



Water, infrastructure and public space in Lisbon. The reservatório de Campo de Ourique as a case study

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Abstract

In the 21st century, the question of how to define a good city is anything but clear-cut. As diverse as the needs of modern society are, as numerous seem to be the answers to them, and yet one cannot arrive at a universally valid answer that serves all registers. The central subject of this investigation always leads back to public space. The living space between buildings is considered decisive for social developments in a city. It results from systems of different scales, territorial, infrastructural as well as cultural. How and where people come together in a city defines it. In the following work, public space is considered in terms of these different scales. The concepts of public space and infrastructure serve as leitmotifs, focusing on the infrastructural interaction between aqueduct and public space in the city of Lisbon. The work is divided into three scales of different size and time. First, the concept of infrastructure itself is explored in order to understand the dialectic in which modernity, infrastructure and public space confront each other. Based on primary sources and texts, an introduction to the history of post-medieval hydraulic engineering in European cities will be given. Then, using the example of the city of Lisbon, which was supplied by an aqueduct for almost two centuries from the 18th century onwards, it will be examined how such a large infrastructure produced public spaces that are still very present in the cityscape today. The discourse will address how historical examples can serve as inspiration for the use, conversion and expansion of public spaces along the aqueduct and provide impulses for the development of new typologies.

Keywords: Infrastructure, public space, Lisbon, reuse

Resumo

No século XXI, a questão de como definir uma boa cidade é tudo menos clara. Por muito diversas que sejam as necessidades da sociedade moderna, por muito numerosas que pareçam ser as respostas, não se pode chegar a um resultado universalmente válido que sirva todos os registos. O tema central desta investigação é o espaço público. O espaço de vida entre edifícios é considerado decisivo para o desenvolvimento social de uma cidade. Resulta de sistemas de diferentes escalas, territoriais, infraestruturais, bem como culturais. Como e onde as pessoas se reúnem numa cidade define-a. Nesta dissertação, o espaço público é considerado a partir de todas estas leituras. Os conceitos de espaço público e de infraestrutura servem de *leitmotif*, centrando-se na interação infraestrutural entre aqueduto e espaço público na cidade de Lisboa. O trabalho está dividido em três escalas de tamanho e tempo diferentes. Primeiro, o próprio conceito de infraestrutura é explorado a fim de esclarecer a dialética em que a modernidade, a infraestrutura e o espaço público se confrontam. Com base em fontes primárias, mas também em textos fundamentais, será feita uma introdução à história da engenharia hidráulica pós-medieval nas cidades europeias. Em seguida, utilizando o exemplo da cidade de Lisboa, que foi abastecida por um aqueduto durante quase dois séculos, a partir do século XVIII, será analisado como uma infraestrutura tão grande produziu espaços públicos que ainda hoje estão presentes na paisagem da cidade. Finalmente, o fruto destas reflexões é uma proposta para a conversão de um reservatório em Lisboa. O discurso terá como base o facto de os exemplos históricos poderem servir de inspiração para a utilização, conversão e expansão dos espaços públicos ao longo do aqueduto e fornecer impulsos para o desenvolvimento de novas tipologias.

Palavras-chave: Infraestruturas, espaço público, Lisboa, reutilização

Introduction

What makes a good city? Can beauty in a city be planned? Is there a recipe for the artistic, the seemingly spontaneous in a city, or is it time that produces such outcomes? Central to this question seems to be the public space. The better it functions in a city, the better the public life there, one would think. Already towards the end of the 19th century, the Austrian urban planning theorist Camillo Sitte asked himself this question. With a chagrin about modernised cities in which all poetry gave way to increasingly formalistic urban planning, Sitte set out to record his theses for a “significant city” in his work “Der Städtebau nach seinen künstlerischen Grundsätzen”. His critics countered that he was ignoring the complexity of the modern city. Again and again, architects and urban planners are faced with the task of rethinking the city according to its time and meeting new demands of a physical as well as programmatic nature. A look ahead seems just as important as a look into the past in order to master the difficult balancing act between considerate and visionary design. Especially in the post-industrial age, cities have become multi-layered compositions of different systems. They have to do one thing above all: function.

In recent centuries, we have experienced technological progress that has made cities in their current form possible in the first place. The city as we know it today can only be regulated in its spatial scope by highly complex infrastructures. The forms of public life



such as squares, promenades, fountains, parks and railway stations that accompany us every day are inextricably linked to these infrastructures and were often brought into being by them. In his article “Constructing Landscape by engineering water” Antoine Picon describes cities as “complex hydraulic systems, a series of watersheds that must be managed with the greatest care”, highlighting the fundamental importance of the role that water takes in the design of cities. He claims that in modern times despite a multitude of technological answers towards technological problems i.e. the accessibility of water, the designers in charge are often missing a clear global vision on how to address the issue at hand. By carefully observing the role that water and hydraulic engineering have taken in the development of European cities over the past centuries, Picon asks how these past developments can be taken as a starting point for present and future urban developments in an increasingly technological age. The following discourse will provide an insight to the history of post-medieval hydraulic engineering in European cities, breaking down the term of infrastructure itself in order to understand the dialectic in which modernity, infrastructure and public space confront each other.

The development from rural to urban space has taken place successively over the last centuries. As late as the Middle Ages, European cities were nothing more than loose human settlements on natural space, enclosed by fortifications at strategic points. Natural elements such as forests and water were still a big part of the urban appearance, and water in the form of many rivers and canals was a major feature of the mediaeval city. This also meant that the relationship to water was a very direct one: people gathered right by the river to make use of the vital resource. Clean drinking water was scarce, as running waters were used for any kind of disposal, and water from wells also came from the same water table of sewage. Water procurement was thus one of the main tasks that had to be addressed in the course of urban modernisation. In the age of industrialisation, both the access to and the removal of water were regulated. Rivers were replaced by underground water pipes and sewerage systems, which largely changed the urban landscapes both in appearance and structure.

Historically, water served as a primary source for transport and energy production until more recent centuries. This meant that urban and rural planning could not be approached without considering the prevailing water situation. Major infrastructures were connected to or built on water from the ground up. If one looks at the depiction of medieval European cities, they all once resembled Venice or Amsterdam before the canals were gradually filled in and replaced by roads or sewage systems. Canals and rivers were mainly used in an utilitarian sense, before they entered the sphere of being viewed as aesthetically stimulating elements of landscape. This changed in the 18th century, when in cities such as Paris, walls were built along the water, leading to a re-alignment of the urban layout towards the waterfront. Facades were facing the river, and the river became the view. Water, the river, the canals were stripped of their physical use and became a visual object.

In the 18th century, the natural canals and rivers became obsolete in their original form and were subsequently being replaced by artificial man-made infrastructures, invisible to the public and laid underground. The cities “dried out” and the canals, which originally served as main arteries for transportation, were gradually replaced by roads, while at the same time representative fountains and wells emerged, marking the new era of industrialization and political representation. This represents a spatial contrast. If one looks at old maps and depictions of cities in the Middle Ages, they are crisscrossed by



diverse waterways. In the age of industrialisation, these disappear from the map and underground pipes and sewage systems take their place. Simultaneously, public places with fountains and wells appear in a very visible and representative decorative function, from which the water, once flowing organically in the cityscape, now gushes out in bundles. It is collected and “spat out”. Something similar could be said about other infrastructures such as the metro: instead of water, people are transported here and let out at strategic points.

Picon goes on to describe the role of water in the 18th century with four key points: water as “inhabited utilitarian milieu”, water as “urban landscape”, as “technological and invisible infrastructure” and as “monumental element in the city”. The juxtaposition of these different characteristics can be seen in the example of Paris, where the Seine took on a representative function while the Canal St. Martin continued to maintain an utilitarian aspect. In the meantime, the underground network of infrastructural water pipes was increasingly expanded. Interestingly, the viewing and knowledge of these infrastructures was reserved for a certain elite, and only evident to the public in the form of fountains and wells. What went on underground was kept from the public. This reinforces the idea that public space was focused on precisely those venues around the fountains, and did not go beyond, or rather, below. As far as current challenges are concerned, Picon points out three main points. Firstly, he mentions the fact that urban space is increasingly expanding, so that territorial boundaries between city and countryside are blurring. The main difference between the traditional and the modern city is that a traditional city has rivers flowing through it, whereas the modern city is built on a complex hydraulic system. As a result, urban water issues are no longer just aesthetic or water supply issues, but reach an all-encompassing environmental dimension. As modern problems, Picon continues to name, in addition to a series of technical water procurement problems, the increasing need for water as an integral part of everyday life in an urbanised society in both public and private contexts, which went beyond the pure entertainment factor of water in the 19th century, when the bourgeoisie was content to take the occasional trip to the sea. The desire in the modern age for proximity to water, especially in cities, far exceeds this dimension. The real estate market is increasingly focusing on waterfront areas and the public and private spaces along rivers are in high demand. Paradoxically, the very rivers and canals with a former utilitarian nature that fell victim to technologisation in the 18th century are now seen as places with a high quality of stay. In the 18th century, the natural watercourses were filled in and artificial access to the water (in the form of fountains) was created for the public. Today, despite the still popular use of these fountains in public places with recreational value, a reversal is taking place and any place with natural water access in a city is welcomed. Hence, the ecosystem is endangered by the growing demand to be and build close to the water. Lastly, due to the expansion of peripheral cities, more and more sealed surfaces can be found on the outskirts of cities, which is why rainwater can no longer run off naturally and large catchment areas have to be created.

Concluding from these reflections, he refers to Bruno Latours “Politiques de la nature”, stating that instead of imposing technology upon nature, an adaptation towards nature is necessary when wanting to adequately react to these challenges. He mentions the term “techno-nature”, meaning that today the lines between technology and nature are no longer clearly defined, but blurred. When in the past the artificial and the natural were clearly distinct, they are nowadays merging.



At this point it can be stated that a characteristic feature of modernisation from the 18th century onwards is the transition from nature to infrastructure. The term “infrastructure” also stems from this period, first appearing in the second half of the 18th century and initially referring in French to a substructure (French: “infrastructure”), i.e. all earthworks to reclaim the land and levelling in railway construction. Infrastructural facilities emerged in the 19th century as a concomitant of industrialisation and urbanisation. In this process, infrastructure and urbanisation were in constant competition with each other in their development. In the case of the construction of canals and railways, infrastructure preceded urbanisation processes; in the case of water supply and sewerage in cities, infrastructure lagged behind the growth of cities. Rapid urbanisation led to hygiene problems and a lack of water supply, especially in poorer neighbourhoods. A regulated water supply was to provide a remedy. This is how the “bacteriological city” came into being.

Matthew Gandy first coined the term “Bacteriological City” and describes it as a phenomenon that developed between the 19th and 20th centuries. He describes the modernisation of cities as a transition from the private to the public city, in which a centralised administration oversaw and uniformly regulated local problems. This process was charged by a conflict of interests that lay between the new and the old capital, i.e. the aristocracy and the new lobby of industrialists. At the beginning of the 18th century, the first centralised water systems were introduced in several major European cities: in Paris in 1802, in London in 1808, in Berlin in 1856. With this turn of events, traditional forms of water supply such as wells, individual water sellers and others were replaced. The city administration was confronted with a political and technical dilemma concerning the contrast between water supply and water disposal. The improved water supply, which was quite easy to produce, led to a huge increase in water consumption, which in turn overloaded the pre-industrial sanitation systems. However, a new system of water disposal posed a technical and financial problem, as the underground sewerage system had to be completely rebuilt. These new technologised sewerage systems provoked a heated conflict between 19th century engineers, as not all were in favour of the change from organic to technological. To give an example, the loss of human waste, which could now no longer be disposed of organically and used as fertiliser, was considered uneconomic from an agricultural point of view. This dilemma highlights the tensions already present in the 19th century, which resulted from the question of how the modern city should be structured. In this context, nature and society stood in opposition to each other.

Furthermore, infrastructures shortened spatial distances and restructured cities. By uniting cities and regions and creating new boundaries, they were instrumental in shaping the everyday life of an entire society and formed the basis for today's globalisation. Already in the 18th and 19th centuries, extensive improvements, river straightening and canals proved to reshape the landscape in a technocratic sense. With the prospect of efficiency, rivers, lakes and seas were connected to shorten transport distances. These serious interventions in nature were registered by artists such as Paul Cézanne and captured, for example, in his painting “The Railway Crossing” in 1870. (Fig.x) Above all, roads, canals and railways have created long-term pathways and partly irreversible path dependencies. Today, the consequences of these sacrifices in favour of efficiency are palpable, and an ecological understanding of counteracting environmental damage is coming to the fore more than ever. The human conquest of nature with the help of infrastructure is viewed critically today. More than ever, ecological



considerations have become a priority in the design of urban spaces. With this moral change of heart, aesthetic sensibilities have also changed: the inclusion of nature and landscape in urban planning has become very important. Given the socio-political and spatial weight that the introduction of infrastructures into the urban fabric has had over the last three centuries, the connection between large-scale functionality and small-scale design of public space becomes clear. What we see in detail on the surface is only a visible fragment of a large underground system. Against the background of Europe's infrastructural development, especially in the field of hydraulic engineering, it becomes clear that a city is a function-dependent construct. A city in the modern sense is a human superstructure based on sub- or infrastructures. Thus, over time, public places that are designed around or result from a function at their core emerge. In the research presented here, the city of Lisbon is used as a case study, where the interplay between infrastructure in the hydrological field and public places is broken down historically. In this city, an aqueduct fed a network of wells for almost 200 years until it no longer met the requirements of water supply in an industrial city and, finally, became obsolete. The large structure, which still exists as such, leaves a clear footprint in the cityscape to this day. The city has grown over time around the fountains, which can be found here and there but no longer serve as water sources. In some places, the original structure of an old road can still be found, which created access to water for livestock and people. The fountains are a grateful respite in the city, an oasis between the hustle and bustle of traffic and big city buildings, and one cannot help but wonder what the city would be without them. Any modern fountain could hardly produce the same effect as the 19th century fountain in the Praça do Príncipe Real or the impressive building of the Mãe d'Água das Amoreiras reservoir, which forms the artistic end of the arches of the aqueduct around the Amoreiras Garden. Although in their simplicity these fountains could no longer supply a large city, they have helped shape the development of Lisbon's public space, and it is no coincidence that many of the green spaces, parks, gardens or squares are located near them. Looking at a map, the course of the aqueduct seems obvious - an interconnected network that runs in fine veins through the city, feeding the fountains and filling the radius around them with life. The map shows the city of Lisbon in the 21st century at a scale of 1:25000. Highlighted in black is the course of the railroad line, which intersects with the aqueduct, highlighted in blue, in Campolide.

The correlation of the superordinate infrastructural system and the public places it generates is also familiar to us from other, more recent infrastructures. Railway networks in large cities are comparable to the aqueduct: underground channels that serve for transport, and at points of tension (train stations, fountains) let out what needs to be transported. Naturally, public centres in the city develop over time at such functionally charged places, because where a function is fulfilled, people will be found.

The direct connection between function and physical point of attraction for people is being challenged in the age of the pandemic, where everything has been converted to delivery service, home office and remote work. What does the city of the future look like and what does public space mean today in the face of a city that can increasingly be experienced from one's desk? To what extent will social changes make today's public spaces and infrastructures obsolete in the future, just as in the case of the aqueduct?

1. Lisbon's Urban development from the perspective of its water supply

1.1 The history of Lisbon's water supply since the city's beginnings under Portuguese rule

Among the great European cities, Lisbon stands out not only for its morphological peculiarities and its location at the estuary of the Tagus, its gateway to the world, but also for its history of water supply. The known historical facts on Lisbon's water supply before the foundation of the monarchy are rather thin, but point to traces of an aqueduct from Portugal's times as a Roman province. This aqueduct was probably underground and was intended to bring water to Lisbon from various sources, including the Águas Livres spring. Under Arab rule, these infrastructural remains were probably used to collect water in a basin in Carenques, near Amadora, for agricultural purposes. When Lisbon was conquered by D. Afonso Henriques in 1147, the city counted around 15,000 inhabitants. However, population growth was slow, which may, amongst other factors, have been due to the poor water supply. Against this background, it becomes clear that the drinking water supply of the city of Lisbon had always been a problem.

During Portugal's period of conquest in the 16th century, the problem of poor drinking water quality became all the more apparent as expeditors could not be supplied with sufficiently good water for their expeditions. The monarch of the time, D. Manuel, recognised the urgency of solving this problem and commissioned Francisco de Holanda to draw up a plan to supply the capital with much-needed water, as well as a project for a large fountain in Rossio, but nothing came of the plans and Lisbon was to remain without an acceptable water supply for another century.

During this period, the majority of the population fetched their water from the Chafariz d'el Rei, few public fountains spread around the city, and private wells. Who drew water from where was subject to strict hierarchical rules. This can be seen in a painting of the Chafariz d'El Rei in Alfama (Fig.x), which is considered the mother of all fountains: each water tap was assigned to a social class or ethnicity, white women and girls, mixed-race men, black women, slaves and so on. The painting depicts an everyday scene in which figures of different social and ethnic affiliations gather around the Chafariz d'El Rei and go about their activities. Because of the diversity depicted, the painting is often described as an example of globalisation during the Renaissance era. Another example of everyday life of Lisbon in the 16th century is the painting Rua Nova dos Mercadores, 1570-1590 (fig. x), which depicts one of the most important commercial entrepôts in Europe, where caravels and carriages from all parts of the world were anchored daily. The importance of water was such that places like the Chafariz D'el Rey and other fountains immediately became the main venues of the social and economic life of the city and its inhabitants.

1.2 The 18th and 19th century

At the beginning of the 18th century, under the reign of Joao V, Lisbon experienced a period of prosperity with monumental buildings such as churches, convents and palaces.



However, the most important project with the greatest public impact was by far the construction of the Aqueduto das Águas Livres. By the middle of the 18th century, Lisbon counted about 80.000 inhabitants and only had a daily water supply of 560 m³, i.e. about 8 litres per person (in comparison, a person in a European household nowadays consumes about 150 l per day). To solve this urgent problem, construction was to begin on the large infrastructure of the aqueduct (Fig. 4). To fund the monumental project, the city solicitor Cláudio Gorgel do Amaral created a new tax in 1731 called “Imposto Real de Água” on basic products such as meat, salt and wine. The aqueduct transported water over a distance of 18 km (today almost 60 km) from the Águas Livres spring north of Caneças to the “Casa das Águas” in Amoreiras, spanning the Alcântara Valley in an impressive series of 35 stone arches, the largest of which is 65 m high. Once the water had bridged the Alcântara Valley, it crossed Campo de Ourique, passing through the “Arco das Amoreiras”, arriving at the Reservatório Casa das Águas das Amoreiras. From here, it was distributed to the West, East and South via three main canals: Galeria das Necessidades towards the West, Galeria da Esperança towards the South, and Galeria do Loreto towards the East (Fig. 5). From 1748 to 1880, Lisbon was supplied solely by the Aqueduto das Águas Livres. Most of the population fetched water from wells and fountains closest to their homes. Access to water was free, and those who could afford it had it fetched by watermen (aguadeiros) and brought to their households in 25-litre buckets at a cost of 20 reis each. In addition, rich households could afford a private water access, a “pena de agua”, which supplied an amount of around 3308 l of water per day.

In the 19th century, Lisbon flourished economically. With the modernisation of water supply and other urban infrastructures, the city experienced population growth and was faced with new challenges. The expanded water supply infrastructures led to an increased use of public space, especially through fairs, where municipal services were installed. Streets inherited from earlier centuries became obsolete and had to be repaved or widened. The existing sanitation system was overburdened with the rapidly growing number of inhabitants, and diseases such as cholera took root. Streets were considered one of the main sources of infection, as both human and animal waste was disposed of here.

All this led to a government modernisation program being set in motion from the middle of the 19th century, which addressed three different areas: the water supply by a private company, the extension and improvement of the old sewerage network, and urban planning that would allow for better traffic and hygiene conditions. In the course of this, the company “Empresa das Águas Livres de Lisboa” was founded in 1858 and obliged by the state to provide 11,300 m³ of water every day for industrial and domestic purposes. The company commissioned engineer M. Mary to study the terrain of Lisbon in order to expand the water network. Lisbon's topography required an elaborate construction of water pipes and water depots at different levels, and planning errors eventually led to faults in the construction. During the reparation works in 1864, a new solution was sought as quickly as possible, and it was finally decided to draw water from the East from Canal do Alviela via another canal. The Reservatório de Campo de Ourique acted as a reserve, receiving water from both the Canal do Alviela and the Aqueduto das Águas Livres.

In 1868, there were 26 fountains in Lisbon with a total of 97 water outlets, some for fetching water by the Aguadeiros and others for private use. The entire city was supplied by a total of 6 public and 1200 private fountains. In 1884, along with other important



urbanisation plans, a new plan for a sewage system was being prepared and presented. The polluted water from wells or households was used for agricultural purposes. The water supply and use in Lisbon at that time was strongly linked to the agricultural activity of the population. Parallel to the hydrological developments, industrial development brought with it an improvement in infrastructure, with new roads and streets being built and the railway line to Sintra inaugurated in 1887. Along with this, construction activity was concentrated mainly in the urban and suburban cores adjacent to the railway line.

In 1894, a total of 12,808 buildings in Lisbon were supplied with piped water. At the time, the population used various springs located in central squares and fountains sited in public squares or in nearby private properties. In Sintra, due to its morphological position on a slope on a high mountain, wells were rarer. Apart from being used for the evermore present issues such as street cleaning and sewerage, the water served as well as for agricultural, industrial and domestic purposes. In 1940, Lisbon counted around a million of inhabitants. The water supply was still provided by private and public wells, furnished by the Aqueduto das Águas Livres (1748) and the Aqueduto Avieira (1880), a system which could no longer sufficiently meet the needs of the growing population. This led to a contractual agreement between the engineer Duarte Pacheco, the Companhia das Águas Livres and the Minister of Public Works, in which it was decided that the Canal do Alviela and the water distribution network to Lisbon would have to be improved and the total water volume per day increased to 800,000 m³. The latter was to be done with the help of a water catchment tank in Zezere. In 1935, construction of the Tejo Aqueduct began, and the improved water supply also made it possible to provide water to the neighbouring regions of Oeiras and Paço de Arcos. The construction and improvement of additional fountains was commissioned as part of a government improvement programme that the city embarked on thanks to an economic boom. Furthermore, investments were made in hydroelectric power plants and the regularisation of water bodies, and each municipality was now served by its own water supply system as well as sewage system. Such improvements were intended to prevent diseases caused by contaminated water, which continued to be a problem. Urban growth gradually displaced the agricultural land in the city and surrounding communities.

The aqueduct's large drinking water supply structure, which included public fountains, supply to farms, public institutions and private homes, functioned for barely 150 years and eventually could no longer respond to the rapid urban growth, so that it was eventually decommissioned. The public fountains belonging to the aqueduct, which were used to supply drinking water during this period, created places of gathering for more than 150 years and marked a concise structure in public places in the city that is still visible today. The existence of the Reservatório da Mãe d'Água das Amoreiras next to Largo do Rato enhanced in this area of the city a new organisation and restructuring of the entire space and surrounding areas. The water supply through the aqueduct was an essential step in the modernisation of Lisbon. By building such a large infrastructure, comparable to the construction of a railway line, the cityscape changed and became increasingly urbanised. Streets became social arteries where people went to access fountains. Fountains and wells developed into new centres and social arenas. New solutions had to be found for the problems that accompanied the modernisation of the city. The capital developed into the only urban centre in Portugal and was thus competitive with other European cities.

In the case of the railway, the aim is to shorten transport routes. The railway network is therefore strategically designed, partly in harmony with above-ground transport routes and main transport hubs. The path of the aqueduct is also strategic, responding to the morphology on the one hand, and on the other hand tangent to axes and centres of the city, which once served the simple purpose of good accessibility. Over the decades, however, these centres have shifted, and what was once an important hub is now no longer a centre in urban planning terms and is disappearing into the density of the modern city. In order to understand the relationship between public space and the aqueduct, it is essential to look at the history and previous events of the place under study and to examine elements such as water reservoirs and fountains, taking into account their historical context, to pose new questions for public uses in the future.

2. The old and the new: public space in changing times

Thus each of these places has its significance, its history, and one now understands why fountains and monuments are not located in the main axes of traffic, not in the centre of squares... Camillo Sitte, 1889

With Lisbon's hydrological development in mind, a look at the representative elements of the aqueduct, such as the fountains, helps to trace its path in the urban fabric.

While the infrastructure of the aqueduct is largely underground, the various water outlets in the city of Lisbon are a key design feature and, as in many of its European counterparts, are an integral part of the cityscape. Considering the early industrial history of the city's water supply, it seems not surprising that an interplay of socio-political and technical developments also has a great influence on the overall image of a city. Fountains and wells developed into hubs of public life in parallel to the development of infrastructure: a fountain with ornamentation, a public square with amenity qualities, sometimes an entire garden or park that provided additional shade in combination with the refreshing fountain. The significance that those fountains had at the time of their original use, the water supply, changed over time. Stripped of their function as mere water givers, these places continue to exist today and shape the cityscape. They are often located at strategic points, manifest themselves through good accessibility and are visibly and representatively designed.

The reflections on the transformation of public places were already recorded by Camillo Sitte in "Der Städtebau nach seinen künstlerischen Grundsätzen". His work raises fundamental questions that are still relevant today. Sitte cites Italy first and foremost as an example of a well-functioning interaction between urban space and quality of life. According to him, the architectural principles on which Italian cities are built are so timeless, humane and insightful that they still lend themselves to modern considerations of urban planning. Public places are the hearts of a city, the paths leading to them urban arteries. Life takes place on the street, at the fountain, in front of the town hall. Thus, over the centuries, many different typologies of public places have emerged that once served a function and eventually outgrew it, while their spatiality still remains. Even if no one reads out announcements in the town hall square anymore, and the square around the fountains is no longer used for fetching water, these places are still centres of public life and signposts for finding one's way around a city, while conurbations of metropolitan



density have grown up around them. Camillo Sitte's work was published at the end of the 19th century and thus written at a time of radical modernisation of cities. The work introduces the term urban planning into the discussion for the first time and continues to provide an impetus for thinking about the qualitative losses that modern urban planning entails. Sitte contrasts the artistic possibilities of urban planning with the pragmatic, mechanised and standardised features of the modern era. He advocates certain principles for the design of public squares, colonnades, gardens, organically winding streets and many other public typologies. For him, it is above all the irregular that gives a city quality.

In the case of Lisbon and the following examples under study, this reference becomes relevant when comparing the pre-modern reservoirs (Amoreiras, Príncipe Real) with those that follow the development of industrialisation (Reservatório de Campo de Ourique), where the pure function of water storage comes to the fore, without ornamentation or quality of stay playing a role anymore.

In his chapter "Keeping the Centre Free", Sitte sets out his reflections on the placement of fountains. Fountains are witnesses of the times; their placement provides information about the historical context in which they were placed. Here, he gives an analogy to so-called "island-squares": he refers to old city maps of the Middle Ages and Renaissance, in which the squares would be crude and unpaved, as in the countryside, criss-crossed by paths. Fountains would be placed on the free "islands" between the naturally formed traffic routes. Thus, in a main square, a fountain would not be placed purely formally in the geometric centre of the square, but rather next to the road leading to the square, which may have originally served to provide water for the draught animals and in this respect had a purely practical and less formal reason. Sitte emphasises this spontaneity from which, in his view, urban beauty would be born, as remarkable, since each fountain has its own individual history and does not follow any formal pattern in its positioning. If it was once placed in an unpaved, traffic-free zone, it still stands there today, even if the city has densified all around it. This means that every city has an individual arrangement of fountains and monuments, as every city has its own history. The younger the fountains, the more symmetrically placed, the older the more asymmetrical. Returning to an Italian example, he cites the fountain in front of the Palazzo Vecchio on the Signoria in Florence and the fountain on the Piazza Farnese in Rome, where the fountain is placed asymmetrically and not centrally aligned with its surroundings. His observations lead him to the following conclusion: "To the ancient rule of placing the monuments around the edges of the squares is thus added another genuinely medieval and more Nordic one: to place monuments, but especially market fountains, on the dead points of the square traffic".

The following are examples of reservoirs and fountains in Lisbon that are linked to the aqueduct and still characterise the city today. Public places have developed around them, so that one could speak of their own typology, composed of reservoir and park. The focus will be on the two oldest and most significant ensembles of this kind, the Mãe d'Água das Amoreiras and the Reservatório da Patriarcal. Based on primary sources such as maps, images and texts, a description of the sites as well as a historical classification will be undertaken. The cartographic comparison is based on a map from 1807, in which Lisbon still consisted largely of farmland, and from 1911, in which the urban structure of the metropole as we know it today can already be seen. Sitte's reflections serve as a starting point for thinking, on the one hand to trace the dialogue-

like development of urban planning parameters of streets and fountains, as well as reservoirs in this case, and on the other hand to make a comparison of pre-industrial plazas (Jardim das Amoreiras) with those from more recent times (Reservatório de Campo de Ourique).

2.1 Historical case studies in Lisbon: Mãe d'Água das Amoreiras

Mãe d'Água das Amoreiras, also known as Arca de Água, Casa da Água ou Castelo de Água, is the main water reservoir that received water from the Aqueduto das Águas Livres in central Lisbon from the beginning. It is the second nucleus of the Museu da Água. The building was designed in 1746 by the Hungarian architect Carlos Mardel and was not completed until 1834, after his death. It was used to collect and distribute water from the Aqueduto das Águas Livres and is located near Largo do Rato. Carlos Mardel was responsible for the design and construction of the Mãe d'Água das Amoreiras (Fig. 1), and the construction of four monumental fountains, including the Chafariz do Rato and Chafariz da Esperança, and the fountain on Rua Formosa, which were integrated into the network of twenty-four fountains in the centre of Lisbon (Fig. 2). He was thus instrumental in the design of public places along the aqueduct. Although Lisbon received its first water from the Carenque Valley in 1748, it took until 1867, almost one hundred and thirty years later, to complete the entire system, including its subordinate and emitting aqueducts as can be seen in the table by Maria Dolores de Ferreira (Fig. 3). In October 1744, the water from the aqueduct flowed for the first time into an improvised tank in Amoreiras. In 1746, construction work began on the arches of Amoreiras next to the reservoir. In 1748, with the completion of the 100th arch of the aqueduct, the Arch of Amoreiras, the distribution of water in the city began.

The Mãe d'Água reservoir is laid out along the longitudinal axis created by the preceding arch. In the vertical of this axis is the facade of the building. The Mãe d'Água building receives the water from the top of the triumphal arch, with a waterfall built from stones from the Águas Livres spring inside, and throws it into a basin placed centrally in the space of the building. Via a footbridge one can walk around this 7.5m deep water tank, which has a capacity of 5500 m³. A staircase on the right side of the waterfall leads to the roof with a view over Lisbon. The roof terrace overlooks the Tagus, the Basilica da Estrela and the Igreja de Santa Isabel. To the South, one looks towards Largo de Rato. The Chafariz do Rato was also designed by Carlos Mardel and was supplied by the Galeria do Loreto.

Attached to the Mãe d'Água building is another smaller building, the Casa do Registo, from which two of the main galleries of the Águas Livres aqueduct emanate: Galeria do Loreto and Galeria da Esperança, as well as a smaller one that serves the Chafariz do Rato. The water transported by the Águas Livres aqueduct, when it arrived in Lisbon, was channelled through a network of five large galleries, most of them underground, with a length of about 12 kilometres, whose function was to ensure the supply of fountains and some public facilities: Chafariz do Campo de Santana, Chafariz das Necessidades, Chafariz do Loreto, Chafariz da Esperança and Chafariz do Rato (Fig. 4). The Galeria do Loreto was built in 1746 and is 2998 metres long. Today it can be visited from the Casa do Registo (Mãe d'Água das Amoreiras) on Rua das Amoreiras southwards to Príncipe Real (Reservatório do Patriarcal) and further on Rua do Século to Miradouro

de São Pedro de Alcântara. It supplied the following fountains: Chafariz da Rua Formosa (1762), Chafariz de São Paulo (1848), Chafariz da Mãe d'Água (1840), Chafariz do Passeio Público (1771, dismantled), Chafariz do Carmo (1771), Chafariz do Loreto (1771, dismantled).

In 1856, a project for a new water distribution network was implemented in Lisbon, which was realised with the construction of new reservoirs between 1869 and 1864, eventually making the function of the Mãe d'Água obsolete. From 1867, the distribution of piped water to some houses in Lisbon began, and from 1880, with the construction of the Canal do Alviela, this distribution network for households became increasingly larger.

The Galeria da Esperança also starts from Mãe d'Água das Amoreiras and runs parallel to Rua de São Bento and Avenida D. Carlos I to the Conde Barão area with a total length of 1425 m. It includes the São Bento Arch (1758, dismantled, rebuilt in Praça Espanha) and the following fountains: Chafariz da Rua do Arco (1805), Chafariz do Arco de São Bento (1805, dismantled), Chafariz da Esperança (1768), Chafariz do Cais do Tojo (1784).

2.1 Historical case studies in Lisbon: Jardim das Amoreiras and Chafariz do Rato

The Jardim das Amoreiras, officially called Jardim Marcelino Mesquita, is a garden located on the Praça das Amoreiras. It was designed by Marquês de Pombal and inaugurated in 1759. It owes its name to the 331 mulberry trees that Marquês de Pombal planned to plant there for silk production. Longitudinally, its entrance is bordered to the southwest by the arches of the aqueduct, which flow into the Mãe d'Água das Amoreiras. On the fifth arch is the chapel of Nossa Senhora de Monserrate (1768). Towards the northeast, it borders a former silk factory and several 18th century houses once built for the silk factory workers. The garden is six thousand square metres in size, with a round fountain in its centre. Primary sources such as illustrations and maps can be used to trace the development of the garden in the urban fabric. As late as 1807 (Figure x), the area to the northeast of the Jardim das Amoreiras (parish of Santo Antonio) was largely agricultural land, while the only development in the area was concentrated around the garden itself and between Mãe d'Água das Amoreiras and Chafariz do Rato. The Jardim das Amoreiras is the only structured garden in the Santo Antonio neighbourhood at this time. The interaction between public space and water collection points seems clear even from this early mapping: the Reservatório da Mãe d'Água and the Jardim das Amoreiras form an urban ensemble that will manifest itself in the same place in the city more than 200 years later. The 1807 map also shows that the density of buildings around the Jardim das Amoreiras is significantly higher than around the neighbouring agricultural fields. In the 1807 map, six streets run towards the Praça do Rato, where the Chafariz do Rato is located. Buildings are mainly oriented along the roads, and wells are again located along roads or at their intersections, as it was necessary to ensure the easiest possible access to water for livestock and people. The Chafariz do Rato fountain is located in the immediate vicinity south of the Mãe d'Água. It is fed by a single branch of the Mãe d'Água das Amoreiras. In 1752, the fountain was designed by Carlos Mardel, which explains its uniform architectural style with the Casa das Águas. The trapezoidal building is divided into two levels, which are connected by a staircase at the side. The lower floor consists

of a basin that was used for cattle to drink. The upper floor, a basin lined by a back wall, was for the people. If one compares the map of 1807 with a map of 1911 (Fig. x Map 1911, Silva Pinto), some conspicuous urban changes become clear: in almost parallel alignment to the longitudinal axis of the Jardim das Amoreiras, the Avenida da Liberdade has been laid out to the east with its mouth in the Praça Marquês de Pombal. The agricultural areas have given way to Parque Eduardo VII, whose outlines are already visible, but which is still under construction. To the west, the geometry of the Reservoir de Campo de Ourique is parallel to the axis of the Amoreiras Garden. Rudiments of the grid in Campo de Ourique already hint at the future urban densification of the neighbourhood. To the southeast and southwest of the Jardim das Amoreiras, two crucial parks have been added: Praça do Príncipe Real to the southeast, whose reservoir is connected to Galeria do Loreto, and Jardim da Estrela to the southwest, which was fed by Galeria das Necessidades. In the urban densification over the centuries, the gardens and parks with their fountains crystallise as timeless oases in the city. The inseparable interplay of water and public (green) space seems to become clear once again from the historical maps and developments of the above-mentioned examples.

2.1 Historical case studies in Lisbon: The Reservatório da Patriarcal and Praça do Príncipe Real

The Reservatório da Patriarcal is the third nucleus of the Museu da Água. It was designed in 1856 by the French engineer Louis-Charles Mary and built between 1860 and 1864 to supply the downtown area of the city. It is located underground in the Jardim do Príncipe Real, under a lake with a fountain whose iron railing matches the octagonal shape of the reservoir. The reservoir has a total capacity of 884 m³ of water and was built to regulate the pressure between the Reservatório do Arco and the network of pipes in the lower part of the city. It was originally supplied by the Aqueduto das Águas Livres and from 1833 by the Alviela system. The cistern is made up of 31 columns, each 9.25 m high, which support the stone arches that support the vaults. On top of the vaults is the basin (lake), with a fountain. Both the lake and the fountain served to aerate the water before it was fed into the tank. The drained water entered the tank through four openings at the bottom of the basin, which were fitted with pipes that reached the surface of the water and served as drains. Three underground galleries emanate from this reservoir: the first, which breaks out on the east wall, is connected to the Loreto gallery and was used to transport the water from the Arco reservoir. The second ends at Rua da Alegria and the third, which begins on the west wall to Rua de São Marçal, supplies the western part of Lisbon. The Reservatório da Patriarcal was shut down in the middle of the 20th century and later integrated into the Museu da Água.

The Praça do Príncipe Real (Fig. x) received its present name in 1855, was renamed Praça de Rio de Janeiro in 1910 and was given the name Praça do Príncipe Real, in honour of Queen Maria II's first son, again in 1949. In 1853 the first plans for the garden were drawn and in 1869 planting began, mainly with the majestic cedars, araucarias and elms that can still be seen today. The garden consists of flowerbeds and paved paths that cut through them. In the midst of the organic structure stands the octagonal tank already described. The organic flowerbeds, together with the trees, form the outer physical boundaries of the garden. The relationship to the outside is open, occasionally the trees provide a visual shelter to the inside. If one compares the urban situation on



the basis of the map of 1807 and 1911, a decisive difference to the case of the Jardim das Amoreiras emerges. While in the early nineteenth century the Jardim das Amoreiras with its adjacent buildings bordered on predominantly rural areas and fields, the area of Príncipe Real was already a dense urban fabric with an open space in the middle, where the Reservatório da Patriarcal and garden would be built about half a century later. One can only guess how the city would have densified if a water reservoir with a park had not been built on this site. Today, however, when walking through the area around the Jardim do Príncipe Real, the presence of the reservoir and the exotic planting are key features of the area's quality of stay. Complimentary amenities such as kiosks, play tables, a children's playground, an esplanade and drinking fountains enliven the square today and build on the almost unchanged substance of the original garden, whose timeless design has become an almost untouchable Lisbon landmark. This example also reveals the relationship between the aqueduct, which provides water, and the resulting lively environment of a park. Quite naturally, this ensemble of water and public space seems to have become an organic unity, and the water, which is a necessity, and in this case piped into the city via an underground canal instead of a natural spring as in pre-industrial times, produces a green space in the midst of urban density. As in the example of the Jardim das Amoreiras, which follows the same typological logic of a reservoir and park ensemble, the Príncipe Real garden is still an essential public space with a high quality of stay, whose reach shapes the entire Príncipe Real neighbourhood beyond its boundaries.

3. The neighbourhood of Campo de Ourique in the end of the 19th century and the Reservatório de Campo de Ourique

The modernisation program in Lisbon was also intended to respond to the increasing housing shortage, and to develop a strategy for the expansion of Lisbon's city limits.

A development project for Campo de Ourique was one of the first attempts to densify the city. Campo de Ourique is a plateau located between two valleys, which in the 17th century was a rural landscape covered with olive trees, fruit trees, fields and mills, (Campo= field). Wheat was grown here to supply the city's bakers. Until the 18 century, the current district was mainly home to convents, some palaces, large estates and farms. After the construction of the Aqueduct (completed in 1748), but especially after the earthquake of 1755, which spared the area, the site experienced a first phase of occupation and construction. By the end of the 19th century (from 1879), a real urban project gave birth to the Campo de Ourique neighbourhood, transforming it into a residential area of Lisbon with well-designed streets, new houses and modern urban architecture, thus extending the perimeter of the capital. At the time of the construction of the Reservoir, Campo de Ourique was a rural area, located northwest of the city centre Rossio. In 1884, the Commission of Urban Works and Improvements announced the intention to extend the road network to increase the size of the neighbourhood. To the east, the neighbourhood was opened up along the street Rua Ferreira Borges, as new plots of land were acquired, and it was extended to the west by opening two new parallel streets: Rua Tenente Ferreira Durão and Rua Azedo Gneco. Due to the change in the alignment, a triangular block was formed to the north of the road network. In the course of the planning, there were a number of expropriations of farm owners to implement urban development plans. The presence of a new neighbourhood with new residents



and demands was increasingly felt, and the architectural response was to develop a proportional block system. This orthogonal system required straightening and rationalisation of the boundary streets to facilitate access. The neighbourhood became more and more important and towards 1887 attempts were made to open up Campo de Ourique to the surrounding areas and the city centre.

The inhabitants of Campo de Ourique felt isolated and demanded further measures to connect the neighbourhood with the city. Among other things, a wall separating Rua de Campo de Ourique from Estrada da Circunvalação was to be demolished. The construction work for the Reservatório de Campo de Ourique also clashed with the wishes of the residents, as this would prevent an extension of the Rua de Infantaria and thus a connection to the city centre. However, the morphological characteristics of the Campo de Ourique plateau proved ideal for the construction of a reservoir. Such a large functional structure required as large and undeveloped space as possible. The Reservatório de Campo de Ourique was connected to both the Aqueduto das Águas Livres and the Canal do Alviela. In 1880, construction work began. The reservoir was built with a capacity for 120.000 m³ of water to reinforce the water supply in summer or in case of a break in the Canal do Alviela. In 1890-1892, Portland cement was imported directly from France for the construction, with a total quantity of 2281 tons. The reservoir covers a total area of 26.136 m² and is held up by a cross vault.

The second planning phase for the Campo de Ourique neighbourhood was mainly dedicated to the improvement and installation of infrastructural fixtures such as latrines, wells and washing facilities in Rua Ferreira Borges. The Campo de Ourique project served less to promote the expansion of the city and more to provide building land for housing. In the context of urban planning at the time, Lisbon was not seen as a unified city, but as a collection of several independent settlements with their own character. Campo de Ourique remained a secondary project in the course of these plans due to its external location.

In terms of urban planning nowadays, the Reservatório, which is currently covered by a lawn and inaccessible to the public, is located in a challenging node: it is bordered to the southwest by the gridded and well-functioning residential neighbourhood Campo de Ourique, and to the northeast it is within walking distance of the Jardim das Amoreiras. Also to the northeast and directly adjacent are the towers of the Amoreiras Shopping Centre, which from the inside have an impressive view over Monsanto and the river, but from the outside, despite their practicality in everyday life, appear imposing and impetuous in the cityscape. Previous urban planning attempts to revitalise the area have failed, and the caesura created by the construction of the large reservoir is being felt more than ever. The strategic connection to the neatly structured and well-functioning neighbourhood of Campo de Ourique is interrupted by the reservoir, which is a large bubble in the city, and the traffic arteries, prohibiting any seamless transition to the surrounding areas, whether to the Jardim da Mãe d'Água das Amoreiras or to get to Campolide. It almost seems as if the modern intervention has failed to include public space in its role compared to its historically earlier counterparts, Mãe d'Água and Reservatório da Patriarcal. Instead of any attempt at a garden or park with fountains, the reservoir rests with a purely functional *raison d'être* underground, and is not visitable either on its surface or as a spatiality. In this way, it differs essentially from the other, earlier reservoirs that combine function with public usability. They can be visited, and their ornamental decoration indicates the historical planning that always included the

public eye. On the basis of this, a change in thought from early industrialisation to modernity can be seen, in which ornamentation and publicity were exchanged for pure functionality, as can be seen in the example of the Reservatório de Campo de Ourique.

The modern urbanisation processes of industrialisation have in many ways shaped the image we have today of a European metropolis. In Lisbon, urban development was primarily linked to the aqueduct and water supply. The public spaces that emerged are testimony to that dynamic infrastructure, which produced not only fountains but entire gardens and magnificent underground water reservoirs.

A chronological examination of the case studies of the reservoirs and the public gardens associated with them reveals a clear change. While the earlier reservoirs were designed with care and representation in both the ornamentation and the design of their gardens, these objectives disappeared with the expansion of the city of Lisbon into a metropolis. Mechanisation and functionality conquer the field, and ornamentation and gardens, it seems, have to give way and no longer have a place in the mechanised water supply that finally reaches Lisbon in the 20th century. When one considers that the first reservoir buildings (Mãe d'Água, Reservatório da Patriarcal) are still timeless and vibrant places of public life today, the radicality of modernity, in which such aspects often found no place, becomes palpable. For future planning, it is worthwhile to take an example from the well-functioning timeless typologies of the 18th century and reinterpret the thinking behind them in order to continue to create timeless places of public life that are linked to infrastructures.

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