will be selected through transparent and competitive processes based on eligibility criteria that consider organizational capacity, commercial potential, alignment with project objectives, and commitment to maintaining climate-resilient production practices.

Parallel to the execution of activity A.1.2.2.1, Fondo Acción will have a specialized technical team to design and manage a competitive call for proposals, conduct the technical evaluation and due diligence processes, and oversee the selection of beneficiaries. Through this process, up to 30 grants will be awarded to producer associations and local organizations operating in the eight prioritized watersheds. This team will interact with the consultants of activity A.1.2.2.1, which will also take part in the selection and evaluation of beneficiaries.

Fondo Acción will then enter into grant agreements with selected beneficiaries, defining implementation responsibilities, performance targets and reporting requirements. Throughout implementation, Fondo Acción will provide technical guidance and ongoing support to facilitate the execution of the proposed business models, monitor progress against agreed milestones, and ensure compliance with project objectives, environmental and social safeguards, and grant conditions. Fondo Acción will conduct nine (9) workshops in Year 2 and three (3) workshops in Year 3, to provide advisory and hands-on support to refine business plans, commercialization strategies, and grant proposals.

Grants will support the implementation of commercialization initiatives, market access strategies, and investments identified through the business planning process, contributing to the economic viability of climate-resilient production systems and the long-term sustainability of watershed-friendly land-use practices. Grants will be disbursed in Y3 and Y4 of the project.

Afterwards grants will be awarded: Cash and/or in-kind Investment Grants to 30 producer associations (Grant size avg. $120,000; competitively selected per selection criteria in Annex 2) – USD $ 3.700.000. Refer to Annex 26 Grants Manual for more information on eligibility criteria.

Local associative organizations and producer associations' role: They will be the primary recipients of grants and will lead the development and implementation of business plans, market and commercialization activities with technical support from specialized consultants hired by Fondo Accion. They will be responsible for executing grant-funded activities as well as reporting on progress in accordance with grant requirements.

Local producers' role: Local producers will participate as members or beneficiaries of selected organizations and will contribute to the implementation of activities associated with the supported business models and market access initiatives.

Implementation timeline[14]

Year 1 – Start-up

- Recruit technical team
- Draft Terms of reference for consultancy and expert team

Year 2

- Procure and start of consultancy
- Draft Terms of reference and launch Call Proposals for producer associations
- The consultancy team will develop customized business models
- Grant contracting/award

Year 3

- Grant implementation
- Technical support from FA and consulting team

Year 4

- Grant implementation
- Technical support from FA and consulting team

Year 5 - Closure

- 30 grants closed
- Completion of support for producer organizations and associations in the development of business models

Deliverables and Impact

- Business development: 30 climate-resilient business models developed and operationalized with local organizations
- Market integration: 20 New commercial agreements established with buyers, facilitating stable market access for producer associations
- Income enhancement: At least 16% increase in income reported by participating organizations through improved commercialization channels

[14] For administrative purposes, Year 1 (6 months effective) is for project start up and Year 6 (6 months effective) is for project close out.

8.1.4.1. Sub-activity 1.2.2.1 Develop business models for climate-resilient production systems.

Sub activity 1.2.2.1 will provide structured technical assistance to local producer organizations to design, validate, and implement sustainable business models that strengthen their access to markets while embedding the conservation of native High Andean Ecosystems as a core component of their value proposition and operational logic. Its objective is to identify economic opportunities that enable producers to generate income while maintaining production practices that contribute to water regulation, climate adaptation, and landscape resilience. By aligning commercial incentives with environmental outcomes, the sub-activity supports the long-term adoption of land-use practices that generate hydrological benefits.

Many rural communities located in, or around critical watersheds and páramo ecosystems generate products with significant market potential, including specialty foods, non-timber forest products, medicinal plants, and sustainably managed agricultural goods. However, without a coherent business model, these organizations struggle to capture fair value from their products, maintain sustainable production practices, or articulate the environmental services their land management provides. This activity directly addresses that gap by building the organizational and strategic capacity needed to connect ecosystem stewardship with economic sustainability.

Fondo Acción will contract a specialized consultant's team to conduct market assessments, identify priority products and value chains, evaluate market demand and commercial opportunities, and develop business models tailored to the characteristics of producer organizations operating in the project area. The consultancy will analyze production costs, market requirements, potential buyers, certification opportunities, value-addition alternatives, and organizational arrangements.

This activity will provide structured technical assistance to local producer organizations to design, validate, and implement sustainable business models that strengthen their access to markets and maximize profit and income while embedding the conservation of water-producing ecosystems, including páramos and other high-altitude wetlands, as a core component of their value proposition and operational logic.

Recognizing that rural producer organizations often possess valuable natural assets, traditional knowledge, and differentiated products, but lack the strategic and organizational tools to translate these into viable and competitive market positions, this activity will accompany organizations through a participatory and iterative process to build business models adapted to their territorial realities, productive capacities, and ecosystems.

A business model is the strategic blueprint that describes how an organization creates, delivers, and captures value, essentially, it answers three fundamental questions: What value do you offer (and to whom?), how do you deliver it?, how do you sustain yourself financially while doing it? In the context of rural products, climate-resilient value chains, and ecosystem-linked products, business models will also answer a fourth question: How does value creation protect or regenerate the ecosystems that make it possible?

30 Organizations will develop business models that validate product-market fit in real-world scenarios, ensuring product consistency and establishing a premium brand identity that connects consumers to watershed protection. With these results, the associations secure predictable, long-term income streams for the communities by formalizing contracts with buyers who value eco-hydrological and social benefits, thereby reducing vulnerability to market volatility. Producer associations can multiply the project's return

on investment by providing a proven and scalable framework that other regional initiatives related to watersheds can adopt to further empower producer organizations.

The core impact is the provision of critical, de-risked financing that allows local organizations (at least 30) to overcome high barriers to market entry. This capital deployment directly funds essential commercialization infrastructure, costly certification processes, and targeted buyer engagement activities, ensuring the economic viability of the climate-resilient production systems.

The establishment of an economic incentive structure where increased market returns are explicitly linked to the maintenance of climate-resilient production systems. The systemic impact guarantees that the commercial success of the producer associations actively finances the continued adoption of land-use practices that generate hydrological benefits measured through VWBA. This creates a self-sustaining cycle where profitable market access secures long-term watershed resilience and water regulation well beyond the project's funding period.

8.1.4.2. Sub-activity 1.2.2.2 Implement commercialization and market access initiatives through producer associations

This sub-activity aims to translate the business opportunities identified under Sub-activity 1.2.2.1 into concrete commercialization initiatives that generate market access and income opportunities for producer organizations. Its objective is to facilitate commercial relationships, investments, and organizational capacities that allow producers to participate in selected value chains while maintaining production practices that contribute to water regulation and climate resilience. The sub-activity provides the practical pathway through which market incentives support the long-term sustainability of hydrological outcomes generated under Component 1.

The sub activity will provide grants and technical assistance to rural producer associations to design and implement concrete commercialization and market access measures that strengthen their position in value chains, improve the economic returns of their products, and consolidate the link between sustainable production, ecosystem stewardship, and market competitiveness. The activity recognizes that producer associations and associative organizations operating in and around critical ecosystems such as páramos and water-producing watersheds possess products with significant differentiation potential but require structured support to translate that potential into stable, fair, and growing commercial relationships.

These organizations and its associates frequently face a dual challenge: on one hand, they manage landscapes and production systems that generate products of good quality and environmental significance; on the other, they operate in conditions of market exclusion, price disadvantage, and commercial vulnerability that undermine both their economic sustainability and their capacity to continue investing in ecosystem stewardship. Weak commercialization capacity reflected in poor post-harvest management, lack of product differentiation, limited negotiation power, and absence of quality or sustainability certifications, combined with structural barriers to market access, including remoteness, lack of market information, inadequate infrastructure, and exclusion from formal commercial channels, results in a situation where the economic value generated by sustainable production is systematically captured by intermediaries rather than retained by the communities that produce it and protect the ecosystems that sustain it.

This activity directly addresses these constraints by accompanying producer associations through the implementation of practical, territorially adapted commercialization and market access strategies that are financially viable, environmentally coherent, and organizationally manageable. Indicative measures through which the project will support local producer organizations are presented in the table below:

Table 35. Indicative measures under activity 1.2.2.2.

Activity	Eligible interventions
Commercialization of value rural products that contribute to water regulation	Including, but not limited to: Business Models & Financials o Climate-resilient business model design aligned with water objectives o Business plans, financial projections, and investment readiness o Cost structure analysis, pricing strategy, and margin validation o Revenue diversification and circular economy approaches Product Development & Value Creation o Product design, standardization, and finalization for consistency o Value addition (processing, differentiation, product lines) o Packaging, shelf-life, and storage optimization o Post-harvest improvements and loss reduction Quality, Standards & Traceability • Quality assurance systems and SOPs • Compliance with standards, certifications, and buyer requirements • Traceability systems and audit readiness • Alignment with sustainability and climate-resilient attributes Branding & Positioning • Brand identity, origin positioning, and storytelling • Sustainability communication and labeling • Marketing content and product positioning strategies Organizational Capacity & Aggregation • Strengthening governance and business management of producer organizations • Aggregation models to ensure scale and consistency • Capacity building in commercialization and operations • Internal coordination and incentive systems Production & Operational Efficiency • Climate-smart production and productivity improvements • Equipment, infrastructure, and processing upgrades • Inventory, supply planning, and logistics readiness • Operational systems and process optimization Risk & Adaptive Management o Identification of business, climate, and financial risks o Risk mitigation strategies and contingency planning o Monitoring performance, learning, and iterative improvement
Access to markets that value rural products that contribute to water regulation	Including, but not limited to: A. Market Intelligence & Strategy o Market segmentation, demand analysis, and competitor assessment o Identification of target markets, niches, and buyers o Value chain analysis and market feasibility

Activity	Eligible interventions
	B. Market Entry & Go-to-Market o Market entry preparation and regulatory compliance o Go-to-market strategies and pilot sales o Testing product-market fit (pricing, packaging, channels) C. Buyer Engagement & Linkages o Direct link creation between producers and buyers o Buyer outreach, matchmaking, and trade events o Alignment with buyer requirements and relationship development D. Contracting & Commercial Structuring o Formal contracts (volumes, quality, pricing, delivery terms) o Negotiation, payment conditions, and risk-sharing mechanisms o Legal compliance and dispute management E. Distribution & Delivery Systems o Development of distribution channels (retail, export, direct sales) o Product delivery models and logistics optimization o Storage, cold chain, and last-mile solutions F. Market Operations & Sales Systems o Operational systems for order management and fulfillment o Coordination of supply-demand flows o Digital platforms and e-commerce integration G. Marketing, Pricing & Market Validation o Market-facing branding, promotion, and visibility o Pricing validation with buyers and willingness-to-pay testing o Margin negotiation and channel-specific pricing adjustments H. Learning, Performance & Scaling o Sales tracking and customer feedback collection o Learning from market performance and adjusting strategies o Scaling to new markets, buyers, and channels

8.1.5. Activity 1.2.3 Implement efficient water use measures in community-run water supply systems in prioritized watersheds.

This activity will work with small-scale rural community-managed water supply system organizations to implement measures to reduce losses of Non-Revenue Water (NRW) and increase operations, service and water quality provided to local communities to improve their resilience. Throughout this activity, the project will work with 40 community-run water supply systems

Access to reliable and affordable access to safe drinking water is a key resilience element to reducing vulnerability of Project target communities. A project aiming for regional water access resilience should also address resilient water access for communities served by community-run water supply systems. The activity contributes to the long-term sustainability of hydrological outcomes generated under Component 1. In addition, by reducing physical and operational losses and increasing the efficiency of upstream water use, the activity contributes to increase water availability downstream.

The activity consists of three complementary sub-activities. Sub activity 1.2.3.1 focuses on the installation of macro-metering systems and upgrades to community-managed water supply infrastructure, sub

activity 1.2.3.2 will implement efficient water-use practices in community-managed systems; and subactivity 1.2.3.3 focuses on implementing drinking-water treatment solutions.

The activity will take place across the 12 prioritized watersheds areas of intervention of the project.

The activity addresses several barriers identified through the feasibility analysis and risk assessment. Community-managed water systems frequently operate with limited technical information, insufficient monitoring equipment, aging infrastructure, operational inefficiencies, and restricted access to financial resources for system upgrades. These factors reduce their capacity to respond to droughts, changing hydrological conditions, and increasing water demand. The activity reduces these barriers by providing technical diagnostics, water accounting systems, operational protocols, and targeted investments that support more efficient management of available water resources. Risks associated with technical capacity, equipment operation, and long-term maintenance will be managed through training, technical and financial assistance, phased implementation, and ongoing monitoring.

Implementation model and partners

Fondo Acción will lead the implementation and contract specialized consultants and two activity-based consultancies that will be hired through competitive processes. Activity1.2.3.2 will be conducted by a consultancy and will focus on diagnostics, operational assessments, and implementation of efficiency measures in community-run water supply systems, while a second consultancy will materialize activities 1.2.3.1 and A1.2.3.3, and will focus on the assessment, installation, operationalization of macro-metering systems, training activities for beneficiaries and the implementation of in-kind grants (drinking water solutions). Fondo Acción will also administer the competitive selection process to provide grants for up to 40 community-run water supply organizations in the 12 prioritized watersheds. For priority investments, FA will supervise implementation and ensure compliance with fiduciary, environmental, social, and reporting requirements throughout the project period. Beneficiary community-managed water systems will be selected from within the project intervention areas, prioritizing those that serve the largest number of users and therefore offer the greatest potential to increase water resilience and generate water-security benefits at scale. (Refer to Annex 26 Grants Manual for information on eligibility criteria).

The sustainability of the implemented actions constitutes a central element of the project and is not limited only to the physical or technical improvements that can be developed in the beneficiary systems. On the contrary, the strategy seeks to strengthen local capacities to ensure that the benefits obtained can be maintained and replicated once the intervention is completed.

Firstly, the project includes a capacity-building component aimed at operators, community leaders and organizations responsible for managing water supply systems. Through training, technical assistance and accompaniment processes, FA will seek to strengthen knowledge related to the operation and maintenance of infrastructure, efficient use of water, community management, financial sustainability and adaptation to climate change. As a complement to these processes, support materials adapted to the context of the beneficiary organizations will be prepared and delivered, such as operational manuals, practical guides, booklets and other consultation instruments. These materials will allow the knowledge generated during the project to remain available to current and future operators, facilitating the appropriation of the tools and methodologies implemented even after the completion of the project. Secondly, interventions will prioritize solutions in line with local operation and maintenance capacities, promoting technically and economically viable alternatives for community organizations responsible for providing the service. This approach seeks to reduce dependence on external assistance and strengthen the autonomy of rural providers in the management of services. Finally, the project will explore mechanisms for cooperation and exchange of experiences between the beneficiary aqueducts, inspired

by the principles of Water Operators' Partnerships (WOPs). These collaboration spaces will allow organizations to share knowledge, good practices, lessons learned and solutions to common problems, strengthening the collective capacities of the territory and promoting continuous learning processes beyond the duration of the project.

The combination of technical strengthening, community appropriation, knowledge transfer and cooperation between operators will contribute to consolidating a solid foundation for the sustainability of investments and for the continuous improvement of water services in beneficiary communities.

Time Table

Year 1 – Start-up

- Recruit technical team
- Draft Terms of reference for consultancy of activity 1.2.3.1 (macro-metering) and 1.2.3.3 (in-kind grant implementation)
- Draft Terms of Reference for consultancy of activity 1.2.3.2 (training and technical assistance and in-kind grant implementation)

Year 2

- Procure and start consultancies
- Launch Call for applications by Fondo Acción
- Formalize grant agreements with beneficiary – up to 40 projects identified
- Start Implementation of technical assistance to water utilities

Year 3-4

- In kind grants implementation
- Technical support from FA and consulting team

Year 5

- Closing awards
- Closing technical support from FA and consulting team

Deliverables and impacts

- Infrastructure upgrades: Installation of macro-metering and system improvements in at least 40 community-run water supply systems, enabling accurate measurement of water intake, distribution, and consumption
- Operational improvements: Implementation of operational protocols and Non-Revenue Water (NRW) reduction measures, improving system efficiency and reducing physical losses
- Water quality enhancement: 40 community-run supply systems with drinking-water treatment and systematic water quality monitoring (reports)

8.1.5.1. Sub-activity 1.2.3.1 Install macro-metering and upgrade community-run systems.

The proposal involves installing large-scale water metering devices and supporting priority equipment improvements in community-managed rural water supply systems. Large-scale metering will enable community operators and local water boards to quantify water withdrawals, production, distribution, and

losses, generating the information needed to improve operational decision-making, reduce water losses, meet water efficiency requirements, and strengthen reporting to environmental and municipal authorities (Ministerio de Ambiente y Desarrollo Sostenible, 2018)

This sub-activity aims to increase the operational efficiency and climate resilience of community-managed water supply systems by establishing reliable water measurement systems and addressing critical infrastructure constraints. Its objective is to generate accurate information on water intake, distribution, and consumption, while supporting targeted pipeline upgrades that contribute to reduced water losses, more efficient resource management, and measurable water savings. The expected outcome is a stronger foundation for evidence-based decision-making and more resilient water services in rural communities.

The intervention will begin with technical, financial and administrative assessments of community-run water systems to identify infrastructure gaps, operational constraints, and opportunities for reducing water losses. Recommended infrastructure and efficiency measures will consider the technical and financial capacity of the organization to adopt them.

Based on these assessments, the project will support the installation and operationalization of macro-metering equipment, including flow measurement devices and associated monitoring systems. Where necessary, complementary infrastructure upgrades will be implemented to ensure the functionality of the metering systems and to address priority operational bottlenecks affecting water distribution and system performance. Technical assistance and training will be provided to local operators to support the use, maintenance, and interpretation of monitoring information generated through the installed systems. The installation of macro-metering systems and the generation of new operational information are not intended to support the introduction of new water charges or modifications to existing water tariffs for end users. Rather, the purpose of the activity is to provide community-managed water systems with the information required to better understand water flows, identify losses, support operational decision-making, and promote more efficient use of available water resources. The activity is therefore focused on water security, resource efficiency, and climate resilience rather than tariff reform.

Fondo Acción will coordinate implementation through a specialized consultancy contracted through a competitive procurement process. The consultancy will conduct technical assessments, define equipment specifications, supervise installation and commissioning, develop monitoring protocols, and provide training to system operators. Fondo Acción will oversee procurement, grant administration, implementation monitoring, and compliance with project requirements. The activity is expected to be implemented between 2028 and 2030, following the selection of beneficiary systems and completion of the initial diagnostic phase.

The transformative impact lies in the establishment of a robust water accounting system that generates reliable data on water intake, distribution, and consumption across at least 40 community-managed water supply systems equipped with macro-metering. This capability enables continuous monitoring and reporting, supporting the generation of measurable Volumetric Water Benefits (VWBs). By providing accurate, real-time information, the system empowers community operators to optimize water management, reduce losses, and demonstrate tangible water savings, thereby strengthening both operational efficiency and long-term water resource sustainability.

8.1.5.2. Sub-activity 1.2.3.2 Apply efficient water use practices in water supply community-run systems

This sub-activity aims to reduce water losses and optimize the use of available water resources within community-managed water systems. Its objective is to support operational practices that increase water-

use efficiency, reduce non-revenue water, and contribute to the generation of measurable water savings. The expected outcome is a more resilient and reliable water service capable of responding to climate-related variability in water availability.

Assessment recommendations on efficient use practices for each participating water system will be tailored into action plans will be prepared and implemented. Measures may include leak detection and repair programs, pressure management practices, operational protocols, maintenance schedules, water accounting procedures, operator training, and other efficiency actions identified through the diagnostic process. Technical assistance will accompany implementation to support adoption of the proposed measures.

Implementation will take place across the 12 prioritized watersheds areas of intervention of the project. Beneficiary community run water systems will be selected through a competitive process managed by Fondo Acción using technical, operational, and vulnerability criteria.

Fondo Acción will coordinate implementation through a specialized consultancy contracted through a competitive procurement process. The consultancy will conduct diagnostics, prepare efficiency plans, provide technical assistance, and support implementation. Fondo Acción will oversee implementation, administer grants where require, monitor progress, and ensure compliance with project requirements throughout the implementation period. Workshops will be delivered across the three intervention landscapes, covering grant proposal launches, capacity building, and exchange of best practices in water system management.

This sub-activity will deliver 40 operational community-run water supply systems, supported by standardized operating protocols and Non-Revenue Water (NRW) reduction reports. The implementation of these protocols translates efficiency measures into measurable climate adaptation outcomes, by actively reducing water losses through leak detection, pressure management, and the uptake of low-cost water-efficiency solutions at the household level. As a result, the activity increases the reliable water supply available to users, particularly during periods of scarcity, while generating verifiable Volumetric Water Benefits (VWBs). These improvements demonstrate tangible water savings and strengthen system performance, contributing directly to the project's hydrological proof of concept and enhanced resilience at the community level.

8.1.5.3. Sub-activity 1.2.3.3 Implement drinking-water treatment in water supply community-run systems

This sub-activity aims to increase the quality and reliability of drinking-water services provided by community-managed water systems, based on the recommendations on water treatment from the community systems assessment. Its objective is to support the adoption of treatment solutions that allow beneficiary systems to provide safer water while maintaining operational performance under changing climatic conditions. The expected outcome is a reduction in water-quality risks and increased resilience of rural populations dependent on these systems.

Depending on system needs, investments may include treatment equipment, filtration systems, disinfection technologies, operational controls, water-quality monitoring equipment, and associated operator training. Technical assistance will support system operators during installation, commissioning, and operation of the treatment systems. Implementation will take place across the 12 prioritized watersheds areas of intervention of the project.

Fondo Acción will lead the implementation of this activity and manage the grant process through which beneficiary community-run water systems will be selected and supported. Fondo Acción will launch and

administer the call for proposals, conduct the evaluation and selection process, enter into grant agreements with selected beneficiaries, and oversee the disbursement and monitoring of grant resources. Priority will be given to community-managed water systems located within the project intervention watersheds and serving the largest beneficiary populations.

To support implementation, Fondo Acción will engage technical experts to conduct system assessments, define treatment requirements, identify appropriate drinking-water solutions, supervise installation processes, and provide training and operational guidance to water-system operators. Fondo Acción will retain overall responsibility for technical oversight, grant administration, procurement of equipment and services, monitoring, compliance with environmental and social safeguards, and reporting requirements, ensuring that beneficiary systems are able to operate and maintain the installed solutions over the long term.

Fondo Acción will provide grants to up to 40 community-run water systems located within the project intervention watersheds. Each selected beneficiary may receive grant funding of up to USD 50,000 to support the implementation of priority investments identified through the technical assessment process

40 community-run supply systems will be equipped with drinking-water treatment and systematic water quality monitoring. Transforming the administrative milestone of executing grants of up to USD 50,000 into a tangible climate adaptation and health outcome, this deliverable focuses on the physical reduction of water-quality risks. The direct systemic impact is the successful installation and operationalization of appropriate pre-filtration, filtration, disinfection, and storage protection systems across up to 40 prioritized community-run water systems. This infrastructure deployment builds direct physical resilience against climate-induced source contamination and heavy sedimentation, ensuring the continuous, reliable provision of safe drinking water for rural populations despite increasing climate variability.

Improvements in water quality in rural systems will yield direct benefits for the health and well-being of the population and will also help reshape perceptions of the value of treated water. By ensuring a safe, treated water supply, the sub-activity reinforces the understanding that this resource, due to its processing cost and vital importance, should be reserved for domestic needs. This appreciation encourages more conscious and efficient consumption and discourages the use of treated water for activities such as crop irrigation or livestock watering, which should rely on lower-quality sources. In turn, this optimizes the capacity of the systems and contributes to a reduction in Non-Revenue Water losses, strengthening both the climate resilience and the operational sustainability of rural drinking-water services.

8.1.6. Scope, beneficiaries and hydrological outcomes of Component 1

This table presents a consolidated overview of the scope, beneficiaries, and hydrological results associated with Outcome 1 and Component 1 of the project. The table summarizes the scale of interventions across protected areas, conservation and productive plots, families and producer associations, and community-run water-supply systems, linking each level of implementation to quantified Volumetric Water Benefits (VWBs) and population impacts. By integrating ecological restoration, climate-resilient productive transformation, and improvements in rural water systems, the Watershed Transformation Model demonstrates its capacity to deliver measurable hydrological benefits while strengthening livelihoods and enhancing water resilience for communities and municipalities across the eight selected watersheds as a prove of concept for the Bogota-Region.

Table 36. Scope, beneficiaries and hydrological outcomes of Component 1.

Log frame	Protected areas	Ha intervened	Families/properties benefited	Productive associations	Community -run water supply systems	VWB (m^3/yr)
Outcome 1. Watershed Transformation Model proved to achieve the highest hydrological benefits	2,940,584 m^3/year of VWBs generated (disaggregated by watershed and intervention type See Annex 24)					
Activity 1.1.1. Conserve high Andean ecosystems	8 protected areas 8 RNSC (26,071 ha)	4,756				1,182,710
Activity 1.1.2 Restore high Andean ecosystems.		2,032				869,549
Activity 1.2.1 Implement climate-resilient production systems at farm level		2,409	1,248			888,325
Activity 1.2.2 Commercializatio n and opening of markets that value rural products that contribute to water regulation				30		
Activity 1.2.3. Implement efficient water use measures efficiency in community-run water supply systems in prioritized watersheds					40	

8.2. Component 2: Finance mobilization and scale-up

Output 2.1 develops two complementary routes for financing the watershed transformation model proven under Component 1, so that the volumetric water benefits (VWBs) generated in the supplying watersheds of the Bogotá Region can be sustained and scaled beyond the project period. Activity 2.1.1 builds the public route, working with EAAB to recognize the cost of source-water protection in the water tariff; Activity 2.1.2 builds the private route to scale and unlock additional resources after project completion.

8.2.1.1. Activity 2.1.1 - Incorporate an environmental investment component into the water tariff

This activity aims to establish the technical conditions necessary for the incorporation of an environmental investment component (EIC) into EAAB's water tariff, establishing a new sustainable financing mechanism for water resilience through watershed protection and climate adaptation investments in the watersheds of the EAAB. This will also set the ground for replication in other utilities in the country.

EAAB currently applies the tariff methodology established by the *Comisión de Regulación de Agua Potable y Saneamiento Básico* (CRA), which includes fixed and consumption charges designed to recover administration, operation, and investment costs associated with water service provision. Under the tariff framework updated by Resolution CRA 1032 of 2026, effective 1 July 2026, environmental investments are recovered as an integrated component of the regulated investment cost, and their inclusion must be grounded in a ten-year Water Sustainability Plan (Plan de Sostenibilidad Hídrica). While the regulatory framework allows utilities to incorporate an additional environmental investment component, this is optional.

The EIC allows the water utility to make environmental investments and recover them through the tariff, provided that the investments are of eligible categories, that they are technically attributable to source-water protection and hydrological regulation, are not double-counted with other tariff components, go beyond the utility's mandatory environmental obligations, and are documented and reported in the form the regulator requires proving cost effectiveness of the investments.[15]

To date, neither the EABB nor any other water utility have operationalized an environmental investment component because EAAB has not been able to operationalize the EIC. To do so, the EABB would need to develop several missing elements required by the regulation:

- There are no established baselines and trends for the environmental service of hydrological regulation in EAAB's supplying catchments, and no capacity to simulate intervention scenarios for against it.
- There is no prioritized and costed investment portfolio for those catchments, mapped to the eligible categories and classified into the regulated cost categories with their corresponding asset lives.
- There is no demonstration of the cost-effectiveness of the investments.
- There is no reporting architecture capable of producing the annual follow-up indicators required by the regulation, of reporting them to SSPD through the *Sistema Único de Información*, and of delivering the supporting cost records to CRA in the form and within the terms the regulation requires.

Consequently, watershed conservation and restoration activities remain dependent on project resources, discretionary public budgets, and short-term funding sources. Throughout this activity, the EAAB, CI and partners will development the necessary elements that enable EAAB include EIC in its tariff structure, thereby strengthening long-term water security and climate resilience for Bogotá.

Eligible investment categories are compatible with the Watershed Transformation Model implemented under Component 1 and include: ecosystem restoration, protection of strategic water-producing ecosystems, riparian restoration, water-resource monitoring, aquifer recharge interventions, land

[15] See Article 164 of Law 142 of 1994, Decree 1207 of 2018, Resolution 874 of 2018 and Resolution CRA 1032 of 2026 (CRA, 2026) (Ministerio de Vivienda, Ciudad y Territorio. , 2018a) (Ministerio de Vivienda, Ciudad y Territorio, 2018b).

acquisition for conservation purposes, and Payments for Environmental Services. The ultimate goal of the activity is a permanent, regulation-backed revenue stream dedicated to ecosystem-based adaptation in the watersheds that supply the water for the City of Bogotá and neighbor municipalities, so that adaptation investment scales instead of depending on discretionary or short-lived funding. This is a clear route for the project to convert one-off watershed interventions into a recurrent, utility-anchored funding source tied to EAAB's service mission, since restoration, conservation and sustainable production only deliver hydrological benefits if they are sustained and expanded over decades, and grant finance alone cannot guarantee that continuity. This addresses one of the key barriers identified in the feasibility assessment, the absence of long-term and predictable financing mechanisms for watershed-based climate adaptation.

EAAB will cofinance farm-level water-resilience interventions in the Susagua catchment, within the Guandoque landscape, executed under Activities 1.1.1, 1.1.2 and 1.2.1. Because those interventions are financed with the utility's own resources, they will be eligible for cost recovery through the EIC. For this, the regulation[16] requires EAAB to rely on hydrological evidence that matches precisely with Component 1: runoff plots installed across land-use types, continuous discharge measurement in the prioritized micro-watersheds, a calibrated SWAT model and the calculation of VWBs (activity 1.2.1). Under this activity 2.1.1 investment and evidence produced under Component 1 will be translated into the technical requirements needed for the EAAB to enable the EIC.

The activity comprises three complementary sub-activities to make the incorporation of source-water protection costs into the water tariff technically defensible and operational, producing the indicators, methodologies, costed portfolio and reporting architecture that the regulatory bodies require. Sub-activity 2.1.1.1 develops the indicators, methodologies, hydrological evidence framework, and watershed investment portfolio required to support a tariff application. Sub-activity 2.1.1.2 establishes a reporting architecture capable of documenting hydrological performance, intervention costs, and climate adaptation benefits in accordance with regulatory requirements. Sub-activity 2.1.1.3 develops replication models and guidance that can support adoption by other water utilities in the Bogotá Region, aiming to replicate and scale the application of environmental component investments, unlocking additional sources of financing over time.

Implementation model and partners

The activity will be implemented by CI-Colombia as Executing Entity. EAAB will participate as technical partner and co-financier, contributing tariff expertise, operational information, hydrological data, and institutional guidance. The Nature Conservancy (TNC) will support development of technical assessments and frameworks needed for EAAB to incorporate the EIC, under acceptable criteria by the CRA. The regulator (CRA) and the oversight authority (SSPD) are engaged from the outset through technical exchanges, again with no GCF funds flowing to them, to reduce regulatory ambiguity and de-risk approval. A central source of efficiency is that the reporting system built by CI-Colombia and EAAB draws directly on the measurement chain already created under Component 1, the ecohydrological monitoring, SWAT modelling and Volumetric Water Benefit calculation operationalized under Activity

[16] The Water Sustainability Plan (Plan de Sostenibilidad Hídrica) required by Resolution CRA 1032 of 2026 requires that the investments be associated with the hydrological services of regulation of the hydrological cycle and/or water yield. The same framework requires the utility to establish the baseline and the trend of those hydrological services in the catchment draining to its intakes, to identify the service it intends to maintain, improve or recover, to demonstrate the impact of the investments in a manner that allows several intervention scenarios to be simulated, to define the objectives of watershed protection, and to determine the type of investment required for the service being addressed.

1.2.1, rather than constructing a parallel system, and is designed to serve both EAAB and future adopters.

Table 37 sets out the ordered sequence of steps that the regulation, together with the technical process consolidated in the Smart Environmental Investments Toolbox developed by TNC with CRA, requires a utility to complete before the cost of environmental investments can be recognized in the tariff. For each step it identifies what the regulation demands, how the project addresses it in the Susagua catchment where EAAB's co-financed investment is executed under component 1, and how it is addressed for the remaining catchments of the Bogotá supply system.

Table 37 Approach to incorporate an environmental investment component into the EAAB's water tariff [17]

Regulatory step	What the regulation requires	Susagua catchment (EAAB co-financed investment under component 1)	Other catchments of the Bogotá supply system covered under component 2.
1. Diagnose the water resource in the supplying catchment	Establish the hydrological baseline and trend of the regulation and water-yield services in the catchment draining to each EAAB intake, and meter abstracted volumes ((Water Sustainability Plan – PSH)).	Activity 1.2.1: updated baseline of the project watersheds through ecohydrological monitoring, runoff plots and continuous discharge measurement.	Sub-activity 2.1.1.1: TNC's hydrological diagnosis will establish the baseline and trend for EAAB's supplying catchments across the northern, eastern (Chingaza) and southern systems.
2. Identify and prioritize intervention areas	Areas must lie in the catchment draining to the EAAB intakes and be of strategic importance for the conservation of the water resources supplying the aqueduct, selected by hydrological service (Water Sustainability Plan – PSH).	Activity 1.1.1, 1.1.2 and 1.2.1: identification and prioritization of intervention areas through the Watershed Vision and spatial prioritization.	Sub-activity 2.1.1.1: the Watershed Investment Portfolio will prioritize areas by their expected contribution to regulation and water yield , feeding directly into EAAB's Water Sustainability Plan (PSH).
3. Determine the eligible investment types	Investments must fall within the six categories of Resolution 874 of 2018, be associated with regulation and/or water-yield services, and not duplicate mandatory obligations,	Activities 1.1.1, 1.1.2 and 1.2.1: definition of the intervention types implemented on the ground.	Sub-activity 2.1.1.1: the Watershed Investment Portfolio will map each nature-based solution to an eligible category and screens out ineligible or already-financed actions.

17 The activity operates on two fronts, and Table 37 is structured accordingly. The first is immediate: supporting the incorporation into the tariff of the executed cost of EAAB's co-financed investment in the Susagua catchment, implemented under Component 1, where the regulatory requirements are met with the evidence the project itself generates. The second is forward-looking: providing the analytical foundation, the hydrological diagnosis, the prioritized and costed investment portfolio, and the cost-effectiveness methodology, that EAAB will need to extend the same recovery pathway to the remaining catchments of its supply system, across the northern, eastern (Chingaza) and southern systems. Table 37 therefore presents each regulatory step in two columns: one showing how the project addresses it for the Susagua investment within the project period, and the other showing how it prepares EAAB to address it for future investments in the rest of the supply system, which the utility will decide upon and execute after the GCF project closes.

Regulatory step	What the regulation requires	Susagua catchment (EAAB co-financed investment under component 1)	Other catchments of the Bogotá supply system covered under component 2.
	and not be financed in full by another entity (Art. 55.H).		
4. Formulate and cost the intervention portfolio	Classify costs within the environmental investments and risk-management component of the regulated investment cost, assign the regulated asset lives, and recognize that payments for environmental services enter only as an operating cost (Resolution CRA 1032 of 2026).	EAAB: the Susagua portfolio is already designed and costed as part of the project activities; EAAB will classify these costs under the regulated investment categories using existing regulatory directives.	Sub-activity 2.1.1.1: TNC will formulate and cost the portfolio for the remaining supplying EAAB catchments , providing the prioritized and costed interventions the PSH requires.
5. Model the tariff impact and assess economic viability	Translate the classified costs into the tariff using the applicable CRA methodology and evaluate the impact on users.	EAAB will model the tariff impact[18] and assess the economic viability of its Susagua investment.	Sub-activity 2.1.1.1: the methodology and cost-effectiveness analysis will provide EAAB the inputs for modelling future interventions.
6. Execute the investment with eligible resources	Only investments financed by the provider itself may be recovered through the tariff.	EAAB co-financing: EAAB invests its own capital in farm-level water-resilience interventions in Susagua under Activities 1.1.1, 1.1.2 and 1.2.1; the project documents their cost and hydrological performance.	After the GCF project period: EAAB decides on and executes the proposed portfolios to scale up to other catchments. The financial mechanism could be a vehicle to execute the proposed portfolios.
7. Calculate the tariff, obtain Board approval and apply it	The cost may be included once a year, from 1 July. Approval by the Board of Directors is required. CRA monitors and SSPD exercises inspection, surveillance and control (Resolution CRA 1032 of 2026).	EAAB institutional act, supported by the project's evidence base. Expected in Year 2 or Year 3. The decision lies with EAAB's Board of Directors and is outside the project's control.	After the GCF project period: EAAB expands, calculates and approves new investments in the tariff.
8. Report indicators and cost records to the authorities	Report the annual follow-up indicators to SSPD through the SUI and submit the supporting cost records to CRA in the form and within the terms the regulation requires.	Activity 1.2.1 supplies monitoring, the calibrated SWAT model and the VWB calculation.	After the GCF project period: EAAB reports the indicators and costs of future investments using the framework developed under Sub-activity 2.1.1.1.

[18] Preliminary estimates do not foresee a significant impact on the tariff. With restoration and riparian-recovery assets recognized as forest plantations over a 30-year regulated life and equipment and monitoring assets over 10 years (under the regulated asset-life criteria of Resolution CRA 1032 of 2026), this yields a recoverable cost of approximately COP 3,111 million in the first year of application, declining thereafter as the asset base depreciates. Divided by EAAB's metered consumption of approximately 299 million cubic meters per year, the resulting unit investment cost is approximately COP$ 10 per cubic meter — around 0.46% of the current consumption charge of COP 2,268.44 per cubic meter.

Regulatory step	What the regulation requires	Susagua catchment (EAAB co-financed investment under component 1)	Other catchments of the Bogotá supply system covered under component 2.
		Sub-activity 2.1.1.2 develops the reporting architecture and four annual reports produce the indicators and records in the form required by the CRA and SSPD.	

Implementation timeline

Year 1 – Start-up

- Sign the grant agreement with TNC
- Initial technical exchange with CRA and SSPD to confirm evidentiary requirements
- Coordination with EAAB on the Susagua portfolio and its cost classification

Year 2

- Start of the design phase: hydrological diagnosis, prioritization of intervention areas and identification of investment-effectiveness indicators
- Establishment of the hydrological baseline and first modelling runs, drawing on Component 1 monitoring
- Start of EAAB's co-financed interventions in the Susagua catchment (Activities 1.1.1, 1.1.2 and 1.2.1)
- Finalization of the indicator's framework and development of the reporting template
- EAAB classifies the executed Susagua costs under the regulated categories investment categories and models the tariff impact

Year 3

- Initial calculation of indicators and first report to EAAB on indicators and cost-effectiveness
- Water tariff adjustment for the Bogotá water system by decision of EAAB's Board of Directors, and official EAAB report to CRA and SSPD on the environmental investments for regulatory compliance monitoring *(outside the project's control)*
- Completion of EAAB's watersheds investment portfolio

Year 4

- Start of the development of the replication model for the environmental component of the tariff
- Second calculation of investment-effectiveness indicators and second report on investments and investment effectiveness

Year 5 – Technical closure

- Third calculation of return-on-investment indicators and third report
- Completion of the replication model, validated with utilities
- Final report on investment-effectiveness metrics, final report on investments, and final report on the replication model and guidelines

Implementation model and partners

CI-Colombia is the EE, keeping the technical development consistent and anchored to the Component 1 proof of concept.

TNC will provide specialized technical support to develop the hydrological assessment, Watershed Investment Portfolio, and cost-effectiveness methodologies required to operationalize the Environmental Investment Component (EIC). It will also support the development of the reporting and replication frameworks needed to scale the model to other utilities.

EAAB will provide cofinancing and contribute its tariff expertise and hydrological data with no flow of GCF funds to the utility.

The regulator (CRA) and the oversight authority (SSPD) are engaged from the outset through technical exchanges, again with no GCF funds flowing to them, to reduce regulatory ambiguity and de-risk the EIC success.

Deliverables

- Indicators and methodology framework, EAAB's investment portfolio, and cost-effectiveness report to achieve an environmental investment component reflected in the water tariff.
- Annual reports on indicators that support the cost-effectiveness of the environmental investment component of the water tariff
- A replication model package with (i) a regulatory and institutional roadmap (ii) a financial model (iii) a methodological annex; and (iv) a monitoring and reporting framework aligned with CRA and SSPD requirements.

8.2.1.2. Sub-activity 2.1.1.1 - Define and validate indicators and methodologies

This sub-activity establishes the technical framework that links territorial interventions with utility-relevant benefits required to make possible the incorporation of an EIC into EAAB's water tariff. Building on ecohydrological monitoring, SWAT modelling, and VWBs assessments developed under Activity 1.2.1, the sub-activity will develop and validate a measurement framework (indicators and methodologies). While reduced or avoided runoff will be used as one of the core indicators for improved watershed regulation, the framework will define four complementary groups of indicators to satisfy regulatory requirements: (i) intervention indicators, measuring implementation progress through variables such as hectares restored, hectares conserved, farms adopting sustainable production systems, and water-resilience measures implemented; (ii) hydrological performance indicators, quantifying changes in runoff, hydrological regulation, and water-yield services; (iii) service-relevant indicators, assessing how these hydrological improvements affect water availability, seasonal flow stability, drought buffering capacity, and raw-water quality for EAAB and other water users within the same watersheds; and (iv) financial and cost-effectiveness indicators by different intervention packages.

Additionally, throughout this activity, CI and partners will develop EAAB's Watershed Investment Portfolio which is required for EAAB to prove that future investment through the EIC is additional, goes beyond the utility's mandatory environmental obligations and does not overlap with other already financed interventions. Each proposed intervention will be compatible with the Watershed Intervention Model, assessed against the eligibility criteria established under the Colombian regulatory framework and mapped to the environmental investment categories recognized by Resolution 874 of 2018, while excluding investments already financed through other mechanisms or which do not meet regulatory requirements. The portfolio will provide the prioritized and costed interventions that EAAB's Water Sustainability Plan (Plan de Sostenibilidad Hídrica) requires under the updated tariff framework (Resolution CRA 1032 of 2026).

The measurement framework and investment portfolio will be developed using EAAB's co-financed interventions in the Susagua catchment, within the Guandoque landscape, as the primary demonstration case. Because these interventions are already designed, costed, and scheduled for implementation with EAAB resources, they provide a real-world basis for testing and validating indicators, methodologies, and cost-effectiveness assessments using observed field data rather than hypothetical assumptions. This approach is particularly important because any future tariff justification must demonstrate a credible relationship between watershed interventions and hydrological outcomes. The evidence generated through implementation and monitoring in Susagua will therefore serve as the reference case from which methodologies and analytical approaches are refined before being extended to the broader Bogotá water supply system, including the northern, eastern (Chingaza), and southern supplying catchments. The resulting framework will thus reflect both site-specific evidence and the broader hydrological diversity of EAAB's supply system.

The sub-activity directly addresses several critical barriers identified in the feasibility assessment. Although the regulatory framework permitting environmental investments in water tariffs already exists, implementation has been constrained by the absence of hydrological baselines and trend analyses, limited evidence on the performance of nature-based solutions, the lack of a prioritized and costed portfolio of eligible investments, and insufficient methodologies to demonstrate the cost-effectiveness of watershed interventions. By generating these elements, the sub-activity reduces technical uncertainty and closes fundamental knowledge and planning gaps that currently limit operationalization of the mechanism. Early and continuous technical engagement with CRA and SSPD will further reduce regulatory risks by ensuring that the methodologies, indicators, and analytical approaches evolve in line with regulatory expectations.

Activities will be implemented during Years 2 and 3 of the project, beginning with diagnosis and prioritization of supplying catchments, establishment of hydrological baselines, and initial modelling activities in Year 2, followed by development and validation of indicators and methodologies, completion of the Watershed Investment Portfolio, and consolidation of the cost-effectiveness framework in Year 3. This sequencing ensures that the technical evidence base is established before the reporting and replication activities under Sub-activities 2.1.1.2 and 2.1.1.3.

8.2.1.3. Sub-activity 2.1.1.2 - Implement systematic reporting on hydrological outcomes

This sub-activity establishes the reporting system required to track, consolidate, and communicate the hydrological, environmental, and financial performance of watershed investments supported by the project. Its specific objective is to transform the evidence generated under Component 1 and Sub-activity 2.1.1.1 into a standardized reporting framework that enables EAAB to assess investment performance, demonstrate cost-effectiveness, and report results in a format consistent with the requirements of the Water and Sanitation Regulatory Commission (CRA) and the Superintendence of Residential Public Utilities (SSPD).

The reporting system combines data from restoration, conservation and productive-transformation EAAB interventions with georeferenced prioritization layers, hydrological model outputs and site-level monitoring, producing periodic reports that show what was implemented, where, what hydrological effect is being observed or estimated, what level of confidence is attached to that estimate, and why the resulting investment is relevant for source-water protection and service resilience, in line with sub activity 2.1.2.2. Because the project works in three intervention landscapes, the architecture is built to show both site-specific performance and an aggregated basin or watershed-level reading. The system also serves

as the mechanism through which interventions and results are assessed against the planning and governance instruments applicable in the intervention area, keeping implementation consistent with approved watershed-planning, environmental-management and territorial frameworks. It is designed to align with the reporting the regulation requires, the annual follow-up indicators reported to SSPD through the *Sistema Único de Información* and the cost records submitted to CRA so that, when EAAB incorporates EIC, those obligations can be met without redesign.

The reporting system is built and operated jointly by CI-Colombia, which develops and runs the system and integrates the data, and EAAB, which provides financial, operational and service-level data and is the principal user of the reports for tariff justification and regulatory engagement; TNC's portfolio-based indicator framework and cost-effectiveness methodology supply the analytical basis the reports apply, and CRA and SSPD are the end users that validate cost-effectiveness and compliance.

This sub-activity produces four annual reports on the indicators that support the cost-effectiveness of the environmental investment component of the tariff. Each report documents what was implemented and where, the observed or estimated hydrological effect and the confidence attached to it, and the relevance of the resulting investment for source-water protection and service resilience, with costs traced through the regulated cost structure. Developed by CI-Colombia using TNC's framework and EAAB's data, the reports matter to distinct audiences: to CRA and SSPD as the evidence base for tariff recognition, to EAAB as its regulatory submission, and to other utilities and territorial entities as a transferable model. Their impact is to turn project evidence into a usable basis for tariff decisions and external uptake, sustaining the recurrent financing on which the activity's adaptation outcomes ultimately depend.

8.2.1.4. Sub-activity 2.1.1.3 - Develop replication models for other water utilities

This sub-activity takes the lessons from the EAAB tariff route and turns them into an implementable model for other utilities in the Bogotá Region and beyond, including water supply systems that benefit from the same watersheds but may not have the scale, information systems or regulatory experience of EAAB. Its specific objective is to produce a practical replication package that sets out the data requirements, minimum methodological conditions, cost categories, reporting logic, institutional roles and recommended sequencing utility needs in order to include environmental investments in its tariff or to co-finance upstream watershed interventions through other available legal channels. The impact it ultimately serves is scale: by lowering the cost and risk of every subsequent adoption, it extends the project's proof of concept beyond a single demonstration and turns it into a regional operating model for financing source-water protection.

The package translates the EAAB experience into transferable guidance and makes it explicit that the tariff is not the only route available to local actors. Some municipalities or local providers may not be in a position to adopt the specific tariff pathway developed with EAAB, yet they may still benefit from the same intervention portfolio and the evidence the project generates. The package therefore shows how tariff finance can interact with other sources, especially "1% resources" expenditure and, where appropriate, PES-related tools, on the principle of consistency: the same technically justified, monitorable and hydrologically relevant intervention portfolio can be financed through more than one institutional route, as long as double counting is avoided and each source respects its own legal conditions. Building on the indicators, the costed Watershed Investment Portfolio and the reporting architecture produced under Sub-activities 2.1.1.1 and 2.1.1.2, it assembles the regulatory and institutional roadmap, the financial model, the methodological annex and the monitoring-and-reporting framework that a new adopter would need, and assesses complementary financing pathways so the model is adaptable to different utility and watershed contexts.

The replication package is addressed to the Region's utilities, regional and municipal water authorities and potential financing partners, and it is built around the watersheds that supply the Bogotá system and the other systems that abstract from the same watersheds. Because the physical benefits accrue wherever the model is subsequently applied rather than in a single predefined site, the work is designed for transferability across the diverse contexts of the Region, from large, first-segment providers such as EAAB to smaller or differently regulated utilities, and validated with a range of utilities and authorities before it is finalized.

The sub-activity is led by CI-Colombia, which oversees implementation, coordinates partners and keeps the model aligned with the broader objectives of the project, with The Nature Conservancy (TNC) leading the technical development through the same grant agreement (flow GCF → CI-Colombia → TNC), systematizing the EAAB experience, preparing the utility-facing package on its Smart Environmental Investments Toolbox and assessing complementary financing pathways. EAAB serves as the primary demonstration case and technical counterpart, contributing tariff-implementation lessons and hydrological data, and CRA and SSPD participate so that the model, technical guidelines and financing approaches remain consistent with regulatory requirements. The sub-activity runs in Years 4 and 5, drawing on the evidence and lessons accumulated under Sub-activities 2.1.1.1 and 2.1.1.2, sequenced as follows:

- Year 4: Systematization of the EAAB experience and assessment of complementary financing instruments; preparation of the draft replication package and guidelines.
- Year 5: Institutional validation with utilities, regional and municipal authorities, CRA and SSPD, through field visits and coordination meetings; finalization of the package and guidelines.

This sub-activity produces a replication model package, comprising a regulatory and institutional roadmap, a financial model, a methodological annex, and a monitoring-and-reporting framework aligned with CRA and SSPD requirements, together with a replication guidelines report addressed jointly to utilities, regulators and financing partners. Developed by TNC with CI-Colombia and EAAB, these deliverables give other water utilities the practical means to include environmental investments in their tariff.

8.2.2. Activity 2.1.2 - Operationalize a long-term financial mechanism for private investments

This activity will operationalize a financial mechanism designed to attract additional private sector resources and establish a long-term continuity financing structure for the watershed transformation model activities. This activity is expected to unlock an additional USD 5 million in private-sector financing during the GCF project implementation period through the establishment and operation of the mechanism. As the mechanism is intended to continue operating beyond the lifetime of the project, it is expected to mobilize additional private-sector resources over time, supporting the expansion and long-term sustainability of the Watershed Transformation Model in Bogotá and the Region.

Resources from private-sector continuity financing may be allocated among (i) long-term stewardship activities and monitoring costs of GCF-restored and sustainable production transformed areas, (ii) restoration, conservation, and sustainable productive transformation activities in new areas within the Bogotá Region watersheds, consistent with the Watershed Transformation Model (Component 1). The

mechanism will support the continuity, expansion, and long-term sustainability of watershed interventions.

The mechanism will not create a market for Volumetric Water Benefits, nor will VWBs be treated as tradable assets. Rather, participating companies in the mechanism will support the continued implementation and expansion of watershed stewardship activities in new or GCF restored and sustainably productive converted areas and may report VWBs generated in those areas in accordance with applicable VWBA principles.

Key concepts

- Stewardship activities: The set of activities required to ensure that the restored, conserved, or sustainably productive converted areas continue delivering hydrological benefits over time consistent with Conservation Agreements and Climate-Resilient Farm Plans.
- GCF upfront capital is provided to establish watershed interventions that would not otherwise happen. Once those interventions are generating measurable hydrological benefits, the continuity financing mechanism supports the long term maintenance, monitoring, stewardship and expansion of watershed interventions, including additional hectares under the Watershed Transformation Model.
- Reinvestment refers to the use of resources mobilized through the mechanism to finance additional watershed interventions beyond those initially supported by the project, allowing restoration, conservation, and sustainable productive transformation activities to expand to new areas and beneficiaries over time.

Importantly:

- companies are not purchasing VWBs; VWBs are not treated as tradable assets;
- companies are financing the continued stewardship of landscapes and expansion to generate measurable hydrological benefits;
- Attribution of VWBs follows VWBA principles and is linked to ongoing financial participation and support.

The next phases explain the link between component 1 and 2 of the project and the potential functioning of the financial mechanism:

Phase 1 –GCF Investment (Under Component 1, years 1-3)

The GCF provides the initial capital to establish conservation, restoration, and sustainable production activities in prioritized micro-watersheds. These investments create the conditions required for avoiding/reducing runoff over time in prioritized landscapes, which generates future “hydrological benefits, quantified through Volumetric Water Benefits (VWBs) while also delivering climate resilience. During this phase, implementation costs are higher because restoration, conservation and productive transformation are implemented mostly in degraded landscapes and they include capital investment of the interventions (CAPEX).

Phase 2 – Generation and Manturity of Volumetric Water Benefits (Under Component 1 – Years 3-5)

As vegetation cover recovers and ecosystem functions improve, hydrological processes are expected to be restored over time. At the farm level, project activities help to reduce excess runoff, sedimentation, and nutrient pollution (e.g., nitrogen and phosphorus). When implemented across a significant and

connected portion of a watershed, they can improve water dynamics by reducing peak flows, low-flow periods, and bank erosion. Consistent with VWBA guidance for nature-based interventions, hydrological improvements, measured through volumetric water benefits, are expected to emerge gradually and increase as the ecological systems recover. The project will quantify and validate these volumetric outcomes through an established monitoring and calibration framework under Act. 1.2.1 led by the CI Freshwater team and the project field teams.

Measurement and calculation of VWBs of investments done with GCF proceeds

In this phase, under Component 1, CI will validate the estimated VWBs resulting from the project interventions financed with GCF proceeds and cofinancing sources by installing run-off plots across all land-use types so that differences in runoff generation mechanisms can be characterized due to differences in land cover, slope, soil compaction, and management (see activity 1.2.1). This will reduce uncertainty around hydrological outcomes and establish realistic and defensible relationships between specific interventions and their resulting VWBs in the prioritized landscapes.

Additionally, continuous field measurements will enable assessment of hydrological changes at the watershed scale, capturing the aggregated effects of all interventions implemented within the watershed rather than only measuring impacts at individual plot level. In this sense, the proof of concept under component 1, will provide concrete field data regarding the magnitude and reliability of hydrological benefits that can be attributed to project actions at the plot and watershed level, rather than relying solely on modeled assumptions.

The continuous field data measurement and model calibration will feed into the design of an automatic tool to calculate VWBs generated by future investments through the financial mechanism (See sub activity 2.1.2.1).

Phase 3 – Continuity Financing (Under Financial mechanism of Component 2)

As interventions transition from establishment to maturity, the cost structure of the program also evolves. The initial investment phase requires significant capital to implement conservation, restoration, and productive reconversion activities, establish agreements with landholders, and develop monitoring systems. Once these interventions are established and ecosystem restoration is underway, ongoing expenditures are expected to decrease, as financing is primarily directed toward maintenance, monitoring, verification, adaptive management, and continued engagement with landholders rather than the implementation of new restoration or productive transformation activities. Consequently, the annual costs required to sustain the watershed interventions and the hydrological benefits they generate at full maturity are generally lower than the original capital investments needed to generate them. As ecological systems improve, annual VWBs are expected to continue increasing until full maturity while the costs required to sustain those benefits become significantly lower than the initial investment needed to create them.

There are two main financing windows through which future private-sector contributions may be deployed. The first window supports new investments in restoration, conservation, and sustainable productive transformation activities in additional hectares within the Bogotá Region watersheds, enabling the Watershed Transformation Model to continue expanding its scale and impact over time.

The second window supports the long-term continuity of areas initially supported with GCF upfront capital. Under this approach, private-sector contributions are structured in two components: (i) a long-term stewardship component that finances the monitoring, maintenance, verification, and ongoing

engagement required to sustain hydrological benefits and watershed outcomes in existing restored and sustainably transformed areas; and (ii) a reinvestment component that finances restoration, conservation, and sustainable productive transformation activities in additional hectares. Because the costs of maintaining mature interventions are generally lower than the costs of establishing new interventions, this structure creates room within the overall contribution for participating companies to support both the continuity of existing outcomes and the expansion of watershed activities through a single financing window.

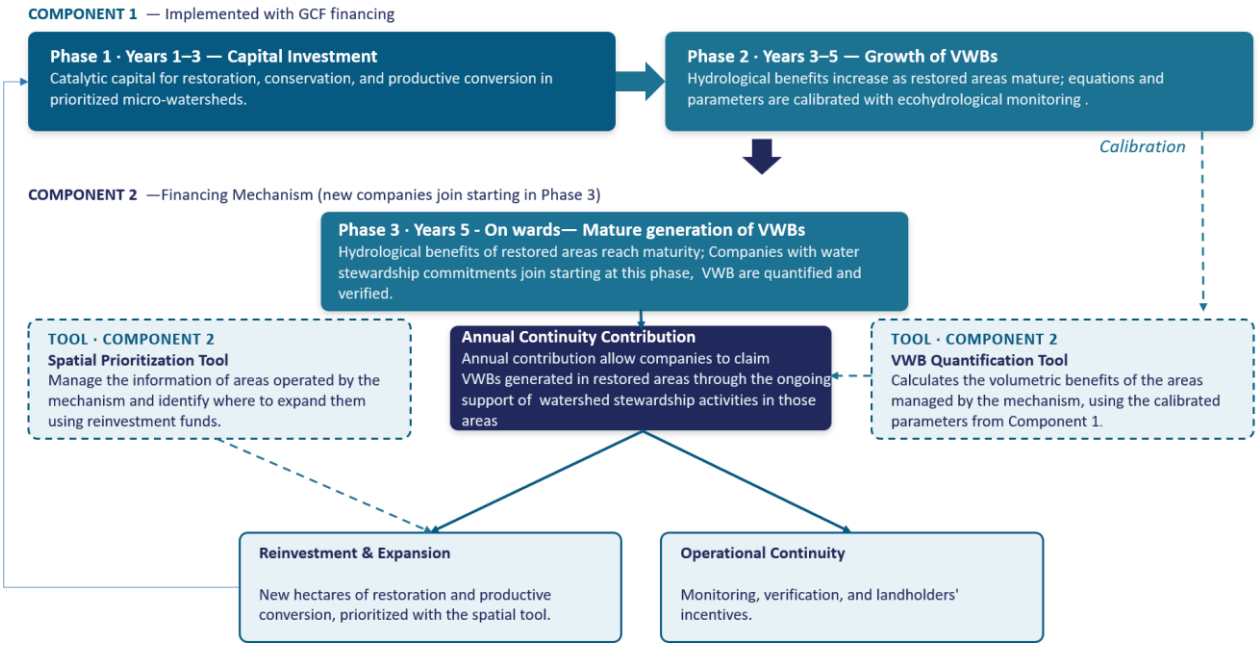
Participating companies may choose to contribute through either financing window depending on their investment objectives, water stewardship commitments, and priority landscapes. Some companies may prefer to support the long-term continuity of existing interventions, while others may prioritize the establishment of new restoration, conservation, or productive transformation activities. The mechanism will be designed to accommodate both approaches while supporting the sustained growth of watershed outcomes across the Bogotá Region.

Under this approach, VWBs reported by companies would be attributable to their financial contribution to, and ongoing support of, watershed stewardship activities in the restored and productive converted areas that generate those benefits. Attribution would therefore be linked to continued participation in maintaining, monitoring, and strengthening watershed interventions over time. This distinction is important because it preserves the stewardship-based nature of the mechanism and avoids the creation of a market in which VWBs are bought and sold as standalone commodities.

Private sector participation is expected to be driven primarily by companies that have operational facilities, supply chains, strategic assets, or significant business interests within the target watersheds or areas of hydrological influence. In accordance with VWBA guidance, **companies may report VWBs associated with their participation only while they remain actively involved in supporting the functioning and long-term performance of the interventions that generate those benefits.**

The different phases and project components are outlined in Figure 50.

Figure 51. Continuity Financing Mechanism – Activity 2.1.2.



The activity addresses the gaps related to lack of sustainable long-term, watershed-level financing for watershed stewardship, and insufficient frameworks for translating hydrological performance into financing decisions and long-term investment planning. The activity addresses the barrier on how private water investment happens today. Companies that need to invest in watersheds for water compensation must currently design their own projects and/or find entities to carry out the investment, one initiative at a time, producing dispersed, small-scale spending that cannot guarantee continuity of intervention, demonstrated results or long-term sustainability of results at the scale of the watershed. The mechanism closes these gaps and barriers by offering a single, credible platform, backed by public sector institutions, private sector and major actors such as CI, TNC and WRI, where contributions are prioritized, implemented at watershed scale, and monitored against both individual and common results, with field data.

The activity is structured as follows. Sub activity 2.1.2.1 focuses on developing automatic tools that will enable the technical functioning of the financial mechanism long-term. Primarily these include the spatial prioritization of future investments and monitoring and reporting of VWBs generated with future investments, which need to be calculated consistently and annually. Sub activity 2.1.2.2 focuses on the assessment, design and operationalization of the financial and operational structure, including the financing model, attribution, allocation and the legal and administrative arrangements required for implementation. This sub-activity also includes consultations and collaborative work with private sector actors to channel new investments through the mechanism and support the long-term continuity and expansion of watershed interventions.

Implementation model and partners

Fondo Acción leads the structuring and operation of the mechanism, drawing on its experience in environmental finance, payments for environmental services and long-term financing vehicles, and acting

as the financial structurer and operator that receives, safeguards, allocates and reports private contributions.

CI-Colombia is the implementing entity for the stewardship activities and deploying new financing into areas not originally funded by the GCF project together with other qualified operators.

TNC develops the automatic tool for the spatial prioritization of investment location. TNC was selected as an implementing partner because the activity aligns with its mission and long-term programme in the Bogota Region. In addition, TNC has developed and operationalized a comprehensive suite of scientific and decision-support tools directly applicable to the Bogotá Region landscape. These include WaterProof, a pre-feasibility and investment-optimization platform that integrates the InVEST and RIOS models to evaluate water yield, sediment retention and the return on investment of nature-based solutions; and SIMA, a cloud-based, open-access decision-support system that combines hydrological modelling, remote sensing (Google Earth Engine) and land-use and climate-change scenario analysis to enable integrated basin planning and climate-resilient decision-making. TNC is a key partner to ensure buy-in, engagement from local actors and sustainability of results over time.

Additionally, FA will hire WRI through a service provider contract to develop the automatic tool for the long-term quantification and reporting of VWBs based on the WRI methodology, incorporating the field learning from Component 1 produced by CI teams under Activity 1.2.1.

During the first two years of project implementation, CI and project partners will undertake the technical, financial and legal assessments necessary to assess and design this long-term watershed continuity financing mechanism.

The detailed model of the mechanism, including funding arrangements, financial engineering for expansion and reinvestment , VWB attribution definitions, legal and institutional arrangements, reporting requirements, and governance procedures, will be developed and validated during this phase under sub activity 2.1.2.2.

Implementation times[19]

Year 2

Signature of Grant Agreement with TNC

Start of consultancy to design financial mechanism

Year 3

Continue the design phase of the financial mechanism

Financial mechanism becomes operationatial

VWBs tool developed

Year 4

[19] For administrative purposes, Year 1 (6 months effective) is for project start up and Year 6 (6 months effective) is for project close out.

Automatic tool for spatial prioritization of investments developed

Deliverables

- Automatic tool for spatial prioritization of investments (Software, user manuals); automatic tool for estimation of VWB (Software, user manuals); prioritization maps and VWBs calculations.
- Report on allocation of funds managed by the mechanism during the project's implementation period. Signed commitments of at least USD 5 million and portfolio of interventions to be financed

8.2.2.1. Sub-activity 2.1.2.1 - Develop tools and methodologies for prioritization, monitoring, quantification and verification

This sub-activity builds the technical core of the financial mechanism, two automatic tools to motivate private sector actors to committing resources by providing technical robustness on where to invest and what that investment achieves. Without a credible and operational basis for these decisions, private finance defaults to the dispersed, small-scale spending the mechanism is designed to overcome. The tools are therefore developed not as standalone analytics but as the decision and accountability engine that the mechanism's allocation and reporting processes will run on, calibrated throughout the evidence emerging from the Component 1 proof of concept.

The first tool, developed by TNC will automate the spatial prioritization of investment location. The single most consequential decision in any watershed financing mechanism is not how much to invest but where to do so. Directing capital to the wrong places, even in good faith, produces diminished hydrological returns and erodes the confidence of the corporate and institutional partners on whose long-term participation the mechanism depends on. The tool addresses this by integrating multiple layers, the hydrological performance criteria derived from the Sub-activity 2.1.1.1 portfolios, spatial data on ecosystem condition and land-use pressures, climate-risk projections at watershed scale, socioeconomic relevance for downstream water users, and implementation-feasibility parameters such as governance conditions, land-tenure clarity and local institutional capacity, into a single, transparent, weighted scoring model. Rather than starting each allocation from a blank slate, it takes the expert-driven portfolio construction already technically validated under Sub-activity 2.1.1.1 and converts it into a repeatable, updatable and investor-facing process that Fondo Acción and its partners can apply consistently as the mechanism grows. It is designed to support not only initial site ranking but dynamic, auditable portfolio construction over the life of the mechanism, so that as interventions are implemented, monitoring data accumulates and hydrological baselines evolve, prioritization can be revisited to identify where incremental investment generates the highest marginal return in water-resilience value. The tool also assesses the demonstration potential of candidate investments, those that, beyond their direct hydrological impact, generate evidence and visibility that accelerate private uptake in adjacent watersheds while complementing the resilience of the Bogotá Region's supply system.

The second tool will quantify the volumetric water benefits (VWBs) generated by financed interventions, applying the volumetric water benefit accounting methodology developed by WRI and incorporating the field learnings from the Component 1 proof of concept and calibrated methodology parameters based on observed field evidence rather than on generic assumptions, which is conducted under activity 1.2.1. Rather than creating a separate measurement framework, the tool extends to the private-finance pathway the same hydrological logic defined under Sub-activity 2.1.1.1. For each contributor, it relates the prioritized interventions in the relevant watershed or sub-watershed to a quantified, traceable and verifiable hydrological result, expressed first in cubic meters of VWB and then in the terms that explain

why those cubic meters matter, the expected contribution to water-resource availability, flow stability across wet and dry periods, buffering under extreme conditions, or reduced stress on raw water quality, according to the intervention type and the strength of the available evidence. The tool also gives the mechanism its credibility: a contributor can see what intervention package was financed, where it was implemented, what hydrological result is estimated or observed, over what timeframe it is expected to materialize, and with what degree of confidence, and the results can be subjected to independent verification where this allows contributors to use them in corporate water-stewardship, sustainability or disclosure processes.

Together, the two tools make a private contribution legible and accountable in a way that is not possible today: the prioritization tool tells a company where its resources generate the greatest impact and in line with its objectives, and the VWB tool tells it how much water benefit results and how that benefit contributes to the common outcome in the watershed.

This sub-activity produces two products: one automatic tool for the spatial prioritization of investments and one automatic tool for the estimation of VWBs, each accompanied by its software, user manuals and technical methodology documentation, quality-control protocols and update procedures that make the tools transparent and independently auditable.

8.2.2.2. Sub-activity 2.1.2.2 - Establish the operational and financial structure of the mechanism

This sub-activity will assess and establish a long-term continuity financing mechanism capable of mobilizing a sustainable source of financing to support watershed management activities. The work will focus on developing the financial model required to determine the structure, operational requirements, and long-term financing conditions needed to support ongoing operations, landscape expansion, and the sustained implementation of watershed interventions in new hectares.

The project will conduct the financial engineering and costing assessments needed to determine lifecycle intervention costs, long-term monitoring and maintenance requirements, administrative and transaction costs, and financing allocation options. The analysis will evaluate different participation and financing assumptions, the structure of the mechanism, and the financial viability of the model under conservative and optimistic private sector uptake scenarios, including its capacity to support ongoing watershed management and the expansion of interventions over time.

The sub-activity will undertake engagement with private sector to assess interest in participating in the mechanism, understand corporate stewardship targets and replenishment commitments, evaluate willingness to contribute financially, and identify potential participation structures, contract durations, and anchor participants. These consultations will inform the design of a demand-driven model aligned with private-sector needs and investment criteria.

Finally, the sub-activity will also assess the legal, institutional, governance, and monitoring requirements needed to operationalize the mechanism. This will include evaluating the legal roles and capacities of CI and Fondo Acción, while developing the attribution, reporting, and verification framework required to ensure that any Volumetric Water Benefits generated and reported through the mechanism remain consistent with VWBA principles and avoid double counting.

9. Expected impacts, indicators and measurement methodology

This chapter defines the expected impacts, indicators, and measurement methodology of the project *Building Water Resilience in Bogotá and the Region*, translating the analytical foundations developed in previous chapters into an operational, results-based framework. It establishes how the climate problem, the identified barriers, the selected interventions, and the feasibility assessment are converted into measurable outcomes that can be monitored, verified, and used to support long-term investment and scaling.

The purpose of this chapter is not limited to reporting expected results. It plays a central role in the feasibility argument by demonstrating that the proposed interventions can generate observable and quantifiable changes in hydrological performance, water system reliability, and climate resilience. In particular, it responds directly to the monitoring, reporting and verification (MRV) gap identified in Chapter 3, by defining a structured approach to measure how land-use change, ecosystem restoration, productive transformation, and water system improvements translate into adaptation outcomes at watershed scale.

The measurement framework is anchored in the concept of Volumetric Water Benefits (VWBs), which provides a standardized and comparable metric to quantify hydrological improvements across different intervention types. This approach allows the project to move beyond activity-based reporting and demonstrate causal links between interventions and changes in water availability, regulation, and efficiency.

9.1. Expected impacts and contribution to climate resilience

The overall expected impact of the project is a sustained increase in water security and climate resilience in the Bogotá Region, achieved through integrated actions in strategic watersheds that influence the reliability, quality, and stability of water supply systems under increasing climate variability.

This impact is grounded in the climate rationale presented in Chapter 2 and the feasibility analysis in Chapter 7, which demonstrate that water vulnerability in the region arises from the interaction between climate hazards, ecosystem degradation, land-use pressures, and structural inefficiencies in water systems. The project addresses these drivers simultaneously, ensuring that its impacts are not incremental but systemic.

The pathway to impact is based on three interdependent processes:

- The restoration and protection of high-Andean ecosystems and hydrologically strategic landscapes, which restore infiltration, soil-water storage, and regulation capacity
- The transformation of productive systems and improvement of water management practices, which reduce runoff, erosion, and water demand
- The strengthening of water systems and the establishment of long-term financing mechanisms, which increase reliability and ensure sustainability over time

These processes result in measurable improvements in hydrological behavior, including reduced surface runoff, enhanced baseflows, reduced sediment loads, and improved efficiency in water use. At the same time, they increase the adaptive capacity of both rural communities and downstream users by improving access to reliable water and reducing exposure to droughts, floods, and water quality risks.

9.2. Results logic and performance-based approach

The results framework follows the theory of change presented in Chapter 6, linking project activities to outputs, outcomes, and long-term impacts through a coherent causal sequence.

At the activity level, the project implements conservation and restoration of ecosystems, climate-resilient productive practices, improvements in community water systems, and mechanisms to strengthen market access and mobilize finance. These interventions generate outputs such as restored and conserved hectares, transformed production systems, upgraded water systems, and operational financial structures.

At the outcome level, these outputs lead to:

- Improved hydrological regulation at watershed scale
- Increased resilience of rural communities and water systems
- Strengthened institutional and financial capacity for adaptation
- Generation of verifiable hydrological evidence through VWBs

At the impact level, these outcomes translate into improved water security and reduced vulnerability to climate-related water risks across the Bogotá Region.

A critical feature of this framework is its performance-based structure. Instead of relying solely on activity completion (e.g. hectares restored), the project measures success through changes in hydrological processes. VWBs function as the central integrating metric that connects environmental outcomes with financial mechanisms, enabling the project to demonstrate results that are both scientifically grounded and investment-relevant.

9.3. Measurement framework and methodological approach

The measurement approach is built around a combination of hydrological modeling, field validation, and socioeconomic and system-level monitoring, ensuring that all key dimensions of the project can be quantified and verified.

Volumetric Water Benefits (VWB)

VWBs quantify the incremental water-related benefits generated by project interventions relative to a baseline scenario. These benefits are expressed in volumetric terms (m^3/year) and reflect improvements in four key dimensions:

- Reduction of surface runoff through increased infiltration and retention
- Enhancement of baseflows and dry-season water availability
- Reduction of sediment and pollutant loads affecting water quality
- Water savings and efficiency gains in supply systems

This approach allows the project to standardize results across different types of interventions and to aggregate them from plot level to watershed scale.

Hydrological modeling and validation

The quantification of VWBs is based on the comparison between baseline and with-project scenarios using hydrological modeling tools consistent with those described in Chapter 7, including the Curve Number method and SWAT-based simulations.

Baseline conditions are defined using land-use data, climate variables, and water system performance indicators, while the with-project scenario incorporates improvements in vegetation cover, soil condition, and water management practices. The difference between these scenarios represents the hydrological benefit attributable to the project.

To ensure robustness, model outputs will be complemented by field-based verification, including monitoring plots, water flow measurements, sediment tracking, and water-quality sampling. This combination of modeled and observed data strengthens the credibility of the results and reduces uncertainty.

9.4. Expected results and indicators

The project's expected results are summarized through a structured set of indicators that link each level of the results chain with measurable metrics and clear verification methods.

Table 38. Expected impacts, indicators and measurement methodology.

Result level	Expected result	Indicative metric	Measurement methodology
Impact	Increased water security and climate resilience	Beneficiaries with increased resilience; improved water reliability	Household surveys, service performance data, aggregated outcome indicators
Outcome 1	Improved hydrological regulation in priority watersheds	Annual Volumetric Water Benefits (VWB); reduced runoff; improved baseflow	Hydrological modeling (SWAT/CN), baseline vs project comparison, field calibration
Outcome 2	Sustainable financing mechanisms for watershed adaptation	Public and private finance mobilized; operational tariff mechanism	Financial records, mechanism reports, institutional validation
Output 1	Ecosystems conserved and restored	hectares conserved and restored	GIS analysis, field verification, monitoring of agreements and restoration progress
Output 2	Productive systems and water systems improved	hectares under climate-resilient practices; upgraded community systems	Farm-level monitoring, system-level data (NRW, water quality)

9.5. Measurement of resilience, systems performance and finance

In addition to hydrological metrics, the project measures its impact through complementary dimensions that reflect its systemic nature.

Resilience and livelihoods

Resilience outcomes are monitored through household surveys and participatory assessments, capturing changes in water access reliability, vulnerability to climate variability, and adoption of climate-resilient practices. For producer organizations, monitoring includes economic performance, market participation, and the adoption of sustainable production models.

Water system performance

Improvements in community-run water systems are measured through indicators such as non-revenue water, system efficiency, water quality, and service continuity. These indicators provide direct evidence of how efficiency measures translate into reduced abstraction pressure and improved service for rural populations.

Financial and institutional performance

The effectiveness of the financial mechanisms is assessed through the amount of finance mobilized, the operational status of the tariff-based and private investment mechanisms, and the extent to which financing flows are linked to measurable hydrological outcomes. Institutional performance is evaluated through the adoption and implementation of governance structures and monitoring systems.

9.6. Contribution of the measurement framework to feasibility

The measurement framework strengthens the project's feasibility in a fundamental way. It demonstrates that project outcomes are not assumed, but can be quantified, verified, and linked to decision-making processes. This is particularly relevant in a context where the feasibility analysis has identified the lack of operational evidence as a key barrier to scaling watershed-based adaptation.

By establishing a clear MRV architecture based on VWBs and complementary indicators, the project creates the conditions for:

- Demonstrating causal links between interventions and hydrological outcomes
- Reducing uncertainty for public and private investors
- Enabling performance-based financing mechanisms
- Supporting replication and scaling beyond the project lifetime

This evidence-based approach is essential to move from project-level interventions to a systemic, financeable model of climate adaptation.

9.7. Conclusion

This chapter provides the operational bridge between the project's analytical foundation and its implementation and scaling strategy. It demonstrates that the expected impacts of the project are

measurable, verifiable, and capable of being translated into investment-relevant results. By integrating hydrological modeling, field validation, socioeconomic monitoring, and financial tracking within a unified framework centered on Volumetric Water Benefits, the project establishes a robust and credible basis for demonstrating climate adaptation outcomes.

In doing so, it addresses one of the fundamental barriers identified in the feasibility study: the lack of measurable evidence linking watershed interventions to water security outcomes. The proposed measurement approach not only enables the project to track its performance, but also positions it as a scalable model for results-based, financeable watershed adaptation, consistent with the paradigm-shift objectives of the project.

10. Expected performance against GCF Investment Criteria

The project aligns with all six GCF Investment Framework criteria:

10.1. Paradigm shift

This section enumerates the specific paradigm-shifting elements that distinguish this project from other watershed and ecosystem projects. The project's central proposition is that previous efforts have not systematically addressed the root causes of water insecurity: they have relied on grey infrastructure and emergency response, financed watershed protection through sporadic, fragmented resources, and treated conservation and production as separate agendas. This project builds a new paradigm of watershed management: integrated, multi-actor and financially self-sustaining; in which demonstrated hydrological benefits are converted into durable finance that mobilizes the private sector.

The project is paradigm shifting because it goes beyond restoring watersheds and uses these results to build a replicable financial model based on measurable water benefits financed under existing regulations. It directly links biophysical evidence in the watersheds with water tariffs and private investment mechanisms, so that adaptation no longer depends on ad-hoc grants.

10.1.1. Paradigm shifting elements

- ✓ Watershed-based transformation model (the paramount shift)

Business-as-usual: Watershed interventions in the Bogotá Region are implemented through fragmented and institution-specific processes, where different entities launch independent calls for proposals without spatial coordination or integration across intervention types. This results in dispersed actions with limited cumulative hydrological impact, weak alignment between conservation and production systems, and duplication of efforts. Historically, investments have focused predominantly on conservation and restoration activities, with limited support for productive transformation and almost no integration with value chains or commercialization processes that could improve local livelihoods. In addition, interventions are often designed primarily to secure water supply for Bogotá, with limited perceived benefits for upstream communities, contributing to weak local ownership and, in some cases, social resistance. As a result, the sustainability of environmental investments remains constrained, as households continue to depend on unsustainable production systems due to lack of viable economic alternatives.

The shift: The project introduces a micro-watershed-level approach as the primary unit for planning and implementation, concentrating interventions sequentially and territorially within prioritized micro-watersheds. Building on lessons from two previous GEF projects, this model aligns conservation, restoration, climate-resilient production systems, water-use efficiency measures, and value chain development within the same hydrological units. The Watershed Transformation Model maintains ecosystem conservation and restoration actions, including economic instruments such as payments for conservation, while integrating productive transformation and commercialization as core components of the intervention. The approach explicitly incorporates local water security as an objective, ensuring that upstream communities experience direct and tangible benefits in water availability, reliability, and income generation. At the same time, the concentration of interventions within defined micro-watersheds enables the validation of Volumetric Water Benefits (VWBs) through field-based monitoring, complementing existing model-based estimates. This provides empirical evidence of hydrological outcomes over time and supports the demonstration of benefits required for tariff-based financing mechanisms.

Why it is better: By shifting from fragmented, project-based interventions to an integrated micro-watershed approach, the project generates cumulative and measurable hydrological impacts, increasing the effectiveness of investments at system level. The integration of productive transformation and market access reduces long-term pressure on ecosystems while improving household income stability, creating the economic conditions necessary for sustained environmental outcomes. The explicit inclusion of local water security aligns incentives between upstream communities and downstream users, increasing participation, ownership, and long-term commitment to watershed stewardship. The ability to validate VWBs through field data strengthens confidence in hydrological impact metrics and provides the evidence required to justify investments in green infrastructure within water tariffs. This, in turn, enables sustained financing beyond the project period. Overall, the approach transforms watershed management from a set of disconnected activities into a coherent territorial system that simultaneously delivers environmental, social, and financial sustainability.

- ✓ A self-sustaining watershed-finance model

Business-as-usual: Watershed protection depends on sporadic grants and partially used statutory resources, and often reverses once external support ends. Existing regulatory tools that could fund watershed resilience (such as tariff-based environmental investments or mandatory public allocations to strategic water areas) remain underutilized and are not explicitly tied to measurable hydrological results.

The shift: The project introduces two financial solutions, an environmental investment component in EAAB's water tariff, and a long-term private investment mechanism, converting verified hydrological results into durable public and private finance and mobilizing the private sector. Component 1 generates territorial evidence of hydrological outcomes measured through Volumetric Water Benefits (VWBs), while Component 2 embeds these results in existing regulatory and corporate stewardship frameworks so that investments can be sustained and scaled through tariffs and private Contributions linked to the quantification and reporting of VWBs to fulfil corporate targets.

Why it is better: This model makes adaptation investments permanent and scalable, with GCF capital used catalytically rather than as a permanent subsidy. Once the proof of concept is established, the tariff mechanism and private-investment vehicle continue to finance watershed resilience beyond the project's lifetime, reducing dependence on future grants and enabling broader replication.

- ✓ Integrated watershed transformation across the full land mosaic

Business-as-usual: Grey infrastructure and emergency responses dominate, while conservation and production are managed separately and underlying land-use pressures remain largely unaddressed. For a long time, decision makers have assumed that there was no serious risk of attending current water demand in the region and that future water demand will be covered with the expansion of the Chingaza supply system. Consequently, watershed interventions were considered minor in relevance, planned in isolation, with limited coordination to deliver coherent watershed-scale hydrological outcomes.

The shift: The project recognizes the need to protect current watershed hydrological services to but also the urgent need to restore degraded watershed hydrological services by combining conservation and restoration of páramo and high-Andean forests, climate-resilient production systems at farm level, and efficiency measures in rural community water-supply systems as an efficient climate change adaptation measure for water resilience in the Bogota region, . Watershed integrated interventions designed to collectively improve runoff regulation, infiltration and baseflow stability from the plot scale up to the watershed scale will conserve current water supply from additional degradation and will adapt watersheds to face climate change.

Why it is better: By tackling root causes rather than symptoms, the project produces higher and compounding hydrological benefits per unit of territory. This integrated land-mosaic approach also strengthens co-benefits for biodiversity and rural livelihoods, increasing the overall resilience of communities and ecosystems that support water supply resulting in effective long lasting climate change adaptation.

Business-as-usual: Most projects report inputs (hectares restored, number of agreements signed) rather than robust, comparable hydrological metrics that utilities, regulators and investors can use to justify and price investments. Hydrological improvements, when quantified, are estimated using generic modeling parameters undermining the credibility of the results.

The shift: The project uses Volumetric Water Benefits (VWBs) as its core impact metric, expressing benefit conservatively as reduced and avoided runoff (quick flow) calculated for an integrated land interventions mosaic that includes protected ecosystems, agricultural areas and peri-urban land in prioritized territories. Throughout the project, the VWB modelling hydrogeological parameters will be calibrate to the local conditions and to the specific type of interventions. This approach yields credible, comparable volumetric values that link upstream ecosystem-based adaptation and productive changes to downstream water services and financing decisions.

Why it is better: By converting hydrological benefit into something utilities, regulators and investors can quantify, price, justify within a tariff and report; and by calibrating accurate local modelling parameters, the project provides the metric that underpins the financing solutions in Component 2. This strengthens transparency and accountability in terms of VWBs to scaling investments in watershed resilience.

- ✓ Multi-actor watershed governance with aligned incentives

Business-as-usual: Governance of the Bogotá Region watersheds is fragmented across EAAB, SDA, CAR Cundinamarca, Corpoguavio, municipalities, communities and private actors that often act separately, with limited coordination or shared metrics. Incentives for long-term collaboration are weak, and efforts can dissipate with institutional or electoral changes.

The shift: The project aligns public regulatory mandates, private water-stewardship commitments, and community participation concentrated in selected watersheds around a single verifiable metric (VWBs) and shared finance mechanisms. By coordinating multi stakeholder interventions with a unified watershed intervention strategy and linking hydrological outcomes to investments, it creates a common results framework that binds these actors to align investments towards the same watershed transformation goals.

Why it is better: This alignment strengthens resilience and multi-actor participation and helps sustain action across electoral cycles and institutional changes. It also clarifies roles and incentives, turning utilities, authorities, communities and companies into co-investors in shared hydrological outcomes rather than isolated project participants.

- ✓ A replicable proof-of-concept and scaling blueprint

Business-as-usual: Traditional watershed investments in the region are fragmented with limited or no connection to verifiable volumetric water benefits. As a result, there is limited documentation with robust backing of effectiveness and replicable impact of past interventions. New interventions have limited access to documented effective and replicable intervention approaches. The shift: Catalytic GCF finance de-risks a demonstrated Watershed Transformation Model that crowds in domestic public finance (through the water tariff and the 1% municipal allocation) and private investments in VWBs, supported by

standardized tools for spatial prioritization, monitoring and hydrological quantification. The model is explicitly designed to be replicated in other Colombian watersheds and in the tropical Andes, including through replication templates for other utilities and companies.

Why it is better: Its impact becomes transformational beyond the initial intervention area, providing a clear blueprint for other territories to implement similar watershed-finance models based on verified VWBs. This accelerates learning, reduces transaction costs for new adopters, and enables climate adaptation finance to scale more rapidly where existing regulations and private stewardship commitments can be leveraged.

- ✓ **Sustainable, climate-resilient livelihoods anchored in watershed resilience**

Business-as-usual: Rural livelihoods in the Bogotá Region's headwaters depend on traditional, often low-productivity low-profitable practices (e.g. extensive cattle, conventional potato) that degrade páramos and high-Andean forests and increase climate vulnerability of local farmers and downstream communities. Existing projects rarely connect livelihood improvements to measurable water-resilience outcomes or to stable markets that reward "water-friendly" production, leaving households exposed to climate shocks and price volatility, undermining long term sustainability of projects interventions.

The shift: The project links sustainable livelihoods directly to watershed resilience by investing in profitable and climate-resilient production systems (silvopastoral practices, agroecology, diversified agrifood systems, efficient on-farm water use), in commercialization and access to new markets that value "water-friendly" production and in improving efficiency, safety and reliability in community-run water-supply systems. The objective is to increase farm productivity, product value, family income, income reliability and wellbeing clearly interlinked with water resilience so that beneficiaries are convinced that improvement on their live conditions are directly associated to contributing to downstream water resilience.

Why it is better: This approach reduces pressure on critical headwater ecosystems while increasing income stability and adaptive capacity for rural households, aligning household welfare with long-term watershed health. By embedding sustainable, climate-resilient livelihoods within the Watershed Transformation Model and its finance mechanisms, the project makes pro-water practices economically attractive and socially durable, strengthening social and hydrological resilience, both locally and regionally, over time.

Table 39. Mapping of the paradigm-shifting elements to the GCF criteria.

GCF paradigm shift criterion	How the project delivers it
Changes the system	Institutionalizes watershed protection and green infrastructure investments within the implementation of Colombia's new water tariff framework (CRA Resolution 1032/2026), shifting water-security planning from reactive infrastructure expansion toward ecosystem-based resilience.
Creates replicable models / markets	Watershed proof of concept with field-validated VWBs creates a transferable model for utilities and investors.
Influences policy / regulation / institutions	Provides one of the first large-scale operational applications of green infrastructure financing under Colombia's evolving water-sector regulatory framework, supporting implementation of the new CRA tariff methodology (CRA Resolution 1032/2026) and strengthening the integration of watershed conservation and climate resilience into utility planning and investment decision

GCF paradigm shift criterion	How the project delivers it
Mobilizes additional finance at scale	Recurrent tariff revenue plus a long-term public-private mechanism crowd in domestic and private finance beyond GCF.
Long-term sustainability beyond GCF	Productive transformation and commercialization secure local livelihoods; avoided treatment costs sustain utility investment; GCF capital is catalytic.
Delivers sustainable, climate-resilient livelihoods	Climate-resilient production systems, diversified agrifood livelihoods and more reliable community water services reduce ecosystem pressure and increase income stability, embedding household welfare in the Watershed Transformation Model

10.1.2. Paradigm shift pathway

The project's paradigm shift pathway is anchored in a results chain that links demonstrated hydrological performance to durable financing for water resilience. Component 1 delivers the proof of concept by generating verifiable Volumetric Water Benefits (VWBs) through an integrated package of ecosystem restoration, conservation, climate-resilient productive transformation, and water-use efficiency measures, thereby producing robust evidence that watershed interventions can deliver measurable hydrological improvements at scale. This component reduces a central market and policy barrier: the absence of credible, territorially grounded evidence that nature-based and productive landscape interventions generate quantifiable water resilience outcomes that can justify recurrent investment.

Building on this proof of concept, Component 2 translates demonstrated results into sustained public and private financial flows by operationalizing financing pathways that are feasible under existing regulatory frameworks and corporate water stewardship incentives. Specifically, the project supports the incorporation of an environmental fee into Bogotá's water tariff and establishes a long-term mechanism for private investment in verified VWBs, enabling the replication and scale-up of the watershed transformation model beyond the initial GCF-funded period. Together, these two components create the conditions for systemic change: grant resources are used not as a stand-alone financing source, but as catalytic capital to validate a model that can subsequently be financed through recurrent tariff-based and private-sector mechanisms, ultimately contributing to strengthened and self-sustaining water resilience in the Bogotá Region.

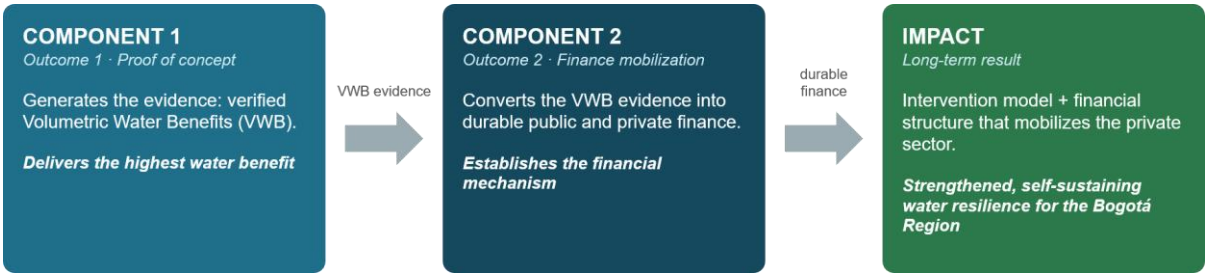


Figure 52. Paradigm shift pathway.

10.2. Impact potential

The project's impact potential is defined by its ability to deliver large-scale, measurable, and climate-relevant improvements in water security through a quantified hydrological outcome: Volumetric Water Benefits (VWBs) generated at watershed scale and directly linked to downstream water-service performance.

Rather than relying on proxy indicators, the project establishes a clear causal chain between climate risks, ecosystem and production interventions, hydrological responses, and human outcomes. Climate variability and land-use pressures in the Bogotá Region are increasing runoff volatility, sediment loads, and water-supply unreliability. The project addresses these drivers through an integrated territorial approach that produces measurable reductions in peak runoff and improvements in baseflow regulation, expressed as VWBs.

Modelled results estimate approximately 2,940,584 m³/year of avoided and reduced runoff (to be field-validated during implementation), positioning VWBs as the central metric linking upstream adaptation actions to downstream water security.

These hydrological improvements directly support water supply systems serving approximately 9.8 million people, including Bogotá's north and south systems, thereby anchoring project impact at metropolitan scale.

10.2.1. Scale of impact

The project operates at both watershed and metropolitan scale, ensuring high-impact outcomes and also the project links upstream interventions to a large-scale urban system, significantly amplifying the magnitude of impact.

Direct beneficiaries:

- ✓ 3,013,383 people with improved climate and water resilience as a result of on-the-ground interventions
- ✓ 1,248 smallholder farmers adopting climate-resilient production systems
- ✓ 30 producer associations supported for commercialization and opening of markets
- ✓ 40 community-run water supply systems with macro-metering, potable water treatments, and capacity building

Indirect beneficiaries:

- ✓ 7,083,799 people and groups who are not directly targeted by field interventions but will benefit from the enabling environment created by Component 2.

Geographic scope

Intervention in 12 prioritized upper watersheds in the Bogotá Region. Total intervention area:

- ✓ 4,756 ha under conservation (páramo, high-Andean forest, riparian ecosystems)
- ✓ 2,032 ha under restoration (páramo, high-Andean forest, riparian ecosystems)
- ✓ 2,409 ha under sustainable and climate-resilient production systems

Hydrological outcomes

- ✓ 2,940,584 m³/year of avoided or reduced runoff (VWBs) in year 5

The project modifies watersheds processes by:

- ✓ Increasing infiltration and soil moisture retention

- ✓ Stabilizing baseflow in dry periods
- ✓ Reducing peak runoff during extreme rainfall

Water infrastructure performance

The intervention improves conditions for key treatment systems (Tibitoc, El Dorado) through:

- ✓ Reduced sediment loads (30% average of reduction of sediment export in the prioritized watersheds- see Appendix II)
- ✓ Improved raw water quality (33% average of reduction of Nitrogen delivery ratio in the prioritized watersheds- see Appendix II)
- ✓ More stable inflows

Expected effects:

- ✓ Reduced operational costs: USD 7.06 million at NPV
- ✓ Improved service reliability

Adaptative capacity of vulnerable populations

The project directly engages smallholder farmers in upper watersheds by promoting:

- ✓ Silvopastoral and agroecological systems
- ✓ Diversified and climate-resilient production
- ✓ Improved water-use efficiency

Results:

- ✓ 1248 families benefited with a diversified climate-resilient production (approximately 4,992 people – 50% women)
- ✓ Reduced exposure to climate variability
- ✓ Lower pressure on strategic ecosystems

Climate relevance

The project responds directly to current and projected climate risks. Colombia implemented water rationing in April 2024, indicating systemic vulnerability, then, under climate change scenarios the Bogotá Region faces increasing:

- ✓ Rainfall variability
- ✓ Drought frequency
- ✓ Runoff intensity

The project addresses these risks by enhancing natural water regulation capacity at watershed scale. As climate variability increases, the value of reduce runoff peaks and improve baseflow stability also increases, ensuring that benefits are dynamic and sustained over time.

Robustness, measurability and attribution

A central strength of the project is the use of VWB as a core metric, because it quantifies hydrological benefits in m^3 of avoided/reduced runoff, links upstream interventions to downstream water outcomes

and enables comparability across sites. These are backed by a monitoring framework for hydrological modelling combined with field validation (for the following variables: runoff, infiltration and sediment dynamics) that provides periodic verification of results.

Monitoring eases a clear attribution between interventions and outcomes, transparent reporting and direct measurement of changes in vulnerability and adaptive capacity.

In summary, the project meets GCF expectations for high impact potential through:

- ✓ Large-scale reach: ~7.08 million indirect beneficiaries
- ✓ Quantified outcomes: ~2.94 million m³/year of VWBs (in year 5)
- ✓ Climate-driven results: direct response to water variability and scarcity
- ✓ System-level effects: improved water infrastructure performance
- ✓ Livelihood impacts: increased resilience and adaptive capacity
- ✓ Robust measurement: verifiable hydrological metric linked to outcomes

By operating at the scale of Bogotá's water supply system, the project ensures that hydrological improvements translate into high absolute benefits, amplifying the impact of upstream interventions on downstream populations and infrastructure.

10.3. Sustainable development potential

The project demonstrates strong Sustainable Development Potential by delivering integrated environmental, economic, social, and mitigation co-benefits that extend beyond its core climate adaptation objective. These co-benefits are not treated as secondary outcomes, but are embedded in the project's design through a territorial approach that links ecosystem restoration, climate-resilient production systems, and water system performance.

The intervention operates on the premise that water security, ecosystem integrity, and rural livelihoods are interdependent. By addressing these dimensions simultaneously, the project contributes to a development pathway in which hydrological stability, economic viability, and social well-being reinforce each other over time. This integrated approach aligns with GCF expectations by ensuring that climate adaptation investments generate broader and sustained development benefits without creating trade-offs across sectors.

10.3.1 Environmental co-benefits

The project generates substantial environmental benefits through the restoration and improved management of high-mountain ecosystems, including páramos, high-Andean forests, and riparian systems. These ecosystems play a critical role in regulating water flows, maintaining soil stability, and supporting biodiversity. By conserving and restoring approximately 26,071 hectares of strategic ecosystems, protected areas and improving land management across agricultural areas, the project enhances ecological functionality at watershed scale.

These interventions contribute to improved hydrological processes such as infiltration, water storage, and gradual release, while also reducing erosion and sediment transport. At the same time, ecosystem restoration improves habitat quality and connectivity, supporting endemic and migratory species and increasing ecological resilience under climate variability. These effects are expected to be monitored through indicators related to habitat condition and the presence of key species across monitoring sites.

In addition, the transition from conventional land-use practices toward sustainable systems contributes to soil recovery, increased organic matter, and reduced land degradation. These environmental improvements are directly linked to the project's hydrological outcomes, ensuring that ecosystem benefits are both ecologically meaningful and functionally relevant for water security.

10.3.2. Economic co-benefits

The project delivers significant economic benefits by reducing system costs, improving productivity, and supporting income generation in rural areas. One of the main economic effects arises from improved watershed functioning, which reduces sediment loads and enhances raw water quality. This translates into lower operational costs for water treatment systems, including reduced use of chemicals, energy, and sludge management, with estimated savings of approximately USD 32.6 million for the 20 year span of the project (EFA Technical Report).

These cost savings are reflected in the project's overall economic performance, with an Economic Internal Rate of Return of approximately 19.84% and net economic benefits of around USD 91.7 million over a 20-year period. This demonstrates that the project not only delivers environmental and climate outcomes, but also creates tangible financial value at system level.

At the local level, the project promotes climate-resilient production systems that increase agricultural productivity and reduce input dependency. By supporting the adoption of silvopastoral practices, agroecological approaches, and diversified production systems with facilitation of value chains and markets that recognize sustainable production practices for producers associations, the project enables associations to achieve sales increases of 16% (See Appendix II). These improvements are complemented by reduced production costs, including lower water use and decreased reliance on agrochemicals. By connecting producers' associations to differentiated markets it contributes to increased price stability and reduced income volatility, enhancing long-term economic sustainability for rural households.

10.3.3. Mitigation Co-benefits

Although primarily focused on adaptation, the project generates mitigation co-benefits through carbon sequestration and improved land-use practices. Restoration of high-mountain ecosystems and improved soil management contribute to increased carbon stocks in both biomass and soils. Estimated mitigation benefits amount to approximately 2,979,323 tCO_2e sequestered over 20 years (See appendix III).

At the same time, the transition away from conventional agricultural practices reduces emissions associated with land degradation, inefficient input use, and, where applicable, extensive livestock systems. These mitigation effects contribute to national climate objectives while reinforcing the environmental integrity of the project.

Overall, the project demonstrates strong Sustainable Development Potential by delivering measurable and interconnected benefits across environmental, economic, and mitigation dimensions. These benefits are directly linked to project activities, supported by quantifiable indicators, and designed to be sustained over time.

Table 40. Co-benefits.

Co-benefit	Indicator	Generating activities and why it is a co-benefit
Environmental (Biodiversity)	Hectares of habitat restored/conserved;	Activities 1.1.1 and 1.1.2.

	presence of target species at monitoring sites	A co-benefit because the activity's designed output is the hydrological benefit (VWB) and community adaptation; habitat gain is additional.
Mitigation (Carbon)	tCO_2e sequestered in soils and biomass	Activities 1.1.1, 1.1.2 and 1.2.1. Additional to the adaptation objective; value to be quantified and, where possible, benchmarked.
Economical (Avoided water-treatment cost)	Avoided treatment cost (US$/yr) from lower sediment load at plants such as Tibitoc, La Laguna and El Dorado	Activities 1.1.1, 1.1.2 and 1.2.1. Less erosion/sedimentation upstream. A co-benefit because the designed output is VWB; the saving is a downstream financial consequence. Savings are reinvested via the tariff component (Component 2), not retained as project revenue.

The project's approach ensures that climate adaptation is not implemented in isolation but contributes to broader development outcomes, positioning it as a comprehensive and financeable intervention aligned with GCF priorities.

10.4. Needs of recipient

The project meets the GCF Needs of the Recipient criterion by addressing a clearly documented climate vulnerability affecting both a large urban population and highly exposed rural communities in the Bogotá Region, while targeting structural barriers that currently prevent adaptation from taking place at scale. The needs addressed by the project are multidimensional. They include:

- ✓ increasing exposure to climate-induced water insecurity at system level,
- ✓ low adaptive capacity among upstream rural populations, and
- ✓ the absence of sustained financing mechanisms for watershed-based adaptation.

The project responds to these needs through a combination of territorial interventions, targeted support to vulnerable populations, and the development of a financing architecture capable of sustaining investments over time.

The Bogotá Region faces increasing climate-related stress on its water systems, driven by higher variability in precipitation, more frequent droughts, and more intense rainfall events. These dynamics are altering hydrological regimes, increasing runoff variability, and reducing the reliability of water supply systems.

This vulnerability materialized in April 2024, when Colombia implemented formal water rationing measures, highlighting the structural exposure of the Bogotá water supply system. Approximately 20% of the national population is affected by water-security risks, with a high concentration in the Bogotá Region. In particular, around 9.8 million people depend on the water systems targeted by the project, making these systems critical for national economic and social stability.

Under business-as-usual conditions, responses to water scarcity have relied primarily on reactive measures and grey infrastructure investments, without systematically addressing the degradation of upstream watersheds that regulate water availability. This creates a structural gap between climate risk and adaptation response, which the project directly addresses.

The project targets rural populations located in upper watershed areas, where climate exposure and socio-economic vulnerability intersect. These communities are predominantly composed of smallholder farmers operating in municipalities classified within the lowest fiscal categories, reflecting limited public investment capacity and institutional resources. These households face multiple constraints, including:

- Dependence on climate-sensitive production systems such as extensive cattle grazing and conventional potato cultivation
- Limited access to finance, technical assistance, and markets
- High reliance on natural resources that are increasingly degraded

As a result, their capacity to respond to climate variability is low, and their livelihood strategies often contribute to further ecosystem degradation, reinforcing a negative feedback loop between vulnerability and environmental decline.

Existing programs have not sufficiently addressed these constraints at scale, particularly in terms of connecting productive transformation with market access and stable income generation. The absence of viable economic alternatives limits the adoption of sustainable practices, reducing the effectiveness and sustainability of conservation and restoration investments.

A critical need addressed by the project is the lack of sustained and predictable financing for watershed-based adaptation. Under current conditions:

- Public funding for watershed protection is fragmented and insufficient, including partial use of the 1% allocation mandated by law
- Environmental investments depend heavily on short-term project-based funding and external grants
- Private sector participation remains limited due to the absence of verified, decision-relevant metrics and investment mechanisms

These constraints prevent scaling of adaptation interventions and contribute to discontinuity once external funding ends. At the same time, regulatory frameworks in Colombia provide latent opportunities for financing, including:

- The possibility of incorporating environmental investments into water tariffs
- Mandatory public allocations for water conservation
- Corporate obligations related to ecological restoration

However, these instruments remain underutilized due to the lack of demonstrated evidence linking watershed investments to measurable benefits for users and investors.

The needs addressed by the project are reinforced by a set of structural barriers (see Chapter 3):

- Fragmentation of interventions, with limited coordination across institutions and territories
- Reliance on conservation-only approaches, with insufficient integration of productive systems
- Weak alignment of incentives between upstream communities and downstream water users
- Lack of standardized, verifiable metrics to quantify hydrological benefits and support investment decisions

These barriers collectively limit the effectiveness, scalability, and sustainability of adaptation efforts.

The project responds directly to these needs through a set of mutually reinforcing strategies:

First, it addresses climate vulnerability at system level by implementing an integrated watershed approach that improves hydrological regulation and water availability, contributing to increased resilience for approximately 9.8 million people.

Second, it targets the adaptive capacity of upstream communities by promoting climate-resilient production systems, improving access to markets, and supporting income diversification. These measures reduce dependence on climate-sensitive practices and enable the adoption of sustainable land-use systems.

Third, it tackles financing constraints by using concessional GCF resources to de-risk and validate a model that links measurable hydrological outcomes (VWBs) with long-term financing mechanisms, including water tariffs and private investment. This addresses the structural gap between available regulatory instruments and their practical implementation.

Finally, the project reduces institutional and operational barriers by introducing a coordinated, micro-watershed-based model that aligns interventions across sectors and actors within the same territorial units.

In summary, the project responds to a high level of need under the GCF criterion by addressing:

- ✓ Severe climate vulnerability affecting a major urban water system
- ✓ Low adaptive capacity among rural populations in strategic watershed areas
- ✓ Structural financing gaps preventing sustained adaptation
- ✓ Institutional fragmentation and implementation barriers limiting effectiveness

Through its integrated design, the project addresses these needs in a way that is:

- ✓ Targeted to vulnerable populations
- ✓ Anchored in climate risk
- ✓ Focused on structural constraints
- ✓ Designed for long-term sustainability

10.5.Country ownership

The project demonstrates strong country ownership by directly addressing a nationally recognized priority: water security under increasing climate variability. Colombia's growing exposure to hydrological extremes, evidenced by the implementation of a national water rationing program in April 2024, has elevated watershed protection and resilience as strategic priorities.

Within this context, the project contributes to national adaptation objectives by focusing on watershed-scale regulation, nature-based solutions, and climate-resilient rural systems, all of which are explicitly prioritized in Colombia's policy framework. The project is consistent with Colombia's climate agenda, including the Nationally Determined Contribution (NDC) and national adaptation priorities, which emphasize ecosystem-based adaptation, water security, and rural resilience as key pillars.

Additionally, the project is fully grounded in Colombia's existing legal and regulatory framework, ensuring that all proposed actions are implementable through national systems.

A central reference is Law 99 of 1993, updated by Law 2320 of 2023, which mandates that territorial entities allocate at least 1% of their unrestricted budgets to the protection of strategic water areas. While this mechanism provides a stable source of public finance, its application has been uneven. The project contributes by structuring these investments within a coordinated watershed model, improving their effectiveness and coherence.

The project also builds on Colombia's water tariff framework, updated by Resolution CRA 1032 of 2026, which allows environmental investments to be incorporated into water tariffs when they generate measurable benefits for users. Operationalizing it requires robust evidence linking ecosystem interventions with service-level improvements, which has so far been lacking. By generating verifiable hydrological results, the project provides the basis to operationalize this regulation.

Additional alignment is established with Law 2173 of 2021 and Resolution 1491 of 2025, which define corporate obligations related to ecological restoration. These instruments enable private-sector participation, which the project mobilizes through mechanisms linked to verified hydrological benefits. The intervention is also consistent with Law 1930 of 2018 on páramos and with territorial planning instruments such as POMCAs and POTs, ensuring coherence with existing land-use and watershed management frameworks.

Country ownership is further reflected in the active role of key institutions responsible for water, environmental management, and territorial planning. The project engages:

- ✓ EAAB, as the main water service provider and a central actor in financing and implementation
- ✓ CAR Cundinamarca and Corpoguavio, as competent environmental authorities
- ✓ The Bogotá District Environment Secretariat and municipal governments, ensuring alignment with territorial planning

These entities have formal mandates over the resources, infrastructure, and ecosystems addressed by the project. Their participation ensures that the intervention is not externally driven but embedded within existing institutional responsibilities. The involvement of EAAB is particularly relevant, as it enables the direct connection between watershed interventions and water service provision, including the potential incorporation of green infrastructure investments into tariff structures.

The project does not create parallel mechanisms. Instead, it activates and integrates existing instruments that currently operate below their potential. It contributes by:

- ✓ Structuring the use of public environmental allocations (1% mechanism)
- ✓ Enabling the practical application of tariff-based environmental investments
- ✓ Linking corporate restoration obligations with territorial priorities
- ✓ Aligning interventions with existing watershed and land-use planning tools

In doing so, the project addresses a key implementation gap: the lack of coordination and evidence required to translate regulatory provisions into sustained action.

The project supports broader national objectives by linking water security, ecosystem management, and rural development within a single framework. It contributes to:

- ✓ Urban water security, ensuring reliability of supply for a major metropolitan area
- ✓ Rural economic stability, through climate-resilient production systems
- ✓ Reduction of territorial inequalities, by targeting municipalities with low fiscal capacity

This integrated approach reflects national priorities to combine climate adaptation with sustainable development, rather than addressing them separately.

In summary, the project demonstrates strong country ownership by:

- ✓ Responding to a clearly identified national priority: water security under climate stress
- ✓ Operating fully within Colombia's legal and regulatory framework, including Laws 99/1993, 2320/2023, 1930/2018, CRA 1032/2026, and Laws 2173/2021 and Resolution 1491/2025
- ✓ Engaging competent national and regional institutions with clear mandates
- ✓ Activating existing financing and planning instruments that remain underutilized
- ✓ Contributing to coherence between climate, environmental, and development objectives

10.6. Efficiency and effectiveness

The project demonstrates a high degree of efficiency and effectiveness by combining cost-competitive intervention strategies, a results-oriented implementation model, and alignment with existing regulatory and financial frameworks in Colombia. The design is based on the premise that watershed-based adaptation can deliver measurable hydrological outcomes at lower cost than conventional alternatives, while generating economic value that supports long-term sustainability.

Rather than focusing solely on delivering outputs during the project period, the intervention is structured to establish a replicable and financially viable model, in which investments in watershed management are justified by their contribution to water-system performance and avoided costs.

The project prioritizes nature-based solutions and integrated watershed management measures that outperform grey infrastructure alternatives in terms of cost-effectiveness under Colombian conditions (See Chapter 5 and Appendix IV). By targeting the upstream drivers of water variability, such as land degradation, low infiltration, and sediment mobilization, the intervention reduces the need for downstream corrective investments.

This approach aligns with the policy direction established in Law 99 of 1993, Law 1930 of 2018, and watershed planning instruments (POMCAs), which emphasize ecosystem-based solutions as a cost-efficient strategy for water regulation. Compared to infrastructure-heavy approaches, investments in restoration, sustainable land management, and water-use efficiency generate higher hydrological benefits per unit of investment, particularly when implemented at appropriate spatial scale.

The economic analysis confirms this relative efficiency. The project yields an Economic Internal Rate of Return (EIRR) of approximately 19.84%, with total net economic benefits of about USD 91.7 million over a 20-year period. These benefits are driven primarily by avoided treatment costs, reduced sedimentation in infrastructure, and improved reliability of water supply systems.

A central component of the project's effectiveness lies in its ability to generate tangible cost savings within the existing water service system, thereby linking environmental investments to financial performance. As said before, improvements in watershed condition are expected to reduce sediment loads reaching treatment plants such as Tibitoc and El Dorado, while also stabilizing inflows and improving raw water quality. These changes translate into lower operational expenditures, including reduced use of chemicals, energy, and sludge management.

Efficiency is further enhanced through a territorially focused and performance-oriented delivery model. The project concentrates interventions within prioritized micro-watersheds, allowing conservation, restoration, production transformation, and water-system measures to interact within the same hydrological units. This spatial focus reduces fragmentation, avoids duplication, and increases cumulative impact.

At the same time, the implementation approach combines targeted technical assistance with performance-linked incentives, ensuring that resources are associated with measurable changes in land use and practices. This approach improves resource allocation efficiency by directing investments toward activities that produce verifiable hydrological outcomes.

A key element of effectiveness is the project's robust monitoring and verification framework, centered on the use of Volumetric Water Benefits (VWBs). This system provides a quantitative measure of hydrological outcomes, linking upstream interventions to downstream water system performance.

The methodology combines hydrological modelling with field-based validation, allowing the project to track changes in runoff, infiltration, and sediment dynamics over time. This evidence supports the attribution of results to specific interventions and enables continuous learning during implementation.

Through this approach, the project applies adaptive management principles, adjusting interventions based on observed performance to maximize effectiveness. This reduces the risk of inefficient resource use and ensures that investments remain aligned with intended outcomes throughout the project lifecycle.

In summary, the project achieves high efficiency and effectiveness by combining cost-effective intervention strategies, measurable outcomes, and a delivery model that maximizes impact per unit of investment. Its design demonstrates that watershed-based adaptation can function as a financially viable complement to traditional water infrastructure, supported by existing regulatory frameworks and sustained through recurrent financing.

10.7. Justification for GCF participation and additionality

Watershed investment in the Bogotá Region has, to date, failed to address the root causes of water insecurity in a durable way. Payments for Environmental Services (PES) deployed in the region are, by design, conditional and temporary: when payments stop, the opportunity cost of conservation re-emerges and land use tends to revert, which prevents long-term consolidation of hydrological regulation functions. The statutory 1% obligation (Article 111 of Law 99 of 1993, updated by Law 2320 of 2023) requires departments, districts and municipalities to allocate at least 1% of unrestricted current revenues to the acquisition, restoration and conservation of strategic water-source areas, yet departments executed only 17% of their potential resources in 2020, leaving over 80% of legally available funding unused, and large cities such as Bogotá operate well below the required threshold. Past GEF projects demonstrated that nature-based and productive solutions can work at scale, but remained grant-bound; each entity opened separate, disarticulated calls, with almost all investment going to conservation and restoration and very little to productive transformation, value chains, or mechanisms to tie actions to Volumetric Water Benefits (VWB). As a result, gains were not institutionalized and did not become self-sustaining.

The magnitude of the system confirms that incremental, fragmented measures are insufficient. The regional water system supplies more than 9.8 million people across 22 municipalities, with an estimated demand of 16–17 m^3/s (approximately 536 hm^3/year), significantly exceeding the useful storage capacity of key infrastructure such as the Chuza reservoir (223 hm^3). At the same time, the system loses around 37% of supplied water as non-revenue water, meaning that a substantial share of existing investments does not translate into effective service delivery and increasing the capital required to counteract inefficiencies. Environmental degradation persists despite existing spending: 49% of natural ecosystems in the region have been transformed and 17.8% of páramo ecosystems are degraded, while water use

exceeds sustainable supply in 45% of the territory in dry years and 41% under average conditions. These figures underline that current instruments, PES, the 1% obligation and scattered NbS, are not yet organized into a basin-scale, performance-based strategy.

Building on more than 30 years of experience in Colombia and the lessons of previous GEF projects[20], the proposed operation introduces an integrated watershed model designed to correct these shortcomings. First, it combines conservation, restoration, climate-resilient production and commercialization concentrically in prioritized micro-watersheds, aligning ecological and productive interventions around hydrological performance rather than sector mandates. Under Component 1, the project will restore 2,032 ha of high-Andean ecosystems in highly degraded areas and transform 2,409 ha of productive land currently dominated by extensive cattle and potato systems into climate-resilient production systems, across at least 1,248 farms, resulting in an estimated 9,984 ha under sustainable management practices at the end of the project (considering an average farm size of 8 ha). The transformation of those 2,409 ha is expected to generate approximately 888,325 m³ of VWB, reflecting improved infiltration, reduced runoff and enhanced water availability in dry periods, while also contributing to reduced erosion and sediment transport.

Second, the project field-validates VWB rather than only estimating it, generating locally calibrated evidence that translates land-use change and water-management improvements into volumetric hydrological outcomes. Hydrological impacts will be validated through runoff plots in different land covers, continuous discharge monitoring using pressure transducers and rating curves in prioritized micro-watersheds, and modelling calibrated with IDEAM and CAR data, creating an original dataset that directly links interventions to changes in runoff, infiltration, baseflow and sediment behavior. Third, the project delivers local water-security gains to vulnerable rural populations (smallholders and community water users) by improving productive systems and upgrading community-run water systems that currently serve 53% of productive units and 23% of users dependent on surface sources, often with high losses and limited treatment capacity. Fourth, it institutionalizes financing through the water tariff and a long-term private mechanism, moving the system from demonstration to a sustained new paradigm in which watershed resilience is recognized and financed as part of the region's water-service function.

The implementation model already mobilizes co-financing from key public and private actors, including EAAB (Bogotá Water Utility), the Secretaría Distrital de Ambiente (SDA), and private companies such as Coca-Cola and AB InBev, but these flows remain essentially project-based and grant-like in the absence of a unified VWB framework and structured mechanisms. GCF resources are used to generate the public goods and reduce uncertainty at scale and level of integration that existing instruments cannot finance, including locally calibrated hydrological models, watershed-scale monitoring systems, the first cycle of field-validated VWB, and an integrated intervention package in the twelve prioritized watersheds. These investments address structural barriers, fragmented governance, limited fiscal space, lack of metrics and mechanisms, that have prevented watershed-scale adaptation from becoming part of the region's standard water-security strategy.

10.7.1. Additionality of GCF financing

The producers and municipalities that occupy and govern the watersheds do not have the financial and institutional conditions to invest at the scale that watershed dynamics require. Municipal own-investment resources are low (e.g. Tausa 10.25; Villapinzón 8.78) and accompanied by weak project management indices, while upstream municipalities exhibit limited internet access (as low as 2.62% in Tausa and 5.26% in Villapinzón), incomplete health and sewerage coverage (e.g. sewerage coverage of 47.97% in

[20] High Mountain Climate Change Adaptation Project

Villapinzón and 62.12% in Cogua), and constrained fiscal capacity. These conditions limit their ability to co-finance and sustain integrated adaptation programs. Although Colombia's water tariff framework (updated by Resolution CRA 1032 of 2026) enables utilities to incorporate environmental investments into tariffs, and Law 2173 of 2021 and Resolution 1491 of 2025 require companies to invest in restoration and report outcomes, these instruments operate in isolation and are not yet connected to a shared hydrological performance framework or to a structured watershed-financing architecture.

In this context, GCF concessional capital is catalytic, not substitutive. It absorbs the front-loaded cost of establishing the integrated watershed mechanism and generating the first cycle of field-validated hydrological evidence, which domestic public and private finance cannot fund on its own at this stage. By financing the design and implementation of the watershed transformation model, the development and validation of VWB, and the structuring of tariff-based environmental investment and a long-term private mechanism, GCF resources create the enabling conditions under which follow-on finance can be allocated on the basis of verified outcomes rather than fragmented project logic. The USD 45.72 million requested from the GCF, within a total project envelope of USD 76.74 million including USD 31 million in co-financing, is directed mainly to public goods and early-stage risk reduction (monitoring systems, data generation, hydrological modelling, coordination structures, proof-of-concept interventions, market creation), which do not generate predictable cash flows and therefore cannot be financed through loans, guarantees or equity.

Without GCF participation, nature-based solutions and ecosystem-based adaptation for water security would remain isolated, temporary and grant-bound. PES would continue to operate as short-term contracts with reversible land-use outcomes; the 1% obligation would continue to prioritize land acquisition without a hydrological performance framework; and private stewardship commitments would remain limited by lack of metrics, regulatory clarity and investment structures. Existing projects would likely continue to invest mainly in conservation and restoration, with limited support to productive transformation and value chains and without tying actions to volumetric water benefits, leaving upstream interventions disconnected from downstream financing decisions. In a GCF-without scenario, there would be no coordinated mechanism to convert watershed interventions into tariff-justified environmental investments or into structured private mechanisms linked to hydrological performance.

GCF support is what enables the transition to institutionalization of an environmental investment component in the tariff and a results-based private mechanism, as a systemic change that would not occur under business-as-usual. It allows green infrastructure and NbS to be justified in the tariff for the first time through VWB, and creates a private vehicle through which large water users and corporate water stewardship commitments can contribute to watershed resilience based on verified hydrological outcomes. The justification for GCF involvement is therefore anchored in paradigm-shift potential (moving from fragmented grants to a sustained, outcomes-based financing system), innovation (field-validated VWB; tariff-recognized NbS; structured private mechanism linked to hydrological performance), and the broader GCF investment criteria, including impact potential, needs of the recipient, efficiency and effectiveness, and sustainable development potential.

By absorbing early-stage risks, addressing affordability and equity constraints, internalizing public-good externalities, and overcoming institutional and technical barriers, GCF support enables a transition that would otherwise remain slower, more fragmented and less climate-effective. It delivers immediate adaptation benefits through integrated watershed interventions, while establishing a replicable model for financing water resilience in the Bogotá Region and other mountain-fed urban systems

10.8. Exit strategy

The project's exit strategy is designed to ensure that investments continue to generate water-resilience benefits in the Bogotá Region long after GCF funding ends and that the watershed transformation model is used for scaling up in the region and replication in other watersheds and regions in Colombia. Sustainability is pursued through four mutually reinforcing pathways: (i) consolidation of a proven watershed transformation model based on verifiable hydrological results, (ii) social and institutional ownership of climate-resilient practices, (iii) increased and reliable income for rural farmers associated with higher productivity, product value and value added from the project's productive transformation, commercialization and water stewardship activities, and (iv) institutionalization of financing tools and mechanisms that replace grant dependence with recurrent public and private flows.

First, the operationalization of Output 2.1 establishes financing instruments and mechanisms for scaling Volumetric Water Benefits. The project will define and validate methodologies to demonstrate the cost-effectiveness of watershed investments for EAAB, establish systematic reporting of hydrological outcomes, and generate the technical and economic evidence required to support the incorporation of watershed conservation and green infrastructure investments within the implementation of a new water-tariff framework under CRA Resolution 1032/2026. This lays the groundwork for recurrent, regulated utility-funded investment in upstream watershed resilience and climate adaptation. In parallel, the project will design and operationalize a long-term financial mechanism for private investments, supported by spatial prioritization tools, VWB quantification and monitoring tools, and a governance and operational structure that allows companies to finance prioritized watershed interventions aligned with their water stewardship and compensation targets. Once these pathways are in place and backed by credible evidence from Component 1, they are expected to channel ongoing public and private resources into the watershed transformation model after GCF support ends.

Second, the project will leave behind a tested, replicable and scalable watershed transformation model in priority watersheds. Under Component 1, restoration and conservation of strategic high-Andean ecosystems, together with climate-resilient production systems and improved community water management, are implemented in a coordinated package that will restore 610 ha of high-Andean ecosystems, transform 2,409 ha of productive land into resilient systems, and generate an estimated 888,325 m³ of VWB, while placing water-friendly products in Bogotá markets and upgrading community-run water systems across at least 1,248 farms and 9,984 ha under sustainable management practices. Using avoided and reduced runoff and VWB as core metrics, grounded in field data (runoff plots, continuous discharge monitoring, SWAT modelling) and monitoring systems established during the project, creates a robust evidence base that can justify continued and expanded investment by utilities, municipalities and private companies beyond project closure, including investments financed from avoided water-treatment costs as sediment loads decline.

Third, social and institutional ownership is strengthened through continuous capacity building, participatory planning and community-based implementation across the intervention landscapes. Smallholder families design climate-resilient farm plans, and rural communities, producer associations, community-based water providers and protected-area managers are directly involved in the preparation of watershed visions. As farm plans and watershed visions materialize through project implementation, ownership and a sense of achievement grow among families and communities, encouraging them to protect and build on the progress. By the end of the project, these actors are expected to have improved technical, organizational and governance capacities to maintain climate-resilient practices, supported by local monitoring systems and evidence of benefits. Productivity, income and income reliability associated

with water conservation and productive transformation will have increased, positioning them as long-term custodians and advocates of project interventions rather than recipients of external projects.

Exit strategy for Component 2 is based on institutional ownership of tools and financial mechanisms by EAAB and the City of Bogotá. The environmental investment component in the tariff framework established by CRA Resolution 1032/2026, creating a new pathway for recurrent, regulated utility financing of watershed resilience that is independent of grant funding. Monitoring, reporting and mechanism operation are institutionalized in EAAB and in the mechanism's governance structure, with reporting formats accepted by CRA and SSPD, so that hydrological performance, VWB and investment results are embedded in institutional practice rather than maintained through project funding. All tools, methodologies and results developed under the project will be documented, made freely accessible and disseminated to foster replication by other utilities and regions. Demonstrating the benefits of climate-informed management of high-Andean ecosystems and climate-resilient production systems, and linking these to concrete financing mechanisms, encourages the incorporation of watershed-resilience considerations into municipal and regional planning processes, utility investment decisions and private-sector water stewardship commitments. Producer associations and community-based water providers, strengthened through business models, market-access strategies and water-use efficiency measures, will be better equipped to maintain and expand climate-resilient practices as part of their normal operations.

At the cost-stream level, the exit pathways are explicit. For agri-producer transformation (Activities 1.2.1 and 1.2.2), market access and price premiums generate revenues so that performance-based grants can be tapered as products are placed in Bogotá markets; producers reach financial independence and sustain practices through income rather than grant support. Conservation and restoration activities with no direct revenue (Activities 1.1.1 and 1.1.2) are financed beyond the project by the long-term private mechanism (Activity 2.1.2), Payments for Conservation and the regulated tariff component (Activity 2.1.1), so recurrent public and private finance replaces grants. Future utility investment in watersheds is funded by avoided water-treatment costs as lower sediment loads reduce potabilization expenditure, allowing EAAB to self-finance upstream interventions from cost savings. The environmental investment component in the tariff constitutes a permanent public financing channel, and monitoring, reporting and mechanism operation under Output 2.1 are embedded in institutions rather than grant-dependent.

Collectively, these pathways ensure that when external grant financing concludes, the Bogotá Region will possess: (i) a proven watershed transformation model with validated hydrological results, (ii) empowered local and regional actors capable of maintaining climate-resilient practices, and (iii) a financing architecture—combining tariff-based environmental investments, private mechanisms and cost-savings reinvestment—that can sustain and expand adaptation measures without future dependence on grants. The project's contribution to a paradigm shift resides precisely in this combination of verified hydrological results, social and institutional ownership, and concrete tariff and private investment mechanisms capable of maintaining and scaling water-resilience investments under existing regulations.

The exit strategy is presented per grant-financed cost stream, demonstrating how all or most costs covered by the grant are scaled up without future dependence on grant financing.

Table 41. Exit strategy by cost stream.

Cost stream	Exit pathway (no future grant dependence)	Result
Agri-producer transformation (1.2.1, 1.2.2)	Market access and price premiums generate revenues; performance-based grants taper as products are placed in Bogotá markets	Producers reach financial independence; practices sustained by income, not grants

Conservation & restoration with no direct revenue (1.1.1, 1.1.2)	Financed beyond the project by the long-term private mechanism (2.1.2) and Payments for Conservation, plus the regulated tariff component (2.1.1)	Recurrent public + private finance replaces grant
Future utility investment in watersheds	Funded by avoided water-treatment costs (lower sediment load → lower potabilization cost); EAAB continues and increases investment	Self-financed by the utility from cost savings
Environmental investment component in the tariff (2.1.1)	Technical, economic and operational evidence generated by the project supports the integration of watershed conservation and green infrastructure investments into utility planning and tariff implementation under CRA Resolution 1032/2026.	Pathway established for recurrent, regulated utility financing of watershed resilienc
Monitoring, reporting and mechanism operation (2.1.)	Institutionalized in EAAB and the mechanism's governance; reporting accepted by CRA/SSPD	Embedded in institutions, not grant-dependent

Source: IDOM, 2026.

10.9. Long term sustainability of the Project

The project is designed so that the watershed transformation model continues and scales after GCF financing ends, moving the system from demonstration (proof of concept) to institutionalization. Sustainability rests on four interdependent pillars: financial, institutional, social, and replication; and, critically, on the proven capacity and embedded roles of the project's partners and subgrantees, each of which carries a specific function beyond the project period rather than depending on continued grant support.

10.9.1. Financial sustainability

GCF capital is catalytic, not permanent: it absorbs the front-loaded cost of establishing the mechanism and generating the first cycle of field-validated evidence. After the GCF phase, the model is sustained by three recurrent domestic streams:

- ✓ the environmental investment component in EAAB's water tariff (Resolution CRA 1032 of 2026), a regulated, recurrent revenue that EAAB continues and increases as it is funded by avoided water-treatment costs (lower sediment load → lower potabilization cost);
- ✓ the long-term finance mechanism operated by Fondo Acción, which channels results-based private investment against verified Volumetric Water Benefits; and
- ✓ the statutory 1% municipal and departmental budgets (Article 111 of Law 99/1993, as updated by Law 2320/2023) and Payments for Conservation.

For producers, the three-year conservation incentive is explicitly transitional: it bridges the period until restoration and production stabilize and the commercialization and market-access activities, supported by a specialized market consultant and performance-based grants, generate the revenues that make the practices self-sustaining through income rather than payments.

10.9.2. Institutional sustainability and the role of partners and subgrantees

The model embeds its functions in existing institutions, without creating a new governance figure, and each partner or subgrantee carries a durable role:

- ✓ CI-Colombia (Executing Entity): more than 30 years in the region; provides technical leadership, coordination and the scientific evidence/narrative, and progressively hands over functions to institutions and communities before project close.
- ✓ Fondo Acción (Executing Entity, GCF Direct Access Entity): administers the Payments-for-Conservation scheme and operates the long-term finance mechanism; it is deliberately engaged so that skills transfer capacitates it for its future role in similar projects, ensuring the financing vehicle persists beyond the project.
- ✓ Instituto Humboldt (IAVH, subgrantee under a Grant Agreement): delivers training and biodiversity-monitoring capacity to protected-area staff and RNSC owners that remain after the project, consolidating the national protected-areas and monitoring system.
- ✓ EAAB: hosts the tariff component, sustains investment from avoided treatment costs, and supports the registration of new Civil Society Natural Reserves.
- ✓ CAR Cundinamarca and Corpoguavio: the environmental authorities co-finance control, surveillance and restoration, embedding these actions in their mandates and in the POMCAs.
- ✓ SDA and Gobernación de Cudinamarca: align the statutory 1% resources and the Sustainable Landscapes governance instruments.
- ✓ TNC: transfer the VWB methodology and accounting/prioritization tools, which become reusable institutional assets.
- ✓ CRA and SSPD: their acceptance of the indicators and reporting protocols makes the tariff mechanism harder to reverse and replicable beyond a single administration.

Crucially, each partner is selected for proven capacity in its specific activity, reduces start-up delays and the need for extensive capacity building, which itself strengthens durability and lowers the cost of delivering impact (See Appendix I).

10.9.3. Social and community sustainability

By delivering tangible local water-security benefits to vulnerable rural populations, the project builds the community ownership that earlier city-focused efforts lacked. Community water operators (*acueductos veredales*) receive operation-and-maintenance, basic asset-management and user-level governance capacity so their systems are sustained locally; producer associations gain business, marketing and financial skills; and community restoration and monitoring brigades sustain field activities and data collection after the project.

10.9.4. Replication and scaling

Field-validated VWBs, the financing facility and the standardized, regulator-accepted reporting together constitute a replicable, self-sustaining model that can be transferred to other Colombian watersheds and the broader tropical Andes, the transformation the GCF investment framework seeks.

In sum, long-term sustainability is built into the delivery design rather than added afterwards: catalytic financing that becomes recurrent, institutional roles embedded in existing entities, and the deliberate transfer of technology and capacity to partners, subgrantees and communities that will carry the model forward.

11. Risk assessment and mitigation strategies

The project applies an integrated risk management approach that integrates Conservation International's institutional risk management framework with project-specific risk assessment and mitigation measures. The assessment presented in this section focuses on the principal risks that could influence implementation, achievement of expected outcomes and long-term sustainability.

Particular attention is given to risks affecting institutional coordination, conservation implementation, adoption of sustainable production practices, local governance, partner implementation capacity and the development of the innovative financing mechanisms proposed under Outcome 2. For each identified risk, mitigation measures have been designed to reduce both the likelihood of occurrence and the potential consequences for project implementation through clearly defined implementation responsibilities, technical assistance, monitoring arrangements and adaptive management measures.

The following subsections first describe Conservation International's institutional risk management framework and then present the project-specific risks together with their corresponding mitigation strategies.

11.1. Institutional Risk Management Framework

Financial integrity and compliance risks, including prohibited practices, money laundering and terrorist financing (ML/TF), sanctions-related risks and conflicts of interest, are managed through Conservation International's institutional governance, risk management and integrity framework, which combines project screening, institutional due diligence, safeguard implementation, compliance oversight and continuous monitoring throughout the project lifecycle. This framework is implemented in accordance with Conservation International's institutional policies, including its Anti-Money Laundering and Counter-Terrorism Financing (AML/CFT) Policy, Prohibited Practices Policy, Code of Conduct, Conflict of Interest Statement, Misconduct Reporting and Anti-Retaliation Policy, and Environmental and Social Management Framework (ESMF), consistent with GCF fiduciary principles and integrity requirements (CI, 2026).

Compliance risks are assessed using Conservation International's institutional project screening process, due diligence procedures, institutional compliance policies and project-level risk management instruments. These include safeguard screening, Environmental and Social Impact Assessments (where applicable), Environmental and Social Management Plans, Stakeholder Engagement Plans and Accountability and Grievance Mechanisms, which collectively support the identification, assessment, monitoring and management of project risks throughout the project lifecycle. In accordance with Conservation International's institutional risk assessment methodology, compliance risks are assessed considering both the likelihood of occurrence and the potential impact on project implementation, financial integrity and achievement of project objectives. These assessments inform the identification of inherent risks before mitigation measures are implemented and the determination of residual risks following implementation of risk controls, allowing due diligence, monitoring and oversight measures to be applied proportionately to the level of identified risk (CI, 2026).

During project preparation, all projects undergo institutional screening to identify environmental, social, fiduciary and integrity risks and determine the level of project risk and corresponding safeguard requirements. The screening process is complemented by institutional due diligence procedures applied to project staff, delivery partners, grantees, contractors, suppliers and consultants. These assessments consider the nature and scope of project activities, implementation arrangements, stakeholder

relationships, project context and potential exposure to prohibited practices, ML/TF, sanctions-related risks and conflicts of interest.

Together, these processes provide the basis for identifying inherent compliance risks before project implementation and establishing proportionate mitigation, monitoring and oversight measures throughout the project lifecycle.

11.2. Risk Mitigation and Residual Risk Management

Following risk identification and assessment, mitigation measures are developed and implemented in proportion to the level of identified risk. Depending on the nature of the project and the associated compliance and implementation risks, mitigation measures may include contractual obligations, internal financial controls, mandatory conflict of interest disclosures, staff training, confidential reporting mechanisms, reporting obligations, stakeholder engagement measures, grievance mechanisms and project-specific safeguard instruments. These measures are designed to reduce both the likelihood and potential consequences of identified risks and to manage residual risks throughout project implementation.

Where required, Environmental and Social Management Plans (ESMPs) establish specific mitigation actions, implementation responsibilities, monitoring arrangements, implementation schedules and residual risks following implementation of mitigation measures. Stakeholder Engagement Plans, Accountability and Grievance Mechanisms and other safeguard instruments further support implementation by identifying project-specific risks, defining mitigation measures, assigning implementation responsibilities and establishing appropriate monitoring and reporting arrangements (CI, 2026).

11.2.1. Monitoring, Reassessment and Adaptive Management

Compliance risks are monitored continuously throughout project implementation through institutional oversight, implementation monitoring, stakeholder engagement, grievance monitoring and periodic reporting. Conservation International applies an adaptive management approach under its Environmental and Social Management Framework, whereby safeguard instruments are treated as living management documents and updated whenever project circumstances change, implementation experience identifies new risks, grievances are received or additional mitigation measures become necessary (CI, 2026).

Monitoring results, stakeholder feedback, grievances, investigations and implementation experience are used to reassess project risks, evaluate the effectiveness of mitigation measures and strengthen institutional procedures where necessary. Where residual risks remain elevated following implementation of mitigation measures, enhanced monitoring, additional due diligence and strengthened oversight are applied in accordance with Conservation International's institutional procedures. This continuous review process ensures that residual risks remain under active management throughout the project lifecycle.

11.2.2. Escalation, Remediation and Continuous Improvement

Escalation may be triggered by suspected prohibited practices, money laundering and terrorist financing (ML/TF) concerns, sanctions-related issues, allegations received through grievance or ethics reporting mechanisms, audit findings, or other material compliance concerns requiring additional review or corrective action. Such concerns are reported through Conservation International's established reporting

mechanisms and referred, as appropriate, to the Ethics and Risk Team and the Office of the General Counsel for review in accordance with institutional policies and procedures (CI, 2026).

Depending on the nature and severity of the issue, Conservation International may undertake additional due diligence, initiate investigations, implement interim protective measures, strengthen project monitoring, require corrective actions or capacity-building measures, or suspend or terminate contractual relationships where warranted.

Findings from compliance reviews, investigations and grievance mechanisms are incorporated into institutional learning to strengthen internal controls, improve compliance procedures and reduce opportunities for prohibited practices. This continuous improvement process ensures that compliance oversight remains proportionate to the level of identified risk and fully aligned with the GCF's risk-based approach to financial integrity and compliance oversight.

11.2.3. Project Risk Identification and Assessment

The assessment therefore focuses on risks that could undermine three linked results: delivery of the proof of concept under Component 1, mobilization of long-term financing under Component 2, and sustained freshwater resilience through hydrological improvements in supplying watersheds.

The purpose of this assessment is to identify the principal threats that could affect implementation, financial sustainability, compliance, and climate results, and to define practical mitigation measures that can be integrated into workplans, budgets, and monitoring arrangements.

The assessment focuses on nine principal strategic risks that are most relevant to project implementation, long-term sustainability and financing scale-up. Additional operational and safeguard-related risks are addressed through the Funding Proposal Risk Register. These risks arise from the project's reliance on coordinated ecological restoration, productive transformation, local service delivery improvements and financial innovation within the existing institutional and regulatory framework, making them critical to the successful delivery of project outcomes and the long-term sustainability of investments.

Because the financing logic is central to the proposal, risks are assessed not only in terms of implementation delays, but also in terms of their potential to weaken the evidence base and confidence needed for water utilities, municipalities, and private companies to invest.

The assessment follows a qualitative risk assessment approach consistent with the GCF Project Risk Register methodology. Risks are identified by origin, categorized by type, and assessed through a combined consideration of likelihood and potential impact on project objectives. Risks are grouped into three practical origins: external factors, project-related risks, and partner-related risks. Likelihood and impact are assessed qualitatively using a consistent five-point scale. The objective is not to generate a mechanical risk score, but to support management decisions regarding preventive actions, implementation sequences, institutional arrangements and allocation of project resources.

Hydrological evidence is not only an adaptation result but also the basis for financing scale-up. This means that implementation risks under Component 1 can quickly become financing risks under Component 2 if interventions fail to generate credible and measurable VWBs within the project timeframe.

The project concentrates on actions considered feasible within the implementation period and under current regulations, while excluding or deprioritizing measures that depend on major policy changes,

extensive social conflict resolution, or uncertain financing conditions. This improves feasibility, but it does not eliminate risks related to adoption, institutional coordination, tariff-related decision-making, private-sector participation, and continuity beyond GCF support.

Additionally, the project relies on several distinct actor groups: protected-area authorities, landowners, farmers, producer associations, community-run water systems, utilities, municipalities, regulators, and private investors. The resulting risk profile is therefore multi-level: operational bottlenecks in the field may reduce hydrological results, while governance or financing bottlenecks may prevent those results from being translated into long-term investment pathways.

Table 42. Consolidated risk assessment.

Risk	Type	Main activities affected	Likelihood	Impact	Priority	Rationale
Delays in formalizing conservation arrangements and incentive schemes	Legal/compliance; operational	1.1.1, 1.1.2, elements linked to incentives for landowners	3	3	Medium	Delays in conservation agreements, reserve formalization, or related incentives can postpone long-term protection of strategic areas and weaken the durability of hydrological gains.
Changes in political or regulatory priorities	Political/institutional	2.1.1, 2.1.2, cross-cutting enabling environment	3	4	Medium-High	The project depends on continuity in institutional support for economic instruments, reporting arrangements, and public-private cooperation on water resilience.
Insufficient financing for long-term sustainability and scale-up	Financial	2.1.1, 2.1.2, all scale-up functions	3	5	High	The proposal's exit strategy depends on tariff-linked and private financing pathways; if these do not mature, proof of concept may not translate into sustained watershed investment.
Weak social inclusion and unequal benefit distribution	Environmental/social	1.2.1, 1.2.2, 1.2.3, stakeholder processes	3	4	Medium-High	Women and other vulnerable groups may face barriers to participation, benefit access, and decision-making, undermining equity and local legitimacy.
Resistance to changing productive practices	Environmental/social; operational	1.2.1, 1.2.2	3	4	Medium-High	Resistance to the adoption of sustainable production

Risk	Type	Main activities affected	Likelihood	Impact	Priority	Rationale
						practices and market-oriented business models.
Limited uptake of nature-based solutions and restoration actions	Technical	1.1.2, 1.2.1, 1.2.2	3	4	Medium-High	If communities value immediate productive gains over ecological restoration, the project may underperform on the hydrological proof needed for VWBs.
Failure to consolidate local water governance	Operational/outcome	1.2.3 and local planning/governance functions associated with watershed management	2	5	Medium-High	Weak ownership by community-run systems and local actors would reduce sustainability, replication potential, and service-level resilience.
Limited capacity of local implementing partners	Operational/execution	Cross-cutting across Component 1 and Component 2	3	3	Medium	Local organizations may lack fiduciary, technical, safeguards, procurement, and reporting capacity required for GCF-compliant delivery.

Source: IDOM, 2026.

11.3. Risk assessment by category

11.3.1. Legal and compliance risk

The principal legal and compliance risk concerns delay in formalizing conservation arrangements, reserve-related procedures, and incentive mechanisms needed to secure long-term protection of priority ecosystems. This risk is especially relevant for activities 1.1.1 and 1.1.2 because proof of concept depends not only on ecological intervention but on maintaining restored and conserved areas long enough to preserve water regulation benefits.

This risk does not necessarily stop field implementation in the short term, but it can weaken permanence and credibility. That matters for Component 2 because utilities and private investors are more likely to finance interventions when hydrological gains are demonstrably tied to durable land management and institutional arrangements.

11.3.2. Political and institutional risk

The log-frame identifies risks linked to changes in political priorities that could slow or block adoption of economic instruments and financial incentives for water resilience. This is a material risk because Component 2 seeks to work through existing regulations, especially the Environmental Investment Component and the Private Investment Mechanism, both of which depend on sustained cooperation among public authorities, utilities, and private actors.

Political turnover or institutional fragmentation could delay approvals, reduce co-financing, or weaken momentum around replication models and investment structures. Even if Component 1 generates technical evidence, a less supportive policy environment could prevent the project from converting evidence into scale.

11.3.3. Financial risk

The most significant financial risk remains insufficient long-term financing following the GCF-supported implementation period. Long-term sustainability is expected to rely on the financing pathways established under Outcome 2, notably the Environmental Investment Component and the Private Investment Mechanism, rather than on continued grant financing.

This makes the financial risk more clearly defined but also more dependent on the successful demonstration of the project's proof of concept. If hydrological evidence is insufficient, monitoring and reporting systems are not accepted by key stakeholders, investor pipelines do not mature, or political support for the Environmental Investment Component declines, the project may generate localized environmental benefits without achieving the intended paradigm shift in financing watershed resilience.

Mitigation therefore focuses on reducing both institutional and market risks associated with the proposed financing mechanisms. Early engagement with water utilities, municipalities, the Water and Basic Sanitation Regulatory Commission (CRA), the Superintendence of Public Utilities (SSPD) and private-sector stakeholders will support the development of common methodologies, reporting protocols and governance arrangements for the Environmental Investment Component. In parallel, the Private Investment Mechanism will be co-designed with potential corporate investors to ensure that the proposed Volumetric Water Benefits (VWB´s) respond to market expectations and can be incorporated into corporate sustainability and water stewardship commitments.

Institutional governance and transparency safeguards are integrated into the design of both financing mechanisms through clearly defined institutional responsibilities, standardized VWB accounting methodologies, independent verification options and transparent reporting arrangements. These measures are intended to strengthen confidence among public authorities, regulators and private investors, reduce governance and reputational risks, and ensure that financial resources remain linked to measurable hydrological improvements in priority watersheds.

Collectively, these measures reduce the principal institutional, governance and market risks associated with Outcome 2 and strengthen the project's capacity to translate successful implementation under Component 1 into sustainable long-term financing and replication beyond the GCF implementation period.

11.3.4. Environmental and social risk

Social inclusion risk remains highly relevant because the project depends on behavior change, local participation, and equitable access to benefits in rural landscapes. The gender assessment identified that women may face barriers to participation and that existing inequalities can reduce project effectiveness and increase exposure to gender-based violence if not proactively addressed.

This risk intersects with technical delivery, especially in activities 1.2.1 to 1.2.3, where adoption by farmers, producer associations, and community-run water systems is essential. If vulnerable groups are not effectively targeted and supported, uptake and ownership may be weaker, with implications for both resilience outcomes and compliance with GCF standards.

11.3.5. Operational and execution risk

A major operational risk is failure to consolidate local water governance and service-level ownership, particularly around community-run water systems and watershed management functions. Although the latest ToC places strong emphasis on efficient water use measures in community-run systems, those investments will not yield durable benefits unless local organizations can operate, maintain, and govern them effectively.

A second operational risk concerns the limited institutional capacity of local partners. Because the project model relies on local organizations, producer associations, and community entities for implementation, weaknesses in fiduciary management, safeguards, technical supervision, or reporting could affect pace, quality, and compliance.

11.3.6. Technical and outcome risk

The technical core of the project is to generate measurable hydrological improvements through ecosystem restoration, conservation, and productive transformation. Risks related to low uptake of nature-based solutions and resistance to changing productive practices therefore become outcome risks as well, since the proof of concept depends on visible and credible VWBs in prioritized watersheds.

The revised activity package improves feasibility by selecting interventions considered capable of producing visible climate and water benefits within the implementation period. Even so, adoption cannot be assumed where traditional dairy and potato systems remain central to household income and where ecological restoration is perceived as less immediately rewarding than productive investments.

11.4. Mitigation strategy

11.4.1. Risk 1. Delays in formalizing conservation arrangements and incentives

Mitigation should combine early legal due diligence, standardized agreement templates, phased targeting of sites with fewer tenure or procedural constraints, and a dedicated legal support function within project management. This support should be linked directly to activities 1.1.1 and 1.1.2 and sequenced so that areas with high hydrological relevance but lower procedural complexity are implemented first. Monitoring should track not only hectares under intervention but also the status of agreements, reserve-related procedures, and incentive arrangements that underpin permanence. This would strengthen the evidence base for subsequent finance mobilization by showing that hydrological benefits are tied to credible long-term management conditions.

Site prioritization should follow the Watershed Visions, farm planning process and eligibility criteria established under the Grant Manual, allowing interventions to focus initially on areas with fewer legal and implementation constraints while maintaining alignment with watershed priorities.

11.4.2. Risk 2. Changes in political or regulatory priorities

Mitigation should focus on institutionalizing the project narrative around water security, avoided treatment costs and measurable hydrological benefits rather than relying on short-lived political sponsorship. A structured engagement plan with water utilities, municipalities, the Water and Basic Sanitation Regulatory Commission (CRA), the Superintendence of Public Utilities (SSPD), business associations and other

relevant national and regional authorities should reduce dependence on individual champions and strengthen institutional ownership across electoral cycles.

The evidence generation, monitoring and reporting functions under Activity 2.1.1 should be treated as early implementation priorities, as robust methodologies, accepted reporting protocols and credible hydrological evidence will strengthen the basis for regulatory decision-making, facilitate implementation of the Environmental Investment Component and support replication beyond a single administration. Communications should therefore emphasize measurable improvements in water security, service delivery and financing outcomes, rather than ecological restoration alone.

11.4.3. Risk 3. Insufficient financing for long-term sustainability and scale-up

Mitigation should ensure that Outcome 2 is implemented in parallel with Component 1 from the outset. This requires hydrological monitoring, cost-effectiveness assessments, investment prioritization tools, replication models and the development of both the Environmental Investment Component and the Private Investment Mechanism to advance concurrently with watershed interventions, rather than as subsequent implementation phases.

The project should also establish clear decision points for scaling up the proposed financing mechanisms, including evidence thresholds based on demonstrated hydrological improvements, readiness criteria for implementation of the Environmental Investment Component, milestones for operationalization of the Private Investment Mechanism, and fundraising and deployment milestones under Activity 2.1.2. This integrated approach will strengthen the project's exit strategy, facilitate the transition from proof of concept to sustainable financing, and reduce the risk of a financing gap following completion of GCF support.

11.4.4. Risk 4. Weak social inclusion and unequal benefit distribution

Mitigation should include targeted beneficiary selection criteria, gender-responsive outreach, practical measures that reduce participation barriers, and safeguards protocols integrated into community-facing activities. Inclusion cannot be treated as a stand-alone plan only; it must be embedded in productive transformation, market access, community water system improvements, and local decision-making processes.

Indicators should capture not only participation numbers but also influence over decisions, access to assets or training, and differential uptake of benefits by women and vulnerable groups. This is important because inclusion failures would reduce both social legitimacy and the durability of behavioral change.

11.4.5. Risk 5. Resistance to the adoption of sustainable production practices and market-oriented business models

Mitigation should combine technical assistance, incentives, demonstration effects and market linkages. The project design supports this approach by integrating farm-level productive transformation under Activity 1.2.1 with business model development, commercialization and market access under Activity 1.2.2, helping ensure that adoption of sustainable practices generates tangible economic benefits and remains viable beyond project support.

Early implementation should prioritize producer organizations and producers with higher readiness, stronger organizational capacity, and stronger market opportunities, while using demonstration farms and producer networks to reduce perceived risk among later adopters.

11.4.6. Risk 6. Limited uptake of nature-based solutions and restoration actions

Mitigation should frame restoration not as a separate ecological agenda but as part of a water-benefit and livelihood package that supports farm resilience, local water security, and future finance opportunities. This requires consistent messaging, visible local demonstration, and practical community roles in restoration processes where feasible.

The project should also make hydrological results visible at local level through simple reporting and feedback loops. Communities are more likely to maintain interest in NbS when ecological actions are connected to observable water-related outcomes and to concrete economic opportunities.

11.4.7. Risk 7. Failure to consolidate local water governance

Mitigation should strengthen governance capacities alongside infrastructure and efficiency improvements in community-run water systems. Activity 1.2.3 should therefore integrate technical upgrades, operational practices, basic asset management, and user-level governance arrangements rather than limiting support to hardware or isolated efficiency measures.

Capacity strengthening should also prepare community-run water systems to participate in future watershed financing arrangements and broader watershed governance mechanisms supported under Outcome 2.

In addition, watershed-level planning and local participation mechanisms should be designed so that community actors can see how service improvements, ecosystem measures, and future financing pathways are connected. This is necessary for replication and for sustaining benefits after the project closes.

11.4.8. Risk 8. Limited capacity of local implementing partners

Mitigation should include structured institutional capacity assessments, differentiated technical assistance packages, simplified compliance tools and ongoing accompaniment from the Project Management Unit. Because multiple organizations are expected to participate, capacity support should be phased and risk-based, with enhanced fiduciary, procurement, safeguards and reporting support provided to partners responsible for grant implementation and financial management.

Capacity assessments consider technical and institutional capability, implementation experience, fiduciary arrangements, staffing and organizational track record in order to tailor support according to the level of implementation risk.

Clear implementation manuals, standardized templates, and supervision arrangements are also necessary. Capacity strengthening is not a marginal administrative task in this project; it is a precondition for quality implementation across Components 1 and 2.

11.5. Integration into activities and monitoring

The project design allows tighter integration of risk mitigation into specific activities. Legal and permanence-related mitigation should be embedded mainly in activities 1.1.1 and 1.1.2; adoption and inclusion mitigation should be embedded in activities 1.2.1 and 1.2.2; governance mitigation should be embedded in activity 1.2.3; and finance and political-risk mitigation should be embedded centrally in activities 2.1.1 and 2.1.2. The following table is an implementation matrix that can guide the integration of mitigation into activities:

Table 43. Implementation matrix for mitigation integration.

Risk area	Primary activities for mitigation integration	Key monitoring focus
Legal/permanence	1.1.1, 1.1.2	Status of agreements, procedures, hectares secured under durable arrangements
Adoption of resilient practices	1.2.1, 1.2.2	Uptake rates, continued practice use, producer income and market participation
Inclusion and safeguards	1.2.1, 1.2.2, 1.2.3	Participation quality, benefit distribution, grievance and safeguards tracking
Community water governance	1.2.3	Functionality, O&M practices, governance improvement, user participation
Finance mobilization	2.1.1, 2.1.2	Methodologies validated, reporting accepted, mechanism operational, funds mobilized
Partner implementation capacity	Cross-cutting	Capacity assessments, reporting quality, fiduciary and safeguards compliance

Source: IDOM, 2026.

The project should monitor a limited set of risk indicators that are directly actionable. Examples include the number and status of conservation agreements, adoption rates for resilient practices, women's participation in decision-making, functionality of community-run systems, validation of VWB methodologies, and funds mobilized or committed through tariff-linked and private channels.

The project description emphasizes that grant-financed activities under Component 1 must be justified as part of the proof of concept required to unlock future financing through Component 2. This has an important implication for risk framing: implementation risks should be written not only as threats to delivery, but as threats to the financial transition that underpins the project's exit strategy. The project should connect Component 1 activities to the generation of credible VWBs, demonstration of cost-effectiveness, and creation of pathways for utilities and private actors financial contributions to scale and sustain over timeAs seen in Chapter 5 (Option Analysis), activities not considered feasible within the implementation period were deliberately excluded or deprioritized. This demonstrates congruency in project design and helps explain why the selected activities are better suited to produce timely, measurable, and finance-relevant results.

The main threats for the project do not arise from a single technical bottleneck but from the need to align ecological interventions, community uptake, institutional coordination, and finance mobilization within one coherent proof-of-concept model.

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APPENDICES

I. Justification for selecting Implementing Partners

A. Executing Entities

Conservation International–Colombia and Fondo Acción have strong track records that justify their roles as Executing Entity (EE) and core partners for this project, especially in a highly institutionalized region like Bogotá, where it is critical to work with actors already embedded in water, adaptation and climate-finance policies.

Conservation International–Colombia (CI-Colombia)

CI-Colombia is the ideal partner to lead technical implementation in the Bogotá Region because it combines three elements that few actors share: hands-on experience in ecosystem-based adaptation in Bogotá's supply watersheds, established working relationships with environmental and water authorities, and the ability to bridge applied science, communities and financial mechanisms. In a context where EAAB, CAR, Corpoguavio and multiple municipalities must coordinate, this previous trajectory and the trust already built are essential not only for effective implementation but also to ensure that results are integrated into existing policies and programmes and continue beyond GCF support.

Emblematic projects underpinning this role:

- ✓ **GEF "Adaptation to Climate Impacts in Water Regulation and Supply for the Area of Chingaza – Sumapaz – Guerrero"** (c. 2012–2019): An adaptation project focused on strengthening the hydrological buffering and regulation capacity of the Chingaza–Sumapaz–Guerrero upper watershed that supplies drinking water to the Bogotá metropolitan area, through high-Andean ecosystem restoration, community agreements and water-management measures. This project shows that CI has already managed ecosystem-based regulation and adaptation interventions in Bogotá's supply watersheds, working with the same institutions involved in the current proposal.
- ✓ **Colombia's first national climate-change adaptation project** (c. 2006–2013): CI, in partnership with the Government of Colombia, implemented the country's first adaptation project with a strong focus on protecting water sources and strategic ecosystems, consolidating EbA and territorial-governance methodologies that are now applied in the Bogotá Region.
- ✓ **WRI–CI water-security studies for Bogotá** (c. 2023–2024): CI co-led, with WRI, a study showing that protecting and restoring native ecosystems, combined with helping communities transition to more sustainable agricultural models, can cost-effectively improve Bogotá's water quality and resilience; this analysis underpins the design of the current "Building a Water-Resilient Bogotá-Region Landscape" project.

These experiences demonstrate that CI-Colombia has already worked in Bogotá's supply basins, understands the territory's institutional complexity and co-developed the watershed-transformation and VWB logic that the project seeks to operationalize. Replacing CI with another actor would mean losing relational capital, territory-specific knowledge and continuity with projects and studies that have already opened doors and built trust with authorities and communities.

Justification for Leadership on Ecohydrological Modeling

Conservation International's (CI) Freshwater Science Team is uniquely qualified to lead the ecohydrological modeling in prioritized micro-watersheds, including impact assessment and calibration of modeling parameters. CI combines advanced scientific expertise in ecohydrology, watershed management, and hydroinformatics with extensive experience implementing field-based monitoring systems that ensure robust, decision-relevant outputs.

CI's comparative advantage lies in its demonstrated ability to quantify, verify, and deliver volumetric water benefits (VWB) in real-world contexts. Through its global portfolio of water replenishment and watershed stewardship projects—implemented across more than 10 countries in partnership with major private-sector actors—CI has established rigorous approaches that integrate ecohydrological modeling with fit-for-purpose field monitoring, baseline development, and parameter calibration. This ensures that modeled outcomes are credible, context-specific, and aligned with internationally recognized standards for water accounting and impact verification.

This capability is particularly critical to the proposed work. Accurate ecohydrological modeling for prioritized micro-watersheds requires not only technical proficiency, but also the ability to link modeled outputs to measurable hydrological responses on the ground. CI's experience ensures that modeling frameworks are properly calibrated using empirical data, and that monitoring systems are designed to reduce uncertainty and support adaptive management. This strengthens the reliability of impact assessments and enables defensible claims regarding water security, ecosystem restoration, and climate resilience outcomes.

In addition, CI's global leadership in freshwater science—including its engagement with the Freshwater Challenge, FAO, and the Science Based Targets Network (SBTN)—ensures that methodologies align with emerging international best practices and contribute to broader knowledge generation.

By leading this component, CI will ensure that ecohydrological modeling is scientifically rigorous, operationally relevant, and directly linked to measurable outcomes, thereby enhancing the credibility, scalability, and long-term sustainability of project investments.

The following section provides the justification for each activity to be implemented by Conservation International–Colombia in its role as an Executing Entity:

Activity 1.1.1 Conserve High Andean Ecosystems

Conservation International–Colombia is well positioned to lead the implementation of Activity 1.1.1 due to its experience in ecosystem-based adaptation, conservation planning, watershed management, community engagement, and coordination with environmental authorities in the Bogotá Region. CI-Colombia will provide overall coordination, technical supervision, and territorial engagement for conservation actions in protected areas and private lands, ensuring coherence between control and surveillance, biodiversity and land-cover monitoring, climate training, Civil Society Natural Reserve registration, and conservation agreements.

CI-Colombia's existing relationships with CAR, Corpoguavio, SDA, EAAB, local communities, and landowners are particularly relevant to an activity that requires coordinated implementation across different land-tenure and governance contexts. Its field teams will support watershed planning, technical

assessments, voluntary agreements, monitoring, and the integration of conservation actions with restoration and climate-resilient production activities at farm and watershed levels.

CI-Colombia also provides the technical and operational link between conservation results and the project's hydrological proof of concept. Through its ecohydrological monitoring, modelling, and Volumetric Water Benefit methodology, CI will ensure that conserved areas and avoided ecosystem conversion are connected to measurable outcomes related to water regulation, infiltration, baseflow stability, and downstream water security.

Activity 1.1.2. Restore High Andean Ecosystems

Conservation International–Colombia is uniquely positioned to lead the implementation of ecosystem restoration activities due to its extensive experience in ecosystem-based adaptation (EbA), restoration of high-Andean ecosystems, and integrated watershed management in the Bogotá Region. Through projects such as the GEF *Adaptation to Climate Impacts in Water Regulation and Supply for the Area of Chingaza–Sumapaz–Guerrero* and the WRI–CI water security studies for Bogotá, CI has developed and implemented restoration approaches that directly support the recovery of ecosystem functions, water regulation, and climate resilience. Its long-standing collaboration with environmental authorities and local communities ensures that restoration interventions are technically sound, coordinated across institutions, and aligned with regional conservation priorities. Furthermore, CI's expertise in ecohydrological modelling, field monitoring, and Volumetric Water Benefits (VWB) quantification provides the scientific basis for prioritizing restoration actions, evaluating hydrological impacts, and generating the evidence required to support adaptive management and subsequent financial mechanisms under Component 2.

Activity 1.2.1. Implement Climate-Resilient Production Systems

CI-Colombia has extensive experience supporting the adoption of climate-resilient production systems through technical assistance, ecosystem-based adaptation, and sustainable land management. Its work with rural communities has demonstrated the capacity to integrate productive practices with watershed conservation objectives while strengthening livelihoods and ecosystem services. This experience enables CI to provide the technical leadership required for the design, implementation, monitoring, and adaptive management of climate-resilient production systems. In addition, CI's experience in ecohydrological modelling and watershed monitoring allows the project to quantify the water-related benefits generated by these interventions and integrate the resulting evidence into the broader watershed transformation approach promoted by the project.

Fondo para la Acción Ambiental y la Niñez (Fondo Acción)

Fondo Acción is a Colombian private environmental fund with more than two decades of experience managing public and private resources for conservation, sustainable rural development and climate-change projects, and is one of the country's leading national entities in climate finance and GCF direct access. Its mandate and experience in managing multiple accounts (including debt-for-nature swaps) and in designing financial-governance schemes make it a key partner to ensure that the project's financial mechanisms (environmental tariff fee, public-private mechanisms) are embedded in Colombia's climate-finance architecture and continue operating after GCF support ends.

Emblematic programs and projects:

- ✓ **GCF Readiness "Adaptation Planning – COL-RS-003"** (c. 2017–2021): Colombia's largest readiness grant, implemented by Fondo Acción, which supported the preparation of the National Climate-Change Adaptation Plan's action plan, produced 27 knowledge-management products and two finance proposals, and developed the SIIVRA system to assess vulnerability and prioritize adaptation activities at regional level. This project demonstrates its ability to manage GCF funds, strengthen institutional capacities and develop prioritization and tracking tools directly relevant to water-resilience planning.
- ✓ **Readiness "Strengthening the Collegiate Body on Climate Finance and Country Programming"** (COL-RS-006, c. 2018–2022): Fondo Acción led the strengthening of Colombia's climate-finance collegiate body and GCF country-programming process, including developing no-objection procedures and a mapping of green financial instruments in the national banking system, enhancing coordination between the NDA and other actors and improving domestic climate-finance mobilization.
- ✓ **Sustainable rural development and natural climate solutions programmes** (c. 2004–present): Created from a debt-for-nature swap, Fondo Acción co-finances and implements projects on livestock transition, restoration of degraded lands, deforestation reduction and improved territorial governance in multiple Colombian regions, with emphasis on protecting water resources, biodiversity and rural livelihoods.
- ✓ **GCF pipeline proposals, such as "Low Emissions Cattle Ranching Landscape" and "Green and inclusive forest business in Colombia"** (since 2020): These initiatives show its active role in structuring large-scale mitigation and adaptation projects with a landscape approach, integrating innovative financial solutions and public-private partnerships.

The following section provides the justification for each activity to be implemented by Fondo Acción in its role as an executive entity:

Activity 1.1.1 Conserve High Andean Ecosystems

Fondo Acción is uniquely positioned to lead the implementation of payment for conservation through conservation agreements and incentive-based conservation mechanisms due to its extensive experience designing and operating Payments for Environmental Services, conservation incentive schemes, and benefit-sharing mechanisms. Its installed legal, fiduciary, and operational capacities reduce transaction costs and implementation risks.

Sustainability is ensured through alignment with Colombia's PES framework and the establishment of long-term conservation agreements supported by public institutions. This ensures that conservation outcomes, and their associated hydrological benefits, area maintained beyond the lifetime of the project.

Activity 1.2.2 Commercialization and Opening of Markets that Value Rural Products that Contribute to Water Regulation

Fondo Accion demonstrates exceptional institutional capacity to successfully execute Activity 1.2.2, which aims to commercialize and open markets for rural products that contribute to water regulation, by acting as the lead implementer and strategic facilitator. As the designated leader for this grant window, Fondo Accion is fully equipped to launch competitive calls for proposals, conduct rigorous due diligence, and administer grants to up to thirty producer associations across the twelve prioritized watersheds. Their comprehensive administrative capabilities are validated by their management of the **Tropical Forest Conservation Agreement**, where they successfully oversaw a large portfolio of projects, managed complex funding structures, and received ISO 9001-2008 certification for their rigorous grant management and integrated information systems. This deep operational background guarantees that they can seamlessly coordinate specialized consultancies to conduct market assessments, identify priority value chains, evaluate market demand, and design customized business models that align commercial incentives with climate-resilient agricultural practices.

Furthermore, Fondo Accion has a proven track record of bridging the gap between rural producers and formal markets, which is critical for ensuring the long-term sustainability of the volumetric water benefits generated by these land-use changes. For instance, through their execution of the **Promoting Green Investment and Bioeconomy** project funded by the Sustainable Colombia Fund, they demonstrated high efficiency and economies of scale by centralizing procurement and providing direct technical assistance to local bioeconomy initiatives. Under this project, they helped multiple organizations develop five-year financial business plans, improve their marketing strategies, acquire necessary commercial infrastructure, and secure crucial regulatory compliances such as Invima certifications to prepare them for impact investment. Their hands-on approach will be directly applied to Sub-activity 1.2.2.2, where they will conduct multiple advisory workshops to refine business plans and commercialization strategies, ensuring that local organizations overcome high barriers to market entry, such as costly certification processes and commercialization infrastructure needs. Additionally, Fondo Accion's expertise in specialized value chains is deeply exemplified by their work with the **REDD+ Community Portfolio and the Achiote del Pacifico project**.

In these specific initiatives, they successfully linked rural communities to demanding specialized markets, such as the cosmetics and food industries, achieving significant sales volumes and formalizing contracts for non-timber forest products while implementing Good Manufacturing Practices and Good Agricultural Practices. They also possess specialized knowledge in deploying de-risked capital and operating impact investment funds, actively targeting businesses that generate social, environmental, and financial returns through mechanisms like their **Impact Mission Investment Fund**. By combining this advanced financial engineering with continuous technical, administrative, and socio-business support, Fondo Accion is uniquely positioned to ensure that the commercial success of producer associations directly finances the continued adoption of watershed-friendly land-use practices, thereby establishing a self-sustaining economic incentive structure that guarantees water resilience and climate adaptation well beyond the project funding period.

The evaluation of recent interventions yields a comprehensive list of favorable impact indicators that validates Fondo Acción's project structuring and market access strategies:

- Regarding **income generation**, Fondo Acción recorded an 18% increase in specific product income and a 28% increase in total income for producers in the **Achiote value chain**.
- Concerning **production volume**, we achieved 198.6 tons of achiote, representing a **199% compliance rate** against our initial targets.

- In terms of **market access**, we successfully directed **87% of total achiote sales** to the specialized cosmetic industry, while also formalizing four commercial agreements for naidi and three for cocoa.
- Regarding **monetary sales**, our supported communities achieved annual sales exceeding 55 million pesos in cocoa, 143 million pesos in coconut, and 275 million pesos in fishing.
- Regarding **product development and compliance**, our beneficiaries developed four cosmetic products and one food product that obtained **INVIMA sanitary registrations**.

Finally, through infrastructure upgrades such as the transition to semi-industrial plants, supported organizations project an average production growth of 38%, with some reaching up to 60%, which aligns with our baseline grant window target of increasing farmer sales volumes by at least 15% in the first year.

Activity 1.2.3 Implement Efficient Water Use Measures in Community-Run Water Supply Systems

Fondo Acción has a proven track record of over 25 years coordinating complex environmental and community-development projects that seamlessly bridge public institutions, local organizations, and technical experts. **Backed by robust administrative and fiduciary systems that meet strict international compliance standards, the organization ensures efficient project execution, risk mitigation, and transparent operational oversight.**

For the implementation of efficient water use measures, Fondo Acción leverages its established sub-grant and technical assistance frameworks to upgrade community-run water supply systems through macro-metering, loss reduction, and infrastructure efficiency.

Long-term sustainability is systematically secured by embedding specialized operation and maintenance (O&M) capabilities, optimizing local governance, and building resilience within the strategic watersheds that supply these local networks.

Grounded in a comprehensive understanding of integrated water resource management, Fondo Acción actively promotes a culture of water care and environmental stewardship directly within the territories. The organization leverages its profound relationship capital and horizontal trust with community stakeholders to smoothly transfer specialized knowledge, administrative process management capabilities, and technical ownership.

Crucially, Fondo Acción's unique approach to territorial accompaniment ensures that capacity building is never perceived by local organizations as a rigid, top-down imposition required merely to check a box or unlock external aid. Instead, through a process of close co-creation, these interventions are deeply internalized as intrinsic tools that directly elevate the organization's long-term autonomy, enhance local public health, and safeguard their immediate natural environment.

Activity 2.1.2 Operationalize a Long-Term Financial Mechanism for Private Investments

Fondo Acción is the ideal entity to operationalize a long-term financial mechanism for private investments due to its **25 years of extensive experience as a Conservation Trust Fund**, having successfully managed over $100 million across more than 1,400 sustainable environmental and social initiatives. The organization possesses a proven ability to design and implement robust, innovative financial tools tailored to specific needs, ranging from successful endowment funds—such as **Malpelo, La Minga, and the TFCA**—to its own mission-aligned impact investment fund, FIMI.

Beyond traditional grants, Fondo Acción effectively utilizes **blended finance, revolving funds** for REDD+ projects, and equity investments, demonstrating a flexible, business-oriented approach that aligns with private sector expectations. Its operations are governed by strict i**nternational fiduciary standards, ESG** (Environmental, Social, and Governance) **criteria, and rigorous due diligence**. This robust governance is further validated by its prestigious accreditations to directly access resources from the Green Climate Fund and, uniquely as the first entity in Colombia, the UN Adaptation Fund.

Furthermore, Fondo Acción excels at acting as a patient-capital investor; it goes beyond merely deploying funds by providing critical non-financial support, capacity building, and market connections to local eco-enterprises and grassroots organizations. This comprehensive, dual-pillar approach of strong governance and financial sustainability allows Fondo Acción to successfully bridge the gap between private impact investors and local sustainable development. By successfully leveraging co-financing from international donors and major corporate partners like **Ecopetrol, Avianca, and Promigas,** Fondo Acción ensures that private capital is deployed efficiently to generate measurable, long-term environmental, social, and financial returns.

Taken together, these experiences show that Fondo Acción not only has proven capacity to administer GCF and other donors' resources, but also to convene national and subnational governments, banks and the private sector around climate-finance strategies. In a highly institutionalized region like Bogotá, its participation helps ensure that the project's financial mechanisms are designed and operated in coherence with national adaptation, green-finance and country-programming strategies, and that they are maintained and scaled once the grant phase ends. Replacing Fondo Acción with another actor would mean losing this rare combination of GCF experience, financial governance and territorial implementation, which is crucial for the durability of the Watershed Transformation Model.

B. Implementing partners

The project design follows an implementation model that delivers activities in partnership with strong local organizations to ensure effective execution and long-term sustainability. The convergence of multiple partners working in the same territory from different perspectives creates synergies, builds momentum, and facilitates systemic change over time.

Having additional partnerships that support CI's and FA implementation of specific activities and sub activities, increases the chances of project success as partners act as an extension of CI's capacities to deliver activities on time and with strong technical soundness.

In selecting implementing partners, CI evaluated the following criteria:

- **Alignment with organization's mission and project objectives.** The organization has similar vision and social objectives to CI's, and they align to the project objectives and expected results. Project activities advance both CI's and the organization's mission.
- **Local expertise and specialized knowledge.** The organization has substantive and active experience working with local partners in the Bogotá Region. The organization has strong capacities and systems in place to deliver results, including the use of institutional knowledge and innovation systems. Organizations are top in their field of expertise and can deliver specialized knowledge.
- **Potential for long-term sustainability.** Partners missions and active work backed up by policy mandates and/or their close collaborations with government institutions, policy advocacy ensures that work continues in the region. Partners are motivated to continue working overtime, beyond the delivery of specific contract-based deliverables.

- **Strong implementation and local buy-in.** Organizations have a strong local recognition by communities, local authorities and key stakeholders such as private sector. Partners' work is recognized by key stakeholders looking to maintain long-term investments in the territory.
- **Cost efficiency:** The use of grants was assessed against economic criteria and the use professional services contracts. Professional services contracts would introduce additional profit and tax costs. Specifically, each contract payment would be subject to an additional 19% VAT, in addition to the Financial Transactions Tax (FTT – 4x1000) applicable to wire transfers. The cumulative effect of these taxes would materially reduce the net resources available for programmatic activities, further diminishing the funds ultimately reaching beneficiaries. CI has conducted a market assessment and a thorough review of the implementing partners' budgets, negotiated where necessary, and ensured that only essential, results-oriented costs are included. As part of this process, CI has already requested reductions compared to the initial budgets submitted by the proposed sub-grantees, those initial numbers are reflected in the first budget submitted to the GCF. Further reductions were also applied after first submission.

In addition to the criteria above, CI brings over 20 years of experience implementing projects through partnerships. Its technical and administrative teams have extensive expertise in managing and monitoring grants and ensuring results delivery.

The following table summarizes the comparative advantage of each partner organization against the criteria presented:

Criteria	IAvH	TNC
Alignment with organization's mission and project objectives	IAvH is Colombia's government agency providing scientific knowledge to guide biodiversity conservation policy, with a key role in managing páramo ecosystems.	The Nature Conservancy (TNC) is a global organization advancing financial, policy, and economic solutions to protect watersheds and strengthen water resilience, with a strong program in Colombia.
	Science-based policy: Generates biodiversity data to inform conservation decisions	**Innovative financing:** Develops watershed investment portfolios and cost-effectiveness frameworks
	Critical ecosystem focus: Leads páramo delimitation and management, protecting key ecosystems	**Water resilience focus:** Leads tools and mechanisms for watershed protection, including Water Funds
	Sustainable management: Guides land-use and conservation planning to balance nature and development	**Implementation at scale:** Applies proven models in Colombia to mobilize public and private investment for water security

Criteria	IAvH	TNC
Potential for long-term sustainability	IAvH is the scientific and technical institution within the National Environmental System (SINA), that provides validated methodologies and technical guidance to environmental authorities in terms of knowledge, management and sustainable use of biodiversity including Paramos and protected areas. Having IAvH impementing project Paramo and protected area activities brings legitimacy and long term support of the official agency for guiding Paramo protection	TNC's work is built to outlast GCF support: the environmental investment component embeds water-resilience financing permanently into EAAB's regulated tariff under Resolution CRA 1032 of 2026, which lets providers recover environmental-investment costs through the tariff, and its replication package extends the model to other utilities. This is anchored in a durable national effort: the TNC–CRA toolbox is being scaled from its Antioquia pilot toward the Magdalena–Cauca macro-basin and nationally, with the aim of consolidating it within long-term water-resource public policy.
Expertise and specialized knowledge required to implement the activity.	IAvH has extensive expertise in climate adaptation in protected areas, Nature-based Solutions, Integrated Fire Management, socio-ecological monitoring, and environmental governance. These capacities have been demonstrated through implementation of flagship initiatives including two GEF projects related to paramo:Páramos para la Vida and Conservation and Sustainable Use ob Biodiversity in the Andes Region. IAvH has extensive high mountain ecosystem knowledge, a vast number of publications in the subject, international experts and teams working on the ground on conservation, restoration, and governance across Colombia's high mountain ecosystems	TNC offers directly relevant, hard-to-substitute expertise. Under a memorandum of understanding with the CRA (the Colombian Water Utilities Regulatory Body) , TNC co-developed and updated the "Smart Environmental Investments Toolbox" — combining technical, legal and tariff components with a step-by-step route, a map of strategic allies and lessons learned from a community of practice of 15 utilities — to guide service providers in channeling the six recognized types of additional environmental investments into the tariff under Resolution CRA 1032/2026. This is precisely Activity 2.1.1, and the toolbox plus the 15-utility community of practice directly underpin the guideline to replicate the model for other utilities (Sub-activity 2.1.1.3). For Activity 2.1.2, TNC's science-based business-case methodology was proven in the Greater Cape Town Water Fund, where investing about US$25.5 million in critical sub-catchments was modelled to yield roughly 100 billion litres of water per year within thirty years, a similar quantification and decision-support capability the project's financial mechanism requires.
Strengthened implementation and credibility to other partners	As Colombia's leading biodiversity research institution and official authority for the delimitation of paramo areas in Colombia, IAvH brings more than 30 years of scientific and technical experience. Its recognized work with international partners, national environmental authorities, and local communities provides legitimacy, strong technical credibility, enhancing coordination, implementation, and stakeholder engagement at multiple governance levels.	TNC is an internationally recognized conservation-science organization with a strong national footprint. Its standing is reinforced by a fruitful memorandum of understanding with the CRA, under which TNC has technically strengthened the regulator itself and convened a community of practice of 15 public-service utilities around environmental investments in the tariff. Together with its existing relationships with EAAB and its role in the Coalición Agua para Colombia — a platform backed by the IDB, the German government and the Coca-Cola Foundation, and supported by MADS and ANDESCO, advancing water security across 15 of the country's main watersheds, this convening power and scientific credibility de-risk the regulatory innovation in the tariff and give confidence to public regulators and to the private companies expected to invest, reinforcing the

Criteria	IAvH	TNC
		credibility of the wider consortium (CI, Fondo Acción and the other partners).
Cost efficiency	IAvH combines a highly qualified multidisciplinary team with vast experience and on the ground teams , ensuring efficient use of resources and high technical quality. Leveraging existing institutional capacities, validated methodologies, and technical platforms reduces implementation costs, minimizing delivery risk while maximizing long-term impact, scalability, and replicability across other high Andean ecosystems.	TNC brings ready, regulator-endorsed instruments: the CRA-validated Smart Environmental Investments Toolbox, and water business-case quantification, plus pre-existing CRA and EAAB engagement, avoiding the cost and time of building these from scratch.

Furthermore, each sub-grantee brings a distinct comparative advantage that the Executing Entity cannot cost-effectively replicate, and their engagement is also a vehicle to embed the Watershed Transformation Model in Bogotá's highly institutionalized governance landscape, which is essential for post-GCF permanence. Below, each partner is justified individually, highlighting added value and the need to build durable relationships among local and national actors.

Instituto Alexander von Humboldt (IAvH)

IAvH is Colombia's national biodiversity research institute and a core technical authority for high-mountain ecosystems, with a central role in the delimitation and management of páramos at the national level. Its mandate includes producing the scientific and cartographic bases that support national policy on páramos, high-Andean forests and other strategic ecosystems, and it has led or co-led emblematic studies on páramo ecology, biodiversity and climate vulnerability that underpin current management instruments. These functions demonstrate that IAvH has the technical capacity and institutional recognition required to guide climate-resilient management of the headwater protected areas targeted by the project.

Beyond its role in páramo delimitation, IAvH has implemented national-scale monitoring and research initiatives in high-mountain regions, including long-term biodiversity and ecosystem-response monitoring programs and studies that link climate and land-use change to shifts in species and ecosystem services. In the Bogotá Region specifically, IAvH has supported the consolidation of the National System of Protected Areas (SINAP) and contributed to the design and operation of monitoring schemes in protected areas and Civil Society Natural Reserves, working closely with regional environmental authorities. This portfolio shows that IAvH can design and implement the biodiversity monitoring systems, climate-adaptation training and fire-ecology and conflict-transformation modules envisaged in the project, using standardized protocols that are consistent with national information systems.

IAvH expertise is backed by emblematic projects:

- ✓ **"Insumos para la delimitación de ecosistemas estratégicos – páramos y humedales"** (c. 2010–2016): Provided the scientific and cartographic basis for the official delimitation of 21 páramo complexes in Colombia, directly informing national policy and management instruments for high-mountain conservation.
- ✓ **GEF project "Páramos para la vida" – Integrated High-Mountain Management** (c. 2015–2022): Supported integral management of high-mountain landscapes by strengthening protected areas,

fostering community participation and installing monitoring schemes for biodiversity and ecosystem services in multiple páramo complexes.

As a sub-grantee, IAvH adds value by ensuring that the project's monitoring, training and adaptive-management tools for PAs and RNSC are fully aligned with national páramo and high-mountain policy, and by bringing lessons from emblematic national projects to the Bogotá headwaters. In a highly institutionalized region, this alignment is essential: it embeds the new monitoring systems and capacities in a wider institutional framework, increases the likelihood that CAR, Corpoguavio and national authorities will adopt and sustain them, and builds durable relationships between local PA teams and the national science and policy community that will persist beyond the life of the GCF project.

The following section provides the justification for the project sub-activity to be supported by Instituto Alexander von Humboldt (IAvH) in its role as an implementing partner.

Sub-activity 1.1.1.1 Implement control and surveillance, monitoring and climate training in Protected Areas

Instituto Alexander von Humboldt (IAvH) is uniquely positioned to support Sub-activity 1.1.1.1 due to its national mandate and specialized scientific expertise in biodiversity management, high-Andean ecosystems, páramo conservation, climate adaptation, socio-ecological monitoring, and environmental governance. Under this sub-activity, IAvH will design and deliver an integrated capacity-building programme for protected-area management teams, park rangers, local communities, and other territorial stakeholders, focusing on climate change adaptation, fire ecology and management, and socio-environmental conflict transformation.

IAvH's role is directly aligned with the technical characteristics of the sub-activity, which combines institutional capacity strengthening, biodiversity and land-cover monitoring, adaptive protected-area management, and community participation. Its leadership in páramo delimitation, the preparation of technical guidance for high-mountain ecosystem management, and the implementation of initiatives such as *Páramos para la Vida* provide the methodological and institutional basis required to ensure that training, monitoring, and adaptive-management tools are consistent with national biodiversity and protected-area frameworks.

Channeling these training and capacity-building functions through IAvH reduces fragmentation and avoids the need to contract multiple separate service providers for climate adaptation, fire management, biodiversity monitoring, and conflict transformation. Its participation therefore strengthens technical coherence, institutional legitimacy, cost efficiency, and the likelihood that the capacities and monitoring systems established through the project will be sustained by environmental authorities and protected-area teams after project completion.

IAvH is the ideal sub-grantee for climate-resilient PA management and biodiversity monitoring because it is Colombia's national high-mountain and páramo science authority, already responsible for national páramo delimitation and monitoring, so no other actor can provide the same combination of technical rigor, policy alignment and continuity with national systems.

The Nature Conservancy (TNC)

TNC has decades of experience in designing and operating water funds and other watershed-finance mechanisms across Latin America, including in Colombia, where it has helped utilities, municipalities, environmental authorities and private companies co-invest in upstream conservation. Emblematic TNC-

supported water funds have demonstrated how to structure governance arrangements, legal instruments and monitoring systems that channel long-term resources to ecosystem-based measures, providing a practical template for the type of Watershed Transformation Model this project seeks to implement. These experiences show that TNC can effectively design multi-actor governance architectures and financing pathways that link upstream actions to downstream water benefits and utility finance.

In the Bogotá Region, where governance involves multiple authorities and stakeholders with overlapping mandates, TNC's role is particularly important for building trust and designing durable institutional arrangements around the watershed-finance mechanisms. As a sub-grantee, TNC can support the development of governance structures, legal frameworks and operational protocols that align public mandates, private stewardship commitments and community participation, ensuring that the model is both robust and socially legitimate. This adds value by embedding the Watershed Transformation Model in collaborative governance structures that are capable of persisting and evolving after the project ends, thereby reinforcing the permanence and scalability of green-infrastructure investments in the Bogotá watersheds.

TNC expertise is backed by emblematic projects:

- ✓ **Bogotá Water Fund** (c. 2009–present): Established a conservation trust fund to protect rivers and watersheds supplying Bogotá, financing upstream conservation and sustainable land-use practices to secure drinking water for the capital.
- ✓ **Cuenca Verde – Medellín Water Fund** (c. 2013–present): Implemented a water fund that has improved management of around 20,000 hectares, planted hundreds of thousands of trees and supported farming families through restoration and agricultural best management practices for water security.
- ✓ **Latin American Water Funds Initiative Flagship Portfolio** (documented c. 2015–2020): Compiled and analyzed multiple water funds across the region (including Colombian cases), using hydrological modeling and standardized governance frameworks to demonstrate replicable models for long-term watershed finance.

The following section provides the justification for the project activities to be supported by The Nature Conservancy (TNC) in its role as an implementing partner.

Activity 2.1.1 Incorporate an Environmental Investment Component into the Water Tariff

The Nature Conservancy is uniquely positioned to support Activity 2.1.1 due to its specialized experience in watershed investment planning, tariff-based environmental financing, cost-effectiveness analysis, and the development of technical and regulatory tools for water utilities. Under its memorandum of understanding with the Comisión de Regulación de Agua Potable y Saneamiento Básico (CRA), TNC co-developed and updated the Smart Environmental Investments Toolbox, which provides utilities with a structured route for identifying, costing, justifying, and reporting additional environmental investments under the applicable regulatory framework.

Under this activity, TNC will support the development of the Watershed Investment Portfolio, the definition of indicators and methodologies, the analysis of cost-effectiveness, and the preparation of the replication model for other utilities. These functions are directly aligned with the activity's objective of converting hydrological evidence generated under Component 1 into a technically defensible and regulator-aligned investment pathway. TNC's previous work with water utilities, CRA, EAAB, and water funds in Colombia reduces the time, cost, and regulatory uncertainty that would arise from developing these instruments from the ground up.

TNC will support the three sub-activities under Activity 2.1.1 through a single grant agreement, thereby minimizing administrative fragmentation and ensuring consistency between the investment portfolio, the indicator and methodology framework, the reporting architecture, and the replication package. Its participation therefore contributes directly to the efficiency, technical credibility, regulatory relevance, and long-term scalability of the tariff-based financing pathway.

Activity 2.1.2 Operationalize a Long-Term Financial Mechanism for Private Investments

TNC will provide specialized technical support to Activity 2.1.2, particularly through the development of the automatic tool for the spatial prioritization of investment locations under Sub-activity 2.1.2.1. TNC was selected for this role based on its extensive experience in watershed planning, nature-based solutions, and the development of technical tools that support evidence-based investment planning.

TNC's technical experience in watershed planning, spatial analysis, and decision-support tools provides the foundation for identifying where watershed investments can generate the greatest hydrological impact and support efficient allocation of resources. The spatial prioritization tool developed by TNC will incorporate evidence generated under Component 1 and the investment portfolios developed under Activity 2.1.1, allowing Fondo Acción and private contributors to prioritize watersheds, intervention types, and investment locations using transparent, science-based, and auditable criteria.

TNC will also provide technical advice to Fondo Acción on investment prioritization and portfolio management under Sub-activities 2.1.2.2. This support will help ensure that the governance and operational structure of the mechanism, as well as the deployment of private investments, remain connected to scientifically grounded spatial priorities and measurable hydrological outcomes. TNC's participation complements, but does not duplicate, Fondo Acción's role as the financial structurer and operator of the mechanism.

TNC is the ideal sub-grantee for watershed-finance governance and multi-actor arrangements because it has decades of experience designing and operating water funds in Colombia and the region, offering tested governance and financing templates; replacing it with a new or purely local actor would increase risk and transaction costs and weaken the model's replicability.

II. Link between EFA variables and project benefits

The Economic and Financial Analysis (EFA) uses the project's causal chain to distinguish between variables that generate directly monetizable benefits and variables that contribute indirectly to project viability, adoption, and welfare outcomes. As shown in the project's causal diagram, Activities 1.1.1, 1.1.2 and 1.2.1 affect land use and land cover, alter hydrological processes, and produce reductions in sediment and nitrogen loads; these changes are then linked to avoided costs in water treatment and infrastructure operation. By contrast, variables such as increased farmer sales, household health gains, and higher farm incomes arise through commercialization and water-service improvements and are

relevant to the broader economic rationale, even where they are not yet fully monetized in the core EFA model.

This distinction is important for methodological consistency. Sediment and nitrogen are used in the EFA as direct environmental drivers of cost savings for the Bogotá Water Utility, while farmer income, health, and commercialization variables are better treated as complementary economic and social benefits that support adoption, persistence, and equity outcomes within the watershed transformation model.

A. Sediment and nitrogen (economic co-benefit)

Modelling of Sediment and Nitrogen Reductions (InVEST SDR/NDR)

This annex summarizes the methodology used to estimate sediment and nitrogen reductions with the InVEST Sediment Delivery Ratio (SDR) and Nutrient Delivery Ratio (NDR) models, which underpin the water-quality benefits and avoided treatment costs used in the EFA.

1. Modelling approach

The SDR and NDR models were applied to the upper Bogotá River basin to quantify baseline (business-as-usual) and intervention scenarios aligned with Component 1 (conservation, restoration and climate-resilient production). Both models operate on gridded inputs derived from a common Digital Elevation Model (DEM) and produce spatially explicit estimates of sediment and nitrogen export and retention at pixel level, aggregated to sub-basins and key intakes such as Tibitoc.

The results used in the EFA correspond to the difference between business-as-usual and the natural-infrastructure portfolio and are summarised in the SDR.xlsx file (sediment and nitrogen export per scenario, percentage reductions at intakes).

2. Sediment Delivery Ratio (SDR) model

The SDR model estimates annual soil loss using a RUSLE-type formulation and the fraction of that loss delivered to the stream network based on a sediment connectivity index.

Inputs

- Digital Elevation Model (DEM) at a uniform analysis resolution.
- Rainfall erosivity (R) and soil erodibility (K) rasters.
- Land-use/land-cover (LULC) maps for baseline and intervention scenarios.
- Biophysical table assigning USLE C and P factors to each LULC class, reflecting vegetation cover and management practices (e.g. conventional pasture vs. silvopastoral systems, conventional potato vs. agroecological practices).

Computation

$A=R\times K\times LS\times C\times P$, where LS is derived from the DEM and C and P from the biophysical table.

A sediment connectivity index (IC) is calculated using upslope contributing area and downslope flow path characteristics.

The pixel-level SDR is computed as a function of IC and the calibration parameters, and sediment export is obtained as soil loss × SDR.

Exported sediment is aggregated to watershed outlets and intakes; sediment retention is the difference between gross soil loss and exported sediment.

3. Nutrient Delivery Ratio (NDR) model

The NDR model estimates nitrogen export and retention using a mass-balance approach that assigns nutrient loads to each LULC class and routes these loads downslope according to hydrological connectivity and retention properties.

Inputs

- DEM and derived flow direction and accumulation rasters.
- LULC maps consistent with the SDR analysis for baseline and intervention.
- Runoff proxy raster (e.g. mean annual runoff or a composite based on precipitation and soils).
- Watershed boundaries and outlet points.
- Biophysical table with nitrogen parameters per LULC: nitrogen load (kg/ha), retention efficiency, critical flow path length

Computation

Each pixel receives a nitrogen load based on its LULC class and the biophysical table.

The model computes an effective flow path length to the stream and estimates the fraction of the load retained along that path versus the fraction exported, using the critical length and retention efficiency parameters.

Exported nitrogen is aggregated at watershed outlets and intakes; nutrient retention is the difference between load and export.

4. Use of SDR/NDR results in the EFA

The SDR/NDR outputs are translated into economic benefits by valuing avoided water-treatment costs at Tibitoc and related infrastructure. The EFA uses EAAB cost data to convert reduced sediment and nitrogen loads into savings in energy, chemical inputs, sludge management and depreciation, over a 30-year horizon.

It considers the studied relationship between sediment and nitrogen reductions in the WRI-CI Green Gray Assessment, where it quantifies the correlation between energy costs and turbidity and Nitrates, as shown in table 44. However, the previous study used a portfolio of up to 3690 ha. To account for the additional area of the project the team performed an extrapolation fitting an equation that coincides with the results modeled by WRI-CI and the maximum expectancy shown in the tables 45 & 46. A detailed explanation is provided in the Annex 3. Economic and Financial analysis.

Table 44. Relationship between sediment and nitrogen reduction with energy costs.

PORTFOLIO	SEDIMENT REDUCTION	NITROGEN REDUCTION	CORRELATION BETWEEN ENERGY COSTS AND TURBIDITY	CORRELATION BETWEEN ENERGY COSTS AND NITRITES	ENERGY COST REDUCTION FROM SEDIMENT CONTROL	ENERGY COST REDUCTION FROM NITROGEN CONTROL
NBS1230	14.2%	2.0%			3.0%	0.1%
NBS2460	21.3%	3.1%	0.2122	0.051	4.5% =0.2122×21.3%	0.2% =0.051×3.1%
NBS3690	26.3%	4.0%			5.6%	0.2%

For the NBS2460 portfolio, an investment of about US$5.3 million yields total avoided costs of US$44.6 million over 30 years, an Internal Rate of Return of 13.19%, and a positive Net Present Value, demonstrating that sediment and nitrogen reductions modelled with InVEST are financially material for Bogotá's water system.

Table 45. Sediment reduction in prioritized watersheds (baseline - intervention scenario).

Basin	Sub-basin	Baseline sed_export (t/yr)	Project scenario sed_export (t/yr)	Avoided sediment (t/yr)	Avoided (%)
Río Curubital	Río Curubital	40,533.5	29,717.8	10,815.7	26.7%
Río Santa Bárbara	Río Santa Bárbara	799,987.0	404,529.0	395,458.0	49.4%
Quebrada Quincha	Quebrada El Rayo	32,276.4	20,954.0	11,322.4	35.1%
Río Bogotá Pte Alta	Quebrada El Rayo	29,814.6	17,061.9	12,752.7	42.8%
Río Guandoque	Río Cuevas - Neusa	46,653.8	33,614.3	13,039.5	27.9%
Río Salitre	Río Cuevas - Neusa	26,825.5	22,274.3	4,551.2	17.0%
Río San Francisco	Embalse Sisga	119,901.0	80,898.6	39,002.4	32.5%
Río Chipata	Río Siecha	37,821.5	35,321.0	2,500.5	6.6%
Río Aves	Río Aves	125,655.0	91,436.8	34,218.2	27.2%

Soure: IDOM 2026

Table 46. Nitrogent surface export reduction in prioritized watersheds (baseline - intervention scenario).

Basin	Sub-basin	Baseline n_surface_export (t N/yr)	Project scenario n_surface_export (t N/yr)	Avoided nitrogen (t N/yr)	Avoided (%)
Río Curubital	Río Curubital	4,355.57	2,852.89	1,502.68	34.5%
Río Santa Bárbara	Río Santa Bárbara	31,512.60	7,108.61	24,403.99	77.4%
Quebrada Quincha	Quebrada El Rayo	570.40	346.93	223.47	39.2%
Río Bogotá Pte Alta	Quebrada El Rayo	842.996	661.946	181.05	21.5%
Río Guandoque	Río Cuevas - Neusa	1,788.50	1,412.39	376.11	21.0%
Río Salitre	Río Cuevas - Neusa	821.47	705.87	115.60	14.1%
Río San Francisco	Embalse Sisga	5,187.76	3,672.97	1,514.79	29.2%
Río Chipata	Río Siecha	2,539.00	2,456.06	82.94	3.3%
Río Aves	Río Aves	4,925.27	3,717.54	1,207.73	24.5%

B. Farmer sales and incomes

Farm income impacts are based on income statements originally developed by Conservation International (2018) for conventional and sustainable potato and milk production systems[21]. The yearly costs were divided into four main categories: Labor, farm inputs, equipment & tools, and indirect costs. These were updated to 2026 values using item-specific price reviews for labor and farm inputs, while equipment, tools, and indirect costs were adjusted using the national consumer price index published by DANE (62%). (Departamento Administrativo Nacional de Estadística, 2026). For milk systems, first-year and recurrent farm inputs were modelled separately to reflect the structural differences in establishment versus operational costs. Revenues were updated through revised farm-gate prices for potatoes, milk, honey, and eggs, which increased by 67%, 101%, 23%, and 18%, respectively. The interventions consider that ~75% of farm transformation activities will be under milk farms, given that it is much more feasible from a financial perspective.

Farmer sales and income effects under Activity 1.2.2 are justified by the demonstrated institutional and operational capacity of Fondo Acción to connect rural producer organizations with formal and specialized markets, while providing the technical, commercial, and compliance support needed to convert improved production practices into sustained revenue streams. As lead implementer for this grant window, Fondo Acción is equipped to manage competitive calls, due diligence, grant administration, and tailored advisory support for up to thirty producer associations across the eight prioritized watersheds, building on experience from the Tropical Forest Conservation Agreement and other complex grant facilities.

The expected increase in farmer sales is conservatively set at 16%, which is consistent with Fondo Acción's recent evidence base and remains below some of the stronger results achieved in prior commercialization initiatives. In the Achiote del Pacífico value chain, Fondo Acción reported an 18% increase in product-specific income and a 28% increase in total producer income, while broader bioeconomy and REDD+ portfolio interventions supported market formalization, value-chain upgrading, specialized product development, and commercial agreements across cocoa, naidí (açaí berries), coconut, fisheries, and other products. In addition, project evaluations cited by Fondo Acción indicate that infrastructure upgrades and commercialization support were associated with projected production growth averaging 38%, with some organizations reaching 60%, and that the grant window baseline target was to increase farmer sales volumes by at least 16% in the first year.

Within the EFA, this 16% sales increase should therefore be treated as a prudent and evidence-based assumption for the income effect of Activity 1.2.2 rather than as an optimistic upside case. The economic relevance of this variable is that higher and more stable sales improve farmer incomes, reduce market-entry barriers, and increase the likelihood that producers maintain climate-resilient and watershed-friendly production systems introduced under Activity 1.2.1, thereby reinforcing the long-term durability of hydrological benefits generated by the project.

C. Health and reduction in disease

The diagram also identifies health improvements as the main economic benefit linked to Activity 1.2.3, which improves community-run water systems through macro-metering, efficient use practices, and drinking-water treatment. Here the relevant causal chain is different from the sediment-nitrogen pathway. The water-related benefit is reduced failures in community-run water supply systems and improved

[21] The income statements can be found in hidden sheets of the EFA Excel file; Papa_Convencional, Papa_Sustentable, Leche_Convencional, milk_Silvopastoril.

potabilization; the economic benefit then arises through lower disease incidence, fewer medical costs, and fewer productivity losses associated with unsafe water.

This relationship is well supported by external evidence. A recent systematic review and meta-analysis in *The Lancet Planetary Health* found that drinking-water interventions that improved service quality were associated with lower risk of childhood diarrheal disease in low- and middle-income settings, alongside complementary benefits from sanitation and handwashing interventions. While this evidence is not specific to Bogotá, it provides a valid justification for including reduced disease burden as a benefit category where the project improves drinking-water treatment and reliability in community systems.

For the EFA, however, health benefits should be presented as a secondary or complementary stream unless local epidemiological and cost-of-illness data are available. The current project diagram supports the qualitative linkage between community water-service improvements and health improvements, but it does not by itself provide a local monetary estimate of avoided disease. The most rigorous formulation is therefore that health benefits are expected and evidence-based, and can be valued if project-specific assumptions are introduced on diarrheal incidence, treatment costs, and time losses avoided.

D. Extraction costs and financial logic

The reference to extraction costs fits best in the chapter as part of the broader rationale for avoiding higher-cost supply alternatives. The JICA studies on Bogotá's water supply system document the large capital and operating requirements associated with expanding and maintaining conventional water-supply infrastructure for the city. In the project's EFA logic, this matters because reducing sediment and nitrogen loads and improving watershed regulation does not only lower treatment costs at existing plants; it also supports a more diversified and resilient water-supply portfolio, reducing pressure to rely exclusively on more capital-intensive supply.

This is the same logic used in the WRI report, which states that natural infrastructure investments can diversify Bogotá's portfolio of water sources and reduce pressure for reservoir expansion. Accordingly, the EFA can legitimately present source-protection benefits as avoided or deferred expenditure pressures in the broader water-supply system, even where the main quantified cash-flow benefit remains treatment-cost savings at Tibitoc.

E. Corporate Water Demand and Investment Benchmarking for Outcome 2

A target of USD 5 million in water-related private investment under Outcome 2 is well justified by the magnitude and concentration of potential corporate demand for water compensation in the Bogotá Region. The table indicates that a relatively small group of large water users – including Postobón/PEPSICO, Bavaria, Compañía Nacional de Chocolates, Nestlé, Alpina, Coca-Cola FEMSA, Cemex, Holcim and others – collectively consume around 40 million m³ per year, with a conservative "compensation target" set at 20%, equivalent to 8 million m³ per year of water-related benefits through watershed interventions. This level of potential demand is fully aligned with current ESG, risk management, and corporate water stewardship trends, where large beverage, food, and cement companies are under increasing pressure to invest in the resilience of the catchments on which their operations depend.

Table 47. Corporate water consumption and compensation targets

Company	Estimated water consumption (million m³ per year)	Compensation target (million m³ per year, 20%)	Notes
Postobón / PEPSICO	13.54	2.71	
Bavaria	9.37	1.87	Plants in Tocancipá and Bogotá
Compañía Nacional de Chocolates	6.66	1.33	
Nestlé	4.94	0.99	
Alpina	2.06	0.41	
Coca-Cola FEMSA	1.46	0.29	Manantial plant – La Calera
Cemex	1.00	0.20	Cement Santa Rosa plant – La Calera
Holcim	1.00	0.20	Chemical Technology plant in Tocancipá
Essity (Grupo Familia)	–	–	Plant in Cajicá
Kimberly-Clark	–	–	Tocancipá plant closed in 2025
I-O (Peldar)	–	–	Plants in Soacha and Cogua
Grupo de Energía de Bogotá	–	–	Tominé reservoir operations
Total	40.00	8.00	

Source: IDOM based on "Agua en Colombia: un privilegio para la industria",

Estimated corporate water consumption and 20% compensation targets are based on internal project assessments and company-level water use approximations for major industrial users in the Bogotá Region (beverage, food, cement, and energy sectors),

Finally, focusing USD 5 million of private investment mobilization on this concentrated group of large users enhances both efficiency and scalability. Because a handful of companies account for a large share of water consumption, individual transaction sizes can be relatively large, reducing transaction costs. By aligning these corporate compensation flows with the project's restoration and sustainable production measures, Outcome 2 ensures that a meaningful share of the 8 million m³ per year compensation potential is translated into recurring, performance-linked investment streams, thereby sustaining watershed-friendly land-use practices and securing long-term water resilience beyond the GCF funding period.

Benchmark dimension	Evidence / benchmark
Corporate water demand base	The identified companies together account for about 40 million m³/year of estimated water consumption in the Bogotá Region, including major beverage, food, cement, and energy users.
Conservative compensation assumption	Applying a 20% compensation target to total estimated consumption yields a potential demand of 8 million m³/year in water-related compensation or watershed investment. t
Implied investment intensity	A USD 5 million target against 8 million m³/year implies sufficient demand for stewardship activities.
Transaction efficiency benchmark	Water demand is concentrated in a relatively small number of large companies such as Postobón/PEPSICO, Bavaria, Nestlé, Alpina, Coca-Cola FEMSA, Cemex, and Holcim.
Strategic fit with Outcome 1	The project logframe links restoration, sustainable production, and water resilience outcomes with financing mechanisms that can sustain watershed-friendly practices over time.

III. Mitigation co-benefit calculation

The mitigation co-benefits of the project were estimated by quantifying the net carbon sequestration associated with ecosystem restoration, conservation, and climate-resilient productive interventions implemented across the selected watersheds. The calculation follows a biomass-based approach consistent with nationally referenced allometric models and peer-reviewed literature.

Reference Carbon Stocks by Life Zone

Baseline carbon content was defined using published estimates of above-ground and below-ground biomass for Colombia's natural forests, differentiated by life zone. For montane tropical forest (bh-M) and high tropical Andean ecosystems (espeletia), total biomass carbon stocks (tCO_2e/ha) were derived from reported above-ground biomass (AGB), carbon content, and associated below-ground biomass, resulting in total reference values of 303.4 tCO_2e/ha and 355.8 tCO_2e/ha, respectively. These values represent the post-intervention equilibrium carbon stock expected under full ecosystem recovery.

Table 48. CO_2 content (tCO_2e/ha) in the total biomass of Colombia's natural forests.

Life zone	AGB (t/ha)	Carbon content AGB	Contenido de CO2 en biomasa aérea	Contenido de CO2 en biomasa subterránea	Contenido total de CO2 en la biomasa
		C (t/ha)	CO2e (t/ha)	CO2e (t/ha)	CO2e (t/ha)
Montane tropical forest	145.4	72.7	267.0	36.4	**303.4**
High tropical Andean (espeletia)	183.0	86.0	315.4	40.4	**355.8**

Source: (Yepes, et al., 2011)

Net Carbon Capture per Intervention Type

For each intervention category, net carbon sequestration was calculated as the difference between the baseline biomass carbon content of the initial land cover and the reference biomass expected after intervention. Baseline values vary by cover type (pastures, herbaceous cover, shrubs, or secondary vegetation), while post-intervention values reflect mature forest or recovered ecosystem conditions for the corresponding life zone. Net capture values (tCO_2e/ha) were calculated separately for:

- Passive natural regeneration
- Active restoration through enrichment
- Active restoration of degraded areas using restoration modules

Average net sequestration values were computed for each intervention type and life zone and applied uniformly across the corresponding intervention areas.

Table 49 CO_2e content in total biomass before, after, and net of interventions, according to initial cover (mountain tropical forest)

Intervention	Land cover before the intervention (baseline)		Capture after intervention	Net carbon capture	Average net carbon capture
	Land cover	Biomass (tCO_2e/ha)	bh-M	(tCO_2e/ha)	(tCO_2e/ha)
Natural passive restoration	Shrubland	87.0	303.4	216.4	**223.9**
	Transitional secondary vegetation	72.0	303.4	231.4	
Enrichment	Shrubland	87.0	303.4	216.4	**233.0**

Intervention	Land cover before the intervention (baseline)		Capture after intervention	Net carbon capture	Average net carbon capture
	Land cover	Biomass (tCO_2e/ha)	bh-M	(tCO_2e/ha)	(tCO_2e/ha)
	Herbaceous vegetation	52.0	303.4	251.4	
	Transitional secondary vegetation	72.0	303.4	231.4	
Active restoration	Pasturelands	23.0	303.4	280.4	265.9
	Herbaceous vegetation	52.0	303.4	251.4	

Source: (Yepes, et al., 2011).

Table 50. CO_2e content in total biomass before, after, and net of interventions, according to initial vegetation cover. (high Andean mountains).

Intervention	Land cover before the intervention (base)		Capture after intervention	Net carbon capture	Average net carbon capture
	Land cover	Biomass (tCO_2e/ha)	bh-M	(tCO_2e/ha)	(tCO_2e/ha)
Natural passive restoration	Shrubland	87.0	355.8	268.8	276.3
	Transitional secondary vegetation	72.0	355.8	283.8	
Enrichment	Shrubland	87.0	355.8	268.8	285.4
	Herbaceous vegetation	52.0	355.8	303.8	
	Transitional secondary vegetation	72.0	355.8	283.8	
Active restoration	Pasturelands	23.0	355.8	332.8	318.3
	Herbaceous vegetation	52.0	355.8	303.8	

Source: (Yepes, et al., 2011).

Biomass Estimation for Productive Systems

For agroforestry and silvopastoral systems, mitigation co-benefits were estimated based on tree-level biomass accumulation. Species-specific morphological parameters (height and diameter at breast height) were used in recommended allometric equations to estimate above-ground biomass per tree. A standard planting density of 200 trees per hectare was applied. Below-ground biomass was estimated as a proportion of above-ground biomass, allowing total biomass per hectare to be calculated and converted to CO_2 equivalents.

Table 51. Morphological parameters of the tree species used in the project's interventions

Common name	Scientific name	Maximum height (m)	DBH (cm) Maximum diameter	Average height (m)	DBH (cm) Agerage diameter	Basic density (g/cm3)
Aliso[1]	*Alnus acuminata Kunth*	25	45	20	36	0.3
Trompeto[2]	*Bocconia frutescens L.*	10	40	8	32	
Nogal Cedro[3]	*Juglans neotropica Diels*	35	100	28	80	0.65
Cucubo, tomatillo[2]	*Solanum ovalifolium Humb. & Bonpl. ex Dunal*	8	20	6.4	16	
Cedro de montaña[4]	*Cedrela montana Moritz ex Turcz.*	7.2	18.95	7.2	18.95	0.4
Mirto[2]	*Myrcianthes leucoxyla (Ortega) McVaugh*	25	50	20	40	
Laurel [2]	*Myrica parvifolia Benth.*	15	30	12	16	

Source. (1) (Ospina, et al., 2005) (2) (EAAB, 2016) (3) (Ospina C. M., Hernandez, Aristizabal, Patiño, & Salazar, 2003) (4) (Barragan & Vargas, 2017)

Table 52. Allometric equations for calculating biomass.

Life zone	Recommended allometric equation	
	Equation 1: ln(BA) = a + B1ln(D) R2=0.954	
bh-M	0.067	2.64
	Equiation 2: ln(BA) = a + B1ln(D^2*H+p) R2=0.948	
bh-M	0.067	0.932

Source: (Yepes, et al., 2011)

Table 53. Estimated above-ground biomass (kg of dry matter) per tree for the species used

Common name	Above-ground biomass (kg of dry matter) per tree		Minimum	Maximum	Average
	bh-M				
	Equation 1	Equation 2			
Aliso	864.3	284.6	284.6	864.3	574.4
Trompeto	633.3	0.0		633.3	633.3
Nogal Cedro	7,115.0	3,546.2	3,546.2	7,115.0	5,330.6
Cucubo, tomatillo	101.6	0.0		101.6	101.6
Cedro de montaña	158.8	43.4	43.4	158.8	101.1
Laurel	1,141.4	0.0		1,141.4	1,141.4
			1,291.4	**1,669.1**	**1,313.7**

Source: IDOM, 2026

Table 54. Estimated total CO_2 sequestration resulting from interventions related to the revegetation of production systems.

Interventions	Above-ground biomass (kg of dry matter) per tree	Density (trees per ha)	ABG (t/ha)	BGB (t/ha)	Total Biomass	Carbon capture (tCO2e/ha)
Agroforestry systems	1,313.7	200.0	262.7	73.0	335.7	615.5
Silvopastoral systems	1,313.7	200.0	262.7	73.0	335.7	615.5

Source: IDOM, 2026

Aggregation at Project Scale

Final project-level mitigation co-benefits were obtained by multiplying the net carbon sequestration per hectare (tCO_2e/ha) for each intervention type by the corresponding area of implementation (ha) across all watersheds. Results are presented as total net carbon sequestration (tCO_2e) over the project horizon and as average annual sequestration (tCO_2e/year), considering indicative growth periods of 10 and 20 years for tree-based systems.

Table 55. Project interventions hectares in each watershed.

Watershed	Total restoration (Act. 1.1.2) (ha)	Total productive transformation (Act. 1.2.2) (ha)	Conservation agreements (ha) (SubAct. 1.1.1.2)	Conservation agreements linked to restoration (ha)
Susagua	488	300	619	488
Salitre	32	100	199	32
Guandoque	102	224	503	102
Parte Alta Río Bogotá	88	126	283	88
Quebrada Quincha	32	70	196	32
San Francisco	439	772	1,195	439
Aves	443	405	1,036	443
Chipatá	18	50	373	18
Río Curubital	169	181	250	169
Quebrada Yomasa	74	60	33	74
Quebrada de Aguadulce	74	60	33	74
Quebrada Paso Colorado	73	61	33	73
	2,032	**2,409**	**4,756**	**2,032**

Source: IDOM, 2026

Resulting Mitigation Co-benefits

Across all restoration, conservation, agroforestry, and silvopastoral interventions, the project is estimated to deliver a total net mitigation co-benefit of approximately 2.97 million tCO_2e for the 20 year period of the project life span. These co-benefits are reported as ancillary mitigation outcomes, fully aligned with the project's primary adaptation objective.

Table 56.Estimated total capture (tCO_2e)and annual capture (tCO_2e/year) by type of intervention.

Intervention	Net carbon capture (tCO2e/ha)	Intervention area (ha)	Total (tCO2e)
Regeneración natural pasiva (Selva tropical montano)	223.9	2,378	532,304.1
Regeneración natural pasiva (Alta montaña andina tropical)	276.3	2,378	656,956.2
Recuperación activa mediante enriquecimientos (Selva tropical montano)	233.0	401.5	93,556.2
Recuperación activa mediante enriquecimientos (Alta montaña andina tropical)	285.4	401.5	114,602.8
Recuperación activa de zonas degradadas mediante módulos (Selva tropical montano)	265.9	1,016.0	270,103.6
Recuperación activa de zonas degradadas mediante módulos (Alta montaña andina tropical)	318.3	1,016.0	323,362.3
Sistemas Agroforestales	615.5	803.0	494,278.0
Sistemas Silvopastoriles	615.5	803.0	494,278.0
Total		**9,196**	**2,979,323**

Source: IDOM, 2026

IV. Options analysis methodology

Multiple approaches and solutions can be used to address Bogota's water security challenges, each with distinct strengths and limitations. The Option analysis functions as a comprehensive, quantitative evaluation framework for assessing the economic, social, and environmental dimensions of a project. The method accounts for viability and climate impact of proposed interventions, setting the GCF investor scope to induce direct comparison of alternative solutions that contribute to the project's objectives.

Conventional grey infrastructure expansion (such as new dams, enlarged storage reservoirs, or expanded treatment and conveyance capacity) can deliver predictable yield increases and acute flood control. However, this approach carries high upfront capital costs, lengthy environmental permitting and social consultation timelines, ecosystem disruption, and operational rigidity if climate conditions diverge from design assumptions.

Demand-side management alone improves system performance and buys time at low cost (for example, investing in water saving faucets and toilets, or increasing urban water users' awareness of scarcity). Yet it faces equity barriers in lower-income communities, and during severe droughts it is insufficient to meet the growing demand without supply augmentation. Also, Bogota has an active program for reducing water consumption through cultural changes.

Numerous interventions can increase the supply of water to help keep pace with the forecasted growth. As degradation of upper watershed land increases, the imperative to conserve water regulating ecosystems becomes vital to deliver effective climate change adaptation measures that achieve social, environmental, and economic goals. The full scope of solutions for hard infrastructure includes green (NbS, reforestation, sustainable land management), grey (Dams, levees, and hybrid approaches (Sustainable stormwater systems, Managed Aquifer Recharge).

The option analysis fulfills a fiduciary requirement inherent to concessional climate finance: GCF resources are catalytic and scarce, and their deployment must be justified against the best available alternatives. This approach acts as a professional decision-support tool, demonstrating rigorous due diligence in investment selection, providing transparent justification for options, and enhancing the quality of the funding proposal by systematically addressing the Green Climate Fund (GCF)'s six investment criteria. By making explicit the rationale for each component (and the cost, feasibility, and climate-adaptation benefits foregone by each alternative) the analysis builds stakeholder confidence and establishes a robust foundation for implementation and adaptive management

A. Prioritization regulations and governance in Bogota

Colombia operates a highly structured public investment system governed by the National Planning Department (DNP), which establishes the institutional architecture for project selection, prioritization, and budgeting across all infrastructure sectors. The DNP sets methods, issues viability opinions, oversees the public investment cycle, and supports scoring/prioritization for royalties-funded projects in Colombia.

Under the framework of Law 2056 of 2020 and Decree 1821 of 2020, the Government of Colombia established technical and objective methodologies for prioritizing projects seeking funding from the 40%

regional allocation of the General System of Royalties (SGR). The SGR is a national mechanism that allocates revenues from non-renewable natural resources to regional development, social projects, and sustainable initiatives. The DNP defines two distinct methodologies for executing an option analysis among alternative solutions identified during the pre-investment phase. The evaluation carried out at this stage seeks to determine which alternative yields the greatest results for the welfare of society as a whole.

- The first pathway is through economic viability analysis, comparing quantitative indicators such as the Economic Internal Rate of Return (EIRR) and Economic Net Present Value (ENPV) as the main decision criteria. In this approach, the evaluation compares the economic flow of each alternative, not merely the financial flow, by adjusting market prices to reflect social opportunity costs using Price-Account Ratios or Shadow Prices. These adjustments correct for market distortions (taxes, subsidies, tariffs, exchange rate distortions, unemployment) to reflect the true economic value of inputs, labor, and outputs to society (Departamento Nacional de Planeación, 2014).
- The second pathway applies a multicriteria analysis (MCA) using the Analytic Hierarchy Process (AHP). These types of analysis present a good tool for projects that hinder benefits that are not captured by economic markets, or are not easily quantifiable, such as cultural heritage preservation, biodiversity conservation, social cohesion, Indigenous peoples' rights, gender equity, governance strengthening, or ecosystem resilience. Therefore, this option is better suited to comparing the projects for the objectives of this proposal, where nature-based solutions generate a portfolio of quantifiable and non-quantifiable benefits.

The team chose to compare the projects using the MCA, because it allows simultaneous consideration of economic efficiency (cost per cubic meter secured), climate adaptation impact (reduction in drought and flood risk), environmental co-benefits (biodiversity, carbon), social equity (vulnerability reduction, rural livelihoods), and institutional feasibility (governance complexity, stakeholder buy-in). Also, performing an economic viability analysis for different projects requires more detailed information about their implementation costs and expected performance. Using a multicriteria analysis that aligns with GCF investment criteria and aligns with DNP standards is the best way to develop a robust option analysis.

B. Identification and comparative evaluation of intervention options

An intervention typology analysis was conducted to classify all measures as grey, green (nature-based), or hybrid infrastructure, thereby establishing a consistent basis for comparative assessment within the option analysis. The resulting classification confirms that the evaluation included a diverse scope of solutions (from green to grey). With this classification, the team can select specific interventions to be compared during the option analysis, providing a more realistic evaluation and allowing for further comparison if local actors need to compare additional solutions.

Grey options include engineered assets such as reservoirs, conveyance networks, and treatment plants; green options encompass ecosystem conservation and restoration, agricultural best management practices, natural structures to improve infiltration and reduce sediment runoff and urban use of natural stormwater regulation; hybrid options combine engineered works with nature-based elements to optimize reliability, cost, and co-benefits.

Table 57. List of interventions to increase water availability in Bogota.

Scale	Grey Infrastructure	Green–Grey Hybrid Infrastructure	Green Infrastructure (Ecosystem-Based Adaptation)
Neighborhoods & Slopes	**Retention Basins** to control flash floods and landslides.	· **Slope Stabilization** combining grey retaining walls with bioengineering (vegetation). · **Wetland–Drainage Integration** restoring small wetlands linked to stormwater collectors.	Pocket Parks with Infiltration Features in high-density neighborhoods. **Streamside Buffers** along quebradas (local streams) for filtration and stabilization.
Peri-Urban Transition (Urban Edge & Agricultural Belt)	**Levees and Floodwalls** along vulnerable stretches of the Bogota River.	· **Floodplain Reconnection** through levee setbacks to restore water retention. · **Agro-Wetlands** combining irrigation canals with ecological treatment. · **Slope stabilization and improvement of shallow aquifer recharge** through the construction of cultivation terraces and perimeter drainage systems (amunas).	**Agroforestry & Soil Conservation** in dairy and potato farming zones (eliminating hillside crops, promoting living fences). · Improved livestock practices and reforestation with species that retain soil. **Sustainable Agriculture** improving farming practices, using efficient irrigation and reducing harmful inputs (such as agrochemicals and pesticides).
River Basin (Bogota River & Tributaries)	**Canals, little reservoirs & acueductos veredales** distributing water for irrigation and supply. · Sewerage systems and wastewater treatment plants for urban centers.	**Riparian Forest Restoration with Structural Embankments** combining ecological and protective functions. Improving water quality through rural sanitation systems that combine sewer infrastructure and natural effluent treatment. · **Managed Aquifer Recharge** using engineered wells to complement páramo storage	**Floodplain Restoration** to absorb floods and recharge aquifers. **Riparian Buffers** enhancing connectivity and biodiversity corridors.
Páramo Ecosystems (Chingaza, Sumapaz, Guerrero, Guacheneque)	**Dams & Reservoirs** (Chingaza, San Rafael, Tominé) securing Bogota's water supply.	Paramo Restoration with Structural Embankments combining ecological and protective functions.	**Páramo Grassland & Wetland Conservation** maintaining water regulation and storage. Reforestation of Degraded Highland Slopes to stabilize soils and regulate flows.

Definition of evaluation criteria

The team selected five main categories to include in the option analysis evaluation. These criteria reflect the experience of the team prioritizing projects with the highest impact and are likelihood for successful implementation. In addition, the five categories collectively provide a holistic assessment framework that directly corresponds to GCF's investment framework and mandate of promoting a paradigm shift towards low-emission and climate-resilient development while ensuring transformative outcomes. The five categories are:

- Economic profile
- Social impact
- Gender & equity
- Environmental impact
- Political-institutional

Each category contains between 2 and 4 key indicators that capture the core intent of the criterion, using qualitative scoring anchors (High/Medium/Low) to allow comparability across diverse project types. Categories and criteria were selected to consider relevant "enabling conditions" that increase the projects uptake by local actors, they also reflect a forward-looking analysis that includes "additional principles" which drive further impact to local communities.





Economic profile

This category is fundamental in both GCF's and local government's investment decision-making processes, reflecting the emphasis on efficiency and effectiveness, as one of the GCF's six core investment criteria. Expert judgment recognizes that climate projects must demonstrate financial viability, cost-effectiveness, and economic sustainability to achieve the paradigm shift that GCF seeks to catalyze. Prioritized projects should make responsible use of financial resources to achieve the desired outcomes. The economic dimension also reflects GCF's policy on providing minimum concessional funding necessary to make projects viable, ensuring that investments leverage additional resources.

The economic dimension addresses a critical challenge in climate finance: bridging the funding gap in the water sector while encouraging private sector participation. Without strong economic fundamentals, projects risk becoming dependency-driven rather than transformative investments. Economic strength also determines whether projects can be sustained, scaled, and replicated—core elements of GCF's paradigm shift mandate.

Criteria:

- Cost-Effectiveness of solution: This criterion ensures that limited climate finance achieves maximum impact by optimizing resource use and operational efficiency. It prevents mal-investment by requiring projects to demonstrate they can deliver climate benefits cost-effectively.
- Job Creation: Climate investments should generate broader economic development, not just infrastructure. Job creation, particularly in sustainable sectors, builds the human capital necessary for long-term climate resilience.
- Estimated Return of investment:. This criterion analyzes financial and bankability of projects, it considers if projects achieve revenue mechanisms and appropriate return on investment.
- GCF Investment Criteria Mapping: Primarily addresses Efficiency & Effectiveness, Sustainable Development Potential and Impact Potential; contributes to Paradigm Shift Potential through economic sustainability and capacity building.

Social Impact

Social impact reflects a project's commitment to improving conditions for all beneficiaries, recognizing the multiplicity of social effects on water-related projects. Water projects that fail to address social dimensions risk exacerbating inequalities, creating infrastructure that serves only privileged populations while leaving the vulnerable behind. Social considerations are therefore not peripheral but central to climate justice and effective adaptation.

Water is fundamentally a social good—its availability, quality, and accessibility directly affect human health, dignity, and economic opportunity. If beneficiaries are not reached, health is not improved, or livelihoods remain vulnerable, then the project has failed to build real climate resilience regardless of infrastructure quality. Hence, social considerations are weighted equally in this assessment with economic and environmental factors to reflect holistic sustainable development principles.

The other type of water-related benefit is the mitigation of risks posed to the lives and property of communities and, therefore, the assessment of reducing these negative effects of flooding, landslides, soil erosion and debris flow is incorporated.

Criteria:

- Health & Safety: Changes in water quality and quantity have significant consequences on people's health and safety. This criterion ensures projects deliver measurable health co-benefits and reductions in climate vulnerability.
- Poverty Alleviation: Climate impacts hit the poor hardest because they lack resources to adapt and recover from shocks. This criterion ensures projects specifically strengthen the resilience of vulnerable livelihoods—small-holder farmers, informal workers, low-income households—who face the greatest climate-related economic risks. Reduced water costs for poor households' free up income for other needs.
- Number of beneficiaries: GCF's impact is measured partly by the number of beneficiaries

- reached, with priority for vulnerable populations. This criterion ensures projects maximize their reach while specifically targeting climate-exposed and underserved communities.

GCF Investment Criteria Mapping: Primarily addresses Sustainable Development Potential, Impact Potential, and Needs of the Recipient.

Environmental Impact

Environmental impact is central to GCF's core mission of delivering measurable climate adaptation and mitigation outcomes. Water projects sit at the intersection of climate, ecosystems, and human development—they can either strengthen or degrade natural systems that regulate water availability, quality, and climate resilience. The Project centers on the relation between water and healthy ecosystems. Therefore, the weight for this category is the same as the economic and social factors, emphasizing the importance the GCF places on environmental factors.

Projects that degrade ecosystems undermine their own climate resilience objectives and create long-term environmental liabilities. Conversely, ecosystem-based approaches can deliver cost-effective, multi-benefit climate solutions that become more valuable over time as natural systems mature. Water projects that ignore environmental dimensions risk non-compliance with GCF policies, mal-adaptation (solving one problem while creating others), and missed opportunities for nature-based solutions that could deliver superior climate outcomes at lower cost.

Criteria:

- **Ecosystem & Land Use Changes:** Ecosystems, particularly watersheds, wetlands, and forests, are natural water infrastructure that regulate hydrological cycles and provide climate resilience. This criterion evaluates whether projects protect and enhance these natural assets rather than relying solely on gray infrastructure which can have an impact on natural ecosystems, both on living elements and the hydrological services they provide.
- **Biodiversity & Habitat Protection**: This criterion prevents environmental harm and aligns with international biodiversity commitments. Endemic and threatened species receive priority because their loss is irreversible. Habitat connectivity ensures species can migrate in response to climate change, maintaining ecosystem function. Robust monitoring enables adaptive management, ensuring projects respond to observed environmental impacts rather than proceeding blindly.
- **Climate Mitigation & Pollution Reduction:** Water infrastructure can be energy-intensive and generate significant GHG emissions through construction, pumping, and treatment processes. This criterion ensures projects minimize their carbon footprint and, where possible, deliver mitigation co-benefits through renewable energy, energy efficiency, or carbon sequestration, enhancing the use of Nabs.
- **Water Quality Improvement:** This criterion ensures projects address both point and diffuse pollution sources that compromise water security. Multi-level coordination is essential because water quality is a basin-scale issue requiring cooperation among upstream and downstream users. Improved water quality increases water availability and reduces treatment costs for water supply, enhances ecosystem health, and increases access to potable water for rural communities.

GCF Investment Criteria Mapping: Primarily addresses Impact Potential, Efficiency & Effectiveness (consider key strategies to achieve GCF's mandates) and Sustainable Development Potential (environmental co-benefits). Given that Colombia has set water action as one of the key pillars of national priorities, this category aligns with Needs of Recipient.

Political-Institutional

Political and institutional factors determine whether projects can be successfully implemented, sustained, and scaled. Even technically excellent projects fail without political support, institutional capacity, and enabling policy environments. This category speaks directly to the country's ownership, reflecting the principle that climate solutions must be nationally driven and aligned with country priorities.

Projects imposed from outside or misaligned with national strategies face political resistance, lack institutional champions, and struggle to secure sustained funding and policy support. Conversely, projects embedded in national climate frameworks benefit from political visibility, policy coherence, and institutional commitment. This category ensures projects strengthen rather than bypass institutions, building the enabling environment for sustained climate action beyond individual projects.

Criteria:

- **Multi-level Policy Alignment & Support:** GCF requires demonstration of alignment with national climate strategies, NDCs, and development plans. This criterion ensures projects support nationally defined priorities rather than external agendas. Multi-level alignment (national, regional, local) is critical because water governance involves multiple jurisdictions. Stakeholder support indicates political will and social license, both necessary for successful implementation.
- **Institutional Capacity & Coordination:** Weak institutions cannot sustain projects after external support ends. This criterion ensures projects build institutional capacity necessary for long-term climate action, while considering coordination and governance structures as a key factor for project feasibility.

GCF Investment Criteria Mapping: Directly addresses Country Ownership and contributes to Paradigm Shift Potential through policy and institutional strengthening.

Equity & Gender

GCF explicitly requires gender and Indigenous people's policies reflecting the GCF principle that climate action must promote social justice alongside environmental outcomes. Gender and equity considerations ensure climate investments are reduced rather than reinforce existing inequalities Equity-focused projects deliver greatest adaptation benefits by strengthening resilience where it's most needed.

Women and marginalized groups face disproportionate climate vulnerabilities due to pre-existing social, economic, and political inequalities. Water scarcity particularly affects women who typically bear responsibility for household water provision—spending hours collecting water reduces time for education, income generation, and rest. Instead of considering equity and gender as part of social impact, this distribution defines a separate category to make it a more important factor.

In addition, Indigenous peoples have distinct rights, knowledge systems, and relationships with water that must be respected. Projects affecting Indigenous territories without meaningful consultation violate international standards and risk community opposition. Conversely, projects that integrate Indigenous knowledge can benefit from generations of accumulated adaptation wisdom and build strong local ownership.

Criteria:

- **Reduction of systemic inequalities / serving the most needed:** This criterion ensures projects specifically target populations with lowest service coverage and highest climate vulnerability, closing critical gaps. Addressing spatial and systemic inequalities prevents elite capture where infrastructure primarily serves privileged populations.
- **Women income and jobs:** Gender-responsive design ensures these needs shape project decisions rather than being afterthoughts. Economic opportunities for women contribute to household resilience and women's empowerment. Transforming gender relations creates lasting change that benefits entire communities and strengthens overall resilience.
- **Indigenous population rights and benefits:** Indigenous knowledge about water management, climate patterns, and ecosystem dynamics can enhance project design and effectiveness. This criterion ensures projects respect these rights through meaningful consultation. Culturally appropriate approaches increase acceptance and sustainability by aligning with Indigenous worldviews rather than imposing external models.

GCF Investment Criteria Mapping: Primarily addresses Sustainable Development Potential (social equity) and Needs of the Recipient (targeting vulnerable groups), Country Ownership is also enhanced by making sure that vulnerable groups are considered as part of the solution.

The scoring methodology developed for the revised water project evaluation framework is designed to ensure both rigor and practicality, allowing direct comparisons of diverse projects while maintaining strong alignment with the Green Climate Fund (GCF) investment criteria. By linking all categories and criteria to GCF's core requirements, the final scoring demonstrates their alignment with the Fund's priorities, facilitating clearer, more defensible funding proposals.

The assessment for each project allows for three different degrees of alignment in each criteria. The underlying category will sum up the grades of the sub-criteria to allow for a final score. This approach ensures high comparability among projects, facilitating the decision-making process.

High (3 points): Project demonstrates exceptional performance with clear evidence and transformative potential.

Medium (2 points): Project shows moderate performance with partial evidence or limited transformative impact.

Low (1 point): Project exhibits minimal performance with insufficient evidence or negligible impact.

Total Project Score = Sum of all category scores (maximum 100 points)

Economic Score = 25 × (sum of criterion points / maximum possible points)

Social Score = 25 × (sum of criterion points / maximum possible points)

Environmental Score = 25 × (sum of criterion points / maximum possible points)

Political-Institutional Score = 15 × (sum of criterion points / maximum possible points)

Gender & Equity Score = 10 × (sum of criterion points / maximum possible points)

C. Selection and justification of preferred interventions

The evaluation of water security and climate resilience interventions for Bogota proceeded systematically to allow for comparison of six different interventions. The evaluation rubric improves the comparability between projects, allowing the team to evaluate each intervention under pre-defined logic, following the indicators expressed in table 3.

The six interventions were chosen to include a mix of solutions; the resulting projects compare two grey approaches (Dams/reservoirs and Levees/floodwalls), green interventions (Páramos conservation & restoration and Stormwater Natural Drainage System), and Hybrid approaches (rainwater harvesting and managed aquifer recharge). The following tables contain the grades given for each intervention in each category and criteria, with its corresponding justification.

Table 58 Comparison table: Evaluation of specific projects (1/2)

Criteria (Weight)	Dams / Reservoirs (Grey)	Rainwater Harvesting (Hybrid)	Páramos Conservation & Restoration (Green)
1. Economic score (25%)	Economic: 25*(8/9) = 22.2	Economic: 25*(3/9) = 8.3	Economic: 25*(7/9) = 19.4

Criteria (Weight)	Dams / Reservoirs (Grey)	Rainwater Harvesting (Hybrid)	Páramos Conservation & Restoration (Green)
1.1 Cost effectiveness of solution: Evaluates how efficiently the project delivers desired outcomes by optimizing resource use, reducing operational costs, and/or improving resilience to climate-related disruptions.	• Project greatly enhances water availability and reliability under drought stress; rationing cause severe economic losses from reduced industrial production, business closures, and productivity losses, at last avoiding water cutoff. Reservoir expansion prevents recurrence of such crises. • Integrates well with existing EAAB water supply system infrastructure (Chingaza, North, South systems) rather than creating parallel systems. • Furthermore, the infrastructure solutions being proposed for EAAB reduce operating costs because the water comes from higher elevations than the PTAPs (without pumping) and improves quality (reduction in the use of reagents and less energy-intensive water treatment technology). **HIGH (3pts)** dam and reservoir expansion prevents massive economic losses from water scarcity and reduce operational costs while being cost-effective relative to alternatives.	• Project delivers moderate water availability and offers moderate resilience during extreme events (not a solution against prolonged droughts). • Operates at building level rather than system level. • Systems can achieve individual cost-savings if water tariffs are high. **LOW (1pts)** while individual buildings can achieve cost operational savings, they need an initial investment and system-wide efficiency benefits are limited.	• Conservation and restoration of páramo watersheds improves the natural hydrological functioning, increasing the availability and quality of water (increasing resilience to climate and extreme events) reducing treatment costs for drinking water). It also reduces sediment inputs to dams and the river in general. reducing water treatment costs for EAAB. • The solution seeks cost-effectiveness by design by incorporating strong decision-making systems that intervene in the most effective areas. • The project aligns with and reinforces the conservation initiatives that other entities are promoting, such as the EAAB PAS or the CAR wetlands management programs. **MEDIUM (2pts)** páramo conservation project demonstrates exceptional cost-effectiveness through multiple documented pathways. However, the benefits do not translate into financially profitable project.
1.2 Job creation: Assesses the project's capacity to generate direct and indirect employment creation, income generation, and support for sustainable livelihoods.	• Project employs primarily short-medium term construction employment, instead of creating sustainable long-term employment. • Some local hiring from surrounding communities, though many positions require specialized skills filled by external contractors. • Expansion of EAAB's professional staff with teams for the operation, maintenance, and monitoring of the new infrastructures. • Project includes training for EAAB personnel in advanced water management and crisis response. **MEDIUM (2pts)** the project creates significant employment during construction, however	• Primarily benefits existing plumbers and building maintenance staff. • Plumbers & electricians hired for installation work. • Maintenance technicians required but in small numbers. **LOW (1pts)** employment is small and primarily short-term technical.	• Project centered around sustainable livelihoods for the conservation of paramo landscape. • Project enhances the rural region economically through new and better jobs. • Permanent employment opportunities in tourism, sustainable agricultural, product processing, and environmental education services. • The project includes comprehensive training aligned with climate resilience. • Páramo restoration requires labor-intensive activities primarily filled by local rural communities in Usme, Sumapaz, Choachí, and surrounding municipalities.

Criteria (Weight)	Dams / Reservoirs (Grey)	Rainwater Harvesting (Hybrid)	Páramos Conservation & Restoration (Green)
	permanent employment is limited & requires specialized skills filled by external contractors.		**HIGH (3pts)** The project creates substantial, long-term, quality positions paying competitive wages prioritizing local hiring from target communities.
1.3 Estimated Return of Investment Evaluates the project's financial sustainability, return on investment potential, and ability to leverage additional funding sources, providing insight into financial risk and liquidity.	• Strong revenue mechanisms through EAAB water tariffs & electricity generation. • Reservoir & Dam projects have proven ability to attract multilateral development bank financing. EAAB credit rating is AAA (Bogota, 2024). • Direct relationship between investment and avoided costs in case of extreme drought or water emergency. **HIGH (3pts)** strong financial viability with revenue generating mechanisms and a possibility to attract co-finance.	• Limited banking products for RWH financing, which requires homeowner capital investment. • Requires public subsidies to achieve low-income adoption, increasing public burden. • Water price volatility affects payback period calculation. **LOW (1pts)** financial viability is low with significant barriers for low-income adoption.	• Water treatment cost reductions create indirect "revenue" through public budget savings that can finance the project. • Project seeks to leverage investment from private sector through water offsets. • The project demonstrates strong potential to attract climate funding from diverse sources (GCF, CAR, NGO's,). **MEDIUM (2pts)** while the project demonstrates strong financial viability, revenue mechanisms are primarily indirect (cost avoidance) rather than direct revenue generation, and some financing depends on sustained institutional commitment (both private and public.
2. Social (25%)	Social: 25*(6/9) = 16.7	Social: 25*(6/9) = 16.7	Social: 25*(9/9) = 25

Criteria (Weight)	Dams / Reservoirs (Grey)	Rainwater Harvesting (Hybrid)	Páramos Conservation & Restoration (Green)
2.1 Health and safety: Measures improvements in community safety, well-being and the reduction of health risks associated with water services and climate vulnerability.	• Water rationing causes malnutrition, dehydration, and hygiene-related diseases; reservoir expansion prevents recurrence of such emergencies. However, those benefits are only for extreme weather events and not a direct improvement from water quality baseline. • The hydraulic regulation of a dam can benefit third-party users of the basin, such as farmers, by providing resources during dry natural periods, not only droughts. • The dam also represents a flood control element and a reduction in the risk of flooding, giving greater safety to downstream populations. • Reservoirs can also become recreation centers that improve well-being. **MEDIUM (2pts)** health benefits exist but they focus on crisis prevention rather than improving baseline health.	• Rainwater is primarily used for purposes other than drinking, usually for garden irrigation or toilet flushing. If it is to be used for drinking, it requires treatment to ensure its potability, which carries health risks since these are individual systems not managed by a water supply company. • It helps overcome drought events by constantly inducing lower consumption of mains water, but it is not a massive alternative to drinking water. No significant improvements in sanitation or hygiene but can provide water for basic farming activities (subsistence food). • Some improvements in well-being due to improved food security. **MEDIUM (2pts)** health benefits exist but they are scarce and focused on crisis prevention and partially improving baseline health.	• Restored vegetation and soil infiltration improve water absorption, reducing runoff and flash-flood risks in steep paramo watersheds that feed downstream communities enhancing farming activities to feed communities. • Also, enhanced paramo water regulation provides reliable water supply for rural communities, with better quality improving water potability and consequently health. • Improves access to natural areas and recreation space providing psychological well-being benefits. • Enhanced community participation for monitoring, which improves local knowledge on how to deal more effectively with climate change. **HIGH (3pts)** the project delivers significant, comprehensive health improvements across multiple dimensions, both locally and for other users throughout the basin.
2.2 Poverty alleviation: Measures how projects reduce poverty, improves living conditions, and strengthens resilience of vulnerable livelihoods against climate impacts.	• Project doesn't extend service to unserved areas—primarily expands capacity in existing system. • Might lead to moderate improvement in water affordability. • Project serves primarily existing urban customers and their economy, reducing disruptions associated to severe droughts. **LOW (1pt)** score because while the project provides important water security for city, it doesn't include targeted measures for poverty alleviation and livelihood support in rural areas.	• For participating households, water supply bills reduced. • An initial investment is needed, which may require subsidies for the most disadvantaged households. • In rural areas, these actions allow water to be reserved for crops and livestock for their basic food and family economy. **MEDIUM (2pts)** poverty alleviation benefits are indirect and limited to lower water bills.	• The activities for the preservation and restoration of paramo with an impact on the guarantee of urban water supply have the mechanism of PES income guarantee, representing reliable income for rural communities aligning with sustainable development. • Direct economic contributions can improve the living conditions and lifestyle of the inhabitants of the most disadvantaged communities, contributing to investments in food security and local water security, thus making it a mechanism for fighting poverty. • Reduces dependency on expensive agricultural inputs (fertilizers, pesticides) improving household budgets. • Contributes to income diversification for small-holder farms. And, it leads to better access for

Criteria (Weight)	Dams / Reservoirs (Grey)	Rainwater Harvesting (Hybrid)	Páramos Conservation & Restoration (Green)
			credits and other financial schemes that are critical for businesses. **HIGH (3pts)** the project directly addresses poverty dimensions through multiple integrated mechanisms.
2.3 # of total beneficiaries: Evaluates the number of people impacted by the project, directly or indirectly.	• Direct beneficiaries are large customer base improving continuity of service. • Agricultural irrigation, water dependent industries and schools are indirectly benefited by the project. **HIGH (3pts) t**he project reaches massive beneficiary populations through existing water system.	• Older buildings and low-income housing are difficult to retrofit. • Reduces pressure on EAAB system benefiting all users indirectly, however, the reduction is small. **MEDIUM (2pts)** direct beneficiaries reach is moderate, and indirect benefits are small.	• Direct beneficiaries are high-altitude municipalities participating in project activities. These communities receive páramo restoration employment, PES payments, training, and improved local water supply. • Bogota Metropolitan area indirectly benefits from the project by ensuring a more reliable water supply, so it adds all the city's population. **HIGH (3pts)** the project reaches both substantial numbers of direct beneficiaries and indirectly benefits broader Bogota area.
3. Environmental (25%) -	Environmental: 25* (5/12) = 10.4	Environmental: 25* (6/12) = 12.5	Environmental: 25* (12/12) = 25
3.1 Land use changes: Evaluates changes in ecosystem health that include vegetational cover, conversion of natural landscapes, and natural infrastructure that enhance hydrological services and climate resilience.	• Does not incorporate watershed management or ecosystem restoration. • Operates independently of ecosystem management strategies. • Reservoir expansion requires flooding of land areas, eliminating terrestrial ecosystems. • Altered flow regimes downstream affect riparian ecosystems. **LOW (1pt)** the project relies on grey infrastructure with negative ecosystem impacts.	• Reduces water extraction from ecosystem but doesn't improve ecosystem condition. • No increase in infiltration or groundwater recharge. • Does not contribute to ecosystem health or biodiversity protection. **LOW (1pt)** project provides no restoration or ecosystem management impact.	• The project is centered around conservation and reducing land degradation of key ecosystems. • The project reduces the expansion of agricultural lands in key areas for water recharge, improving water and land management. • Restoration connects fragmented páramo patches, enabling genetic flow and resilience of endemic plant and animal species. • The páramo complexes targeted—Chingaza, Sumapaz, Guerrero—were identified through hydrological analysis as most critical for Bogota's water supply.

Criteria (Weight)	Dams / Reservoirs (Grey)	Rainwater Harvesting (Hybrid)	Páramos Conservation & Restoration (Green)
			HIGH (3pts) the project implements scientifically targeted ecosystem restoration with extraordinary potential impact on hydrological systems.
3.2 Biodiversity impact: Assesses the project's impact on biodiversity conservation, habitat quality, and species protection.	• Net habitat loss from flooding of terrestrial areas. • Potential displacement of endemic species without alternative habitat. • Mitigation actions may be insufficient to offset habitat loss. **LOW (1pt)** the project leads to negative impacts for local biodiversity.	• Infrastructure in urban buildings or rural houses do not have direct biodiversity considerations. • No protected or enhanced habitats. • Does not threaten or benefit biodiversity, beyond inducing a reduction in water consumption in traditional systems that capture it from the environment. **LOW (1pt)** urban rainwater harvesting has no biodiversity dimensions.	• Restoration of the endemic species is a direct benefit from the project and the MRV system will consider this as a key metric. • Project establishes forest corridors linking Chingaza complex with Sumapaz complex. • The project includes comprehensive biodiversity monitoring, ex-ante & ex-post. **HIGH (3pts)** the project incorporates specific, evidence-based actions for protecting globally significant biodiversity.
3.3. CO2 emissions and other pollution sources: Estimates greenhouse gas emissions and other pollutants resulting from the project	• Concrete production for dam construction generates GHG emissions. • The transformation of an original paramo into a reservoir reduces carbon sequestration. • Dam and transfer infrastructure could provide clean energy generation plants, reducing consumption of energy from fossil fuels or polluting sources. • Relatively low operational emissions. **MEDIUM (2pts)** because construction emissions are significant while operational emissions are moderate or possibly negative- electricity generation could potentially offset some of the emissions.	• Reducing water replacing it with rainwater contributes to reduce water pumping inside Bogota's supply network. Therefore, energy has a considerable reduction. • Rainwater harvesting systems are low carbon designs and have minimum effects of GHG emissions. **MEDIUM (2pts)** rainwater harvesting can reduce energy-intensive water supply operations.	• Project leads to net GHG emission reductions. • Incorporation of low-emission technologies and nature-based carbon sequestration. • Significant reduction in water pollution and contaminant sources. **HIGH (3pts)** the project delivers substantial climate mitigation benefits alongside primary adaptation objectives.
3.4. Evolution of Water Quality: Measures improvements in water quality at source and throughout water systems; as an environmental recovery	• Potable water accessibility improvements (in the case of increasing the proportion of the Chingaza River in EAAB's mix, the quality of the raw water increases significantly, lowering treatment costs). • Larger storage allows sedimentation and settling of particles.	• Does not address pollution sources affecting water quality. • Systems include filters which can improve the quality of water delivered at rural homes. • In the case of urban buildings, their contribution is for uses unrelated to drinking water.	• Protecting and restoring the paramo enhances infiltration, which generates a global water quality improvement. • It also retains the soil and prevents sediment runoff. • Improved water quality in sources reduces need for complex treatment.

Criteria (Weight)	Dams / Reservoirs (Grey)	Rainwater Harvesting (Hybrid)	Páramos Conservation & Restoration (Green)
mechanism, also as a direct impact on the water quality on natural ecosystems.	• No change in water quality is expected at the source. **LOW (1pt)** water quality is not improved, dams could lead to increase sediment load, and project doesn't address upstream pollution sources.	• Using rainwater for some purposes allows the better conservation of clean, potable water for the right usage. **MEDIUM (2pts)** water quality in the system remains unaltered, the project doesn't address upstream pollution. However, quality water get's replaced by rainwater, improving availability of quality water in the system.	• Improving water quality at the source benefits EAAB's treatment facilities, but also facilitates access to drinking water for rural communities with targeted interventions to rural water supply systems (water utilities). • Higher water quality at the sources represents higher environmental quality in ecosystems. **HIGH (3pts)** because the project restoration activities also aim to improve water quality before reaching the water treatment facilities. It also leads to high quality infiltrated in the paramos, addressing upstream pollution directly.
4.Political-Institutional (15%)	P-I: 15* (4/6) = 10	P-I: 15* (4/6) = 10	P-I: 15* (6/6) = 15
4.1 Multilevel Policy alignment and support: Assesses how project supports and considers priorities across national, regional, and local levels. It looks at arrangements like the National Plan for Adaptation to Climate Change, National Development Plan or the Colombian Green Taxonomy and National Plan for Drinking Water Supply and Basic Rural Sanitation, watershed management plans, and territorial planning (POMCA's and POT's)	• Bogota City POT includes water infrastructure expansion in territorial plans, however its priorities are to align with environmental protection. • EAAB's Master Plan to long-term water supply includes new dams in Chingaza basin. • Colombian Green Taxonomy includes large dam construction in certain contexts. • Environmental and climate policies increasingly emphasize NbS over large dam expansion, creating potential policy misalignment with paradigm shift toward ecosystem-based approaches. **MEDIUM (2pts)** demonstrates consistency with national priorities and frameworks but lacks alignment with environmental action.	• Aligns generally with Bogota POT sustainability goals. • The District Secretariat of Habitat of Bogota has developed a standard to promote the use of rainwater in buildings. • No explicit policy or political opposition. • Consistent with Colombian Green Building Standard. • National Water Plan emphasizes centralized efficiency over decentralized approaches. **MEDIUM (2pts)** project has general alignment but is not identified as critical priority.	• Páramo protection is explicitly listed priority in Colombia's NAP with water security as primary objective. • Current PND prioritizes water security and ecosystem conservation, with páramo protection cited as key mechanism. • The POMCAs of the environmental agencies of the Bogota and Chingaza rivers include the protection and restoration of the páramo among their measures. • Cundinamarca Department climate adaptation strategies explicitly reference páramo conservation as priority. • Bogota's POTs identifies páramo conservation as a development priority. • Municipal POTs identify páramo conservation as development priority, and contributes to abidance of the law: Ley 1930 del 2018. • **HIGH (3pts)** the project demonstrates exceptional alignment across Colombia's entire policy hierarchy and has support from all governance levels.

Criteria (Weight)	Dams / Reservoirs (Grey)	Rainwater Harvesting (Hybrid)	Páramos Conservation & Restoration (Green)
4.2 Institutional Capacity and Coordination: Considers the synergy of the project among different institutions and how it improves coordination, governance and institutional capabilities	• Advanced technical expertise from EAAB in dam operations, water treatment, distribution. • Can achieve coordination with CAR on environmental management. • The project is not aligned with the policy of the Ministry of Environment and requires modifications to the protection status of the areas affected by the dam. • The governance of the project is not guaranteed, with many voices opposing its development. **MEDIUM (2pts)** EAAB has strong technical capacity for infrastructure management & coordination but, the conditions for governance among the various institutions and civil society to carry it out are not in place.	• Limited to municipal government role; permitting and subsidy administration. • An architectural intervention guide has been developed that allows for technical training. • Limited institutional embedding in water management strategy. **MEDIUM (2pts)** because institutional requirements, like subsidies and permits are modest, and coordination is informal.	• Strengthening rural community associations for self-governance and resource management. • Building technical capacity in information systems for monitoring, decision-making, and planning. • Project seeks to establish coordination between all levels of government from the start, identifying common objectives and detailing roles for each institution. **HIGH (3pts)** because the project explicitly builds institutional capacity and establishes coordination mechanisms that will sustain beyond the project.
5. Equity & Gender (10%)	E & G: 10* (5/9) = 5.6	E & G: 10* (7/9) = 7.8	E & G: 10* (8/9) = 8.9
5.1 Reduction of systemic inequalities / serving the most needed: Assesses the project's capacity to address and reduce pre-existing social inequities related to water access, climate vulnerability, and service quality.	• Some existing settlements may be relocated due to the flooding caused by the dam, although the project would incorporate mitigation measures. • Rural areas and informal settlements continue to lack service. • Doesn't address urban-rural divide in water access. • It is a neutral project that will benefit all users of the urban network equally, regardless of their group affiliation. **MEDIUM (2pts)** while the project doesn't actively reduce systemic inequalities, it could implement further actions to improve water availability for rural households.	• Subsidy programs can include equity components ensuring poor access to water supply systems. • Project could extend service to unserved poor populations and reduce vulnerability to droughts. • It complements actions in urban buildings with actions in rural homes with less access to water. • No negative consequences perceived. **HIGH (3pts)** project attempts inclusivity, addressing most critical inequality and promoting water availability for vulnerable populations.	• Specific design to serve populations with lowest water service coverage and highest climate vulnerability. • Supports rural autonomous water systems through improved source protection, recognizing and strengthening existing community-based approaches. • Concessional finance will be directed to the most needed populations, ensuring that resources have an aggregated impact dimension, targeting the most needed. **HIGH (3pts)** the project is specifically designed to address the most severe inequalities in water access and climate vulnerability.

Criteria (Weight)	Dams / Reservoirs (Grey)	Rainwater Harvesting (Hybrid)	Páramos Conservation & Restoration (Green)
5.2 Women income and jobs: Evaluates the extent to which the project addresses gender-specific needs, creates economic opportunities for women, and transforms gender relations.	• Without specific gender targeting, women unlikely to access project employment. • Project doesn't include mechanisms targeting women's economic empowerment. • No attention to women's water collection burden. **LOW (1pt)** construction employment is typically male-dominated, and project creates no specific opportunities for women's, nor it has a gender perspective.	• Reduced water bills provide modest economic benefit. • Limited time burden reduction benefit. • Maintenance positions could employ women with training. **MEDIUM (2pts)** project leads to women benefits, but they are mostly indirect and moderate.	• As restoration and conservation lead to better hydrological behavior, access to water improves and the typically female activity of bringing water to homes is reduced. • Project commissioned gender analysis identifying women's specific water roles, vulnerabilities, and priorities. • Support services enabling women's participation in training and meetings. • Project includes gender safeguards to ensure representation and design solutions around their needs. **HIGH (3pts)** project includes important women's considerations, considerations, and specific gender solutions.
5.3 Indigenous populations rights and benefits. Assesses the involvement of, benefit to, and respect for Indigenous communities, ensuring projects are inclusive, culturally appropriate, and responsive to their specific needs	• Environmental licensing for projects requires consultation with affected Indigenous communities, if any. • If Indigenous communities affected by reservoir flooding, resettlement compensation and relocation support required. **MEDIUM (2pts)** consultation is required by law but Indigenous leadership and priorities may not drive project design.	• No consultation with Indigenous communities required or relevant. • No Indigenous peoples' benefits, unless it is specified in project design. **MEDIUM (2pts)** project leads to no harm nor benefit for Indigenous groups, yet it could be designed to improve access for them.	• Project conducted formal consultations with Sumapaz Indigenous population. • Project incorporates Indigenous knowledge in specific practices. **MEDIUM (2pts)** Project includes appropriate Indigenous consultation but could deepen integration of Indigenous knowledge and strengthen recognition of Indigenous leadership.
	Total: 64.9	Total: 55.3	Total: 93.3

Table 59 Comparison table: Evaluation of specific projects (2/2).

Criteria (Weight)	Levees / Floodwalls (Grey)	Stormwater Natural Drainage System (Green)	Managed Aquifer Recharge (Hybrid)
1. Economic score (25%)	Economic: 25*(6/9) = 16.7	Economic: 25*(6/9) = 16.7	Economic: 25*(6/9) = 16.7
1.1 Cost effectiveness of solution: Evaluates how efficiently the project delivers desired outcomes by optimizing resource use, reducing operational costs, and/or improving resilience to climate-related disruptions.	• Levees reduce flood exposure by 70-90% in protected zones, translating to avoided costs from disaster management and response. • Infrastructure with virtually no O&M costs. • Levees often operate in isolation, complementing without depending on coordination with other stormwater management, drainage, or conservation projects. **HIGH (3pts)** levees provide critical flood damage reduction, being very cost-effective relative to alternatives.	• Project can be integrated with sewer network and improve water treatment. • Integrated stormwater systems reduce flood risk in treated areas, significantly reducing flood damages • Enables smaller conventional drainage pipes and treatment capacity. • Green infrastructure reduces urban heat island effect, improves air quality and can be used for recreation. **HIGH (3pts)** stormwater systems deliver exceptional cost-effectiveness through multiple benefit pathways.	• On the one hand, it is a solution that allows for the control of groundwater reserves and provides an alternative in the event of drought. It is, therefore, a key element in avoiding the costs of an emergency situation. • On the other hand, this infrastructure CAPEX are high, and annual maintenance requirements are expensive and technically demanding. • System could require additional treatment to prevent aquifer contamination. • Bogota's water system relies mostly on surface water, so this is a very useful alternative water to increase resilience. **MEDIUM (2pts)** while aquifer recharge provides valuable supplementary supply specially in drought events, cost-effectiveness is constrained by technical complexity and maintenance requirements.
1.2 Job creation: Assesses the project's capacity to generate direct and indirect employment creation, income generation, and support for sustainable livelihoods.	• Mostly employs construction workers with potential for local labor hiring for initial phases. • For monitoring and maintenance employment opportunities are very scarce because they are autonomous infrastructures. • Minimal pathways for unskilled community members into permanent employment. **LOW (1pts)** while construction creates temporary employment, permanent job opportunities are very limited.	• Most employment focuses on construction, design and site preparation. • Employments for maintenance and operations would be limit, but carry on local and lead to few income generation for communities. **LOW (1pts)** employment is moderate and primarily short-term, however it is likely to support local communities and be designed by local consultants.	• This infrastructure would need to be designed by foreign consultants, due to lack of local expertise. • Employment opportunities after construction exist, mostly technical and highly specialized. The level of technological sophistication of these infrastructures will require permanent specialized teams at EAAB, as the main beneficiary of these projects. • Capacity building programs would be a requirement for this project. **Medium (2pts)** The project creates substantial, long-term, quality positions specially in EAAB, supported by capacity building programs. However,

Criteria (Weight)	Levees / Floodwalls (Grey)	Stormwater Natural Drainage System (Green)	Managed Aquifer Recharge (Hybrid)
			the project would be designed and initially conducted by foreign contractors.
1.3 Estimated Return of Investment Evaluates the project's financial sustainability, return on investment potential, and ability to leverage additional funding sources, providing insight into financial risk and liquidity.	• Avoided flood losses provide implicit benefit but no direct revenue; Levee-protected areas become more valuable for urban development. • Return on investment is dependent on extreme weather events and damage protection, which increases uncertainty of liquidity. Its valuation is in terms of damages avoided under a probability. • Typically funded through municipal budgets, however they tend to attract other development banks for co-financing (like IDB, World Bank, CAF). **MEDIUM (2pts)** while flood protection has economic value, financing structures are challenging.	• Available financial mechanisms through municipal fees for stormwater and land value capture mechanisms like property taxes (based on increases in property value). • With good co-financing potential through multilateral climate and environmental funds and development banks. **MEDIUM (2pts)** financial viability is moderate with significant barriers to create a bankable project; dependent on capacity to implement financial mechanisms.	• Water infiltration would not generate any direct revenue, but it is a guarantee of extra water availability during droughts. Including a surcharge on the water tariffs might be the most feasible way to fund this project, bearing in mind that the main beneficiary is the water supply company and its users. • The project is in the portfolios of mixed solutions financeable by multilateral banks, in addition to the water supply company itself. **MEDIUM (2pt)** the project has revenue mechanisms that are not an excessive burden for water users from a EAAB point of view. Also, the project is innovative and might get financial support out of direct beneficiaries.
2. Social (25%)	Social: 25*(6/9) = 16.7	Social: 25*(6/9) = 16.7	Social: 25*(7/9) = 19.4

Criteria (Weight)	Levees / Floodwalls (Grey)	Stormwater Natural Drainage System (Green)	Managed Aquifer Recharge (Hybrid)
2.1 Health and safety: Measures improvements in community safety, well-being and the reduction of health risks associated with water services and climate vulnerability.	• In terms of improving water quality or access to drinking water, this type of infrastructure has no impact. • Project prevents flood-related injuries and drowning deaths. • They also bring substantial psychological benefits by reducing trauma and anxiety. • Contributes to preventing cascading disasters like landslides, and infrastructure failings. **MEDIUM (2pts)** levees directly prevent life-threatening flood impacts, but no impact in water and food security.	• In terms of improving water quality or access to drinking water, this type of infrastructure has no impact. • Although in some cases water retained in wetlands can be used for irrigation, in general that use will be focused on environmental areas or green spaces. • Health benefits through reduced injuries from flooding. • NbS lead to reductions of heat island effects and improvements in air quality, willingness to pay surveys demonstrate great enhancement in life quality (Zambrano-Monserrate, 2024). • Well-being enhanced through improvements in public green spaces and reduced flooding risks. **MEDIUM (2pts)** project has multiple health benefits beyond flood control but without any impact on the availability of drinking water or on food production activities.	• Provides backup supply during droughts and can help the water supply system during pollution events and other operational problems. • The recharge ends up benefiting all users of the aquifer to a greater or lesser extent, not only the city's supply, therefore also the irrigators who use it for agricultural production. • Infrastructure provides no well-being or mental health benefits. **HIGH (3pts)**. this activity has multiple benefits, providing greater water security both in the availability of resources to cope with the lack of "ordinary" resources and in guaranteeing the resource in case of risk of shortage due to extreme drought. It increases the robustness of the system at its baseline.
2.2 Poverty alleviation: Measures how projects reduce poverty, improves living conditions, and strengthens resilience of vulnerable livelihoods against climate impacts.	• Project leads to flood prevention protecting household assets and significantly reducing disruptions from extreme weather events. • Levees have potential for poverty reduction through reducing economic shocks, yet it lacks direct support mechanisms to strengthen economic resilience or new income opportunities. • Levees do not generate a direct contribution to the economy of the most disadvantaged communities. **MEDIUM (2pts)** score because while the project provides protection against disasters, it doesn't include targeted measures for poverty alleviation and livelihood support.	• Green spaces are demonstrated great life quality enhancement projects, bringing benefits to all populations around the area. • Scare direct income generation mechanisms. • Prevention of floods that threaten private assets among householders. **MEDIUM (2pts)** poverty alleviation benefits exist but without direct income generating mechanisms.	• The costs for operating and building this infrastructure are likely to cause an increase on the base tariff for water users. • Useful as an emergency supply such as overcoming episodes of eco-pollution or shortages due to extreme drought. • Indirectly, it can improve access to water for domestic activities (crops, livestock) in communities with access to the aquifer where recharge occurs. **LOW (1pt)** the project doesn't address poverty, and it might lead to higher water tariffs but has some indirectly and local benefits.

Criteria (Weight)	Levees / Floodwalls (Grey)	Stormwater Natural Drainage System (Green)	Managed Aquifer Recharge (Hybrid)
2.3 # of total beneficiaries: Evaluates the number of people impacted by the project, directly or indirectly.	• The direct beneficiaries are restricted to the levees protection zones and, therefore, there is no overall effect on large populations. • Indirect benefits come from protection form avoiding the reach of pollutants to waterways, improving the water quality for the broader region. **MEDIUM (2pts) t**he project reaches multiple direct beneficiaries, but no indirect ones.	• Residents in flood zones directly benefit from flood prevention. • Indirect benefits to broader populations in terms of avoiding the reach of pollutants to waterways and improving the water quality. **MEDIUM (2pts)** direct beneficiaries reach is considerable, and indirect benefits are high.	• Large customer base of Bogota region improves continuity of service. • Agricultural irrigation, water dependent industries and other activities depending on the aquifer are indirectly benefited by the project. **HIGH (3pts) t**he project reaches massive beneficiary populations through existing water system.
3. Environmental (25%) -	Environmental: 25* (4/12) = 8.3	Environmental: 25* (9/12) = 18.75	Environmental: 25* (6/12) = 12.5
3.1 Land use changes: Evaluates changes in ecosystem health that include vegetational cover, conversion of natural landscapes, and natural infrastructure that enhance hydrological services and climate resilience.	• Protection with levees prevents the flooding of natural areas and reduces the presence of wetlands. • Levees eliminate periodic flood deposition that maintains riparian soil fertility and ecosystem function. **LOW (1pt)** the project degrades riparian ecosystem health and doesn't incorporate ecological management.	• Repurposing urban and rural landscapes into flood zones can have a positive impact using NbS that increase the importance of natural landscapes. • Green stormwater system projects can improve land management, enhancing ecosystem health, while services like water infiltration and flood protection. **HIGH (3pts)** projects have a positive effect on land use conservation and restoration, due to the hydrological services for flood protection.	• The project Maintains water table during dry periods and prevents excessive groundwater depletion. • It may support riparian vegetation and base flow in streams during droughts. • In the case of using recharge through infiltration lagoons, new bodies of water and wetlands will be generated in the river plain, enhancing its ecological functions. Limited ecosystem impact compared to surface reservoirs. **MEDIUM (2pts)** because the project has mixed, and local environmental effects, but not a general improvement.
3.2 Biodiversity impact: Assesses the project's impact on biodiversity conservation, habitat quality, and species protection.	• Levee construction and maintenance removes riparian vegetation. • Project prevents periodic inundation that sustains flood-dependent species like amphibians, birds, and plants. • Standalone levees without ecological restoration represent net habitat loss.	• Stormwater drainage systems could be designed for biodiversity with native species selection and connectivity corridors but currently prioritize drainage function over ecological value. • Even in urban cases, it can lead to the recovery of ancestral wetlands and their associated ecosystems. • Maintenance requirements conflict with habitat development.	• No protected or enhanced habitats. • Does not threaten or benefit biodiversity directly. • Groundwater-dependent ecosystems (springs, seeps) may benefit from maintained water tables. • The infiltration lagoons would enhance some biodiversity.

Criteria (Weight)	Levees / Floodwalls (Grey)	Stormwater Natural Drainage System (Green)	Managed Aquifer Recharge (Hybrid)
	LOW (1pt) the project actively degrades habitat with no biodiversity protection.	**MEDIUM (2pts)** because the project provides some habitat improvements or connectivity benefits.	**MEDIUM (2pts)** aquifer recharge has minimal direct biodiversity impacts but potential indirect benefits.
3.3. CO2 emissions and other pollution sources: Estimates greenhouse gas emissions and other pollutants resulting from the project	• Concrete production for levees construction generates GHG emissions. • Low operational emissions. **LOW (1pt)** construction emissions are significant while operational emissions are moderate or none.	• Green stormwater systems have modest mitigation of carbon emissions, but they increase the surface area of green spaces that help capture GHG. • Reducing urban flooding can improve air quality in cities. **MEDIUM (2pts)** because green drainage infrastructure achieves pollution reduction but with limited mitigation benefits.	• The use of groundwater requires pumping from wells, which increases energy consumption in the EAAB system as a whole. • Artificial recharge project risk carrying pollutants to the aquifers if not managed well. • Significant emissions from construction. **LOW (1pt)** the project delivers net carbon emissions from operations, with elevated energy demands for pumping.
3.4. Evolution of Water Quality: Measures improvements in water quality at source and throughout water systems; as an environmental recovery mechanism, also as a direct impact on the water quality on natural ecosystems.	• Levees prevent point-in-time contaminated flood water mixing with drinking water supplies. • Doesn't prevent non-flood-related pollution entering water supplies. • There is no effect on the quality of water in the sources. **LOW (1pt)** water quality impacts are concentrated in very specific episodes and there is no improvement in the quality of water in the sources.	• Green drainage infrastructure filters urban pollutants (oils, metals, sediment) and improves water quality in downstream sources. • Some risk of localized groundwater contamination if pollutant loads exceed soil filtration capacity. • Rural green drainage system contributes to facilitate community's water supply. **MEDIUM (2pts)** water quality is partially improved but the project doesn't address upstream pollution.	• Requires treatment to prevent aquifer contamination. • Project does not lead to improvements in water quality for the system. **LOW (1pt)** because the water quality is maintained but not improved. Pollution risks need to be assessed and mitigated.
4.Political-Institutional (15%)	P-I: 15* (5/6) = 12.5	P-I: 15* (6/6) = 15	P-I: 15* (3/6) = 7.5
4.1 Multilevel Policy alignment and support: Assesses how project supports and considers priorities across national, regional, and local levels. It looks at arrangements like the National	• Bogota City Territorial planning document (POT) identifies flood risk reduction as priority. • At the National level disaster risk reduction is general priority but specific to larger national strategies. • Climate adaptation policies prioritize ecosystem restoration and conservation.	• The POMCA of the environmental agency of the Bogota river (CAR) includes the recovery of urban wetlands for the improvement of local drainage and the reduction of the impact of flooding. • These types of solutions are aligned with climate adaptation policies, representing a recovery of ecosystem services.	• CAR is interested in conducting the first pilots for MAR in BOGOTA (Observador, 2025). • New Water security Program agreed between EAAB and World Bank identifies this activity as key to the fight against droughts. • Some support from water utilities interested in supply diversification (most supply relies on the Chingaza system).

Criteria (Weight)	Levees / Floodwalls (Grey)	Stormwater Natural Drainage System (Green)	Managed Aquifer Recharge (Hybrid)
Plan for Adaptation to Climate Change, National Development Plan or the Colombian Green Taxonomy and National Plan for Drinking Water Supply and Basic Rural Sanitation, watershed management plans, and territorial planning (POMCA's and POT's)	**MEDIUM (2pts)** demonstrates consistency with national priorities and frameworks but lacks alignment with environmental action, which is prioritized in adaptation plans.	• The municipal and metropolitan plans for the Bogota area have a strong focus on the recovery of these spaces. **HIGH (3pts)** There is an alignment with the policies of various levels of territorial government and although some official documents do not explicitly name this type of intervention, it can be considered fully aligned with the country's adaptation policies.	• General water management policies support groundwater conservation. **MEDIUM (2pts)** Artificial aquifer recharge has general policy support but limited explicit prioritization. Priorities may change after the first pilot is implemented.
4.2 Institutional Capacity and Coordination: Considers the synergy of the project among different institutions and how it improves coordination, governance and institutional capabilities	• Advanced technical engineering expertise available for levee design and construction. • Coordination between flood management, municipal government, and water supply agencies. **HIGH (3pts)** all the technical teams in each government's level have strong technical capacity for infrastructure management & coordination with and environmental and government agencies.	• There are local technical capabilities since the recovery of green drainage systems has been developing for years. • There is coordination between CAR and the municipalities for its construction, use and maintenance. **HIGH (3pts)** These actions are already being carried out successfully, strengthening inter-institutional coordination and demonstrating local capabilities.	• EAAB or CAR have no experience with Artificial recharge water systems and the operations are complex, involving high risks of contamination. • Coordination between CAR, EAAB and environmental agencies over groundwater management exists, yet this project might pose new challenges given the intrinsic complexity of operating a MAR system. **LOW (1pt)** Technical capacity is limited, and coordination challenges are significant.
5. Equity & Gender (10%)	E & G: 10* (5/9) = 5.6	E & G: 10* (6/9) = 6.7	E & G: 10* (4/9) = 4.4
5.1 Reduction of systemic inequalities / serving the most needed: Assesses the project's capacity to address and reduce pre-existing social inequities related to water access, climate vulnerability, and service quality.	• Low-income households without resources to self-protect benefit from public investment. • Doesn't provide economic opportunities, water supply access or livelihood improvement. **MEDIUM (2pts)** levees directly protect vulnerable populations but don't address underlying inequality drivers.	• Green infrastructure creates accessible public spaces. • Low-income neighborhoods receive same protection as wealthy areas. However, flooding is more common in poor neighborhoods. **MEDIUM (2pts)** stormwater systems provide universal flood protection but don't directly reduce inequality, however, flooding mostly affects low-income houses.	• The strategy might lead to increased water expenses and pose no direct solution to help underserved people or communities. • Only useful for emergency supply. The indirect benefits for improving the water table don't distinguish among sectors or vulnerable users. **LOW (1pt)** the project doesn't address underlying water service inequalities nor benefits poor communities. In addition, it could make water more expensive.

Criteria (Weight)	Levees / Floodwalls (Grey)	Stormwater Natural Drainage System (Green)	Managed Aquifer Recharge (Hybrid)
5.2 Women income and jobs: Evaluates the extent to which the project addresses gender-specific needs, creates economic opportunities for women, and transforms gender relations.	• Without specific gender targeting, women unlikely to access project employment. • Project doesn't include mechanisms targeting women's economic empowerment. • No specific benefits for women beyond general disaster protection. **LOW (1pt)** construction employment is typically male-dominated and project creates no specific opportunities for women's, nor it has a gender perspective.	• Construction and maintenance creates mostly male jobs. • Programs can include women employment, if a social inclusion program takes place. • In the case of Tunjuelo wetland, could be an specific gender inclusion program for the transgender community. • **MEDIUM (2pts)** because women benefits are potential and employment opportunities are better than levees but not transformative.	• No specific benefits for women, beyond the extended supply under extreme droughts, which doesn't benefit women in particular. • Without specific gender targeting, women unlikely to access project employment. • Project doesn't include mechanisms targeting women's economic empowerment. **LOW (1pt)** construction employment is typically male-dominated and project creates no specific opportunities for women's, nor it has a gender perspective.
5.3 Indigenous populations rights and benefits. Assesses the involvement of, benefit to, and respect for Indigenous communities, ensuring projects are inclusive, culturally appropriate, and responsive to their specific needs	• Environmental licensing for projects requires consultation with affected Indigenous communities, if any. • Project design is without Indigenous culture considerations. **MEDIUM (2pts)** consultation is required by law but Indigenous leadership and priorities may not drive project design.	• If green infrastructure incorporates native species reflecting Indigenous knowledge, could provide cultural value. • Urban Indigenous residents benefit from flood protection and green space access **MEDIUM (2pts)** stormwater systems are urban infrastructure with minimal Indigenous dimensions.	• Project would require formal consultations with Indigenous groups. • Project design is without Indigenous culture considerations. **MEDIUM (2pts)** Project includes appropriate Indigenous consultation but no broader actions are taken to ensure benefits for minorities or Indigenous groups.
	Total: 59.8	Total: 73.9	Total: 60.5

D. Synthesis of results

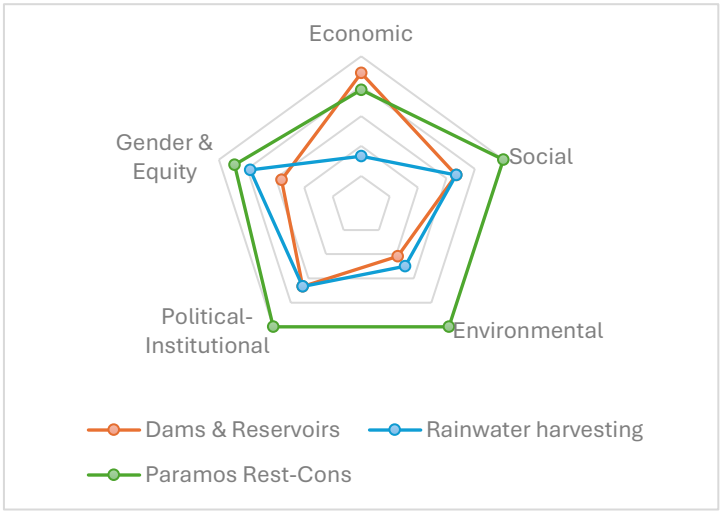
The evaluation compared six interventions, spanning conventional grey infrastructure, green nature-based solutions, and hybrid systems, on their potential to advance water security, mitigate climate hazards, and deliver enduring social, environmental, and economic benefits to the metropolitan region. The analysis revealed consistent evidence that nature-based solutions, particularly páramo conservation and restoration, outperform traditional engineered interventions across most assessment dimensions.

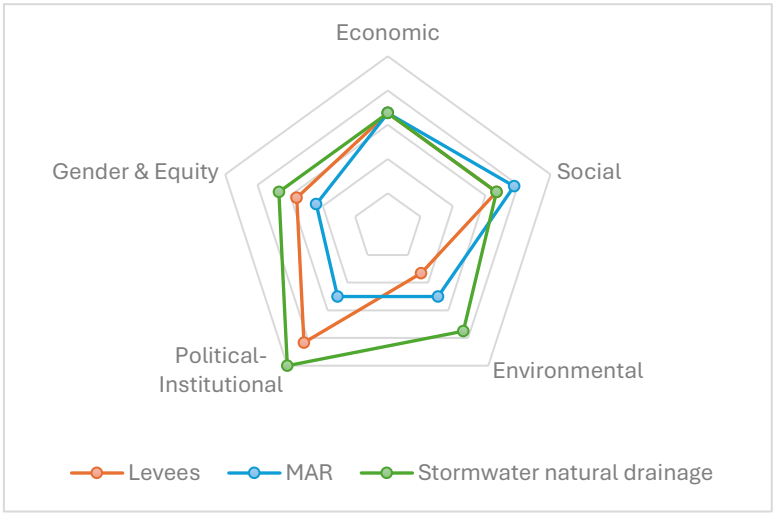
The evaluation results also highlight the importance of promoting natural stormwater systems, with high scores on environmental impact and political-institutional alignment. The two green solutions are the preferred interventions if criteria is aligned with GCF's investment profile. This analysis reveals the paramount importance of prioritizing nature-based solutions to meet Bogota's water security and climate resilience goals.

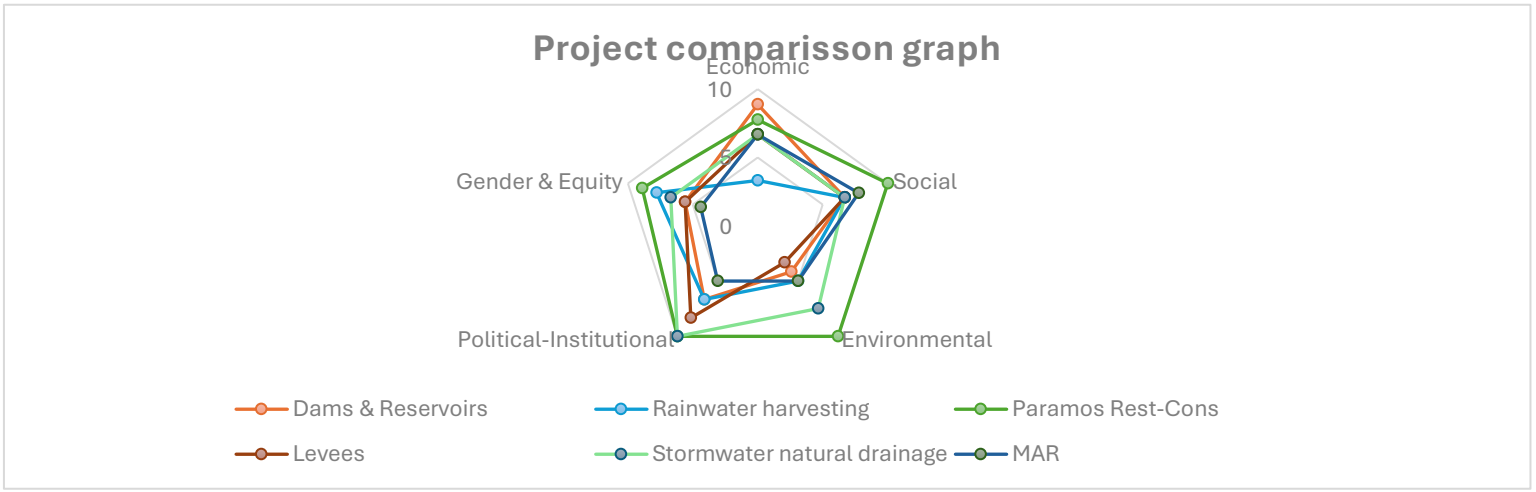
Traditional engineered solutions and hybrids, such as infrastructural upgrades or peri-urban retrofits, carry significant implementation complexity, limited evidence of transformative impact, and risk reinforcing systemic inequalities unless accompanied by robust social programs and inclusive design. Their benefits are largely constrained to already-served urban populations, with limited extension to marginal and rural communities.

The following graphs allow for a visual comparison of the interventions. The results indicate that green interventions perform best in all domains, except economic performance.

Figure 53 Spider Graphs of multicriteria performance of proposed interventions.







Rationale for selection of preferred options

Economic (25 points maximum): While dams scored highest in this category (22.2 points, 88.8%), páramo restoration achieved a competitive 19.4 points (77.6%). This near-parity performance is noteworthy given that green interventions avoid the massive upfront capital expenditures, lengthy construction timelines, and operational rigidity characteristic of large dams. All other interventions scored similarly at 16.7 points, except for rainwater harvesting that achieved only 8.3 (33% attainment) due to its limited capacity to deliver systemic results.

A more detailed cost-benefit analysis reveals bigger differences in this category. The economic and financial analysis (EFA) performed for the Annex 3 complements this section.

Social (25 points maximum): Páramo restoration achieved a perfect score of 25.0, demonstrating superior capacity to deliver health benefits, poverty alleviation, and broad beneficiary reach spanning both high-altitude rural communities and downstream urban populations. The intervention's integration of Payment for Conservation mechanisms creates sustainable income streams for vulnerable rural households while simultaneously securing water supply for nearly 10 million metropolitan residents.

Environmental (25 points maximum): Páramo conservation again achieved a perfect score of 25.0, representing 100% attainment. The second best in this category was the natural stormwater systems with a score of 18.75 (75%). This reflects exceptional performance in land use optimization, biodiversity protection, carbon sequestration, and water quality enhancement—domains where ecosystem-based approaches inherently outperform engineered solutions. By contrast, dams and reservoirs scored only 10.4 points (41.6%), and levees and floodwalls achieved 8.3 (33%); reflecting risks of habitat loss, sedimentation, GHG emissions, and ecosystem disruption derived from grey interventions. Social and environmental scores ensure good alignment with the Sustainable Development potential.

Political-Institutional (15 points maximum): Both páramo conservation and natural stormwater drainage systems achieved the maximum possible score of 15.0, reflecting perfect alignment with Colombia's National Adaptation Plan (NAP), the Colombian Green Taxonomy, watershed management plans (POMCAs), and territorial development frameworks (POTs). This institutional embeddedness ensures sustained political support, facilitates inter-agency coordination, and creates enabling conditions for scaling and replication beyond initial project boundaries.

Perfect scores in Political-Institutional alignment (15.0 out of 15) demonstrate that the intervention is embedded in national planning documents, regional adaptation strategies, and local governance priorities—creating enabling conditions for broader adoption and long-term transformation of water governance paradigms. By identifying alignment with national and regional planning the project responds to the recipient’s needs.

Gender & Equity (10 points maximum): Páramo restoration scored 8.9 points (89%), substantially outperforming dams (5.6 points, 56%) and other grey alternatives. The intervention's design prioritizes women's participation in restoration activities, creates income-generating opportunities accessible to women in rural communities, and integrates Indigenous knowledge systems that respect cultural practices and water rights. The rainwater harvesting approach scored 7.8 (78%), demonstrating a high impact on this category mainly through its capacity to deliver effective solutions for reducing systemic inequalities and delivering water to unserved populations.

Analysis of different green interventions for páramo protection

Now that the comparative study has shown a clear preference to invest through green interventions, the option analysis will define which type of interventions are feasible within the lifespan and scope of the project. Among the different interventions that could be used for páramo protection some should be considered unviable due to factors like political alignment, social factors, constraining timeframe, financial resources, or other factors. This section will define a list of interventions that can be executed, differentiating from those that have an enabler factor that is not present in this proposal.

The activities considered feasible are those that can be directly executed through project financing, technical assistance, local agreements, and on-the-ground implementation in prioritized watersheds, without depending on legislative reform, restrictive zoning, or politically complex land-use decisions. By contrast, interventions that require new regulatory mandates, expansion of protected areas, territorial planning changes, relocation processes, or strong enforcement of livelihood restrictions depend on enabling conditions that are not fully present in this proposal and therefore fall outside its immediate implementation scope.

The following table shows a list of traditional interventions that fall within the green infrastructure or natural capita interventions. On the left side are the interventions considered feasible within the scope of the project, on the right side are the interventions that could deliver great impact but are not achievable within the project's current landscape.

Table 60 Activities that can achieve páramo and upper watershed protection, aligned with green interventions.

Activities that are feasible in a 5-year implementation period, with relatively low barriers and have visible climate and water benefits	Activities that require policy changes, financing, and social agreements are not totally feasible in a 5-year implementation period.
- Conserve high Andean ecosystems - Restore high Andean ecosystems - Implement climate-resilient production systems at farm level in prioritized watersheds - Commercialization and opening of markets that value rural products contribute to water regulation - Implement efficient water use measures efficiency in community-run water supply systems in prioritized watersheds.	- Extensive control of invasive species - Control or expand protected areas with more restrictive zoning - Water infiltration techniques - Territorial planning (land management) - Relocation of populations/land purchase from farmers for restoration - Prohibiting cattle and potatoes in critical zones

Feasible activities:

Conserve High Andean Ecosystems - No major external enabler required, alignment with government priorities

This intervention consists of protecting existing páramo and high Andean ecosystems in prioritized watersheds through voluntary conservation agreements, community stewardship, exclusion of degrading activities in selected sites, and local management actions that maintain hydrological regulation functions. It is feasible within the project scope because the project has already identified prioritization zones for ecosystem conservation. The government has declared it a core adaptation measure, and these actions can be implemented directly with participating stakeholders without requiring new laws, new zoning categories, or formal political decisions beyond normal project coordination.

This intervention is feasible within the project scope because it operates directly within the framework established by Ley 1930 de 2018 (*Gestión Integral de los Páramos*), which formally designates páramo ecosystems as strategic territories of national priority, establishes a legal mandate for their preservation, and provides the basis for conservation agreements with landowners without requiring new legislation (Goverment Colombia, 1993)

Restore High Andean Ecosystems — Technical Feasibility Proven by Developer's Previous Experience

This intervention consists of restoring degraded páramo and upper watershed areas through passive regeneration, active revegetation, enrichment planting, erosion control, and other ecological rehabilitation measures that recover vegetation cover and hydrological function. These ecosystems, often described as Colombia's "water factories," owe their hydrological value to a unique combination of native vegetation, organic-rich soils, and climatic conditions that allow them to capture, store, and gradually release water. From a regulatory standpoint, restoration activities in the corridor benefit from the mandate under Ley 1930 de 2018, which explicitly requires restoration as part of the integral management of páramos.

Critically, restoration can be carried out on private and community lands through voluntary agreements and technical incentives, without requiring changes to land ownership, land use classifications, or protected area boundaries — placing it entirely within the project's operational and financial reach over a 4-year period. CI has been active in restoration activities in the paramo for more than 10 years and this work provides the executing entity with technical capabilities to successfully implement conservation actions. This previous experience and the current landscape in Bogota suggest that implementation is feasible over a four-year period without depending on legislative reform or politically sensitive regulatory change.

Implement Climate-Resilient Production Systems at Farm Level in Prioritized Watersheds — Technical Assistance Within Existing Agricultural Frameworks

Intensive agriculture in the paramos has as fundamentally altered their capacity to fulfill their primary ecological function: the regulation and provision of water. The dominant form of agricultural pressure in these highlands is the *sistema papa-leche*, a rotational production model in which land is first cleared of native vegetation and planted with potatoes, typically two or three cycles, after which the exhausted, fertilizer-loaded soil is converted to introduced pasture grasses for dairy cattle grazing. Addressing this situation requires a set of interventions that simultaneously reduce the agricultural pressure on the ecosystem, rebuild its hydrological function, and create economic conditions that allow rural communities to shift away from the *papa-leche* system without losing their livelihoods.

Potato cultivation is particularly damaging to hydrological services in the services. These plots showed the highest evapotranspiration and the lowest soil infiltration capacity of all covers. Cattle grazing compounds these effects through a different but equally destructive mechanism. Studies show that a single bovine of average weight exerts between 500 and 800 kPa of vertical tension with each step on flat terrain, a pressure that compacts the spongy organic soils of the páramo, collapsing the pore structure that gives them their water-holding capacity (van der Tol, 2003).

On contrast, silvopastoral systems show higher infiltration rates than conventional farming systems, Vallejo et al. found that soil under these systems have more macro and micropores, and lower penetration resistance for water (Chará, 2019). Beyond reducing the damage caused by conventional cattle ranching, silvopastoral systems actively reconstruct the hydrological and ecological functions that intensive land use has dismantled. A silvopastoral system introduces trees and shrubs into cattle-grazing

areas, creating a stratified, multi-species cover that simultaneously maintains a productive livestock operation and restores many of the structural and functional properties of native vegetation.

This intervention is feasible within the project scope because it is structured as a technical assistance and capacity-building activity — introducing agroforestry systems, rotational grazing, organic soil management, and reduced agrochemical use — that requires no land tenure changes, no regulatory amendments to agricultural policy, and no institutional restructuring. Additionally, results in improved soil health and water quality are demonstrable within a 3–4 years horizon.

Commercialization and Opening of Markets for Rural Products that Contribute to Water Regulation — Market-Based Incentives Within Existing Private Value Chains

This intervention consists of developing commercial channels, eco-certification schemes, and market linkages for products generated through sustainable land management practices. The rationale for these interventions stems from the need for rural producers to receive a financial premium that makes conservation-compatible agriculture economically competitive with high-impact farming. Without economic support from stronger value changes, that boosts financial viability of sustainable alternatives, conservation agreements and agroecological transitions cannot be sustained beyond the project implementation period.

Strengthening market structures, helping with sustainable certification processes, and initiating commercialization agreements are activities that can be executed within the timespan of the project and have lasting benefits for smallholder farmers. These actions are not bound by any legislative changes, as they are feasible under current laws. This approach is also coherent with the project's emerging financial mechanism logic, which will seek to promote a paradigm shift that makes sustainable land management an attractive economic and financial investment.

Implement Water Use Efficiency in Community-Run Water Supply Systems in Prioritized Watersheds — Compliance with Existing Water Efficiency Obligations

This intervention targets *acueductos veredales* —community-managed rural water supply systems that serve farming and rural residential— improving their operational efficiency through leak detection and reduction, installation of basic metering, infrastructure optimization, and strengthening of community governance and operational capacity. Reducing extraction losses and improving demand management directly reduces pressure on the water sources that feed into the Chingaza, Sumapaz, and Guerrero systems, complementing conservation and restoration investments upstream.

This intervention responds to the Colombian context because Investments in water infrastructure in rural areas is imperative to closing the water access gap (ProColombia, 2023). Community-run water supply systems are a major part of rural service delivery, they often have limited resources and technical capacity, and national evidence shows that they commonly need support for infrastructure maintenance, source conservation, potabilization systems, and measurement equipment. Also, the *acueductos veredales* often lack technical capacity, knowledge, and resources to implement lasting changes.

This intervention is feasible within the project scope because it operates entirely within the regulatory obligations already established by Ley 373 de 1997, which mandates that all water service providers must design and implement a *Programa para el Uso Eficiente y Ahorro del Agua* (PUEAA) (Colombia C. d., 1997). This means the intervention does not introduce new regulatory requirements; it supports communities in meeting obligations they already have under existing Colombian law.

Non-feasible activities:

The following activities are not considered fully feasible within the project's implementation scope, not because they lack environmental relevance, but because their execution depends on external enabling conditions that are not fully under project control.

Extensive Control of Invasive Species — Financial Continuity, Temporal Viability, and Social Constraints

This intervention consists of identifying, removing, containing, and monitoring invasive species across large páramo and high Andean landscapes in order to reduce their effects on native biodiversity, soils, and hydrological function. Non-native plant species, like *Ulex europaeus* (retamo espinoso) and *Pinus patula*. have colonized degraded páramo and high Andean areas and compete aggressively with native vegetation, altering the hydrological, ecological, and fire dynamics of the ecosystem.

However, this intervention is not feasible as a primary project activity because effective and durable control of invasive species at the landscape scale demands sustained multi-year financial investment far exceeding the project's budget. Furthermore, successful control requires a minimum level of community awareness and cooperation that is currently constrained by the fact that local populations often do not recognize introduced species as harmful, and in some cases ascribe cultural or economic value to them

Control or Expansion of Protected Areas with More Restrictive Zoning — Political, Institutional, and Multi-Jurisdictional Barriers

This intervention consists of declaring new protected areas, expanding existing ones, or imposing stricter use restrictions through formal zoning instruments in strategic water-source landscapes. Currently, only 51.57% of Colombia's páramo complexes are currently included in any protected natural area category, meaning nearly half receive no formal protection (Vergara Buitrago P. A., 2020).

Expanding or strengthening protected area boundaries requires formal coordination between the Ministry of Environment and Sustainable Development (MADS), the regional environmental authorities (CAR Cundinamarca, Cormacarena), and Parques Nacionales Naturales de Colombia, followed by technical cartographic delimitation studies, legal publication of the proposed boundaries, and a period of public comment and challenge, a sequence that typically extends across multiple years and electoral cycles. The project can inform these processes and provide technical inputs to boundary revision discussions, but it cannot initiate, control, or guarantee their conclusion within a 4-year implementation horizon.

The political dimension is equally significant. Past attempts to expand or re-delimit páramo protection zones have triggered intense resistance from farming communities whose agricultural activities would be restricted and from local governments whose development plans would be constrained. While the project aims to limit agricultural expansion, it seeks to do so through economic incentives rather than prohibiting certain farming practices, which many people rely on as their main source of income.

Direct Water Infiltration Techniques — Technical Complexity, Licensing Requirements, and Temporal Limitations

Direct water infiltration interventions refer to engineered or semi-engineered measures designed to artificially increase the rate of water percolation from the soil surface into deeper soil horizons and underlying aquifer systems. The exact measure can include infiltration trenches, subsurface recharge wells, check dams, and permeable surface treatments, measures that help to compensate for the reduction in natural infiltration capacity caused by intense agriculture in the watershed. While the

hydrological rationale for these interventions is aligned with the project, the engineering solution to this problem operates on a scale and timeline that falls outside what a 4-year project can responsibly deliver.

Effective infiltration infrastructure requires prior geotechnical and hydrogeological baseline studies to characterize subsurface permeability, aquifer structure, and optimal placement zones, followed by environmental licensing through the CAR. This process is described in Decreto 2811 de 1973 and involves technical reviews, field inspections, and formal resolutions that can take 18 to 24 months alone (Colombia P. d., 1974)

Territorial Planning (Land Management) — Institutional Sovereignty and Multi-Year Legislative Process

Territorial and land management planning refers to the formulation or amendment of *Planes de Ordenamiento Territorial* (POT) or equivalent rural planning instruments, such as *Planes de Manejo de Cuencas Hidrográficas* (POMCA) These instruments determine, at the most fundamental level, what activities are legally permissible on what land. While their modification is the most powerful lever available for achieving lasting changes, this intervention is structurally incompatible with project-level implementation because POT revisions are an exclusive municipal legislative competency.

Additionally, these processes require the preparation of diagnostic and prospective studies, multi-round public hearings, formal deliberation in municipal councils, and legal adoption by elected governments. Hence, the timelines of these processes are set by political and electoral calendars entirely independent of GCF project implementation. However, the project can contribute meaningfully by generating technical inputs, land cover analyses, and hydrological modeling data that inform these planning processes

Relocation of Populations / Land Purchase from Farmers for Restoration — Financially Unscalable, Low Cost-Benefit Ratio, and Socially Complex

The relocation of resident populations or voluntary purchase of land from farming households in ecologically critical páramo zones is conceptually one of the most direct paths to ecosystem recovery in areas where agricultural damages have been most severe. The intent of this practice is to remove human pressure and enable natural regeneration or active restoration to proceed. However, it is among the most complex, expensive, and socially sensitive interventions in the Colombian rural context, and its feasibility as a primary project activity is fundamentally constrained by the scale of resources required and the duration of the social processes involved

Relocation through broad land-purchase schemes would require substantial financing, safeguard management, and social consent that exceed the scale and risk profile of this project. Experience from Colombia and across the Andes confirms that rushed or underfunded land purchase programs generate conflict, legal challenges, and community resentment that can undermine the broader conservation objectives of a project

Prohibiting Cattle and Potato Farming in Critical Zones — Regulatory Enforcement, Livelihood Rights, and Social Conflict

Prohibiting cattle ranching and potato cultivation in ecologically critical páramo zones is, on paper, an activity already partially supported by existing Colombian law. There has been continuous legislative progress to delimit farming activities in páramos, however, enforcement of these regulations has come with loaded problems and resistance from communities who argue that they were occupying this land before the conservation boundaries were drawn.

Enforcing land use prohibitions on farming families whose entire economic livelihood is built around potato cultivation and dairy farming requires three enabling conditions that are each independently beyond the project's reach: first, a robust enforcement mechanism backed by the environmental authority with the institutional capacity and political will to impose sanctions; second, legally sound and adequately funded compensation mechanisms and livelihood transition programs for affected families, without which prohibition constitutes an unconstitutional taking of economic rights; and third, genuine social consensus and community acceptance, which in the Colombian highlands has historically proven extraordinarily difficult to achieve through top-down regulatory imposition.

E. Scaling Water Resilience – Project's Exit strategy

The previous list of activities corresponds to Component 1 of the project, and they represent the ecological foundation of this project. However, the most persistent barrier to achieving durable water resilience in the Bogota Region is not technical knowledge or political will; it is the chronic insufficiency and fragmentation of financing flows directed toward watershed protection and climate adaptation. Without a structural solution to this financing gap, any gains achieved through conservation agreements, ecological restoration, and sustainable production transitions during the implementation period risk reversal once external support is withdrawn.

The Green Climate Fund's investment mandate is explicitly oriented toward transformation rather than incremental improvement. Under its Investment Framework, the GCF prioritizes interventions that shift financial markets and public investment systems toward climate-resilient development pathways by deploying public climate finance in ways that generate demonstration effects, reduce perceived investment risk, and catalyze additional co-financing. Component 2 is designed as a financial mechanism to ensure that GCF funding is catalytic in enhancing and leveraging other investments from beneficiaries of the project.

The GCF's own operational guidelines require that funded projects demonstrate a credible exit strategy, a specific pathway through which interventions can be sustained and institutionalized after GCF financing concludes. For this project, the exit strategy operates on three levels.

- At the institutional level, Component 2 invests in the governance and operational capacity of the watershed investment facility, ensuring that by the end of the 4-year period it has established legal standing, a functional investment committee with multi-stakeholder representation, and a track record of verified results sufficient to attract successor financing.
- At the financial level, the strategy is grounded in the progressive replacement of GCF grant resources with domestic and blended finance flows. GCF capital absorbs the front-loaded costs of establishing the facility and generating the first cycle of results-based evidence, then, EAAB tariff-based contributions, and private-sector water stewardship commitments provide the recurring financing that sustains the program independently.
- At the economic level, Component 2 supports the development of cost-benefit analyses and avoided treatment cost calculations that reframe watershed protection as a rational infrastructure investment with quantifiable returns, rather than an environmental expenditure dependent on donor goodwill.

Beyond sustaining the specific investments in the corridor, Component 2 is designed to generate a replicable model adaptable across Colombia's other critical water supply watersheds and across the broader tropical Andes, where the challenge of financing nature-based water security in highland

ecosystems under threat from agricultural encroachment and climate change is universal. By proving that catalytic public climate finance can crowd in domestic investment, institutionalize results-based watershed protection, and build a financially self-sustaining exit structure in one of Latin America's most complex urban water supply contexts, the project establishes a proof of concept with transformational implications for how climate finance is deployed in water-stressed Andean cities across the region.

The team also identified a list of feasible and non-feasible activities that could achieve the goals of component 2. The following table summarizes this segregation of activities, considering constraining criteria like political will, broader social consensus, additional stakeholders' involvement, social and environmental safeguards or long timespans.

Table 61. List of activities aligned with the goals of component 2.

Activities that are possible under current landscape	Activities that are unlikely to be fully structured within the 5-year GCF project timeframe
- Incorporate an environmental investment component to the water tariff. - Operationalize a long-term financial mechanism for private investments	- Increase and improve the use of the "1% resources" usually allocated to land purchase - Impact compensations from projects subject to environmental licenses - Flexibilization and expansion of PAS (PES) - Green bonds - Credits (green or concessional credit lines) - Carbon credits - Tax for investment scheme - Regulation of Law 2173 (Areas of Life)

Feasible Activities for the Component 2

Incorporate an Environmental investment component to the Water Tariff — Political Commitment Already Secured

Incorporating an environmental investment component into the water tariff consists of adding a dedicated surcharge to the bills paid by water users in the Bogota metropolitan region. This income will be earmarked exclusively for conservation, restoration, and climate adaptation investments in the prioritized watersheds as they can deliver the most valuable returns on investment due to their hydrological services. There has been previous studies that demonstrate that citizens of Bogota expressed a strong willingness to pay for conservation and restoration of paramos and other critical ecosystems, especially when the relationship between water production and these ecosystems is outlined (The Nature Conservancy & Global Environment Facility, 2018).

This intervention is feasible within the project scope because the political commitment required to establish it has already been publicly made: Bogota's Mayor Carlos Fernando Galán formally announced, at the November 2024 GCF project launch, that Bogota would introduce a new component in the water tariff to finance environmental investments in the project's watersheds. This removes the most critical enabling condition — political will — from the list of uncertainties, making institutional design, regulatory formalization, and operationalization of the fee collection and disbursement system achievable within the 4-year implementation horizon.

Operationalize a Long-Term Financial Mechanism for Private Investments — Institutional Design Within Existing Market Frameworks

This activity refers to the design and launches of a structured vehicle that can receive funding from different stakeholders, such as companies with water-depending businesses, financial institutions, NGO's and private actors. The purpose is to develop scaffolding that can attract and sustain long-term investments into water security, an investment vehicle supported by a decision-making system that identifies where interventions deliver the most.

This intervention is feasible within the project scope because it does not require new legislation, regulatory reform, or political negotiation; it requires institutional design work, legal structuring, and the establishment of governance protocols, all of which can be accomplished within a 4-year implementation period. The GCF investment provides the anchor capitalization and credibility signal that makes the vehicle attractive to first-movers in the private sector, while the ecohydrological monitoring system established through Component 1 provides the results data that allows private investors to verify the environmental outcomes of their contributions. This component is the central apparatus that facilitates the exit strategy for the project, attracting catalytic finance, and ensuring continuance of the project and its interventions for the future years.

Non-Feasible Activities for the Component 2

Beyond the two prioritized options, the project team reviewed a broader set of nationally available instruments, including the statutory 1% environmental investment obligation, environmental compensation under licensing frameworks, green bonds, carbon credits, tax-for-investment schemes and the implementation pathway of Law 2173 on "Áreas de Vida". While all of these instruments are legally possible in Colombia, their effective use as core financing pillars for Component 2 would require conditions that extend beyond the five-year GCF project horizon, such as revised regulatory guidelines and enforcement practices for the 1% obligation, systematic alignment of biodiversity offsets with the project's target watersheds, substantial scaling of PES registries and monitoring systems, mature and sufficiently large pipelines for labelled green bonds, fully developed and validated carbon accounting methodologies for páramo ecosystems, and new fiscal legislation establishing dedicated tax-based earmarks or the territorial operationalization of Law 2173 through municipal designation of "Áreas de Vida". For these reasons, the project considers these instruments as complementary, long-term opportunities to be explored as the watershed portfolio matures, rather than as primary financing mechanisms to be structured and operationalized within the initial five-year period.

Increase and Improve the Use of the "1% Resources" — Institutional Coordination, Political Will, and Reform of Investment Priorities

The 1% Environmental Investment Obligation, established under Article 111 of Ley 99 de 1993, requires all Colombian municipalities to invest at least 1% of their annual revenues in the acquisition and maintenance of water source areas and strategic ecosystems that supply their drinking water systems. This activity consists of redirecting or optimizing the statutory "1% resources" associated with strategic water-source protection so that they are used more flexibly and effectively.

In theory, this is a powerful, nationally mandated, and self-replenishing financing instrument, representing tens of billions of pesos per year in legally earmarked conservation resources. In practice, however, the mechanism has severely underperformed its potential for two structural reasons. First, the regulation has historically been interpreted in ways that allow municipalities to spend almost exclusively on land

purchase, an expensive and slow modality that generates little ecological benefit relative to its cost. Second, many municipalities simply do not comply with the obligation, and enforcement mechanisms are weak and inconsistently applied (Etter A. A., 2020).

Reforming how these resources are allocated requires changes to regulatory guidelines, inter-institutional coordination between different government authorities (DNP, CAR, DNP), and sustained political pressure on municipal governments to prioritize these investments. These are multi-stakeholder policy processes that extend well beyond a single project's scope. For that reason, better use of these resources is not impossible, but it depends on broader public-finance coordination and administrative willingness beyond the project's direct authority.

Impact Compensations from Projects Subject to Environmental Licenses — Regulatory Alignment for Resource allocation

This activity consists of channeling biodiversity or environmental compensations required from licensed projects toward restoration or conservation priorities that support water regulation in the Bogota region. Colombia has one of the clearest biodiversity-offset frameworks in the region, and licensed projects can be required to compensate residual impacts through restoration or protection actions, which makes this an attractive potential funding source.

The main constraining criterion is regulatory allocation, because these compensations are tied to the location, ecological equivalence, and conditions established in each environmental license, not to the financing needs of a separate project. As a result, mobilizing them systematically for Component 2 would require stronger coordination with licensing authorities, project developers, and offset operators, as well as assurance that the compensation obligations are legally compatible with the target intervention areas.

Flexibilization and Expansion of Payment for Conservation — Regulatory Clarity, Scaling Barriers, and Long-Term Sustainability

This activity consists of broadening the use of Payments for Environmental Services so that more landholders, more ecosystems, or more types of conservation and restoration agreements can be financed under a larger or more flexible scheme. Colombia already has a legal framework for PES under Decree 870 of 2017, which defines PES as a voluntary incentive for owners, possessors, or good-faith occupants who undertake preservation or restoration actions in strategic ecosystems.

PES already exists but expanding it substantially requires stronger financing sources, institutional capacity, registries, monitoring systems, and in some cases adjustments in how the instrument is applied. The project can use PES, but a true flexibilization and expansion of PAS as a national or regional financing platform requires broader policy consensus and administrative capacity. Expanding PES also requires legislative decisions that allocate more resources to this program.

Also, PES instruments carry an inherent structural limitation that is critical to acknowledge in designing the long-term financing architecture of this project: they are, by design, conditional and temporary mechanisms. A PES agreement compensates a landowner for the conservation value of their land management decisions only as long as the payment flows. When the payments stop the fundamental economic calculus that drove the land use change reverses. If this happens the opportunity cost of conservation has not changed, and without the financial incentive that made the conservation alternative competitive, the rational response is to revert to the most profitable available land use. Therefore, PES do not provide a long-term solution to make conservation an appealing practice (Etchart, 2020).

Green Bonds — Capital Market Infrastructure and Pipeline Maturity

This activity consists of raising capital through labeled green bonds whose proceeds would finance eligible environmental or water-related investments, potentially including watershed protection or water-security infrastructure. Colombia already has a functioning green-bond landscape, including a sovereign green-bond framework and sectoral experience from utilities such as EAAB and EAAP, so the instrument is technically available in the country.

The main constraining criterion is pipeline maturity, because bond financing requires a sufficiently large, clearly structured, and monitorable portfolio of eligible investments, along with issuers that can meet reporting, verification, and investor requirements. For Component 2, this means green bonds are more likely to serve as a later-stage scaling instrument than an immediately deployable financing source for a still-emerging watershed portfolio.

Carbon Credits — Market Development and Socio-Environmental Safeguards

This activity consists of generating tradable carbon credits from restoration, conservation, or land-use change activities and using the proceeds to finance watershed interventions. Colombia has an active carbon market linked both to voluntary transactions and to the national carbon-tax non-causation mechanism, which allows entities to avoid paying the tax by acquiring eligible carbon credits under the regulatory framework of Law 1819 of 2016 and Decree 926 of 2017.

The methodological development and validation of carbon accounting approaches specific to Colombian páramo ecosystems is technically complex and requires multi-year scientific work that has not yet been completed at the scale needed for credit issuance. Until these methodological and regulatory foundations are in place, carbon credits cannot be relied upon as a predictable and compliant financing stream for project activities.

Another main constrain criterion is ensuring robust, certifiable carbon outcomes, since projects must also address additionality, permanence, leakage, monitoring, and social safeguards. This makes carbon finance potentially useful for some restoration components, but not yet a straightforward or comprehensive financing solution for the broader set of Component 2 interventions.

Tax for Investment Scheme — Legislative Process and Fiscal Authority

A tax-for-investment scheme in the context of watershed conservation refers to the creation of a dedicated fiscal instrument whose revenues are legally channeled into a dedicated fund for watershed protection and climate adaptation (For example, a levy on water-intensive economic activities, property taxes with conservation earmarks, or municipal environmental taxes). This activity consists of creating or adapting a tax-based scheme that directs tax-related resources into watershed investments. Such a mechanism could in theory mobilize larger and more predictable funding flows, but it would require a clear legal basis defining who pays, who benefits, how resources are earmarked, and how fiscal administration is handled.

Designing a new tax or fiscal earmark specifically structured to finance this project's conservation goals requires legislation or formal regulatory instruments that must be adopted through Colombia's constitutional fiscal framework. Tax instruments cannot be operationalized simply through project design or voluntary agreement. They depend on national or subnational legal change, treasury approval, and broader political consensus, which places them outside the set of instruments that can be activated directly under the current project landscape.

Regulation of Law 2173 of 2021 (Areas of Life / Áreas de Vida) — Pending Secondary Regulation and impact scale

This activity consists of leveraging the framework of Law 2173 of 2021, which requires medium and large companies to plant two trees per employee in designated “Areas of Life” defined by municipalities for restoration programs. In principle, this could become a relevant source of restoration finance or in-kind implementation support if municipal “Areas of Life” overlap with strategic water-source areas.

The main constraining criterion is pending regulatory and territorial implementation, because the law depends on municipalities delimiting the relevant areas and on practical regulatory arrangements that translate the legal obligation into an operational investment mechanism. Until those areas are defined and the implementation pathway is clearer, Law 2173 remains a promising but not yet fully bankable source for Component 2 financing. The mechanism could be further integrated into the financial vehicle, but until clarity of the secondary regulation, its impact scale remains questionable for the project’s scope.

V. Support for the quantification of reduced/avoided runoff: VWB and Seasonal Water Yield evidence

This appendix consolidates the runoff-related evidence used to support the feasibility assessment of Component 1. It brings together: i) the Volumetric Water Benefit (VWB) results already presented in Section 7.1 through the Curve Number-based approach; ii) the exploratory Seasonal Water Yield simulations carried out during project design using graduated intervention levels; and iii) the updated Seasonal Water Yield results aligned with the final intervention targets by watershed under baseline (BL 2020), with-project (100% intervention), and business-as-usual 2050 (BAU2050) scenarios, under both current climate and SSP585 conditions. The purpose of presenting these analyses together is to distinguish clearly between exploratory design evidence and the final scenario set used to interpret project impacts and climate risk.

As described in Section 7.1, Curve Number–based modelling was used to quantify Volumetric Water Benefits (VWBs) in terms of avoided surface runoff for each prioritized watershed. Table 28 reports VWB coefficients in $ML \cdot ha^{-1} \cdot yr^{-1}$, while Table 29 aggregates these coefficients to total annual avoided runoff volumes ($m^3 \cdot yr^{-1}$) per watershed. These results show that conservation, restoration and climate-resilient production activities generate positive VWBs across all targeted watersheds, with total avoided runoff ranging from approximately 50,000 $m^3 \cdot yr^{-1}$ in smaller watersheds to over 600,000 $m^3 \cdot yr^{-1}$ in larger systems such as Río San Francisco and Río Aves.

Additionally, and to further proof the results modeled with the VWB methodology, the intervention landscapes selected and the activities were modelled in InVEST through Seasonal Water Yield, confirming the direction and magnitude of the changes identified through VWB calculation, particularly in relation to runoff reduction.

This appendix should be read as the detailed runoff evidence package underpinning the avoided/reduced runoff dimension of the project's VWB framework. The official VWB metrics reported to the GCF remain those derived from the VWB–Curve Number approach described in Section 7.1 and summarized in Tables 28 and 29. The Seasonal Water Yield results presented here are complementary and are used for three specific purposes: to test the hydrological sensitivity of runoff to increasing levels of intervention during project design; to confirm the direction and relative magnitude of runoff changes under finalized project scenarios; and to illustrate the climate risk associated with a no-project pathway.

A. VWB as indicator of Outcome 1

The project adopts the Volumetric Water Benefit methodology as a robust, outcome-oriented framework to quantify hydrological improvements derived from ecosystem conservation, restoration, and water-management interventions. VWB translates biophysical changes into standardized volumetric metrics, enabling the measurement of how interventions improve water availability, regulation, and efficiency at watershed scale. This approach is particularly suited to high-Andean systems, where hydrological responses to land-use change are significant but spatially heterogeneous.

Volumetric water benefits VWBs are the volume of water resulting from water stewardship activities, relative to a unit of time, that modify the hydrology in a beneficial way and/or help reduce shared water challenges, improve water stewardship outcomes, and meet the targets of Sustainable Development Goal

6. Therefore, VWB measures the incremental water-related benefits generated by interventions relative to a baseline scenario. These benefits are expressed in volumetric terms (m^3/year) and reflect four main hydrological performance dimensions: avoided runoff (improved infiltration and retention), enhanced baseflows (increased dry-season water availability), reduced sediment and pollutant loads (improved water quality), and water savings and efficiency gains (reduced non-revenue water and losses).

To quantify these benefits, the Curve Number CN runoff method was applied following the approach outlined in Volumetric Water Benefit Accounting 2.0. The methodology estimates the reduction in surface runoff generated by water stewardship activities planned for the Bogota region by comparing two scenarios: i) a baseline scenario, reflecting current land-use conditions, and ii) a with-project scenario, representing expected ecosystem recovery and improved land management at full project maturity. The difference in runoff between these two scenarios is treated as the VWB, and results are expressed as a VWB rate in megaliters per hectare per year (ML/ha/yr) for each intervention landscape and proposed activity.

The combination of passive restoration, active restoration, conservation, and transformation of productive systems constitutes the core intervention package under Outcome 1, generating positive and quantifiable Volumetric Water Benefits (VWBs) across all targeted watersheds. These interventions act directly on land use and ecosystem condition and management practices, modifying hydrological processes such as infiltration, runoff generation, and soil water storage. As a result, they provide a robust, model-based basis for estimating watershed-scale improvements in water regulation and retention.

For ease of interpretation, the key VWB runoff results are those already reported in Tables 28 and 29 of Section 7.1. Table 28 presents runoff-reduction coefficients by intervention type and watershed, while Table 29 aggregates those coefficients into annual runoff volumes whose hydrological behaviour is improved at watershed scale. These results remain the official quantitative basis for reporting the avoided/reduced runoff benefit of the project.

The excel file **VWB_model_calculations.xlsx**, provides the coefficients by intervention landscape, watershed, and intervention type, together with the underlying VWB calculations, hydrologic soil group and slope classifications, and watershed-specific summaries used to derive the coefficients. These results serve as the basis for the estimation of annual hydrological benefits throughout financial and economic analyses. The model and results are presented by watershed and intervention area, each of the sheet of the excel are identified in the INDEX sheet.

B. Explanatory Seasonal Water Yield simulations used during project design

During early stages of project design, the Seasonal Water Yield module was used to simulate graduated intervention levels (10%, 25%, 50%, 75% and 100% coverage of preliminary intervention areas in each watershed). These exploratory runs were not intended to define final targets, but to test the sensitivity of rapid surface runoff (Quick Flow, QF) to increasing intervention intensity and to corroborate the theoretical expectation that larger gains in avoided runoff and regulation would be achieved as conservation, restoration and climate-resilient practices expand across hydrologically sensitive areas.

The results confirmed that moving from low to higher intervention shares systematically reduced QF per hectare, with particularly strong gains between intermediate and full intervention levels in headwater catchments. This behavior was consistent with the Curve Number–based VWB coefficients reported in Table 28 and provided empirical support for prioritizing high coverage levels in the most strategic

watersheds. Based on these findings, the project team optimized the distribution of intervention hectares across watersheds, leading to the final intervention targets that underpin the baseline (BL 2020), with-project 100%, and BAU2050 scenarios presented later in this appendix.

The exploratory simulations therefore served as a design and validation function corroborating the underlying hydrological theory of change by showing that as intervention coverage increases, rapid runoff tends to decline, and retention improves and supporting option analysis by showing which watersheds produced larger hydrological gains per unit area under higher intervention effort. Finally, they informed the final spatial allocation of intervention hectares among watersheds once the project moved from preliminary delineations to finalized intervention targets.

As watershed boundaries and intervention areas were refined during subsequent stages of project preparation, the spatial configuration underlying the 10–25–50–75% simulations changed and no longer matches the finalized intervention design. For this reason, detailed numerical results for those exploratory scenarios are not reported here as project indicators. Instead, they should be interpreted as internal design evidence demonstrating the robustness of the project's intervention logic. The definitive Seasonal Water Yield results used to interpret project impacts and climate risk are those aligned with the finalized BL 2020, with-project 100%, and BAU2050 scenarios described below.

Exploratory models were run for: (i) baseline land use (LUC 2020) and current climate, (ii) LUC 2020 under SSP585, (iii) projected land use (LUC 2050) under current climate, and (iv) LUC 2050 under SSP585, capturing both climate- and land-use-driven changes in runoff.

Procedure to derive avoided and reduced runoff

Exploratory models are quantified through two complementary indicators: reduced runoff and avoided runoff:

- Reduced runoff is defined, for a given climate and baseline land cover (BL), as the decrease in QF when land use shifts from the baseline configuration to an intervention configuration that incorporates nature-based solutions (NbS) and improved land management. It is computed as the difference in QF (m^3/ha) between the baseline and intervention scenarios.
- Avoided runoff refers to the additional QF that would occur under a business-as-usual (BAU) trajectory or under a high-emissions climate scenario in the absence of the project, compared with the intervention scenario.

In this framework, reduced runoff captures the immediate physical effect of NbS on the current runoff regime, whereas avoided runoff captures the hazardous runoff that is prevented in the future by deviating from BAU and by moderating climate-induced increases in QF.

QF is particularly suitable to demonstrate that more water is retained within the catchment because it isolates the fast surface runoff component that leaves the basin quickly, rather than the total rainfall. A reduction in quick flow for the same climate forcing implies that a larger fraction of precipitation is being intercepted, infiltrated, stored in soils and aquifers, or delayed in vegetated and restored areas, instead of immediately running off to the river network. Hydrological studies (Zhang, Wang, Liu, Li, & Yang, 2024) (Hale, Jefferson, Seyfried, & Dunne, 2024) (Farley, Jobbágy, & Jackson, 2005) (Diaz-García, 2022) explicitly show that land-use and vegetation cover strongly control quick-flow generation: more impervious or degraded surfaces increase QF, while forests and well-managed soils decrease QF and enhance subsurface storage and baseflow. By comparing QF volumes (m^3/ha) between the baseline/BAU

and intervention scenarios, the project is therefore measuring not only less hazardous surface runoff but also, implicitly, more water retained within the catchment's soil and subsurface reservoirs.

In this sense, the reduced and avoided QF volumes provide conservative, lower-bound evidence of increased water retention at landscape scale. Any modeled decrease in quick flow (for a given rainfall regime) indicates that an equivalent volume of water remains within the catchment for longer, either as soil moisture supporting vegetation and climate-resilient production, as shallow groundwater sustaining baseflows, or as temporary storage in restored riparian and wetland systems. This interpretation is consistent with the hydrological ecosystem services literature, which uses alterations in surface runoff and quick flow as indicators of changes in the partitioning of rainfall between rapid runoff and slower, beneficial storage pathways (Brauman, Daily, Duarte, & Mooney, 2007) (Terrado, Sabater, & Acuña, 2014) (Guzha, Rufino, Okoth, Jacobs, & Nóbrega, 2018) (van Oel, Mulatu, Hoogland, & van der Velde, 2023) (Tarboton, 2003). Therefore, framing QF reductions as volumetric evidence is a robust way to substantiate the project's claim that its nature-based interventions increase water retained within the Bogota Region basins, while simultaneously reducing damaging runoff exported downstream.

Quick flow (QF) was modeled for the selected watersheds: Quebrada Quincha, Río Bogota Parte Alta, Río Guandoque, Río Salitre, Río San Francisco, Río Chipata, Río Aves, and Río Susagua. For each watershed, the runoff summary reports:

- → QF in mm under:
  - current climate with land use 2020 (LUC 2020),
  - SSP585 climate with LUC 2020,
  - current climate with land use 2050 (LUC 2050),
  - SSP585 climate with LUC 2050, and for different intervention levels (BL, 10, 25, 50, 75, 100, BAU 2050);
- → QF in m^3 and m^3/ha for the same combinations, converting mm to m^3/ha using the standard relation 1 mm over 1 ha = 10 m^3;
- → Reduced runoff indicators (m^3/ha) comparing:
  - baseline vs intervention for current climate (LUC 2020 and LUC 2050),
  - baseline vs intervention for SSP585 climate,
  - BAU vs intervention for current climate and SSP585, and
  - baseline vs SSP585 deltas for both BL and BAU land uses.

First, InVEST outputs of annual QF in mm for each raster cell were spatially aggregated to the delineated sub-basins to obtain area-weighted mean QF values by scenario.

These depths were multiplied by basin area and converted from millimeters to cubic meters, generating total annual quickflow volumes, and then normalized to m^3/ha to provide a comparable runoff intensity indicator across basins.

Second, avoided and reduced runoff were calculated as differences between baseline and intervention scenarios for each climate–land-use combination. Positive values indicate reductions in runoff due to interventions.

Third, climate-change effects independent of interventions were quantified through the "BL 2020 Delta current – SSP585" and "BL 2050 Delta current – SSP585" indicators, which subtract the SSP585 QF (m^3/ha) from the corresponding current-climate QF for the same land-use configuration. These deltas allow the project to distinguish runoff changes driven by climate forcing from those achieved by land-use

and restoration measures, which is essential for a robust feasibility assessment under the GCF's climate rationale.

Finally, reduced runoff from current and SSP585 climate change scenario were compared with the intervention scenarios directly against the BAU 2050 trajectory rather than only against the historical baseline. This approach provides conservative estimates of avoided runoff, as it reflects the additional runoff that would occur under continued degradation and urban expansion, and the volume that the project prevents through restoration and sustainable land management.

These indicators allow a transparent, volumetric assessment of how the project changes runoff behavior in each basin under multiple combinations of land use and climate.

Under current climate and land cover 2020, all modeled basins show positive reduced runoff values when comparing baseline (BL) with intervention scenarios (BL–10, BL–25, BL–50, BL–75, BL–100), expressed in m³/ha. This indicates that the NbS interventions consistently reduce surface runoff volumes relative to the baseline in every basin.

Error! Reference source not found. summarizes the magnitude of reduced runoff for a representative intervention level (BL–75), the 75% of the possible intervention in properties identified as FC+FP in Level 2 multicriteria, under current climate and LUC 2020, based on the "reduced runoff BL – int current climate LUC 2020 (m³/ha)" indicators. Values are indicative ranges consistent with the results in the runoff summary.

Table 62 Reduced runoff at BL-75 under current climate (LUC2020)

Basin	Basin area (m²)	Reduced runoff BL–75 (m³/ha per event, current climate LUC 2020)*
Quebrada Quincha	19,074,400	~9–10
Río Bogota Parte Alta	22,323,900	~3–4
Río Guandoque	34,041,000	~5–6
Río Salitre	23,379,100	~2–3
Río San Francisco	90,654,304	~11–12
Río Chipata	39,332,000	~2–3
Río Aves	94,256,896	~7–9
Río Susagua	31,238,500	~5–6
Río Curubital	35,435,600	~1–2

Source: IDOM, 2026

From these values, it is evident that larger and more heavily intervened basins (e.g. Río San Francisco, Río Aves) exhibit the highest per-hectare reductions, while smaller or more urbanized basins (e.g. Río Salitre, Río Chipata) show smaller but still positive reductions. When multiplied by basin area and by the number of relevant runoff events per year, these per-event reductions imply annual reductions of hundreds of thousands to several million cubic meters of surface runoff for the system as a whole.

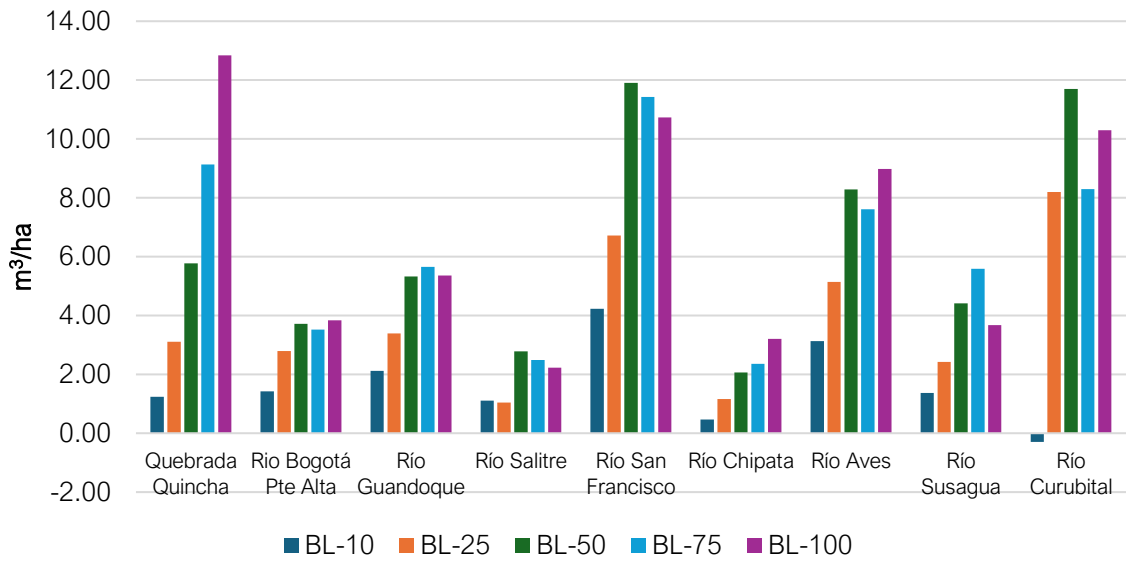


Figure 54 Reduced runoff (m³/ha) under current climate
Source: IDOM, 2026

Exploratory Seasonal Water Yield simulations of Quick Flow (QF) under graduated intervention levels (10%, 25%, 50%, 75% and 100%) for prioritized watersheds, based on preliminary intervention-area allocations. Results were used to test runoff sensitivity and to inform the selection of final intervention targets by watershed; they do not represent the finalized project scenarios.

Reduced runoff under SSP585 climate

Under the SSP585 climate scenario, QF in mm and m³/ha increases relative to the current climate for all land-use configurations, reflecting more intense or frequent rainfall events. However, the absolute reduced-runoff gains from the interventions typically increase as well, particularly at higher intervention levels.

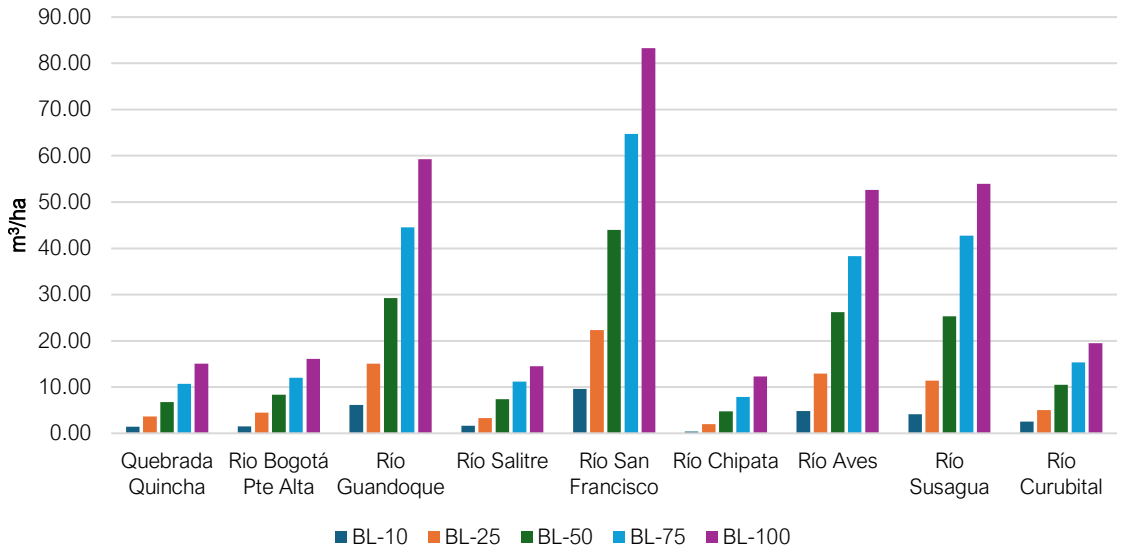


Figure 55 Reduced runoff (m³/ha) under climate scenario SSP585
Source: IDOM, 2026

For basins such as Río San Francisco, Río Aves and Río Susagua, reduced runoff at BL–75 and BL–100 under SSP585 is larger in absolute terms than under current climate, often exceeding 20 m³/ha per event at the highest intervention levels.

In more urbanized basins like Río Salitre and Río Chipata, the magnitude of reduced runoff remains lower, but increases between current climate and SSP585, confirming that NbS continue to moderate extreme runoff even where sealed surfaces are more prevalent.

These results support the conclusion that the project's hydrological benefits are climate-robust and increase in importance as rainfall extremes intensify.

Avoided runoff relative to BAU trajectories

Beyond reductions relative to the 2020 and 2050 baselines, the project also avoids future increases in runoff that would occur under a BAU land-use trajectory. Specifically

- "reduced runoff BAU current climate – int current climate LUC 2020/2050 (m³/ha)" quantifies how much more QF would be generated if BAU land-use change proceeded without the project, compared to the intervention configuration, under current climate;
- "reduced runoff BAU SSP585 – int SSP585 LUC 2020/2050 (m³/ha)" provides the analogous comparison under SSP585 climate.

For many basins, these BAU–intervention differences reach double-digit m³/ha per event, especially at higher intervention levels and under SSP585. For example, in Río San Francisco, Río Aves, and Río Susagua, the BAU–intervention reduced-runoff values under SSP585 amount to several tens of m³/ha per event at BL–75 or BL–100, indicating that the project prevents a substantial escalation of runoff volumes that would otherwise result from ongoing deforestation, agricultural expansion, and urbanization.

Error! Reference source not found. provides an indicative summary of these avoided runoff volumes per event for selected basins and SSP585, based on the "reduced runoff BAU SSP585 – int SSP585 LUC 2050 (m³/ha)" indicators.

Table 63. Indicative avoided runoff per event vs BAU under SSP585 (LUC 2050, high intervention)

Basin	Indicator	Approx. avoided runoff (m³/ha per event)*
Río San Francisco	BAU SSP585 – intervention SSP585, BL–75	≥30–40
Río Aves	BAU SSP585 – intervention SSP585, BL–75	≈30–40
Río Guandoque	BAU SSP585 – intervention SSP585, BL–75	≈30–35
Río Susagua	BAU SSP585 – intervention SSP585, BL–75	≈30–40
Río Bogota Pte Alta	BAU SSP585 – intervention SSP585, BL–75	≈10–15
Other basins	BAU SSP585 – intervention SSP585, BL–75	≈5–20

Source: IDOM, 2026

When scaled to basin area and an annual sequence of events, these per-event differences correspond to very large volumes of runoff that are prevented every year, directly reducing flood risk, erosion, and sediment loads in the Bogota River system.

C. Updated Seasonal Water Yield analysis aligned with the final intervention targets

The land-use scenarios used in the Seasonal Water Yield analysis are strictly aligned with the current intervention design of the project. The BL 2020 configuration reflects observed land use and land cover in 2020; the 100% intervention configuration represents full implementation of conservation, restoration and climate-resilient production practices across the finalized intervention areas in each watershed; and the BAU2050 configuration projects land-use evolution to 2050 under a no-project pathway. Earlier exploratory runs with partial intervention levels were used internally to select the optimal ambition level but are not reported as project indicators because subsequent refinements in the delimitation of intervention areas and watersheds make those scenarios no longer fully representative of the final project design.

The BL 2020, with-project 100%, and BAU2050 Seasonal Water Yield simulations presented in this appendix build on the insights from the graduated intervention analyses but reflect the finalized spatial distribution of intervention hectares by watershed. They therefore represent the definitive hydrological scenarios used to interpret project impacts and climate risk, while the earlier 10–25–50–75–100% simulations remain part of the internal design evidence supporting the choice of ambitious coverage levels in priority basins.

Table 64 Total intervened areas with sub-activity 1.1.1.2, activity 1.1.2 and activity 1.2.1

Watershed	Area (ha)	Total intervened areas (ha)
Río Susagua	3,123	919
Río Salitre	2,337	199
Río Guandoque	3,404	503
Río Bogotá Parte Alta	2,232	283
Quebrada Quincha	1,907	196
Río San Francisco	9,065	1,195
Río Aves	9,425	1,036

Watershed	Area (ha)	Total intervened areas (ha)
Río Chipatá	3,933	373
Río Curubital	3,544	431
Quebrada Yomasa	1,343	94
Quebrada de Aguadulce	1,882	94
Quebrada Paso Colorado	1,916	94
	44,111	**5,416**

Source: IDOM, 2026

Quick Flow (QF) and reduced runoff under current climate and SSP585 for baseline, with project (100%) and BAU2050 scenarios in periodized watersheds: “reduced runoff BL-100” indicate lower QF in the with-project scenario relative to BL, while positive values of the current climate – SSP585 delta indicate an increase in QF under climate change for the same land-use configuration.

Table 65. Quick Flow (QF) and avoided/reduced runoff under current climate, SSP855 scenario and with intervention of the project (100%)

Priritized watershed	Watershed area (m2)	QF current climate LUC 2020 (mm)			QF SSP585 LUC 2020 (mm)			QF current climate LUC 2020 (m3)			QF SSP585 LUC 2020 (m3)			QF current climate LUC 2020 (m3/ha)			QF SSP585 LUC 2020 (m3/ha)			Reduced runoff BL-100 current climate (m3/ha)		Reduced runoff BL-100 SSP585 (m3/ha)		BL 2020 Delta current - ssp585	
		BL	100	BAU2050	BL	100	BAU2050	BL	100	BAU2050	BL	100	BAU2050	BL	100	BAU2050	BL	100	BAU2050	BL-100	BL-BAU2050	BL-100	BL-BAU2050	100	BAU2050
Quebrada Quincha	19,074,400	39	38	39	46	46	47	734,467	733,214	748,957	876,379	874,921	893,487	385	384	393	459	459	468	1	-8	1	-9	0	-1
Rio Bogotá Pte Alta	22,323,900	45	44	45	51	51	52	993,895	981,622	999,928	1,143,230	1,131,171	1,149,932	445	440	448	512	507	515	5	-3	5	-3	0	0
Río Guandoque	34,041,000	43	43	43	78	76	78	1,480,281	1,454,983	1,480,281	2,669,383	2,590,610	2,669,383	435	427	435	784	761	784	7	0	23	0	16	0
Río Salitre	23,379,100	40	40	40	52	52	52	930,435	929,300	933,615	1,214,535	1,212,104	1,220,637	398	397	399	519	518	522	0	-1	1	-3	1	-1
Río San Francisco	90,654,304	52	50	53	73	70	76	4,699,330	4,529,909	4,833,367	6,618,309	6,311,356	6,860,697	518	500	533	730	696	757	19	-15	34	-27	15	-12
Río Chipata	39,332,000	71	71	72	81	81	83	2,794,432	2,794,432	2,846,401	3,203,824	3,203,824	3,276,152	710	710	724	815	815	833	0	-13	0	-18	0	-5
Río Aves	94,256,896	47	46	50	59	58	64	4,465,502	4,373,456	4,729,770	5,588,295	5,446,214	6,018,543	474	464	502	593	578	639	10	-28	15	-46	5	-18
Río Susagua	31,238,500	45	43	46	82	75	84	1,408,154	1,335,796	1,430,707	2,563,119	2,341,994	2,624,018	451	428	458	821	750	840	23	-7	71	-19	48	-12
Río Curubital	35,435,600	58	57	58	37	36	37	2,052,086	2,008,484	2,053,211	1,308,621	1,286,338	1,309,218	579	567	579	369	363	369	12	0	6	0	-6	0
Quebrada Yomasa	13,433,219	119	118	122	73	72	73	1,604,931	1,587,042	1,637,194	974,861	969,193	985,823	1,195	1,181	1,219	726	721	734	13	-24	4	-8	-9	16
Quebrada de Aguadulce	18,815,649	80	78	81	41	40	41	1,506,331	1,472,821	1,525,641	769,725	757,500	776,484	801	783	811	409	403	413	18	-10	6	-4	-11	7
Quebrada Paso Colorado	19,164,233	27	25	27	14	14	14	509,505	486,216	509,580	273,522	262,717	273,637	266	254	266	143	137	143	12	0	6	0	-7	0

Source: IDOM, 2026

D. Interpretation of integrated results

Across most prioritized watersheds, the 100% intervention scenario reduces QF in m³/ha under both current climate and SSP585 conditions relative to the BL 2020 configuration, indicating lower rapid surface runoff and improved seasonal water regulation under the finalized intervention package. In contrast, the BAU2050 scenario generally shows higher QF than BL, particularly under SSP585, illustrating how business-as-usual land-use trajectories combined with climate change can increase peak runoff and erosion risk. The current climate–SSP585 deltas confirm that climate change alone tends to increase QF for BL and BAU2050 in several watersheds, while the 100% intervention scenario attenuates or partially offsets this effect.

The Seasonal Water Yield results are consistent in magnitude and tendencies with the avoided runoff VWBs reported in Tables 28 and 29. Watersheds that show higher avoided runoff volumes in the VWB analysis, such as Río San Francisco and Río Aves, also exhibit comparatively larger reductions in QF between BL and the 100% intervention scenario. Smaller watersheds, such as Quebrada de Aguadulce and Quebrada Paso Colorado, show smaller absolute reductions in total volume but still present meaningful per-hectare improvements, which is important for comparing hydrological performance across basins of different sizes.

Taken together, Curve Number–based VWBs and Seasonal Water Yield QF reductions provide a coherent picture of hydrological benefit. The two modelling approaches are not intended to produce identical numerical outputs, because they rely on different structures and assumptions, but they converge on the same conclusion: the finalized intervention package reduces rapid surface runoff and enhances water retention at watershed scale, while business-as-usual trajectories under climate change increase runoff and associated risks. In this sense, the Seasonal Water Yield analysis strengthens confidence in the direction, plausibility and climate relevance of the runoff-related benefits reported through the VWB framework.

The reduced and avoided runoff results have several implications for climate adaptation and water security in the Bogota Region:

- ✓ Systematic moderation of extreme runoff: Across all basins and for all intervention levels, the project reduces QF volumes relative to the baseline, thereby moderating peak flows and reducing the likelihood of flood events and associated damage. The largest reductions occur where the project concentrates restoration, conservation, and sustainable production measures, confirming the strategic targeting of interventions.
- ✓ Increased benefits under climate change: Under SSP585, overall QF increases, reflecting more intense rainfall. However, the absolute reduced-runoff values also increase, especially at higher intervention levels. This indicates that the project's hydrological benefits are not only maintained but become more valuable as climate risks intensify, a key requirement for GCF investments.
- ✓ Avoided lock-in into a high-hazard trajectory: The BAU–intervention indicators demonstrate that, in the absence of the project, continued land-use change would move the Bogota basins towards substantially higher runoff volumes and thus higher flood and erosion risk. By altering the land-use trajectory, the project avoids this lock-in and keeps the system within a more manageable hydrological regime.
- ✓ Volumetric evidence base for NbS: Expressing reduced and avoided runoff in m³ and m³/ha provides a robust, volumetric basis for attributing adaptation benefits to NbS and land-use interventions. These volumetric indicators can be directly linked to downstream impacts (e.g. reduced flood damages, lower sedimentation of reservoirs, improved water quality), and to the broader Theory of Change of the project.

Overall, the modeling results confirm that the project delivers significant, quantifiable reductions in surface runoff and avoids substantial future increases under BAU and climate change. These benefits are spatially distributed across the main basins of the Bogota watershed system and increase with the scale and ambition of the NbS interventions, reinforcing the project's paradigm-shift potential in the water-land-use nexus.