Amortiguador Ribereño: A Resilient Hydro-Urban Corridor along the La Silla River in Monterrey, Mexico

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City Population	4,011,151
City Area	685 km²
City GDP	123 billion USD
Climate Zone	BSh (Subtropical steppe)
CSA Climate Solutions	Nature-based Solutions (NbS)

Introduction. This case study examines a proposed riparian buffer (*Amortiguador Ribereño*) along the La Silla River (LSR) in the Monterrey Metropolitan Area (MMA) in northeastern Mexico (Figure 1), as a nature-based climate adaptation strategy focused on flood resilience. The LSR originates in the mountains of the Sierra Madre Oriental and runs through densely urbanized areas of Monterrey and Guadalupe before joining the Santa Catarina River (Figure 2). Over the past three decades, rapid urban expansion has nearly tripled the urbanized area of the MMA, increased impermeable areas and reducing groundwater recharge capacity. Impermeable surfaces now cover 24% of the metropolitan area, while 38.6% of environmentally valuable permeable land has been lost over the past two decades, well above the national average (SIUM, 2024; Ferreyra et al., 2022). Between 1990 and 2022, areas with very high recharge potential declined by 13.9%, while zones with very low recharge potential expanded by over 50% (Aceves-Padilla et al., 2026). These transformations have intensified climate vulnerability, with flooding, drought, and extreme heat occurring in succession within relatively short periods. Floods are driven by intense rainfall events and storms such as Hurricane Alex (2010) and Tropical Storm Alberto (2024), which caused damages estimated at MXN 20.5 billion and 1 billion, respectively (Aguilar-Barajas et al., 2019; Mendoza Tinoco et al., 2019; Robledo, 2024). These hazards are accompanied by interconnected risks, particularly water insecurity across the city, driven by drought, declines in reservoir levels, and overexploitation of aquifers (Breña Naranjo, 2022). These dynamics are particularly acute along the La Silla River, which is the focus of the *Amortiguador Ribereño* project.

Current responses to hydrometeorological risks in Monterrey, primarily based on grey infrastructure, have focused on providing short-term flood control but have contributed to ecological degradation and reduced adaptability, limiting their effectiveness under increasingly variable climate conditions. In this context, the *Amortiguador Ribereño* intervention reimagines a section of the LSR as a resilient hydro-urban corridor that amplifies the river's capacity through controlled flooding, water retention, and ecological regeneration, while also creating public space. This intervention, currently at the design and pre-implementation stage, proposes a riparian buffer system based on a flexible landscape that allows the river to expand and contract, while also supporting localized cooling, increased biodiversity, and social reconnection along the corridor. In this sense, the LSR becomes a critical site for rethinking urban climate adaptation strategies through nature-based design that focuses on hydrological flexibility

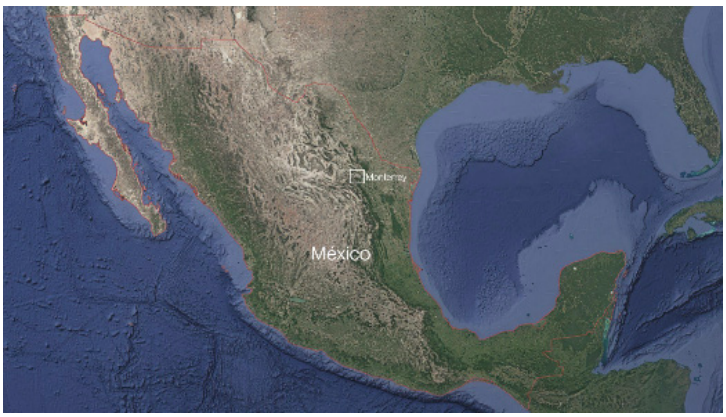

Figure 1: *Location of the MMA within Mexico. Source: elaborated by the authors*

Figure 2: *Route of the La Silla River through the Monterrey Metropolitan Area. Source: Bonilla Jaramillo et al. (2024).*

within a rigidly engineered urban system dominated by grey infrastructure.

Brief History of Climate Action in the LSR. A tension between hydraulic risk management and ecological conservation has historically shaped climate action along the La Silla River (LSR). While urbanization in the Monterrey Metropolitan Area (MMA) has relied heavily on grey infrastructure, including the channelization of rivers for flood control, the LSR, often described as the last "living" river in the MMA, has retained segments of its natural channel open, preserving key riparian ecosystems and hydrological functions. The significance of this river has been documented in scientific studies and conservation assessments, which document both its ecological value and its role in hydrometeorological risks such as flooding (Cantú Ayala et al., 2013). Subsequent ecological research reinforces its role as an urban biodiversity corridor, recording 152 bird species, including migratory and at-risk species, and 69 vegetation species, while demonstrating that increasing urban disturbance reduces biodiversity presence along the river (Castillo-Muñoz et al., 2021; López-Castillo et al., 2018). Despite this evidence, the LSR has experienced progressive degradation due to urban expansion, land-use change, and pollution, as documented in recent media reports (Villasáez, 2021; Narváez Domínguez, 2025).

Governance and Institutional Frameworks in the LSR. Governance of the LSR involves a multi-scalar network of actors, including municipal, metropolitan, and federal institutions, alongside NGOs, academic actors, and communities linked to approximately 128,600 residents living near it, many concentrated in its more urbanized and flood-exposed sections (Gobierno de Monterrey, 2025). However, inter-institutional coordination remains limited, with weak integration of nature-based strategies for river management.

A more coordinated framework began to emerge with the declaration of the LSR as a Municipal Natural Protected Area (ANP) in 2023 under the category of riparian biological corridor, recognizing its role in biodiversity conservation and hydrological regulation (Gobierno de Monterrey, 2023; Pronatura Noreste, 2023). This designation led to the development of a Management Program, published in 2025, and under public consultation as of spring 2026 (Gobierno de Monterrey, 2026; Villasáez, 2026). Within this evolving landscape, the *Amortiguador Ribereño* project, which emerges from a thesis-based initiative at the National Autonomous University of Mexico (UNAM), later recognized through

Year	Event	Key Actors	Significance
2010	Responses to flooding from Hurricane Alex	Federal, state, and municipal governments	Major flood event exposing hydrometeorological vulnerability in Monterrey
2013–2020	Scientific studies, Ecological monitoring, management assessments	Autonomous University of Nuevo León; Municipality of Monterrey; academic community	Comprehensive ecological and risk assessments; identification of biodiversity value, flood risk, and conservation strategies
2022	Responses to the Water Crisis and Extreme Drought	State agencies and water authorities	A crisis that reveals systemic water insecurity and increasing climate variability
2023	Declaration of the LSR as a Municipal Natural Protected Area (ANP)	Municipality of Monterrey; Secretary of Sustainable Urban Development of Monterrey	Legal recognition as a riparian biological corridor that establishes the basis for conservation and regulation
2024	Responses to flooding from Tropical Storm Alberto	Federal, state, and municipal governments	An event that shows the persistence of hydrometeorological vulnerability in Monterrey
2024	Amortiguador Ribereño — recognition in the *Climatón* UNAM	UNAM student team	Introduces a nature-based, adaptive design approach to the river, with institutional visibility
2025	Publication of the Management Program for the ANP	Autonomous University of Nuevo León; Municipality of Monterrey; Secretary of Sustainable Urban Development of Monterrey	Defines the regulatory framework for land use, restoration, and risk mitigation
2026	Public consultation of the Management Program	Municipality of Monterrey; Secretary of Sustainable Urban Development of Monterrey; civil society; local communities	Opens participatory governance process; ongoing

Table 1: *Key Milestones in the Evolution of Climate Governance of the La Silla River. Source: elaborated by the authors*

the Climatón UNAM 2024, proposes a shift towards a river-centered design that integrates flood management, drought resilience, and ecological restoration (Arratibel, 2024). Despite these advances (summarized in Table 1), the transition toward integrated, nature-based river management remains constrained by fragmented governance, competing land-use priorities, and the enduring dominance of grey infrastructure approaches. These conditions define the context within which the *Amortiguador Ribereño* is conceived as a nature-based intervention to reconfigure river governance and management.

Analysis, Evaluation, and Implementation. The *Amortiguador Ribereño* targets a specific section of the La Silla River within Monterrey where underutilized land, chronic flood exposure, and socially vulnerable communities converge (Figure 2). As Figure 3 shows, there is an overlap between areas of high social deprivation, population

density, and flood risk zones in the section targeted by this intervention. This overlap is the result of a pattern of urban expansion that has resulted in heightened exposure to flood risks, affecting lower-income communities that are in some of the most hydrologically exposed sections of the corridor. The intervention begins with a pilot segment (known as *proyecto semilla*) of approximately six hectares, designed to test the feasibility of the intervention before scaling along the corridor. Estimated carbon sequestration capacity reaches up to 600 tons annually for this pilot area alone, according to the design team's calculations (Bonilla Jaramillo et al., 2024).

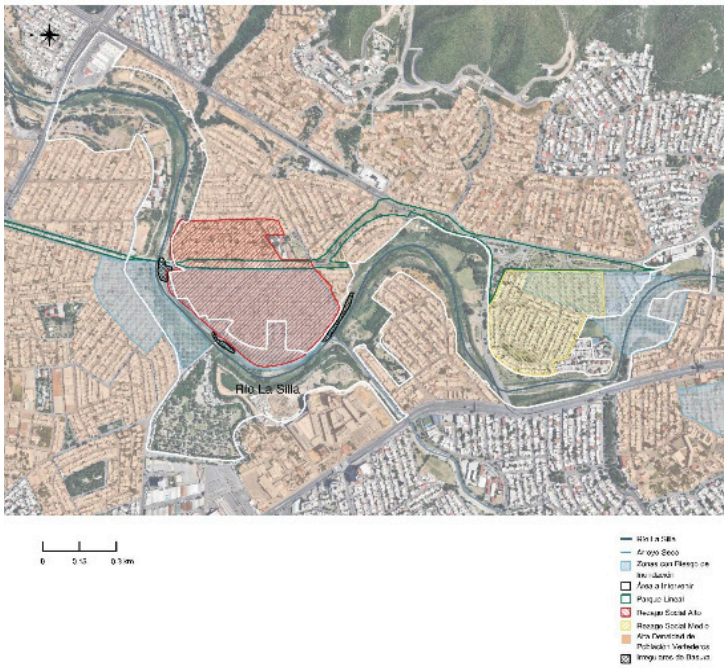

Figure 3: *The implementation area of the project and territorial characteristics. Source: Bonilla Jaramillo et al. (2024).*

The proposal follows a phased ecological restoration and urban integration process. The first phase begins with geospatial and hydrological assessment to identify flood-prone zones, patterns of ecological degradation, and areas of highest urban pressure. Based on this diagnosis, the design introduces adaptive riverbanks composed of terraced landscapes, wetlands, and permeable soil systems that expand and contract according to seasonal water levels. These areas act as both flood buffers and drought water reserves.

An important element of this implementation strategy is the reconnection of previously fragmented ecosystems, particularly between the surrounding mountain (Cerro de La Silla) and the LSR biological corridor (Figure 4). Runoff from the mountain currently reaches the river without filtration or attenuation, carrying solid waste and surface eroded material. As Figure 4 shows, the *Amortiguador Ribereño* intercepts these flows through irrigation ditches, vegetative buffers, and biofiltration systems. In this way, it facilitates hydrological flows, runoff filtration, groundwater recharge, and ecological connectivity across the urban landscape, supporting biodiversity movement between the mountain system and the

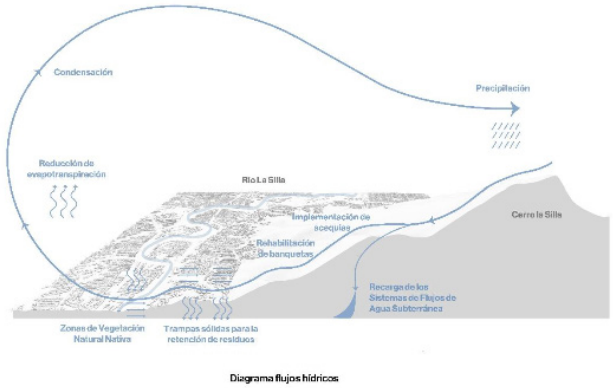

Figure 4: *Diagram of water flow between Cerro and the La Silla River.*

riparian corridor.

The second phase focuses on ecological restoration through native vegetation reintroduction, soil decompaction, and the creation of biofiltration systems to improve water quality. It also involves the integration of public space through pedestrian paths, cycling routes, and parks that are designed to remain functional under variable water conditions, including

Figure 5: *Visualization of the proposed hydro-urban corridor and its connection to the nearby spaces. Source: Bonilla Jaramillo et al. (2024).*

Figure 6: *Visualization of the proposed hydro-urban corridor illustrating the integration of ecological restoration and public space. Source: Bonilla Jaramillo et al. (2024).*

community-oriented programs such as urban gardens, environmental workshops, and local stewardship initiatives. In this sense, the river corridor is reconfigured as a hybrid socio-ecological infrastructure that combines environmental functions with urban accessibility and public space, and the project adapts to fluctuations in river levels throughout the year. Figure 5 shows the full spatial extent of this vision, while Figure 6 offers a ground-level perspective of what this corridor would look and feel like.

Advantages, Challenges, and Broader Alignment with SDG. This proposal directly addresses tensions between urban safety and ecological openness that have historically defined river management in the MMA. Conventional flood-control engineering has prioritized containment in this city, through channelization and grey infrastructure designed to move water away as fast as possible. While the default and dominant response to flood risk in the MMA, grey infrastructure alternatives have proven insufficient under increasingly variable rainfall conditions.

By replacing rigid containment systems with adaptive infrastructure, the Amortiguador Ribereño proposes the opposite logic and builds a solution that involves letting the river expand into a managed floodplain rather than forcing it through a rigid channel. Its implementation would require coordination across municipal authorities, environmental agencies, and local communities, and would face challenges such as land acquisition, regulatory adaptation, and resistance to the modification of existing concrete infrastructure, particularly in later phases involving the gradual transition from rigid containment in intervened segments toward more permeable and adaptive conditions.

A key advantage of the *Amortiguador Ribereño* is its multifunctional approach, addressing flood mitigation, drought resilience, ecological restoration, and urban livability simultaneously. Compared to conventional hydraulic infrastructure, it offers longer-term benefits through the recovery of ecosystem services and reduced maintenance costs, while also fostering community engagement with the river. The project aligns with broader climate adaptation goals such as the UN Sustainable Development Goals (and in particular, SDG 11 and SDG 13), by advancing nature-based solutions that seek to reconcile urban development with hydrological and ecological processes, while directly addressing the coupled risks of flooding and water scarcity in the MMA.

Since the proposal for the Amortiguador Ribereño was first presented in 2024, developments around the challenges in the LSR offer a mixed picture of progress and continued problems. Heavy rain in 2025 and 2026 has led to flooding in the LSR, killing two people in September 2025 and trapping a further five people who were rescued in June 2026 following a rapid rise in water levels (Carrera et al., 2025; Arias, 2026). Ecological degradation has also persisted, with reports in 2025 and 2026 documenting untreated wastewater discharges into the river (Martinez, 2025; Narváez Domínguez, 2025; Vega, 2026). Drought conditions, while intensified across Nuevo León according to early 2026 assessments, eased following above-average rainfall in the spring, reflecting an ongoing and fluctuating situation (Perez, 2026). These developments suggest that, even if institutional advances have been made, including the 2025 Management Program and its public consultation, the underlying challenges that motivated the proposal remain unresolved.

Future Implementation and Conclusion. The *Amortiguador Ribereño* project reflects a shift from flood risk management based on grey infrastructure toward climate adaptation approaches grounded in ecological restoration and the integration of public space. A key lesson from this case is that urban rivers cannot be managed as isolated hydraulic systems or as separate domains from other urban infrastructures, but rather as socio-ecological systems embedded within the urban fabric. The project shows how a hybrid infrastructure approach can address flooding, drought, and urban heat as interrelated risks. However, its implementation will depend on early-stage community participation, interdisciplinary coordination, and a shift from conventional short-term engineering responses toward long-term adaptive planning strategies.

As the project remains in a pre-implementation phase, its realization will depend on overcoming institutional fragmentation, adapting to regulatory frameworks, and securing sustained investment. The designation of the La Silla River as an ANP and the development of its Management Program provide an emerging institutional framework to operationalize nature-based interventions such as the *Amortiguador Ribereño*. However, implementation will require stronger alignment across government levels, active community involvement, and financial mechanisms that support green infrastructure. Further research is needed to strengthen its feasibility, particularly in hydrological modeling, long-term ecological performance, and the evaluation of social impacts across different population groups, such as within the vulnerable communities identified in the design and pre-implementation phases of the project.

The project offers two transferable elements for cities navigating similar climate and hydrological risks. The first is a phased pilot strategy that allows for small-scale and iterative learning before committing to full corridor transformation, and the second is a design approach that treats the river not as a channel to be controlled but as a flexible and dynamic hydro-urban corridor that is deeply connected to its surrounding urban landscape. Beyond the implementation outcomes and process, it is important to recognise the value that the design and project itself already carry. In contexts where nature-based solutions remain institutionally marginal, a rigorously developed proposal like the Amortiguador Ribereño demonstrates that alternative approaches that incorporate the characteristics of the landscape and suggest hybrid, adaptable infrastructures are technically and spatially viable. This experience also illustrates how innovation emerging from students at academic institutions with a vocation to address the climate challenges of contemporary cities offers a replicable model of evidence-based, place-grounded design for cities that will face similar decisions.

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Additional Data

- **Population Density:** 5,856 people/km²
- **Gross National Income (GNI):** 13,730 USD (Upper-middle Income)
- **Gini Coefficient:** 42.6
- **Human Development Index (HDI):** 0.789 (High)
- **Type of Climate Intervention:** Adaptation