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Territorial and social connections of bridges over the Bogota River, Colombia

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Abstract: The Bogotá River forms the territory of the Savannah of the Colombian capital. Its bridges define the history of how people have related to the river and the territory; they show the technological evolution and social changes. The construction techniques of the historical moment build connections capable of overcoming geographical limitations. This article proposes a historical and technological analysis through three bridges that represent three key episodes in its history based on three structural types and their corresponding technological and social moments: the Común Bridge, the Antonio Nariño Bridge and the Guadua Bridges. The research is based on an unpublished compilation of historical and documentary sources on which it is argued that bridges, beyond their constructive and technological relevance, provide important identity value. They constitute relevant elements as cultural heritage and establish connections that configure the social identity of the territory.

Key words: bridges; heritage; structural design; public works; cultural identity; sustainable development

1 Introduction

Transportation during the colonial era in Colombia was limited to existing indigenous trails and roads, especially in the central part of the country, where the terrain plays a significant role in road construction. For this reason, opening new transportation routes was one of the most difficult problems to solve, since, in addition to the geography, the abundance of rivers and the flooding they caused limited access. These territorial limitations hindered the growth of the new capital of the New Kingdom of Granada (1538–1819), Santa Fe de Bogotá, which was virtually cut off from its surrounding territories during the 16th and 17th centuries.

As the economic hub and most important city in the kingdom, Santa Fe de Bogotá needed to be connected to the rest of the country. This is where the long history of territorial connections via bridges over the Bogotá River begins. The bridges along the river have gradually become more than just functional elements linked to roads and the expansion of the territory. Today, they are also part of the history and culture of the regions where they are located.

The Bogotá River is the main watercourse of the Bogotá Savanna. This river originates in the Guacheneque páramo at 3,300 meters above sea level and flows into the Magdalena River about 380 km from its source, meaning it crosses almost the entire city and many of the neighboring territories. Throughout history, the river has gradually changed in appearance

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and significance for the inhabitants of its watershed. Initially, indigenous legends recount how its waters flooded the entire Sabana; later, with the urbanization and growth of Bogotá, the river was channeled and gradually became a dumping ground for trash and polluting liquid waste for the 8,800,000 residents of the metropolitan area. Today, the river represents the sustainable future the city is committed to, aiming to improve the quality of life for its residents as well as water quality and biodiversity.

Along the route, there are more than 50 road bridges and about 20 pedestrian bridges, as the river flows through 29 municipalities and supplies water to the Tominé reservoir north of Bogotá and the Muña reservoir south of the city. Bridges are structures that accommodate both vertical and horizontal movement; in this case, the river is the obstacle that must be crossed to ensure road connectivity. Therefore, these structures not only must withstand gravity—as they must resist the bending of the span—but their piers must also withstand the weight and hydraulic force of the water [1]. Below, we present three bridges that illustrate the relationship between the river and people's needs — both for transportation and for connecting with the rest of the country. The selection criteria for the bridges included as case studies in this research are based on typological and chronological diversity, allowing us to trace the evolution of the landscape and public works along the river. The bridges will be discussed in historical order, beginning with 1. Puente del Común, a colonial bridge that was the first to connect the capital with its neighboring areas; continuing with 2. Puente Antonio Nariño, which replaced the Puente de los Suspiros to shorten distances; and concluding with 3. Gua-dua Bridge, which represents a sustainable future and the positive relationship between residents and the Bogotá River (Figure 1).

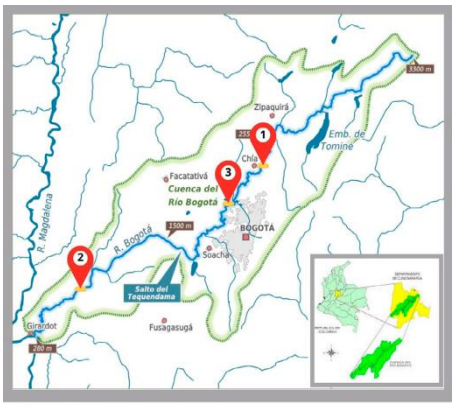


Figure 1. Location of the three bridges over the Bogotá River. Source: Prepared by the author based on data from the CAR—Regional Autonomous Corporation of Cundinamarca

Bridges are structures that demonstrate the desire to create connections and expand the territory through roads that address a territorial divide such as a river. The design and importance of the bridge's connections are closely related to the river's channel and width, as described by Aguiló: "Hydraulic factors influence the number and arrangement of the spans, the specific position of the foundations for each pier, and the ratio of the bridge's superstructure to its span in relation to the current" [1]. Making changes to the river's flow regime and geotechnical conditions by placing piers in the riverbed has consequences for the hydraulic conditions, as it reduces the space through which water can flow. The piers must withstand the new pressure and force of the water, as well as changes in the river that may be unpredictable, especially in a river that experiences several floods a year, such as the Bogotá River.

Throughout history, the engineers who designed bridges over the river took into account the characteristics of each location to minimize these consequences and ensure the structure's stability in light of the hydraulic-structural equilibrium.

Each bridge addresses specific needs and particular constraints, even when spanning the same river, because the topography and landscape change along its course.

2 Three technological and construction milestones

2.1 The Común Bridge, 1796

The Común Bridge, built in 1796 during the colonial era, retains its original design intact. It is located in the municipality of Chía, about 30 km north of Bogotá. It was built by order of Viceroy Don José de Ezpeleta, who entrusted the project to engineer Domingo Esquiaqui, known for combining functionality and aesthetic appeal in his designs. The bridge stands seven meters above the river, and its 32-meter length improved transportation routes between northern towns such as Zipaquirá, Tunja, and Sogamoso and the capital (Figure 2).

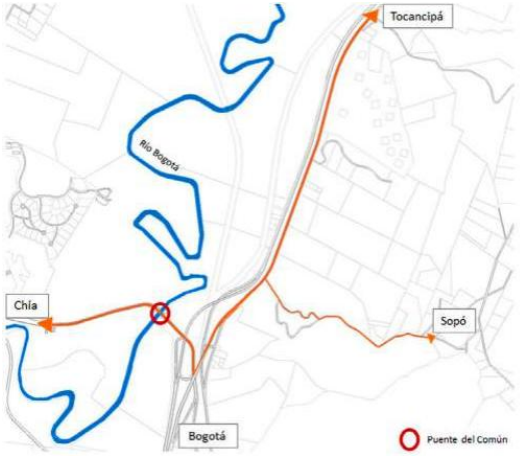


Figure 2. Connections facilitated by the Puente del Común

The description in Figure 2 highlights the bridge's importance for land transportation. In turn, the Puente del Común improved transportation routes between Cundinamarca, Boyacá, and Santander—three of the most important departments of the time for the development of this region of the country.

The bridge was built to ease congestion in agricultural trade in the northern Sabana region and to accommodate horse- and ox-drawn carts, as can also be seen in Figure 3.

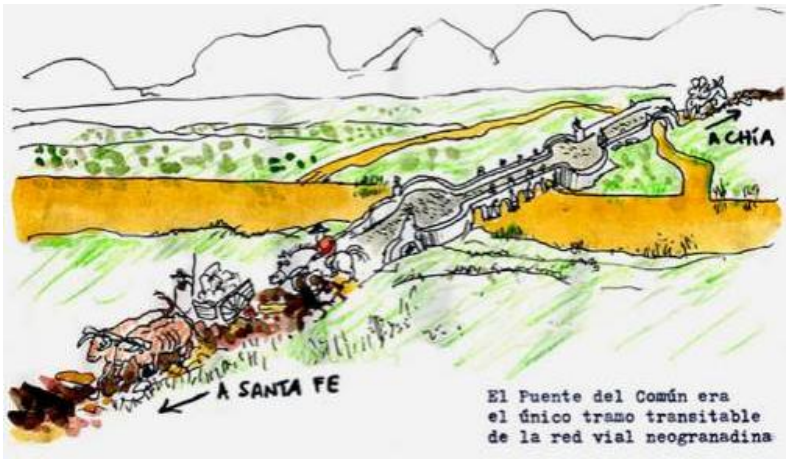


Figure 3. "The Puente del Común was the only passable section" (n.d.). Source: Caballero, A. [2]

The Puente del Común is a bridge with modest spans featuring semicircular arches made of stone and brick masonry. It has five arches and four piers within the riverbed. The central arch is the largest, with a clear span of six meters, while

the remaining arches decrease in size toward the abutments, with diameters of five and four meters, respectively. The bridge's piers have triangular cutwaters upstream and downstream with pyramidal tops (Figure 4).

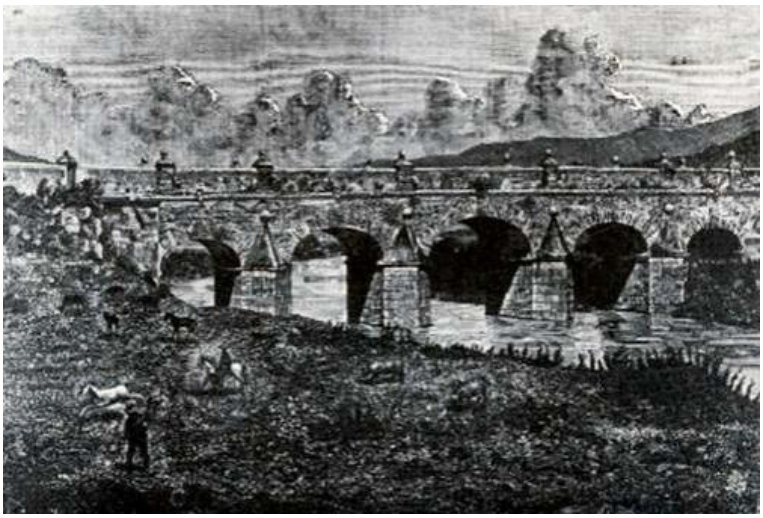


Figure 4. Puente del Común in the 19th century. Source: Engravings, published by the Banco de la República, 1968, p. 117. Retrieved from [3]

The technology for building masonry bridges spread throughout Colombia through European religious orders and architects, who employed the system in the network of roads and bridges across the country. Figure 5 shows a 1753 bridge design by Simón Schenherr over the Cauca River in Colombia, where the characteristic arches and buttresses can be seen. However, since this bridge was intended to connect the capital with the northern region, the Puente del Común was also designed with aesthetic value in mind. The parapets of the semicircular access plazas on both banks are decorated with ornamental elements ninety centimeters high, topped with sculptural vases such as the one shown in Figure 6 [4].

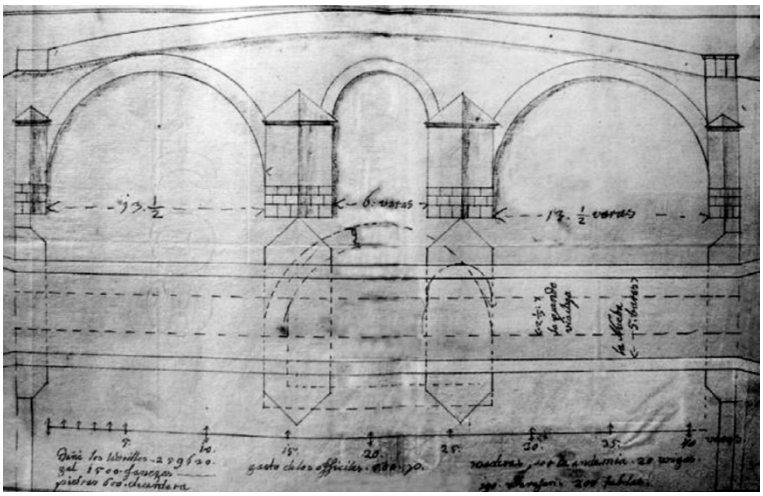


Figure 5. Simón Schenherr's design for a masonry arch bridge over the Cauca River in 1753. Source: National Historical Archive in Bogotá

The solidity of the structure allowed the bridge to withstand multiple floods caused by the Bogotá River overflowing for some two centuries. Today, the river does not overflow as frequently thanks to the improvement works carried out by the Regional Autonomous Corporation of Cundinamarca (CAR) between 2012 and 2016.



Figure 6. Detail of the Puente del Común. Source: G. Cuéllar. Banco de la República Virtual Library

The bridge remained open to vehicular traffic until the second half of the 20th century, when it underwent structural repairs and was declared a National Monument in 1967. Along with these repairs, the Concessions Subdirectorate of the National Roads Institute (INVIAS) built a viaduct parallel to the original bridge as part of the Northern Road Development [5] (Figure 7). This allows vehicular traffic to continue flowing without affecting the historic bridge, which is now open to pedestrians. In 2013, work was carried out to reinforce the original structure with lime and sand following the 2010–2011 floods, which left approximately 3.6 million hectares of the Bogotá Savanna practically underwater [6].



Figure 7. Aerial view showing the Puente del Común and the Viaducto Vial del Norte. Source: Google Earth

2.2 The Antonio Nariño Bridge, 1862

About 123 km downstream along the river lies the Antonio Nariño Bridge, built to replace the old Puente de los Suspiros from 1862 and designated a Site of Cultural Interest in 2011 due to its historical significance for the region. The

Puente de los Suspiros was the first suspension bridge in Colombia and features a single lane spanning its 110-meter span (Figure 8). Its original purpose was to connect the municipalities of Tocai-ma and Agua de Dios in order to isolate leprosy patients in Agua de Dios, since it is located on the other side of the river [7] (Figure 9). However, with the region's economic and tourism development, the Puente de los Suspiros became too small to handle the volume of traffic—both tourist and commercial—since only one vehicle can cross at a time. Furthermore, its suspension cables are not strong enough to support large vehicles such as cargo trucks and buses, which were forced to take a detour that added about two hours to their travel time. For this reason, the municipal government decided to build the Antonio Nariño Bridge parallel to the historic bridge.



Figure 8. Puente de los Suspiros. Source: Jiménez, A.M. CC-BY-SA-3.0

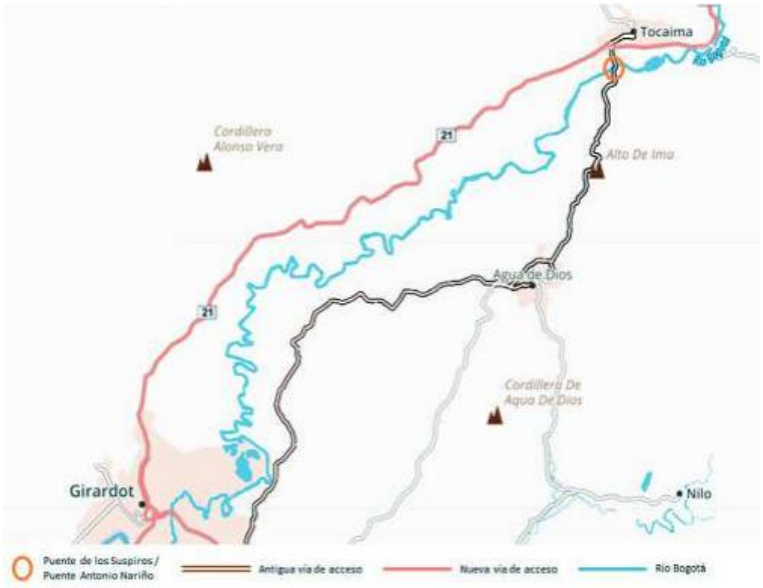


Figure 9. Connections facilitated by the Antonio Nariño Bridg

The Puente de los Suspiros was not only replaced by the Antonio Nariño Bridge to improve access routes; it was also necessary to build a more efficient bridge. Since it is a suspension bridge, the catenary supports of the old bridge operate exclusively under tension, and the cables require massive anchor blocks that complicate the support systems but counteract the inclined tensile forces (Figure 8). This is why the new bridge features a new configuration with an upper arch structure.

Although "arched and suspension structures necessarily produce inclined reactions at their supports" [1], in bowstring arch bridges, the deck balances the horizontal thrusts of the arch so that its supports receive only vertical reactions. This structural type was adopted for the new Antonio Nariño Bridge. A steel bridge with two structural planes, two braced upper arches support, via pendulums, the respective lateral beams that balance the horizontal reactions through tension. The structure rests lightly on the abutments at the riverbanks.

Construction on the new bridge began in 2006 but was halted due to a lack of funding until 2013, when the new governor took charge of improving access roads to the municipality of Tocaima. The new bridge, with a span of 115 m and a width of 11 m, has two lanes and sidewalks on both sides, allowing multiple vehicles to travel at the same time. Its structure is a steel cable-stayed arch with the road surface located above the flood level. Figure 10 shows the distance between the Bogotá River channel and the bridge abutments. The construction work was carried out by the Sabana Road Development Consortium (Devisab), which also conducted the historical study to restore the Puente de los Suspiros and transform it into a tourist attraction. The new bridge shortened travel times along the Chía-Mosquera-Girardot highway corridor, reducing the journey from two hours to fifteen minutes. In turn, this road connects to the national highway corridor of the Bogotá-Girardot Expressway to attract more tourists and promote the region's economic development [8].



Figure 10. View of the Antonio Nariño Bridge from the Puente de los Suspiros and a satellite image of the bridge. Sources: Google Earth and Vanguardia Liberal [9]

2.3 Guadua Bridge, 2020

Finally, we come to the most recent structures spanning the Bogotá River. Significantly, instead of relying on conventional technological solutions and materials such as steel and concrete, these structures utilize traditional, sustainable materials. These consist of two guadua footbridges and two bridges located at the mouths of the Soacha River and the Tibanica Canal where they flow into the Bogotá River. The bridges have spans of 32 m and 42 m, respectively, and their structure is made of guadua (Figure 11); a natural material that is a giant grass and is considered "vegetable steel" because its physical and mechanical properties make it flexible and resistant to compression and tension[1] [10]. Furthermore, it is a material that can be produced sustainably thanks to its rapid growth and has been used in construction in Colombia since colonial times. Drawings by Ricardo Moros Urbina from the late 19th century show details of the guadua and a small structure built with this material (Figure 12).



Figure 11. Detail of the interior of the Guadua Bridge. Source: Cundinamarca Regional Autonomous Corporation

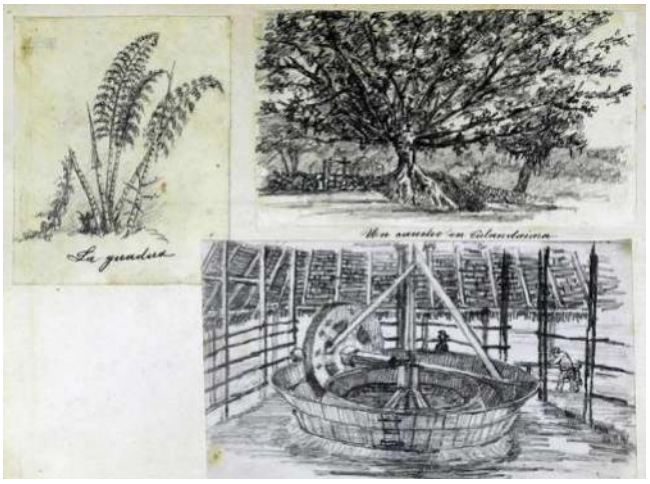


Figure 12. Ricardo Moros Urbina's Album of Sketches from Life, 1883–1888. Source: General Archive of the Nation of Colombia [11]

Both the bridge structures and the footbridges feature green roofs to purify rainwater; they also retain the natural color of the guadua and the wood of the decking so that they blend into the landscape [13].

Both guadua and wood offer numerous advantages: they are natural and sustainable materials, highly versatile, naturally durable and strong, and allow for a rapid construction process, resulting in savings in both time and budget (Figure 13).



Figure 13. Footbridges over the Bogotá River. Source: Cundinamarca Regional Autonomous Corporation

The design of the bridges also pays homage to the artisans of the colonial era, who built wooden bridges well into the 20th century. The design of these bridges was known as the "Antioquia system" and consisted of a structure of wooden beams forming parallel trusses, with a gabled roof and simple supports resting on stone or brick walls (Figure 14).

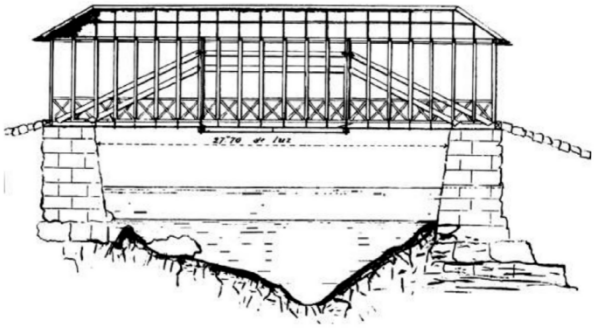


Figure 14. Bridge built using the Antioquian system in 1887. Source: National Historical Archive in Bogotá

The new footbridges followed this same design, visually highlighting the material used by combining functionality and durability as an aesthetic approach. In this way, visual priority is given to the guadua while the bridge blends into the landscape; as Aguiló states, "when functionality intertwines with durability, the power of the solution prevails over any other consideration" [1]. The design with inclined struts reduces beam deflection. Furthermore, the sequence of struts balances the horizontal forces at each pier.

The inauguration of these bridges was scheduled for early 2020, but the event was postponed for public health reasons. The idea behind the footbridges is also to create landing stages to facilitate guided navigation along the middle reaches of the river, that is, approximately 110 km from the Puente de la Virgen to the Puente Vargas (Figure 15). This will be possible following extensive efforts to clean up, relocate, and construct embankments[2] or levees, widen the river channel, and create controlled floodplains to reduce the risk of flooding [5].

One of the objectives is for the bridges and piers to improve the quality of life for the city's residents, foster a positive relationship with the Bogotá River, and boost tourism in areas that are currently considered marginalized.

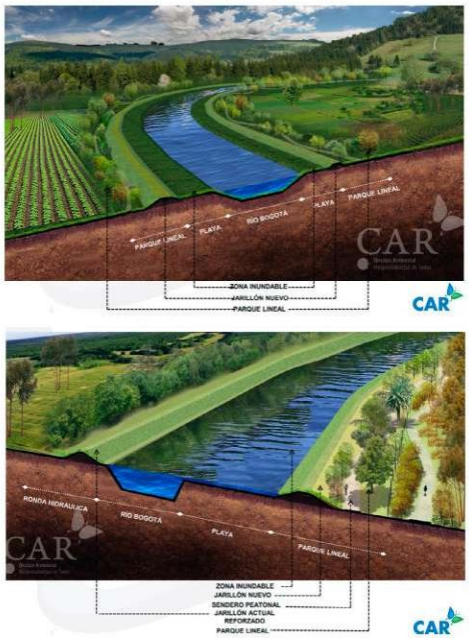


Figure 15. Flood zones and flooded areas. Source: CAR

3 Heritage and cultural value

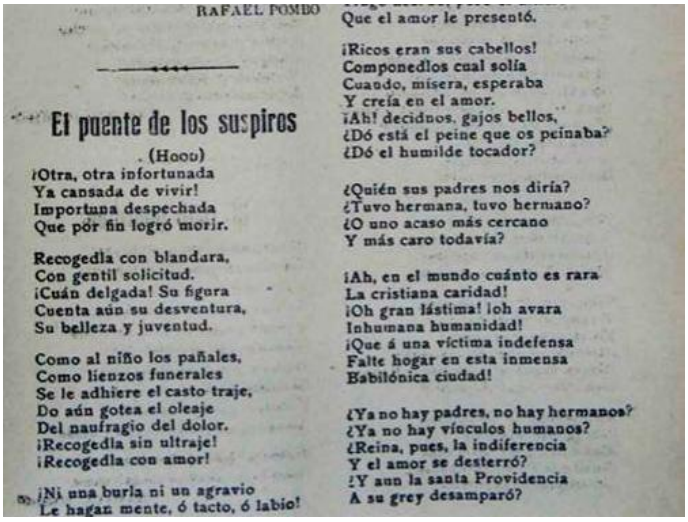
The bridges over the Bogotá River have not only shaped the landscape by shortening distances and improving transportation routes in the country's central region, but they have also contributed to the cultural history of the areas where they are located, given that "public works require a broad territorial context to acquire their full meaning, just as the territory cannot be understood without considering public works as the backbone of the landscape and the foundation of cultural and historical processes" [14].

One of the main challenges in the process of valuing bridges is to restore their significance to local identity [15]. In the case of two of the bridges, references to them can be found in the popular culture of the regions where they are located. The most notable example is the coat of arms of Chía, where the Puente del Común is depicted framing the coat of arms as if it were a crown, representing the heritage gem that is now a symbol of the municipality (Figure 16).



Figure 16. Coat of arms of Chía. Source: Chía Municipal Government [16]

The second example is the poem "Puente de los Suspiros" (1912), translated by Rafael Pombo (Figure 17), a Colombian poet, fabulist, and translator, who wrote about the Puente de los Suspiros and what it meant both to families and to the people who crossed it.



RAFAEL POMBO

El puente de los suspiros

(Hood)

¡Otra, otra infortunada
Ya cansada de vivir!
Importuna despechada
Que por fin logró morir.

Recogedla con blandura,
Con gentil solicitud.
¡Cuán delgada! Su figura
Cuenta aún su desventura,
Su belleza y juventud.

Como al niño los pañales,
Como lienzos funerales
Se le adhiere el casto traje,
Do aún gotea el oleaje
Del naufragio del dolor.
¡Recogedla sin ultraje!
¡Recogedla con amor!

¡Ni una burla ni un agravio
Le hagan mente, ó tacto, ó labio!

Que el amor le presentó.

¡Ricos eran sus cabellos!
Componedlos cual solía
Cuando, mísera, esperaba
Y creía en el amor.
¡Ah! decidnos, gajos bellos,
¿Dó está el peine que os peinaba?
¿Dó el humilde tocador?

¿Quién sus padres nos diría?
¿Tuvo hermana, tuvo hermano?
¿O uno acaso más cercano
Y más caro todavía?

¡Ah, en el mundo cuánto es rara
La cristiana caridad!
¡Oh gran lástima! ¡oh avara
Inhumana humanidad!
¡Que á una víctima indefensa
Falte hogar en esta inmensa
Babilónica ciudad!

¿Ya no hay padres, no hay hermanos?
¿Ya no hay vínculos humanos?
¿Reina, pues, la indiferencia
Y el amor se desterró?
¿Y aun la santa Providencia
A su grey desamparó?

Figure 17. Excerpt from Hood's poem "Puente de los Suspiros," translated by Rafael Pombo in 1912. Source: National Historical Archive in Bogotá

To recover or preserve the cultural heritage associated with the engineering works that have shaped the landscape in Colombia, it is necessary to create a framework that allows for the cataloging and definition of the importance of public works in order to foster research and public interest in them. Although there is currently no initiative in Colombia to begin cataloging and disseminating information about its public works, the first step can be taken by following the model of the pilot project "Valoración del Patrimonio Rural de la Obra Pública" (VAPROP), developed by the Miguel Foundation Aguiló, like the more recent G·O·ING (Great Engineering Works in Spain), was carried out under a collaboration agreement with the Association of Civil, Canal and Port Engineers [17], and which, in turn, is modeled after initiatives by the American Society of Civil Engineers (ASCE), such as the Civil Engineering Landmarks program, which has contributed to the recognition and preservation of the heritage of public works within society, raising awareness among engineers so that they become conscious of the historical significance of their profession [18].

The goal is to bring public works closer to citizens through initiatives that promote the identification, appreciation, and dissemination of civil engineering landmarks, incorporating them into regional tourism and cultural information. Some of these initiatives include the use of new information and communication technologies that explore new ways of viewing and understanding the heritage of public works and their relationship with the landscape and the region.

This initiative, which could begin with the analysis and evaluation of the three bridges presented in this article, would be complemented by other bridges to ensure a representative sample in geographical, chronological, and typological terms, and could be extrapolated to other geographical areas and other types of public works. Table 1 applies the six evaluation criteria used by the project G·O·ING for the three bridges analyzed across the Bogotá River: historical significance, scientific or technological quality, social or identity-related significance, uniqueness, documentary value, and landscape interest.

Therefore, the development of a mobile app and a website with a search engine that would allow for the geolocation of the structures and access to organized information (texts, current and historical photos, plans, reports, etc.) would enable a new cultural travel experience across the bridges over the Bogotá River.

Table 1. Summary table of the bridge evaluation

	Puente del Común	Puente Antonio Nariño / Puente de los Suspiros	Puente de Guadua
Historical importance	Very relevant	Significant	Significant
Scientific or technological quality	Little interest	Medium reference in collective memory	Very high reference in collective memory
Social importance	Very high reference in collective memory	High reference in collective memory	High reference in collective memory
Uniqueness	Unique	Slightly unique	Very unique
Documentary capacity	Preserves vestiges from different periods	Preserves vestiges from different periods	Preserved according to the original design
Landscape interest	Does not affect the atmosphere of the site	Does not affect the atmosphere of the site	Driver of the atmosphere of the place

4 Conclusion

This article compiles, organizes, and correlates documentation on three bridges over the Bogotá River, with the aim of tracing the evolution of the river landscape and highlighting the importance of the conservation, research, and

dissemination of these public works. History demonstrates how these bridges have been a determining factor in many aspects of urban growth, particularly for commercial transportation and economic development. By enabling the transport of goods between various municipalities in the country's central region, the major cities were able to connect with one another, thereby diversifying trade and shortening distances. The bridges helped cities grow more rapidly, but their structures soon became inadequate, making it necessary to build bridges better suited to the new needs.

Beyond their technological significance, these bridges also contribute social, cultural, and identity-related value to the regions where they are located, as they were the first stable means of communication in the territory. That is why their cataloging and promotion are important to prevent them from being forgotten or even overlooked.

A comparison of the three bridges reveals how structural designs and the use of materials have evolved over time to better account for the conditions of the river and the surrounding landscape. Initially, as with the Común Bridge, wide piers with buttresses were used to counteract thrusts, support the span, and reduce the risk of collapse. However, this resulted in bridges that were visually heavy and ill-suited to river floods. Over time, masonry was phased out as a construction material, and steel made it possible to build lighter bridges with larger spans without the need for piers within the riverbed, as is the case with the Antonio Nariño Bridge. Finally, beam bridges such as the Guadua Bridges offer great versatility; this, combined with their technological simplicity, makes this type of bridge an attractive alternative for spanning small and medium-sized spans in a sustainable manner, while integrating more naturally into the landscape.

The evolution of bridges over the Bogotá River demonstrates that it is not necessary to design large structures to withstand natural forces; on the contrary, it is important to build bridges that adapt to the river's changes, are in harmony with the terrain, and account for the interactions among all elements to foster a positive relationship with the Bogotá River and future urban developments. From its oldest bridges to the most recent ones, one can observe historical and technological evolution, and the aim is to recover the legacy of these bridges to raise awareness of the importance of their maintenance and rehabilitation as a cultural asset and part of the built heritage of the Bogotá River landscape.

Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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Note

[1] Physical and mechanical properties of Guadua angustifolia. Tensile strength: 503 MPa. Parallel shear strength (fv-max): 7.1 MPa to 7.8 MPa. Maximum strength (fcmáx): from 37.6 MPa to 42.1 MPa. Elastic modulus (Ec): from 14.9 GPa to 20 GPa. MOR bending strength: 86.9 MPa. Tensile strength (ftmáx): 187.7 MPa [12].

[2] In Colombia, jarillones are civil works consisting of barriers built from material extracted from the same river or earth, parallel to the riverbank, intended to channel water or protect river banks from floods.