

## Article

# Living with the River: The Role of Bridges in Shaping Valencia's Urban Form Until 1957

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## Abstract

This study offers a novel perspective on the role of bridges as agents of urban transformation by examining their influence on the morphological development of Valencia (Spain) from the 13th century to the catastrophic flood of 1957. Traditionally viewed as mere connective infrastructure, bridges are reframed here as key structuring elements that shaped urban expansion, resilience strategies, and socio-spatial dynamics. Through an innovative classification based on *stages of bridges*, the research integrates historical cartography, cadastral data, and Geographic Information Systems (GIS) to trace how successive waves of bridge construction aligned with distinct socio-political, environmental, and technological contexts. The study demonstrates that bridge development not only facilitated territorial connectivity but also directed urban growth patterns, enabled functional zoning, and responded adaptively to flood risk and demographic pressure. The case of Valencia is particularly significant in light of contemporary challenges in climate adaptation and sustainable urban planning. By unveiling bridges as morphological and functional drivers of urban form, this research offers transferable insights for cities worldwide grappling with the legacy of riverine geographies and the pressures of resilient transformation.



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**Keywords:** bridge functionality; urban development; urban morphological

## 1. Introduction

In every city subjugated to a riverbed, bridges, beyond being part of a road network, become powerful tools for the generation and modification of urban spaces. They are backbone axes of growth and development in which technical, urban, social, and economic aspects converge, leading to a practical solution that, in turn, as Büller said [1], *has an impact on the social urban space*. Using the poetic term of the engineer Juan José Arenas, *they are paths in the air* that allow us to live an experience that unites us with its origin, its past, its present, and its future [2].

The relationship between rivers and urban environments dates back to ancient times. Many major cities were founded along rivers and estuaries, strategically taking advantage of their resources for navigation, water supply, hydropower, and other purposes. Although this fact may seem self-evident, the role of rivers—and water more broadly—has often been underestimated in the study of urban history and theory [3].

Over the past decade, interest in the interconnection between rivers and urban morphology has grown significantly. Recent studies highlight how hydrological patterns

influence not only a city's spatial development but also its potential for urban regeneration. Case studies from cities such as Barranquilla, Monteria, and Honda in Colombia; Banjarmasin in Indonesia; and Istanbul in Turkey illustrate this evolving perspective [4–9].

This growing body of evidence underscores the imperative to further investigate the structural relationship between river channels and the infrastructure developed along their course. These elements serve as organizing frameworks that guide and shape the urban form, ultimately influencing the configuration and identity of the city itself.

Infrastructures that favours the “rediscovery of water”—a term used by Göbel [10]—refer to a relatively recent phenomenon in Europe, where riverbanks were absent from urban images for centuries. Thanks to the backbone of these infrastructures in shaping the urban fabric, as well as an urbanization process driven by public administrations, they have significantly contributed to contemporary urban morphology. Similarities to the city of Valencia are found in cities such as Munich, which would not see its south-eastern area developed after the riverbed until well into the 19th century, creating areas such as *Au-Haidhausen*, *Oberföhring*, or *Untergiesing-Harlaching*; Amsterdam, of similar size, did not begin its urban development on the northern bank of the Amstel River until well into the 19th century.

Another aspect to consider regarding bridges is mobility. Various studies have analysed the impact that bridge construction has on urban patterns, with vehicular bridges having the greatest influence [11,12].

In Valencia, understanding the history of its bridges is essential to grasping the city's core identity and the unique process of urban evolution and resilience that has shaped its morphology. Due to its geographic location and the topography of the surrounding terrain, the region has a unique climate, characterized by significant variability and a high propensity for the formation of cold drops, phenomena that can generate intense rainfall in short periods of time [13,14]. The consequence of this particular characteristic is the severe flooding that has occurred practically since its foundation. A city linked to the Turia River, its riverbed is rather sparse in its normal state, becoming virulent in times of heavy rain, and bridges have been subjected to the consequences of flooding.

However, cities are exposed to various factors of transformation, such as natural disasters or human actions, which create paradoxes in urban organization and hinder the legibility of inherited morphological elements within the contemporary urban fabric [15]. To this end, various administrations are implementing measures, such as the *Amsterdam Rainproof Plan*, created in 2014 by the city of Amsterdam, to manage the risks posed by a new environmental hazard threatening European cities: pluvial flooding, known locally as downpours [16].

The tragic flood that hit Valencia in 1957 was so severe that it forced the state government to take extraordinary emergency measures to try to permanently protect the city from these catastrophic events. The consequence was the implementation of the well-known *Plan Sur* project, which consisted of constructing a new channel through the southern lands of the city, diverting the river's flow.

This study employs a mixed-methods approach, combining qualitative analysis—through an in-depth historical investigation of the motivations behind bridge construction, enabling their classification into distinct *stages of bridges*—with a morphometric analysis—offering a contemporary quantitative perspective on urban morphology [17–19]. In the quantitative component, a Geographic Information System (GIS) is utilized—a consistent and robust methodological tool that enhances the understanding of current urban–riverine relationships. This integration of methods has proven effective in prior studies conducted in cities such as London, Paris, and others in the South of England, which advocate for GIS-

based historical urban cartography to enable planning analysis with a degree of flexibility, accuracy, and responsiveness often lacking in traditional planning systems [20–22].

In the specific case of Valencia, GIS has already been employed in notable studies. For instance, Portugués-Mollá's research [23] enabled the georeferencing of the hydrographic dynamics of the 1957 flood, the characterization of the urban stretch of the Turia River, and the interpretation of hydrogeomorphic processes. Similarly, the study by López González [24] revealed how the landscape of Valencia's historic center has been transformed over time, shaped by the influence of various cultures since its founding by the Romans.

In the present case, the application of GIS has made it possible to evaluate the consequences of bridge construction on the evolution of Valencia's urban fabric over the studied period, making this a distinctive contribution within the field.

In this last aspect, a Geographic Information System is used to evaluate the consequences that the construction of these bridges has had on the evolution of the urban fabric.

Therefore, the main objective of this document lies in questioning how bridges have conditioned the morphology and urban development of the city between the 13th century and the flood of 1957. It corresponds to a period in which the city ceased to belong to an island—*first stage of bridges*—and was subordinated to a river channel until the flood of 1957, which meant another drastic change in the relationship with the river. In this research, it is essential to analyse this temporal space from the perspective of its bridges, in which the city begins and ends in two completely opposite scenarios. Understanding its growth mechanism translates into obtaining data for developing any future management system. And the results demonstrate not only the influence of bridges on the city's current morphology, but also their importance for its survival.




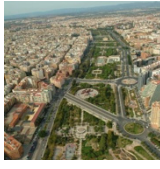
## 2. Materials and Methods

The broad temporal perspective of the research makes it necessary to carry out a temporal delimitation of bridges in different periods that we will associate with stages. With a scope that spans from the city's origins to the present day, the research is structured into what is known as the *bridges stages* which allows for the dissection of these infrastructures and their function at each given time. A temporal limitation marked by an event of no return that has transformed the city and the way bridges are built. These stages are as follows (Table 1):

1. *First stage*: It dates from the period between the city's founding in 138 BC and the 13th century, when it ceased to belong to an island. This first stage survived with three bridges that overlapped, two by two, superimposing two very distinct urban layouts: the organized grid-like urbanism of the Roman period and the narrow winding streets of the Muslim era.
2. *Second stage*: It corresponds to a time frame between the 13th and early 19th centuries, when the city faced the Turia River for the first time on its north side. It is notable for the creation of stone bridges, all of them as a result of tragic events caused by the strong floods of the Turia River. The establishment of the Christian era encouraged the generation of the first regulations regarding urban planning [25], and the city doubled its size and, with it, the generation of new bridges.
3. *Third stage*: It spans the period from the 19th century to the flood of 1957. This period begins with a major global milestone: *the industrial revolution*. One of the greatest social, economic, and intellectual transformations in history, which, in the purely constructive aspect, led to new processes and uses of materials that modified, in the specific case of bridges, their appearance and construction methodology. This period ends with the great flood that hit Valencia in 1957, a sudden event that had a

- significant social and governmental impact, leading to the drafting of an emergency plan that resulted in one of the greatest metamorphoses the city had ever undergone.
4. *Fourth stage*: It spans the period from the 1957 flood to the present day, including a period of transformation of the old riverbed into a large park. Population growth was encouraged on the northern bank of the Turia River, resulting in a demographic balance on both banks. The construction of new bridges no longer served the function of safeguarding the riverbed as their predecessors had, and existing bridges underwent significant horizontal transformations as a result of adapting to new mobility plans.

**Table 1.** Stages of bridges.

Stages	Period	Era	Means of Transport	Urban Area	Population	% Relative Population Growth	% Absolute Population Grow
Stage 1 	138 BC–13th century (1.162 years)	Roman Visigothic Islamic	Horse-Drawn Carriage	Roman wall: 10 Ha  Islamic wall: 49 Ha	Roman: 500 pop  Islamic: 15.000 pop	3.000%	3.000%
Stage 2 	13th century–19th century (600 years)	Christian	Carriage	Christian wall: 142 Ha	Early 14th century: 27.940 pop  End 18th century: 215.687 pop	772%	43.137%
Stage 3 	19th century–Flood 1957 (158 years)	Industrial Revolution	Vehicle Railway	13.465 Ha	Early 19th century: 215.687 pop  Year 1957: 550.000 pop	255%	110.000%
Stage 4 	Flood 1957–the present (67 years)	Globalization	Vehicle Railway Bicycle	13.465 Ha	Year 1957: 550.000 pop  Year 2024: 844.424 pop	53.53%	168.785%

As part of the ongoing research, the first stage of bridges, which corresponds to the origin of the city in 138 BC until the 13th century, has already been published in the article *Bridges over the River Turia: Genesis of the Urban History of Valencia* [26]. As a continuation, this document focuses on the research of the second and third stages.

The methodological approach begins with an analysis of the motivations behind the construction of new bridges and their impact on the city at each stage of development. Simultaneously, bridges from the second stage are monitored to assess their interaction with the third stage and their ongoing influence on the processes of urban growth and transformation. The methodology applied at each stage includes the following components:

- Bibliographic review of the evolution of the city and the impact of its bridges.

- A cartographic analysis was performed using historical maps and aerial photographs and interpret the spatial influence of the bridges on the morphology of the urban fabric.
- Examination of the city's socioeconomic characteristics, including demographic and economic structure.
- Analysis of the evolution of urban planning policies and instruments.
- Consideration of the impact of significant flooding.

In a second phase, the study employs a *growth typology methodology* [27] to analyze the forms of urban expansion associated with the second stage of bridge construction, distinguishing between the following processes:

- *Growth by annexation*: Through administrative integration, an independent urban center is incorporated into a larger one, usually due to proximity or strategic growth policies. In some cases, mutual interests (e.g., the management of infrastructure such as ports or airports) foster such integration.
- *Growth by connection*: This occurs when two adjacent urban centers merge as a result of their natural expansion.
- *Growth by extension*: The controlled and planned external growth typical of a single urban center.

To examine the relationship between bridge construction and urban growth, current administrative districts have been incorporated into the analysis (Figure 1). This framework allows for the analysis of the spatial location of bridges in relation to the city's district distribution, as well as for tracing their sequential development throughout the different urban phases. For clarity, a dual numbering system is used to reference each bridge: the first digit corresponds to the stage to which it belongs and the second indicates its relative position from upstream to downstream.



**Figure 1.** Location scheme of bridges in relation to the current districts of the city of Valencia.

Third and finally, the functional classification of the bridges has been established. To this end, detailed urban-scale data—such as the Real Estate Census—has been analyzed to determine the role of each bridge within the city and its influence on the surrounding urban fabric. Three functional types have been distinguished:

- *Connection bridges*: These facilitate links with the surrounding area and the rest of the territory and are key to establishing the main communication routes.
- *Urbanizing bridges*: These promote urban expansion, especially during periods of strong population growth.
- *Flow bridges*: These bridges, once the city is full, are necessary to facilitate flow between riverbanks, obscuring the existence of a depression that needs to be crossed.

In conclusion, the data obtained are incorporated into a Geographic Information System (GIS), which allows for the creation of a map of the evolution of the city's urban fabric based on the construction of its bridges. This analysis makes it possible to identify the spatial characteristics generated by these infrastructures, which can be interpreted as potential urban phenomena.

### 3. Results

#### 3.1. Bridges of the City of Valencia from the 13th to the 19th Century Subsection

##### 3.1.1. Bridge Generation in the Second Stage

The beginning of the Christian era with the reconquest by Jaime I in 1238 marked one of the major urban planning changes that the city of Valencia has undergone to this day. The arrival of a new era meant the establishment of a new way of thinking and doing. One of the first actions undertaken was the gradual destruction of the Muslim wall in order to expand the city's urban structure. The construction of the new Christian wall, and with it new bridges, was governed by three factors: military interests, protection against the continuous rises in the Turia River, and population growth. This wall, 4 km long and with 14 gates, would occupy a habitable area of 142 hectares.

But the constant rise of the Turia River and its effects were the main reason for the gradual transformation of the city's appearance. According to the book *Las Riadas del Turia (1321–1949)*, a total of 45 periods of rising water levels were recorded in this stage [28].

The great flood of 1358 marked a turning point in the city's growth. The flood, in addition to structural damage, claimed the lives of more than 500 people. This event triggered government alerts, and King *Pedro IV de Aragón* himself encouraged a significant financial injection to rebuild the city and strengthen its infrastructure. Thus, in the 14th century, Valencia became the nerve center of the eastern part of the peninsula, and its port became the most important in Mediterranean Hispania. For the proper economic management and procedure for reconstruction, "*ordinances*" were drafted, which constituted the first regulations in the history of Valencia for territorial planning. The *Fábrica de Murs y Valls* was founded in 1358, with the walled enclosure being one of its first projects, which lasted from the mid-14th century to the 15th century [25].

Another flood in 1589 led to the creation of another institution, the *Fábrica Nova dita del Riu* in 1590, in response to the overflow of work to which the *Fábrica de Murs y Valls* was subjected [29]. Among the functions of this last institution were to be in charge of everything related to the Turia River: construction, reconstruction, and maintenance of bridges; construction of parapets to enclose and align the riverbed; dredging of the canal, etc.






As for infrastructures of passages over the riverbed, at the beginning of the 13th century, there were two bridges: one made of ashlar and the other of wood. Nevertheless, well into the century, two more were added. Due to their fragile construction, these

four structures were constantly being rebuilt to cope with the rising waters of the Turia River [29–36].

However, it was ultimately institutional action—driven by social pressure and the devastation caused by repeated floods at key crossing points—that led to the construction of stronger more durable bridges. This marked the beginning of the era of stone bridge construction in the city of Valencia.

Of all the floods, the most notable were the one in 1358, which led to the new construction of the *Trinidad Bridge*; the one in 1517, which triggered the construction of the *Serranos Bridge*; and the one in 1589, which prompted the new construction of the *Del Mar Bridge*, the *Real Bridge*, and the *San José Bridge*. All of them remain in existence today (Table 2) (Appendix A).

**Table 2.** Stone bridges.

Bridge	Characteristics	Flood that Motivated Its Construction	Year of Completion of Construction	Construction Time from the Previous One	Image
2.1 San José Bridge	148 m span and 5.96 m wide with 13 segmental vaults of 8.8 m span, the highest of the 5 bridges, with triangular cutwaters.	1589	1608	9 years	
2.2 Serranos Bridge	159.50 m long and 10.90 m wide, with nine segmental vaults spanning 14.60 m with triangular breakwaters. Access ramp to the riverbed.	1517	1518	111 years	
2.3 Trinidad Bridge	158 m long and 10.5 m wide, with 10 pointed vaults spanning 13.6 m on 2.5 m wide piers with triangular cutwaters topped with stepped caps. Two staircases lead down to the riverbed.	1358	1407	319 years	
2.4 Del Real Bridge	170 m long and 10.5 m wide, with nine segmental vaults with a span of 13.2 m over triangular breakwaters and a pier thickness of 3 m. Maximum height above ground level is 7.6 m	1589	1599	3 years	
2.5 Del Mar Bridge	160 m long and 8.35 m wide, with 10 pointed vaults with a span of 15.5 m over triangular breakwaters and a pier thickness of 3 m. Maximum ground level height 8 m.	1589	1596	78 years	

An examination of Table 2 reveals a striking historical gap: more than 300 years elapsed between the collapse of the Al-Qantara Bridge during the 1088 flood—a structure classified within the *first stage of bridge* development—and the construction of the next bridge, which inaugurates the second stage addressed in this study. Remarkably, the five bridges attributed to this second stage were built over a span of just 200 years, with four of them

constructed within a mere 90 years. This accelerated pace of infrastructure development underscores the growing strategic and urban importance of Valencia during its integration into the Crown of Aragon and later under the rule of the Catholic Monarchs [37,38].

### 3.1.2. Influence of the Second Stage Bridges on the Urban Fabric

The five bridges built during this second phase have demonstrated their primary requirement during construction, which was durability, as all remain standing and in use. Their durability not only attests to their structural resilience but also highlights their lasting relevance within the city's evolving urban fabric. They had the effect of opening and connecting the city with the rest of the territory. They facilitated access to the population centers on the other side of the river, as well as the creation and consolidation of the first communication routes with the north and west of the country. Some of them remain in use today. Only the *Trinidad Bridge* (2.3) and the *Serranos Bridge* (2.2) had specific settlements adjacent to the road after crossing the riverbed, whose main function was accommodation and trade.

An analysis of the 1695 map of the city of Valencia and its surroundings, attributed to the Jesuit Francisco Antonio Cassaus (Figure 2), allows us to identify the locations and rural estates that were connected by the existing communication routes [38]. The bridges were strategically located, providing links to the towns in the region and communicating with the main source of supplies, the port. The roads created a radial network that connected the main towns in the area, allowing access to the religious buildings and farmhouses in the orchard.

An in-depth examination of the communication routes established by each bridge reveals the following:

- The San José Bridge of 1608 (2.1), which provided access to the Llano de Zaidia, generated two roads: one parallel to the riverbed that connected to the town of Campanar, and another that provided access to the towns of Paterna and Burjasot.
- The Serranos Bridge of 1518 (2.2), also generated two other marked roads: one to the town of Albalat del Sorells and another to the northwest, connecting to the Puertos de Morella region, 100 km from Valencia. The latter branched off in its first section to access the town of Rocafort. The continuation of these main arteries would connect with the Kingdom of Aragon and the central area of the Crown of Castile.
- The Trinidad Bridge (1407) (2.3), which connected directly to the Convent of Trinidad, split into two paths: one headed toward the town of Alboraya, while the other branched off toward the monasteries and farmsteads located in the north-eastern orchards of the territory.
- Del Real Bridge 1599 (2.4) allowed connection with the Palacio del Real located on the north bank of the river. The extension of its route ended at the Monastery of Our Lady of the Angels, in present-day Cabañal.
- Del Mar Bridge 1596 (2.5), connected with the Port of Valencia, generating the main commercial route of the city.

Over time, settlements along these communication routes were consolidated on the left bank of the river, modifying the urban form of the city of Valencia. These settlements were most prominent around the *Trinidad Bridge* (2.3) and the *Serranos Bridge* (2.2), as can be seen in the “Carta di controni de Valenza, 1812” (Figure 3). *Growth by extension* would begin, especially with the construction of the *Serranos Bridge* (2.2), which became one of the main communication routes of the time, facilitating access to the Kingdom of Aragon and Castile. At the same time, *growth by connection* can be seen from the route generated by the *Puente de San José* (2.1), which boosted the development of Marxalenes. This fact

would define a first organic urban form, with no further planning than the construction of bridges [39].

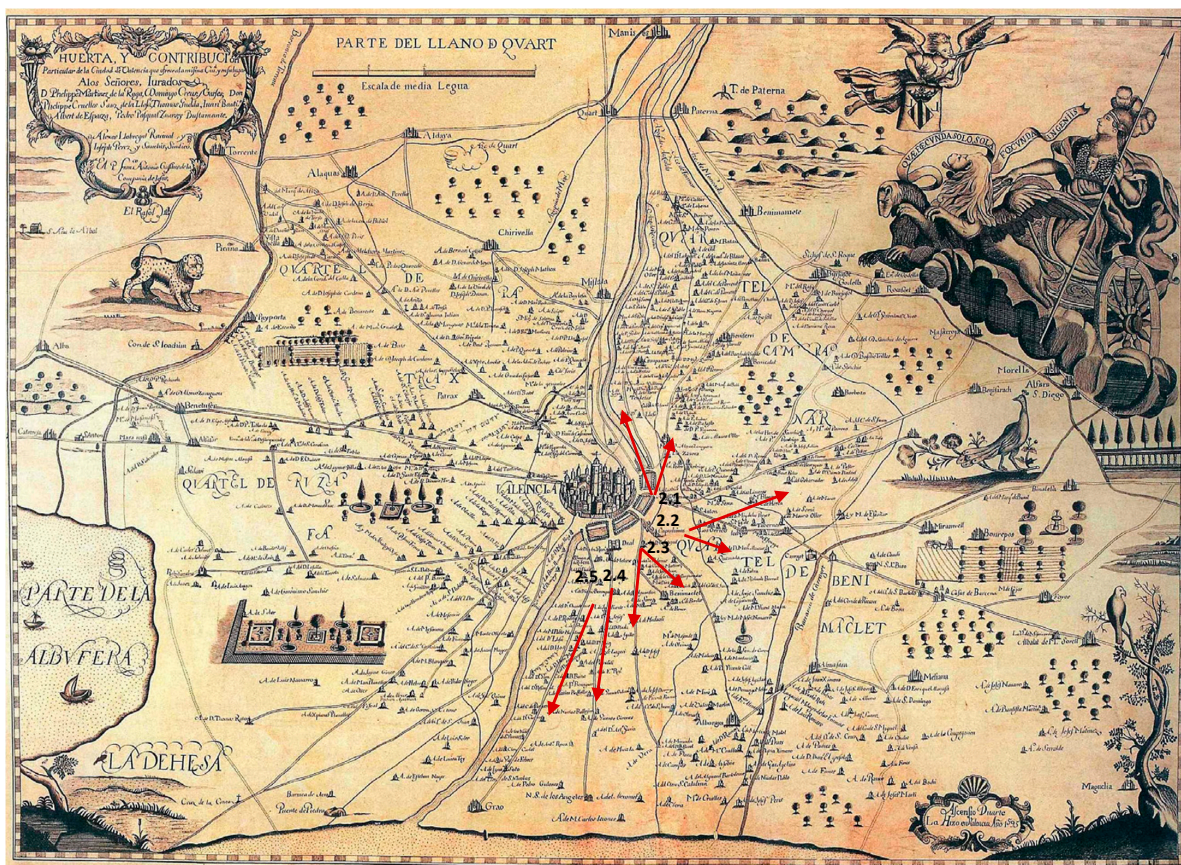


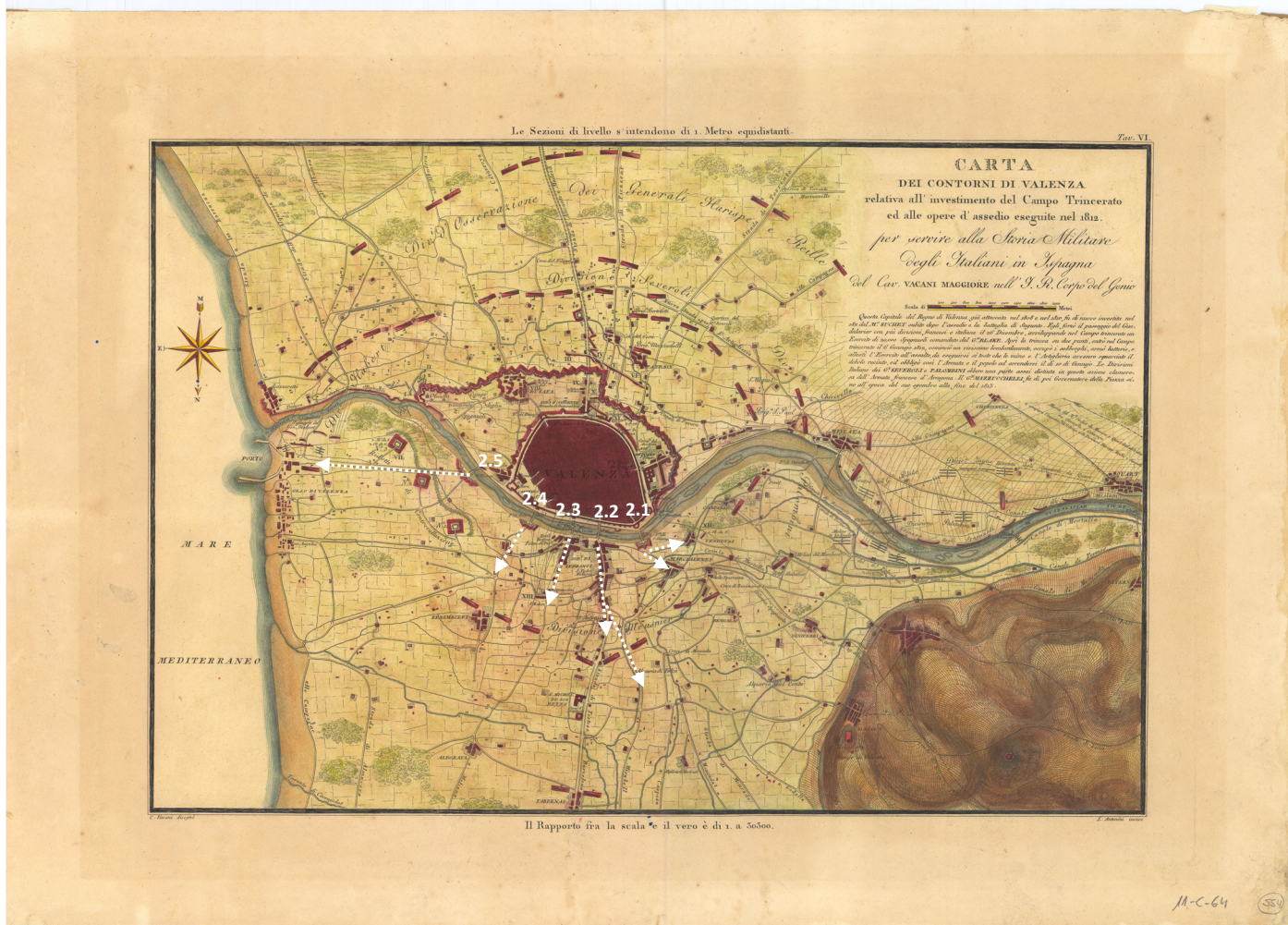
Figure 2. Cassaus, F.A. (1694–1695). Huerta and private contribution of the city of Valencia.

### 3.2. Bridges of the City of Valencia from the 19th Century to the Flood of 1957

#### 3.2.1. Bridge Generation in the Third Stage

Once again, a milestone would mark the change of stage in the generation of bridges. The industrial revolution (IR) that emerged in the United Kingdom represented a transformation at all levels, where technological progress and innovation became the main drivers of economic growth [40–43]. Analysing the term revolution implies those transformations that present three essential characteristics: they occur in a comparatively short time; they profoundly transform economic, political, social, or cultural structures; and they imply a *point of no return* to the previous situation [44].

It was precisely during this period that the city of Valencia experienced one of its greatest transformations, the result of a process of economic growth and a buoyant population increases driven by the relocation of the rural population to the city. The approval of the expansion plans of 1887 and 1912 was key to its new urban form. These corresponded to urban projects that sought to expand the city beyond its medieval walls, especially after their demolition in 1865. These defined new alignments and subdivisions on the outskirts of the city with a model of wide avenues and square blocks [45,46]. This was compounded by the arrival of new materials and revolutionary construction processes that fostered the emergence of diverse modes of transport. During the expansion of the railway in the 1830s and 1840s, numerous bridges were needed to cross rivers and estuaries and create a viable network.








**Figure 3.** Carta dei contorni de Valenza relativa all’investimento del campo Trincerato es alle opere dássedio eseguite nel 1812 Cartographic Archive of Geographic Studies of the Army Geographic Center.

Faced with this situation, Valencia found itself forced to build new bridges. This was no easy task, considering that, just a century earlier, the city was an urban core entrenched within a walled enclosure bordered by roads and scattered population centers. Generating a new urban fabric that would connect with the existing one while maintaining the main communication routes could not have been an easy task. An example of this was the work carried out by Casimiro Meseguer, Director of Roads for the City Council, between 1874 and 1914. His signature achievement was the installation of metal rails on roads to improve the new capacity for traffic loads resulting from the movement of goods (4 tons per wheel). This approach eventually extended to many of Valencia’s bridges and roads and was adopted by various European cities. Among his projects was the renovation and connection of the Paseo de la Alameda with the new Camino del Grao, where the *Del Mar Bridge* (2.5) concentrated all freight traffic heading toward the port, bridge maintenance and the preliminary design for the widening of the *Del Mar Bridge* (2.5) in 1890, and even the pavement composition works in 1912 [47].

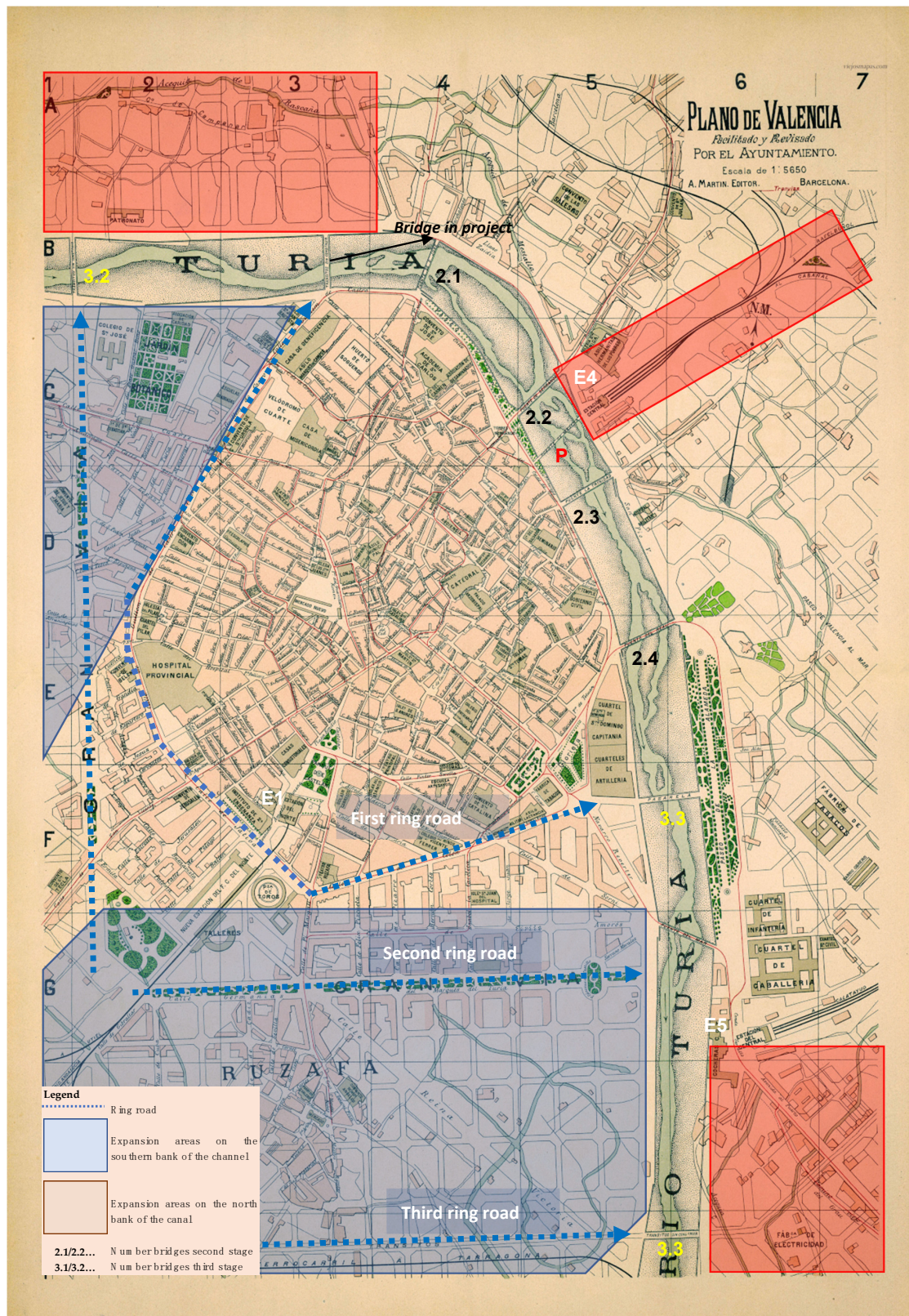
The following Table 3 shows a histogram of the bridges built in the third stage [48]. In this stage, the use of new materials and innovative construction processes differed significantly from their predecessors, leading to a distinct evolution in bridge design and execution (Appendix B).

**Table 3.** Third stage bridges.

Bridge	Characteristics	Author	Year of Inauguration	Construction Time from the Previous One	Image
3.1 Campanar Bridge	170 m long and 10.5 m wide, with nine segmental vaults with a span of 13.2 m over triangular breakwaters and a pier thickness of 3 m. Maximum height above ground level is 7.6 m.	Ing. Arturo Piera	1937	4 years	
3.2 La Pasarela Bridge	The first bridge built with concrete; 166 m long, with a deck 8.47 m wide and eight spans of 19.25 m each.	Ing. José Alubán	1909	301 years	
3.3 Aragón Bridge	170 m long, the vaults have 6 spans of lowered arches with a span of 25 m, each formed by 14 concrete arch trusses on which the uprights supporting the 30 m wide deck rest.	Ings. Arturo Monfort & José Bruguera & Gabriel Leyda	1933	1 year	
3.4 Ángel Custodio Bridge	150 m long after its split, it has a width of 31.6 m, six central sections of 20 m span made with straight concrete beams with a solid core resting on ashlar masonry with polygonal breakwaters and two decorative abutments at the ends with drains formed by semicircular vaults of 5 m in diameter.	Ings. Arturo Piera & Juan Fornés	1940	3 years	
3.5 Astilleros Bridge	175 m long and 25 m wide. It has two access ramps and five straight sections, each 23 m long, between the pier axes and four straight sections, each 9.45 m long, between the support axes, separated from the previous sections by abutment piers lightened in the center.	Ings. Federico Gómez Membrillera & Luis Dicenta Vera	1932	23 years	

### 3.2.2. Influence of the Third Stage Bridges on the Urban Fabric

The gradual demolition of the medieval wall, as determined by the *Expansion Plans of 1877 and 1912*, generated initial growth through expansion and annexation. This *growth by extension* occurred on its southern and western margins, creating an organized structure with grid-like blocks that practically doubled the area of the existing one. On the other hand, *growth by annexation* resulted from the integration of the town of Ruzafa on its southern margin (Figure 4).

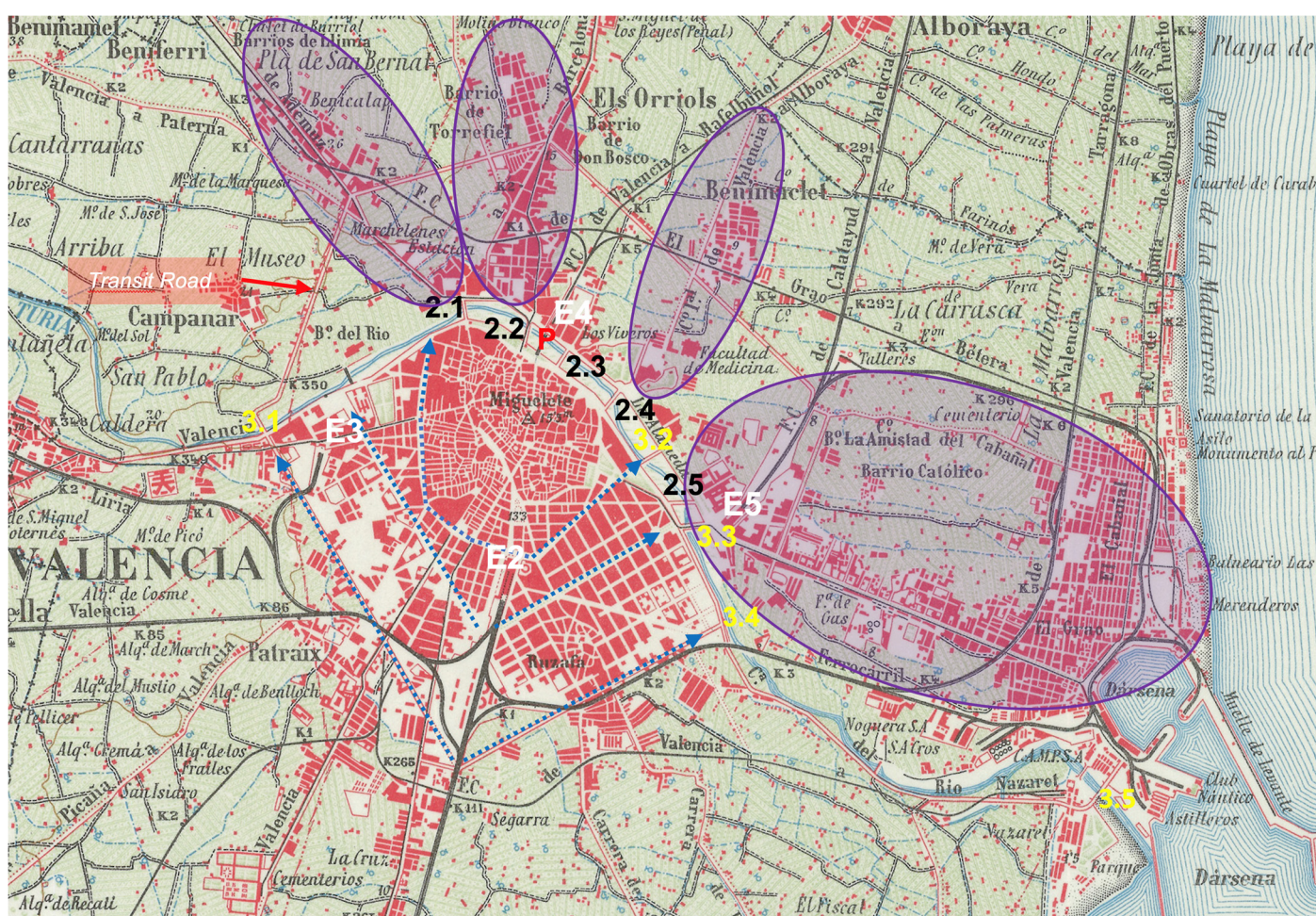


**Figure 4.** Growth process and generation of ring roads based on the cadastral data of Valencia, 1918 (Urban Planning Department, Valencia City Council [49]).

To connect this new structure with the existing one, perimeter streets were created, delimiting the old wall as a first ring road embracing the original urban space. This first ring road would be made up of the current Guillem de Castro Street, Játiva Street, and Colón

Street. From this ring road, the new grid extension of blocks would be projected, which would be bound again by the second ring road, this time with a perpendicular morphology and in accordance with the generated grid. Thus, the *Grandes Vías* (Great Roads) were created. From these, further expansion would repeat the same structure, creating the third parallel ring road outwards, which would correspond to the so-called Camino de Tránsitos (Transit Road). Its layout along the south side of the riverbed would correspond to the current Avenida Pérez Galdós, Avenida Giorgeta, and Avenida Peris y Valero.

These three ring roads accommodated the main traffic flows, allowing access to any point in the city and relieving congestion in the more established urban centers. In all cases, these ring roads were limited by the riverbed (Figure 5). It was precisely this direct confrontation with the riverbed that necessitated the construction of bridges to facilitate, on the one hand, the connection between the new growth areas and the rest of the territory and, on the other, prevent the possible collapse of the second stage bridges, which served as the only infrastructure connecting them to the other side of the river.



**Figure 5.** Growth process and generation of ring roads based on the Valencia cadastral database 1944 (General Directorate of the Geographic and Cadastral Institute, 1st edition, 1944. Cartography—National Geographic Institute).

However, the existing bridges inherited from the second stage continued to influence the growth of the existing urban fabric (Figure 5). This is the case of the *Del Mar Bridge* (2.5), where an urbanized area was generated on the margins of the access road to Grao, causing, over time, *growth through annexation* as the population of Grao was subjugated. On the other hand, at the northern end behind the riverbed, these growths by connection were more developed in the communication routes of *Del Real Bridge* (2.4), the *Serranos Bridge* (2.2), and the *San José Bridge* (2.1), where the tram (1889), an emerging public transport system, helped to promote this type of growth by increasing the volume of urban area on the margins of the road.

During this process of growth and the need for infrastructure to protect the riverbed, the arrival of the railway to the city in 1852 (Figures 4 and 5) played an important role in generating and refurbishing bridges.

The first railway station was the *Del Norte old Station* (1852) (E1-Figure 4), located near the current *Plaza del Ayuntamiento*, within the city walls. Its original route served as a link to the *Puerto del Grao*, which eased traffic congestion by facilitating the transport of goods, especially agricultural products. This station was demolished and replaced by the current *Del Norte Station* (1917) (E2-Figure 5), built just 200 m from its predecessor outside the city walls. The track layout (common to both stations) extends from the first ring road, extending diagonally toward the next two ring roads. It would be the only station located in the city center. In the area of the Valencian Railways, specifically on Quart Street, the *Valencia-Quart Station* (1889) (E3-Figure 5) was built. It served the north-western part of the territory, connecting Manises, Villamarchante, and Benaguasil, terminating in the town of Llíria. It was connected to the *Del Norte Station* via tram. Taking advantage of the initial stage of development on the other side of the river, two more stations were built. The first was the *Santa Mónica Station* (1892) (E4-Figures 4 and 5), belonging to the Valencia Tram Company, connecting the city of Valencia with Rafaelbunyol. Its location, between the *Trinidad Bridge* (2.3) and the *Serranos Bridge* (2.2), necessitated the rapid construction of a pedestrian walkway, which was named “Pont de Fusta” (Fusta Bridge) for its first construction entirely made of wood. A rudimentary pedestrian crossing was rebuilt repeatedly due to its temporary structure and did not take on the status of a bridge until its new construction in 2012 (shown as P in Figures 4 and 5).

The second station, located across the riverbed on its northeast side, was the *Valencia-Alameda Station* (1902) (E5-Figures 4 and 5). It was known as Aragón Station because it belonged to the Central Aragon Railway Company and served the region. Located at the end of Avenida Alameda, it served as a link to the northern part of the country, providing access to the towns of Sagunto, Segorbe, Teruel, Calatayud, and Zaragoza (Figure 6).

During the third stage, priority was given to the third ring road, known as *Transit Road*, which functioned as the primary corridor for heavy traffic. Consequently, with few exceptions prompted by specific emergencies, new bridges were constructed from the periphery inward, beginning at this outer ring and progressing toward the urban core.

With the exception of the *Astilleros Bridge* (3.5), all the structures from this period were located within a 4.5 km stretch of the riverbed. This spatial concentration reflects the intensity of an evolutionary process fuelled by industrialization, especially considering that 50% of the bridges were constructed within just three decades (Figure 7, Table 4).



(a) "Del Norte old Station" 1852 (E1)



(b) "Del Norte Station" 1917 (E2)



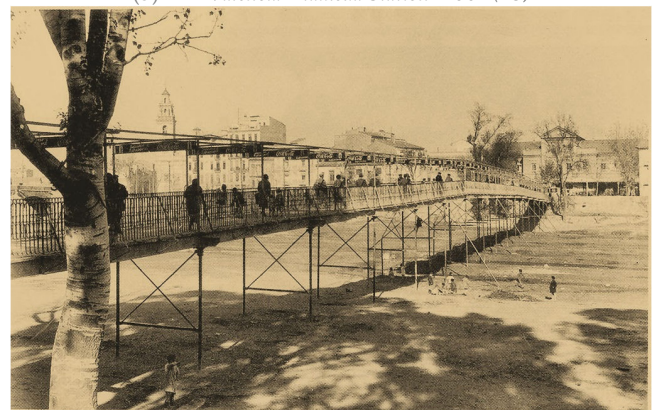
(c) "Valencia-Quart Station" 1889 (Photo Vicente Ferrer) (E3)



(d) "Valencia-Alameda Station" 1902 (E5)



(e) "Santa Mónica Station" 1892 (E4)



(f) "Pont de Fusta" access to Santa Mónica Station

Figure 6. Year 1852, the arrival of the railway to the city of Valencia. First stations.

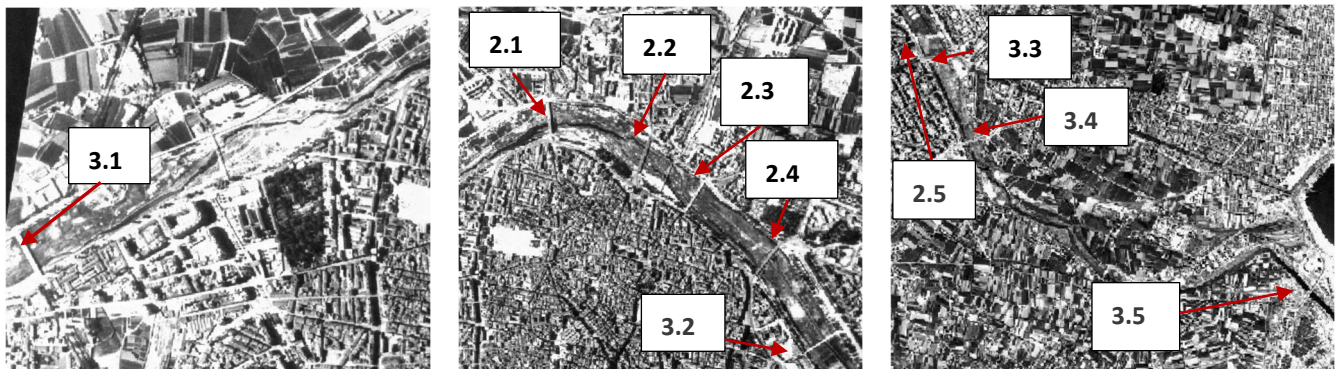
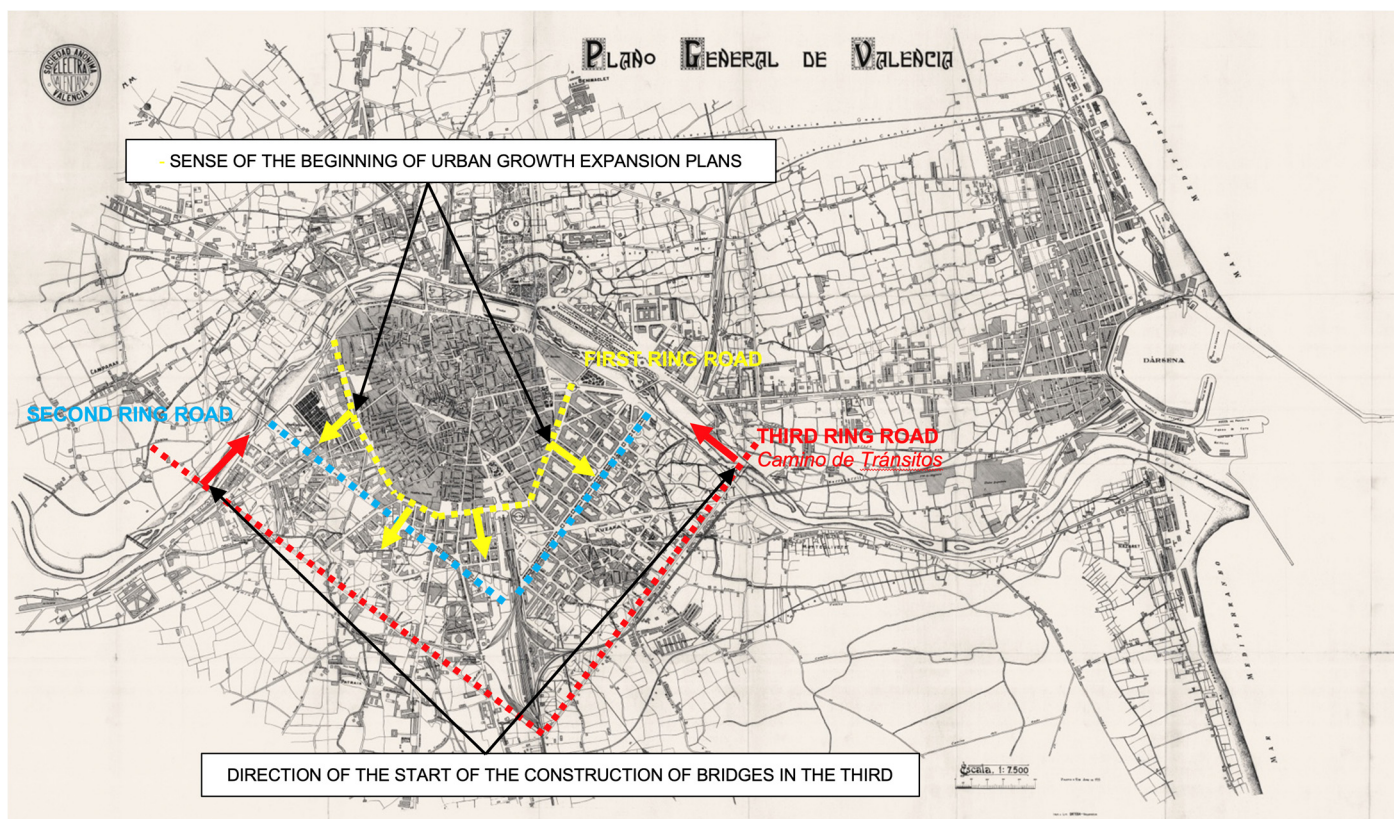


Figure 7. Layout of bridges generated from upstream (Orthophoto 1956, Valencia City Council).

**Table 4.** Table showing the distance between existing bridges in Valencia until 1957.

Bridges	Relationship	Distance Between Them
3.1 Campanar Bridge	3.1-2.1	1550 m
2.1 San José Bridge	2.1-2.2	450 m
2.2 Serranos Bridge	2.2-2.3	290 m
2.3 Trinidad Bridge	2.3-2.4	500 m
2.4 Del Real Bridge	2.4-3.2	400 m
3.2 La Pasarela Bridge	3.2-2.5	350 m
2.5 Del Mar Bridge	2.5-3.3	160 m
3.3 Aragón Bridge	3.3-3.4	700 m
3.4 Ángel Custodio Bridge	3.4-3.5	3000 m
3.5 Astilleros Bridge	3.5-3.1	7500 m

In contrast, urban expansion in the southern area of the riverbed followed a reversed pattern, as evidenced by the expansion plans, where growth proceeded outward from the historic center. This logical trajectory of urban development facilitated connections to Valencia’s traditional commercial and administrative hub (Figure 8).



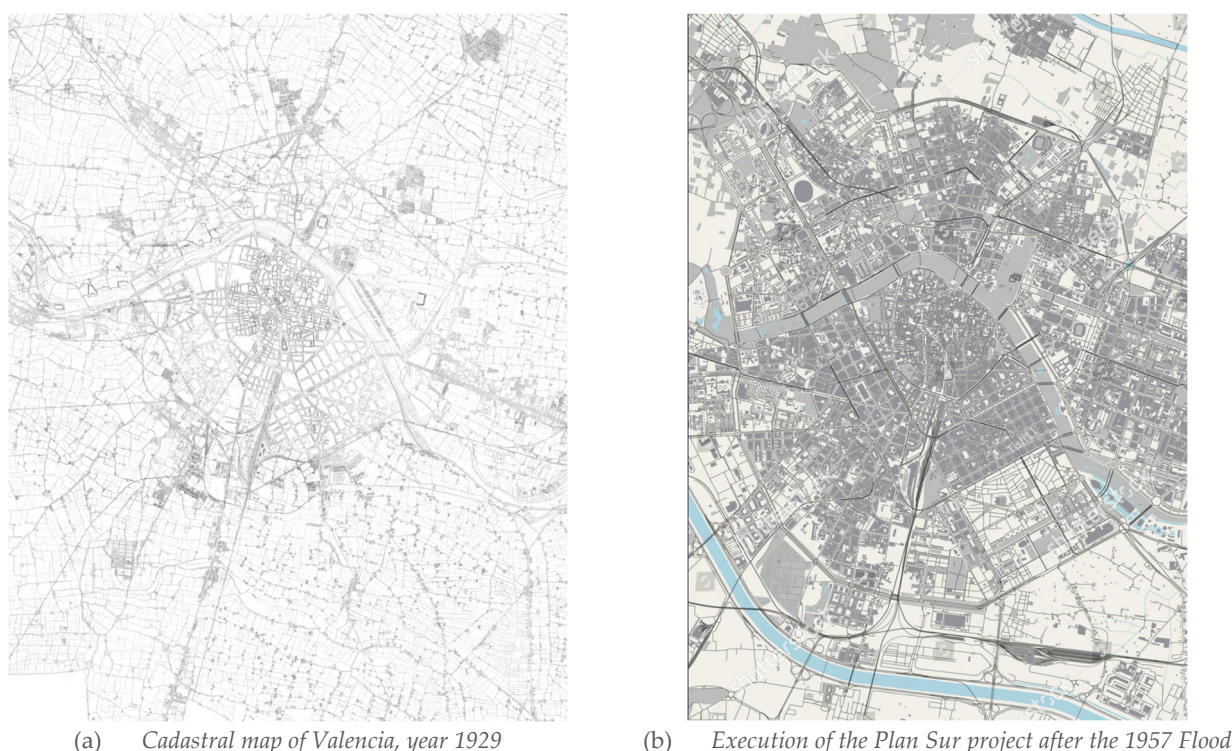
**Figure 8.** Historical cartography of the city of Valencia 1944, Valencia City Council Department of Urban Planning [49].

By the time of the 1957 Flood, Valencia counted a total of ten bridges. Significantly, the chronology reveals yet another 300-year hiatus in bridge construction between the second and third stages, reflecting the time gap already observed between the first and second stages.

## 4. Discussion

### 4.1. Period of Functionality of Bridges

The functionality of Valencia's bridges denotes an adaptability and resilience to the vicissitudes that favours the city's survival and evolution throughout history. While the bridges of the first stage helped generate a new city, those of the second stage favoured its consolidation by strengthening the main communication routes. Regarding the bridges of the third stage, whose origin stems from industrialization, they emerged from a need for growth and ease of transit in a city with a strong immigration resulting from the rural exodus due to industry and development. Today, these bridges coexist in the city, each serving a specific function, e.g., connection, growth, and ease of flow (Figure 9).



**Figure 9.** The urban expansion of Valencia before and after the 1957 Flood.

To justify the influence of bridges on urban development, an analytical study was conducted, taking into account two factors: the evolution of historical cartographic maps, referencing them with current districts, and a census of properties registered by district, taking into account data from the *Real Estate Cadastre of the Statistics Office of the Valencia City Council*.

#### 4.1.1. Real Estate Analysis

Compiling temporal data from the *Real Estate Cadastre for 2024*, the estates were grouped by time period, starting with those registered from 1900 onward. It was decided to exclude data from earlier estates because they were not sufficiently accurate to be taken into account in the analysis, primarily due to the number of demolished constructions. On Table 5, the grouping is based on the periods of bridge construction, since, until 1920, the influence on estate growth in the different districts was affected by the bridges of the second phase. Considering that all the bridges of the third phase, except for the *La Pasarela Bridge* (3.2), were built in just 8 years (from 1932 to 1940), it is in the period between the years 1941 and 1960 that the influence of these bridges on urban expansion begins to be appreciated.

**Table 5.** Range of estates surveyed by districts (*dates obtained by Real Estate Cadastre of the Statistics Office of the Valencia City Council*).

Districts	1801–1900	1901–1920	1921–1940	1941–1960
1. Ciutat Vella	3.140	1.405	2.082	2.389
2. l'Eixample	428	2.104	8.470	5.930
3. Extramurs	1.368	1.040	4.015	8.133
4. Campanar	27	78	184	1.097
5. la Saïdia	103	93	534	2.971
6. el Pla del Real	47	58	347	1.981
7. l'Olivereta	10	4	279	5.292
8. Patraix	10	64	200	2.386
9. Jesús	47	172	376	1.953
10. Quatre Carreres	156	340	961	2.714
11. Poblat Marítims	10	1.108	2.379	4.803
12. Camins al Grau	16	85	504	2.684
13. Algirós	8	13	28	1.947
14. Benimaclet	77	175	162	988
16. Benicalap	33	66	123	1.327
19. Pobles del Sud	299	271	618	1.368

Therefore, by analysing Tables 6 and 7 the following information is obtained:

**Table 6.** Delimitation of sections of estates due to the construction of bridges.

Districts	1801–1900	1901–1940	1941–1960
1. Ciutat Vella	4.545	6.627	9.016
2. l'Eixample	2.532	11.002	16.932
3. Extramurs	2.408	6.423	14.556
4. Campanar	105	289	1.386
5. la Saïdia	196	730	3.701
6. el Pla del Real	105	452	2.433
7. l'Olivereta	14	293	5.585
8. Patraix	74	274	2.660
9. Jesús	219	595	2.548
10. Quatre Carreres	496	1.457	4.171
11. Poblat Marítims	1.118	3.497	8.300
12. Camins al Grau	101	605	3.289
13. Algirós	21	49	1.996
14. Benimaclet	252	414	1.402
16. Benicalap	99	222	1.549
19. Pobles del Sud	570	1.188	2.556

Until 1920, the majority of registered estates were located in district 1 *Ciutat Vella*, the original core of the city, delimited by the first ring road corresponding to the ancient Christian wall. The bridges of the second phase coexist in this area, with the exception of the *Del Mar Bridge* (2.5). District 2 *l'Eixample* and district 3 *Extramurs* begin to emerge, revealing the expansion process of the 1877 expansion plan, the peak of which can be seen in the following range. It is precisely in district 2 *l'Eixample* that the *Del Mar Bridge* (2.5) is located, providing access to the port, and where district 11 *Poblat Marítims* stands out due to the port area's boom. Of note is district 2 *l'Eixample*, which went from 428 registered units in 1900 to 2104 units in 1920, and district 11 *Poblat Marítims*, which went from barely 10 units in 1900 to 1108 units in 1920. It is worth highlighting the 103 properties in district 5 *La Saïdia* in 1900, the result of the first settlements generated after the *Serranos Bridge* (2.2) and the *Trinidad Bridge* (2.3) were filled.

**Table 7.** Percentage of real estate growth.

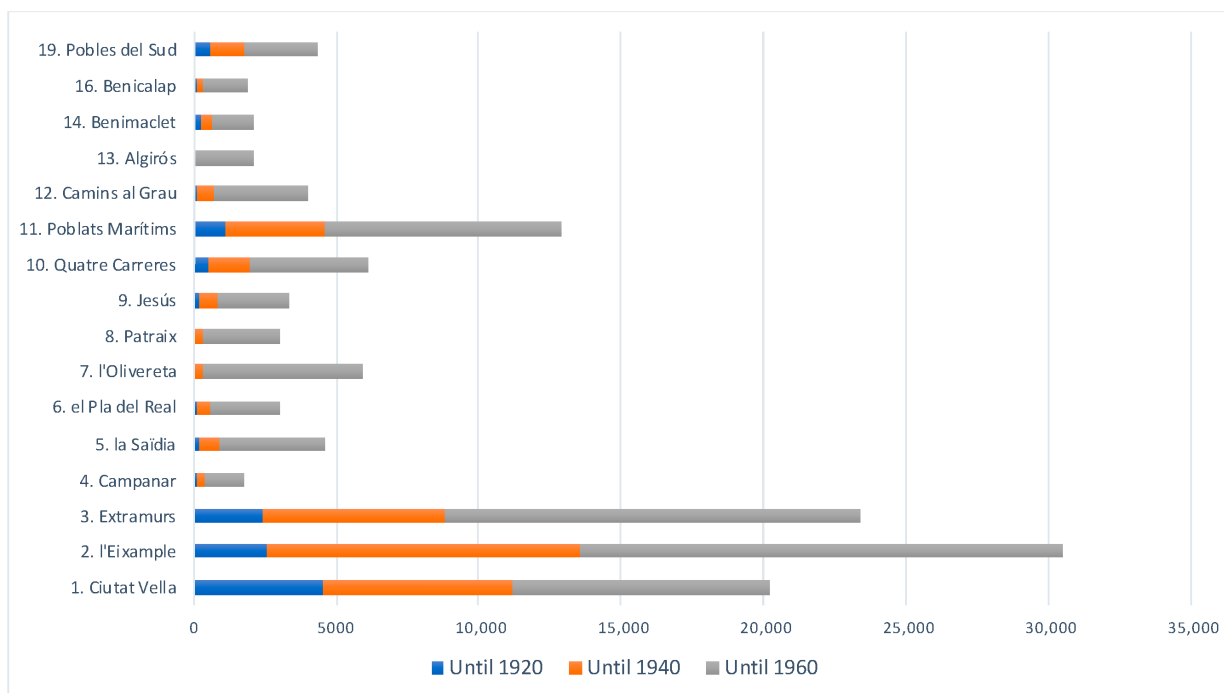
Districts	% Increase 1900–1940	% Increase 1940–1960
1. Ciutat Vella	472%	136%
2. l'Eixample	523%	154%
3. Extramurs	618%	227%
4. Campanar	371%	480%
5. la Saïdia	785%	507%
6. el Pla del Real	779%	538%
7. l'Olivereta	2930%	1906%
8. Patraix	428%	971%
9. Jesús	346%	428%
10. Quatre Carreres	429%	286%
11. Poblat Marítims	316%	237%
12. Camins al Grau	712%	544%
13. Algirós	377%	4073%
14. Benimaclet	237%	339%
16. Benicalap	336%	698%
19. Pobles del Sud	438%	215%

**Until 1940**, during the full development of the Valencia expansion area, and in the last decade during which most of the bridges in the third stage were built, the most notable districts were the 2 *l'Eixample* and 3 *Extramurs* districts on the southern and southwestern edge of the city. From upstream, the construction of the *Campanar Bridge* (3.1) would initiate a process of annexation of the population of Campanar, current district 4. The *Puente del Real* (2.3) together with the recent *Aragón Bridge* (3.3) would favour settlement in district 6 *Pla del Real*; in addition, this last bridge would accelerate the growth process by annexing the population of El Grao, favouring the growth of district 12 *Camins al Grau*. In the port area, the *Astilleros Bridge* (3.5) enabled communication between the southern towns, boosting the growth of district 19 *Pobles del Sud*. Furthermore, district 11 *Poblat Marítims* continued to grow, and district 10 *Quatre Carreres* grew exponentially, rising from 496 units of real estate in 1920 to 1457 units in 1940. Of particular note is district 2 *l'Eixample*, which increased from 2532 units of real estate in 1920 to 11,002 units in 1940, and district 3 *Extramurs*, which increased from 2408 units in 1920 to 6423 units in 1940. Furthermore, the recent construction of the *Campanar Bridge* (3.1) is notable as district 4 *Campanar* increased from 105 units in 1920 to 289 units in the year 1940.

**Until 1960**, the urban consolidation of district 1 *Ciutat Vella* and the growth of district 2 *l'Eixample* led to expansion along the north bank of the river, driven by the *Campanar Bridge* (3.1) and the *Aragón Bridge* (3.3), in collaboration with the bridges of the second phase. This is reflected in the rise of districts 4 *Campanar*, 5 *La Saïdia*, 8 *Patraix*, 12 *Camins al Grao*, and 16 *Benicalap*. The latter corresponds to the former population center of Benicalap, which would gradually consolidate its integration into the city after a process of growth through annexation. During this period, expansion plans were implemented in the western part of the city, with the largest number of properties being built in district 3 *Extramurs* and district 7 *l'Olivereta*, facilitated by the *Campanar Bridge* (3.1), which in turn formed part of the third ring road. Downstream, the *Ángel Custodio Bridge* (3.4), part of the third ring road, helped integrate Ruzafa and facilitated the growth of district 10 *Quatre Carreres*. The *Astilleros Bridge* (3.5) continued to promote development around the port, as seen in the continued growth of district 11 *Poblat Marítims*, which grew from 3497 units registered in 1940 to 8300 units in 1960.

This estate analysis reveals how the bridges of the third stage, in collaboration with the existing ones from the second stage, favoured the city's growth in a period of need in the face of the demographic avalanche. These infrastructures acted as a muscle for the

expansion plans, and this can be seen in the increase in properties detected in districts 1, 2, 3, 5, and 11 by 1960, as shown in Figure 10. Strategically located bridges formed part of the main ring roads, such as the *Campanar Bridge* (3.1) and the *Ángel Custodio Bridge* (3.4), whose affiliation with the third ring road facilitated the flow of heavy traffic towards the main communication routes with the rest of the country. Meanwhile, a process of growth by extension was taking place, favoured by the rest of the bridges located within the area of the first ring road, the original nucleus of the city (Figure 8). The results of this analysis have therefore demonstrated that the bridge's infrastructure has sufficient urban planning attributes to be considered a backbone of any urban transition process.



**Figure 10.** Evolution of estates by district and range of annual rent.

#### 4.1.2. Functionality of the Bridges

Based on the previous analysis, it is possible to group bridge functions, allowing us to associate these infrastructures based on their main functions in the city's growth, which ultimately determine its current morphology. This newly generated methodology addresses:

- *Connection bridges*: These were primarily the bridges of the first and second stages, which were key to establishing the first communication routes with the outside world, some of which are still in use today. At the same time, although the bridges of the third stage played a fundamental role in the city's growth on its northern and eastern margins, some of them were forced to perform a dual function, assuming the role of main communication and link infrastructures with the outside world. The following bridges have served as connecting bridges:
  - The San José Bridge;
  - The Serranos Bridge;
  - The Trinidad Bridge;
  - The Puente del Real Bridge;
  - The Puente del Mar;
  - The Aragón Bridge.
- *Urbanizing bridges*: These bridges, in response to incipient population growth, facilitated urban expansion. In the specific case of Valencia, they allowed, on the one

hand, settlements on the northern bank of the riverbed and, on the other, the eastern expansion of the city to its connection with the sea. The bridges that have fulfilled this function are as follows:

- The Astilleros Bridge;
- The Aragón Bridge;
- The Campanar Bridge;
- The Ángel Custodio Bridge.

From the second stage that contributed to the city’s growth process starting in the 19th century are the following bridges:

- The Trinidad Bridge;
  - The Serranos Bridge;
  - The Del Mar Bridge;
  - The Del Real Bridge;
  - The San José Bridge.
- *Flow bridges*: Bridges that, once urban equity has been consolidated, need to be built to facilitate flow between both sectors, improving communication in such a way that the channel is not perceived as an impediment to be crossed.
    - The La Pasarela Bridge.

In Table 8, the bridges from each stage are grouped according to their functionality across different historical periods. When cross-referenced with the districts affected by the construction of each bridge, this reveals—as previously mentioned—a notable increase in residential developments, highlighting the susceptibility of these districts to the influence of new infrastructure.

**Table 8.** Urban evolutionary and functional characteristics of the second and third stage of bridges.

Bridges Stages	Bridges	Functionality Connection	Urbanizing	Flow	Ring Road	Affected Districts	Real Estate Evolution Until 1920	Until 1940	Until 1960
Second stage	San José Bridge (2.1)	x	x			District 1 Ciutat Vella District 4 Campanar District 5 La Saïdia	4,545 105 196	6,627 289 730	9,016 1,386 3,701
	Serranos Bridge(2.2)	x	x			District 1 Ciutat Vella District 5 La Saïdia	4,545 196	6,627 730	9,016 3,701
	Trinidad Bridge (2.3)	x	x			District 1 Ciutat Vella District 5 La Saïdia	4,545 196	6,627 730	9,016 3,701
	Del Real Bridge (2.4)	x				District 1 Ciutat Vella District 5 La Saïdia District 6 Pla del Real	4,545 196 105	6,627 730 452	9,016 3,701 2,433
	Del Mar Bridge (2.5)	x	x			District 2 L'Exemple District 6 Pla del Real District 12 Camins al Grao	2,532 105 101	11,002 452 605	16,932 2,433 3,289
Third stage	Campanar Bridge (3.1)	x	x		Third	District 3 Extramurs District 4 Campanar District 7 l'Olivereta District 8 Patraix District 9 Jesús		6,423 289 293 274 595	14,556 1,386 5,585 2,660 2,548
	La Pasarela Bridge (3.2)			x		District 1 Ciutat Vella District 6 Pla del Real	4,545 105	6,627 452	9,016 2,433
	Aragón Bridge (3.3)	x	x		Second	District 2 L'Exemple District 6 Pla del Real District 12 Camins al Grao		11,002 452 605	16,932 2,433 3,289
	Ángel Custodio Bridge (3.4)	x			Third	District 10 Quatre Carreres District 12 Camins al Grao District 13 Algrós District 14 Benimaclet			4,171 3,289 1,996 1,402
	Astilleros Bridge (3.5)		x			District 10 Quatre Carreres District 11 Poblats Maritims District 19 Poblats del Sud		1,457 3,947 1,188	4,171 8,300 2,556

This data was then integrated into the Geographic Information System (GIS). Figure 11 presents a spatial map illustrating the urban growth patterns shaped by the bridges of the second and third stages, showing how these infrastructures contributed to the evolving urban form of Valencia up until the 1957 flood.

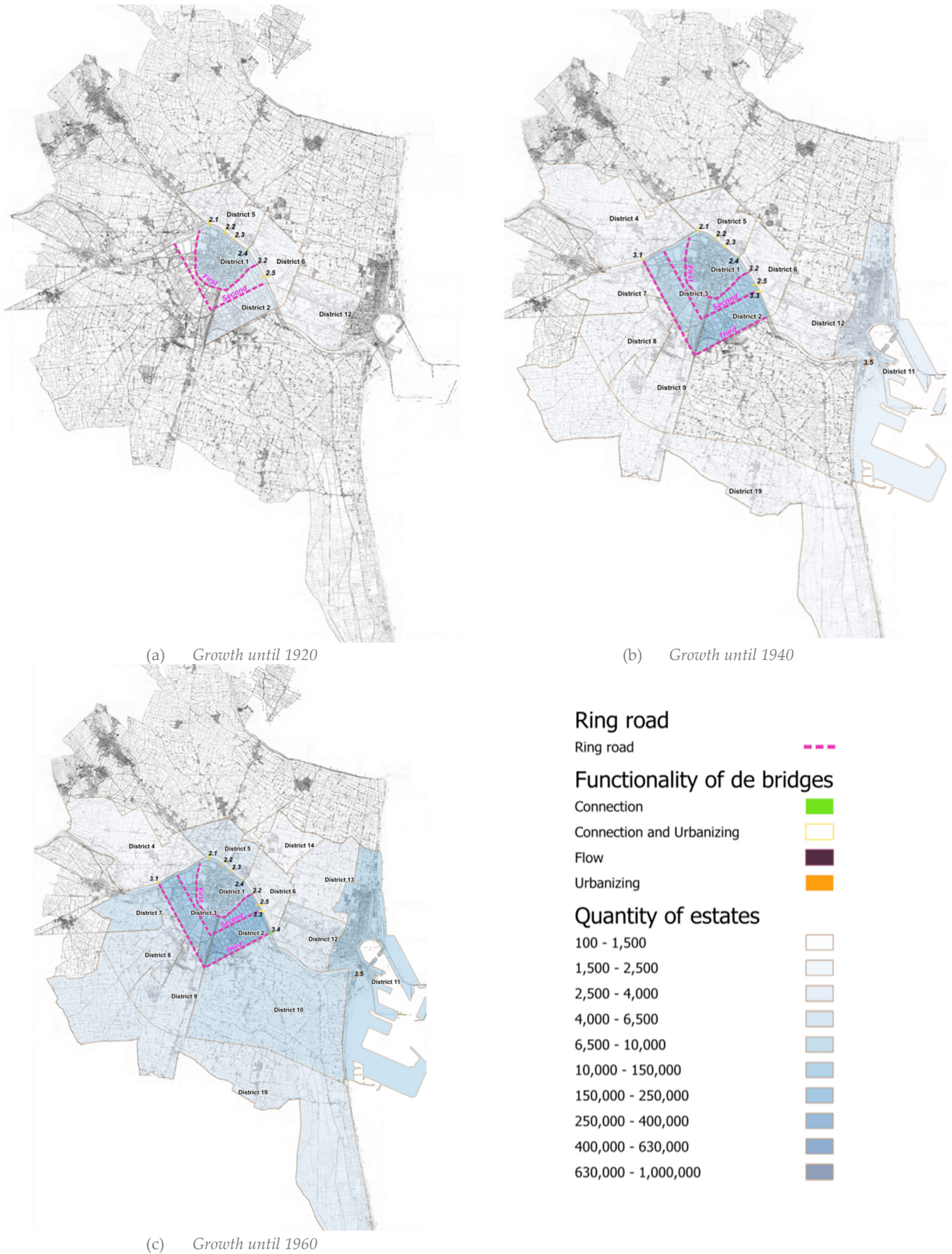


Figure 11. Areas of growth influence by range of years.

## 5. Conclusions

Historically, river channels offered cities protection, but today they often constrain urban growth, especially amid rising population pressures and land scarcity. Bridges have long served as essential tools in overcoming these spatial limitations, enabling connectivity, expansion, and adaptation.

The case of Valencia illustrates this dynamic vividly. Shaped by repeated flooding and major infrastructural responses, the city's development is deeply intertwined with the evolution of its bridges. This study, focusing on the second and third bridge stages, spanning the period from the 13th century to the 1957 flood, uses a multidisciplinary methodology to examine how these structures influenced the city's morphology over centuries.

In the second stage, bridges were built in response to catastrophic floods, with their durability enabling the formation of long-standing communication routes. In the third stage, driven by the industrial revolution and urban migration, bridge construction accelerated, enabling horizontal urban expansion and new mobility systems.

The concept of bridge functionality emerges from this analysis, classifying bridges by their role in connection, urbanization, or facilitating internal flow. Valencia's experience highlights how bridges not only respond to environmental and social challenges but actively shape a city's evolution, demonstrating their enduring significance in sustainable urban planning.

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**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A.

Bridges of the second stage presented in order of construction.

### *Appendix A.1. The Trinidad Bridge (2.3)*

Government aid after the flood of 1358, along with the siege of the town demanding a passage over the Turia of sufficient quality, led to the construction of the bridge known to this day as the *Trinidad Bridge (2.3)*.

The layout of this structure was carried out in September 1402 and was completed in April 1407, as documented in the *Manual de Consells [34]*. Mateu Teixidor, Pere Balaguer, and Julià Martíneç were the master builders. In terms of style, it is not a typically medieval archetype, with its characteristic defensive towers; on the contrary, it is a work that would serve as a reference for the other masonry bridges that would be built at the beginning of the 16th century [36]. This bridge came to be known as the “strongest” as it is the only one that has not succumbed to subsequent floods. It has undergone some modifications throughout history, but its vaulted structure of eight arches remains intact.

### *Appendix A.2. The Serranos Bridge (2.2)*

The construction of this bridge was a consequence of the flood of 1517 and was commissioned from the master builder Juan Bautista Corbera in 1518. Built entirely of stone, its design at that time acquired the monumentality required for an infrastructure connecting the city's main gateway. Problems with levelling to ensure the correct placement

of the piers and vaults constructed by Corbera meant that the construction of the last two piers and arches was carried out under the direction of Joan de Alacant [50]. The bridge was configured with nine segmental arches with a span of 14.60 m and triangular cutwaters, just as we know it today [36]. Aside from the restoration and maintenance work carried out in recent years, the bridge retains its entire original structure and envelope, except for the horizontal traffic plane, which, like the rest of the bridges, has undergone modifications to adapt to the resulting changes in mobility [51].

#### *Appendix A.3. The Del Mar Bridge (2.5)*

This bridge was a consequence of the flood of 1589, and its stone construction was commissioned in accordance with the guidelines of its two predecessors. The project was designed by Pedro Guevara, with the stone, brick, and mortar construction agreed upon by Juan Bautista Corbera. Finally, its construction was carried out by the stonemasons Pedro Tacornal, Antonio Deixadi, Pedro del Solar, and Pedro de la Hoya, and the work was completed in 1596 [52]. Due to its function as the only route of connection and communication with the sea and therefore significant commercial traffic, it was always a priority in terms of repairs [53]. On the one hand, given the damage suffered by the various floods, especially before its stone construction, and, on the other hand, the transit of wooden blocks (from the carpentry shops in the Rambla de Predicadores and the area around Las Barcas Street) continued to damage the bridge even when it was made of stone, as they became blocked in the vaults and blocked them, causing them to rise upstream, damaging piers and overflowing the channel [54]. Another significant aspect was its location. At the time, it was the only bridge not attached to the city wall. Its construction was to be carried out tangentially downstream to the foundations of its predecessor and bent away from the perpendicular to the riverbed, taking into account functional, hydraulic, and urban planning decisions, emphasizing the sea gate as a vanishing point and settling any debates that had arisen at the time.

#### *Appendix A.4. The Del Real Bridge (2.4)*

As with the *Del Mar Bridge (2.5)*, it was the flood of 1589 that prompted its construction, with King Philip II himself urging the juries of Valencia to take action, awarding the contract to the Nova dita del Riu Factory. Its construction was put to public auction in 1594, and the winning bidders were the local workers Guillen Salvador, Jerónimo Negret, and Francés Antón. After problems with its foundations, it was finally inaugurated in 1599. As with the *Del Mar Bridge (2.5)*, its axis is slightly inclined with respect to the perpendicular to the riverbed. This may be due to the fact that they were built at the same time, so it is not ruled out that the technical advice was the same. The name refers to its function, as it was the connecting element with the royal palace and its gardens located at the northeast end of the riverbed. Originally, this bridge was repaired repeatedly after suffering various catastrophes, including the accident that occurred in August 1528 upon the arrival of Charles I in Valencia. The people crowded the railings, falling into the riverbed as the emperor passed, resulting in the deaths of nearly a thousand people [54].

#### *Appendix A.5. The San Jose Bridge (2.1)*

Located upstream from *Serranos Bridge*, it linked the ancient gateway in the Christian wall, "Portal Nou," with the Monastery of Zaidia or "Gratia Dei." Although it was built of stone in 1517, the flood of September 27 destroyed it within an hour on the feast day of Saints Cosmas and Damian [18]. After its reconstruction, this bridge, along with the older Paso del Mar and Paso del Real bridges, was once again subject to the effects of the 1589 flood. The Nova dita del Riu Board decided to rebuild the three stone bridges with a

more robust and resilient design. The fact that priority was given to the *Del Mar Bridge* (2.5), a hub for trade, and the *Del Real Bridge* (2.4), led to the *San José Bridge* (2.5) being delayed until 30 July 1604, with its completion in 1608. Even so, it underwent modifications during the design and planning phase, going from the original 9 spans to 13.

It was the last bridge to be built but the first in terms of its upstream location, being the most severely affected by heavy flooding. As a defence against the French attack of 1810, it was demolished and rebuilt again in 1819. Finally, when the community withdrew from the convent located on the other side of the river to the town of Benaguasil, interest in this crossing was lost, and it was never restored to its former charm. In fact, the hydraulic problem of this bridge is considerable. Its solid span coefficient is 2.1, a very low coefficient that, in the long run, would have caused problems in a strong flood.

## Appendix B.

Bridges of the third stage.

### *Appendix B.1. The Campanar Bridge 1937 (3.1)*

It emerged as an extension of the third ring road, providing access to the old road to the town of Campanar, which eventually joined the new urban segment through annexation, hence the name Campanar district 4. As part of the transit route, on the northern side, it would connect with all the radial roads that emerged with the bridges of the second phase. This ring road would end at the old Cabanyal Road.

### *Appendix B.2. The La Pasarela Bridge 1909 (3.3)*

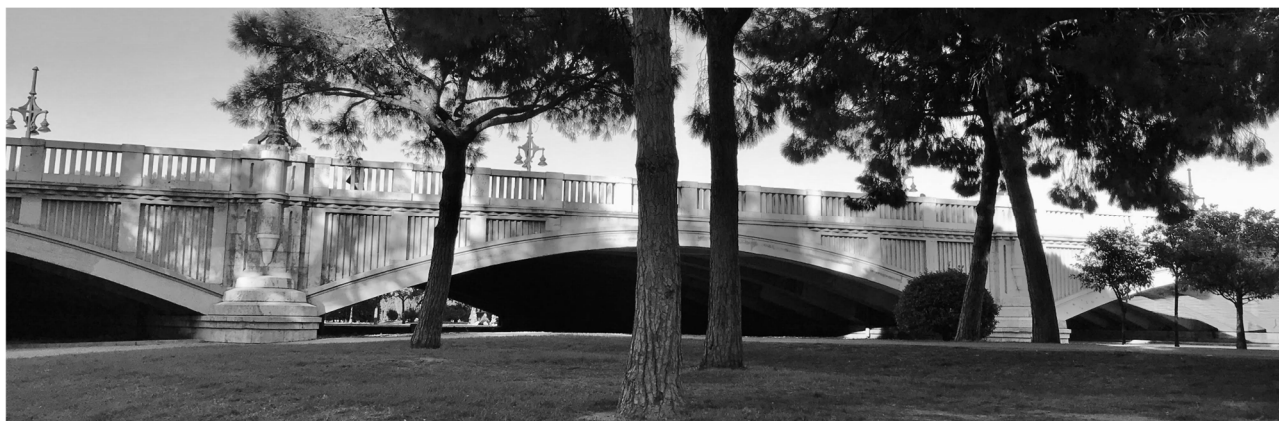
Its construction was motivated by the 1909 Valencian Regional Exposition, an event held on the Paseo de la Alameda on the northern bank of the riverbed. It was the first concrete bridge, a demonstration of the emerging technologies and construction processes derived from the industrial revolution. It marked a turning point in the way bridges were built in the city of Valencia, serving as a launching pad for urban development on the left bank of the riverbed, specifically in the current Pla del Real district 6. It collapsed in the notorious flood of 1957.

### *Appendix B.3. The Aragón Bridge 1933 (3.4)*

Its construction was a consequence of the overload to which the old *Del Mar Bridge* (2.5) was subjected, endangering its structure. Although reinforcement was considered, the final decision was made to build a new bridge just 150 m downstream (Figure 9). After its construction, the demolition of the old *Del Mar Bridge* (2.5) was contemplated, but the circumstances that Valencia was going through led to the postponement of this project, which fortunately was not carried out, and the old bridge was used as a pedestrian crossing. Its location was to be channelled with the Avenida del Puerto and the Gran Vía, thus closing the ring road of the second ring road, hence its layout in plan is twisted with respect to the perpendicular to the channel (Figures 5 and A1). This bridge links the current district 2 *L'Eixample 2* with the district 12 *Camins al Grao*.

### *Appendix B.4. The Ángel Custodio Bridge 1940 (3.5)*

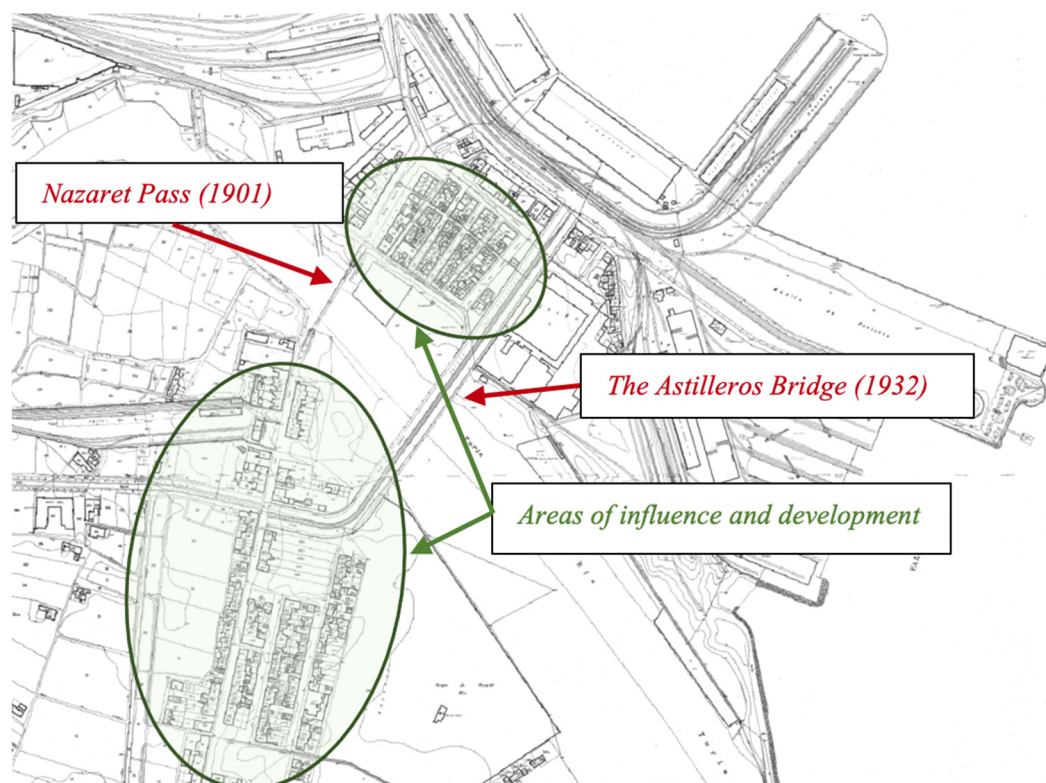
Its construction was part of the third Camino a Tránsito ring road, as it crossed the riverbed, connecting the other side of the river with the power plant and the old *Valencia-Alameda Station* (Figure 4). This estuary would eventually form the first section of what is now Avenida Cardenal Benloch as part of the third ring road. It connects district 10 *Quatre Carreres* with district 12 *Camins al Grao*.



**Figure A1.** The Aragón Bridge (photography by author).

#### *Appendix B.5. Astilleros Bridge 1932 (3.6)*

There has been a long-standing need to connect the port with the southern districts and maritime settlements currently included in the current districts of 11 *Poblats Marítims* and 19 *Pobles del Sud*. Prior to this bridge, the transport of goods to the port prompted the creation of a first bridge called the *Nazaret Bridge (1901)*. Initially designed by Antonio Guijarro Montó and Fernando Prósper y González, it passed through many hands during its construction process (Casimiro Meseguer, José Blanco, Francisco Climent, etc.). A work intrinsically linked to the growth and development of the port area and surrounding neighbourhoods, it remained standing until the flood of 1949. Next to this bridge, on the right bank of the channel, the Nazaret Station would be built, bringing the railway to the *Poblats Marítims*. However, this development brought with it a strong logistical demand on the port, and the construction of the new bridge was necessary just 165 m downstream from the previous crossing (Figure A2).



**Figure A2.** Nazaret Pass and the Astilleros Bridge.

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