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RESEARCH ARTICLE

The management of water heritage in Portuguese cities: Recent regeneration projects in Évora, Lisbon, Braga and Guimarães

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Abstract Given the cultural and environmental potential presented by historical water infrastructures in urban contexts, this article states the evidence of a not much documented urban phenomenon in Portugal, the refurbishment of water heritage protected areas motivated by European-based regeneration projects. By employing a case-study design, four good practices -placed in Évora, Lisbon, Braga and Guimarães-are chosen to enlighten this growing and aware trend. The assets located there -the Água de Prata Aqueduct, the Águas Livres Aqueduct, the Sete Fontes water-supply system and the Zona de Couros industrial area, respectively-are geographical, historical and culturally characterised, while the projects that concern them are documented by visiting the areas and analysing the available sources. Then, open-data platforms and heritage protection decrees are processed to graphically code the topography, hydrology, urban land use, infrastructures, landmarks and protected areas, employing QGIS free software for Geographic Information Systems. As a result, the four practices are documented, discussed and compared. A table assesses and summarises their pre-existing and currently added values and a series of diagrams illustrates the landscape changes generated. These graphics validate the practices and update the status of the assets, enhancing the rediscovery of the existing landscapes and showing the main challenges and future opportunities faced by these areas.

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Abbreviations

CME	Câmara Municipal de Évora
CML	Câmara Municipal de Lisboa
CMB	Câmara Municipal de Braga
CMG	Câmara Municipal de Guimarães
GTLCMG	Gabinete Técnico Local da Câmara Municipal de Guimarães
DGPC	Direção Geral do Património Cultural
DG	Diário do Governo
DR	Diário da República
MC	Ministério da Cultura
ZGP	Zona General de Protecção
ZEP	Zona Especial de Protecção

1. Introduction

Water heritage presents universal values and is a testimony to the uses and historical management of the territories; therefore, its landscapes conservation is a reason for study and valuation at the international level (Castro García, 2012). It is an issue of multi-disciplinary nature, as the heterogeneity of boundaries that it lies at demonstrate (Hein, 2020; Hunter, 2021). Some of these studies also reinforce the need to innovate in the management of these heritage resources, valuing their historical, cultural, urban and environmental potentialities (Deng et al., 2020; Duarte Rodrigues and Toribio Marín, 2020; Giusto, 2020; Havlíček et al., 2020; Jover Biboum et al., 2020; muleac et al., 2020). Others specifically remark the importance of the conservation and valuation of their landscapes (Mata Olmo and Ferrer Jiménez, 2013; De la Cal Nicolás, 2021; López-Bravo et al., 2021). Due to the urban spread, their interferences with the city fabric result in a particular contemporary problem, and the lack of reflection about this predicament would evolve towards the waste of great urban heritage resources and opportunities.

This water heritage typology is extensively spread through the Portuguese urban and rural landscapes, as Fig. 1 illustrates with examples. An inherited richness that has been intensely studied and informed by researchers, attending to the different chronological periods. From the Roman aqueducts (Cardoso et al., 1998; Quintela et al., 1986), or the Cistercian Monasteries (Puga, 2020; Jorge, 2012, 2018; Maduro et al., 2017; Martins and Carlos, 2016; Martins, 2011) to the splendid stone monuments which brought water to Portuguese Cities during the Modern Age (Tchikine, 2020; Marat-Mendes, 2013). Unsurprisingly, based on this wealth, the French historian and traveller Ferdinand Denis named it “the country of the aqueducts” in the late 19th century (Caetano, 1991).

Most of these heritage assets have been progressively classified, starting March 1910 (Diário do Governo, 1910) under different protection categories at both national and international level, as Table 1 displays. In spite of being protected, their conservation and accessibility status



Fig. 1 Amoreiras Aqueduct in Elvas (above) and São Sebastião Aqueduct in Coimbra (below). Source: the authors, 2020.

becomes a real challenge for Portuguese governments, as complaints in several press publications evidence (O Mirante, 2020; Alemão, 2019; Faria, 2015). Unfortunately, at the worst-case scenarios, these infrastructures and their General or Special Protection Zones¹ (ZGP or ZEP) have turned into forgotten, fragmented and deteriorated inaccessible spaces due to the scarcity of resources.

However, Portugal’s commitment to urban regeneration has been clear over the recent years (Medeiros, 2020). Sustainable development plans at international, national, regional and municipal levels, involving architectural, cultural and environmental issues have grown. These efforts have led many Portuguese cities to become candidates or even designated at numerous European initiatives in pursuit of development and acknowledgment, such as the World Heritage enrolment or the European’s Capital of Culture, Youth Capital or Green Capital candidacies. As the European Union outlines, these awards carry important incentives for urban restoration, export the international profile of the city and promote ambitious challenges to improve its urban environment (European Union, 2020). In evidence of this, Lisbon, Oporto and Guimarães were European Capitals of Culture (1994, 2001 and 2012 respectively); Cascais was European Youth Capital (2018) and, recently, Lisbon was also European Green

¹ These legal instruments increase the asset’s protected area beyond its perimeter in two different ways, regularly (ZGP) or specifically shaped (ZEP), due to their landscape and territorial influence and value.

Table 1 Heritage protection status of the main Modern-Age waterworks in Portugal. Source: the authors, 2020.

Waterworks	Location	Protection typology	ZGP	ZEP	World Heritage	
Estrada dos Arcos Aqueduct	15 th Setúbal	Public Interest Building	1971	Yes	No	—
São Sebastião Aqueduct	15 th Coimbra	National Monument	1910	No	Yes	UNESCO List (2013) University of Coimbra Alta and Sofia
Amoreira Aqueduct	15 th Elvas	National Monument	1910	No	Yes	UNESCO List (2013) Garrison Border Town of Elvas and its Fortifications
Água de Prata Aqueduct	16 th Évora	National Monument	1910	Yes	No	UNESCO List (1986) Historic Centre of Évora
Watermills on Guadiana river	16 th Beja	In classification process	2008	No	No	—
Usseira Aqueduct	16 th Óbidos	Public Interest Building	1962	Yes	No	—
Torres Vedras Aqueduct	16 th Torres Vedras	National Monument	1910	Yes	No	—
Serpa Aqueduct	17 th Serpa	National Monument	1954	Yes	Yes	—
Zona de Couros	17 th Guimarães	ZEP Historical Centre	2010	No	Yes	UNESCO Tentative List (2017) Historic Centre of Guimarães Extension
Pegões Aqueduct	17 th Tomar	National Monument	1910	No	Yes	UNESCO List (1982) Convent of Christ in Tomar
Sete Fontes System	18 th Braga	National Monument	2011	No	Yes	—
Santa Clara Aqueduct	18 th Vila do Conde	National Monument	1910	No	No	—
Santo Antão do Tojal Aqueduct	18 th Santo Antão do Tojal	Public Interest Property	2012	No	Yes	—
Águas Livres Aqueduct	18 th Lisbon	National Monument	1910	Yes	Yes	UNESCO Tentative List (2017) Águas Livres Aqueduct
Gargantada Aqueduct	18 th Queluz	Public Interest Building	1978	Yes	No	—
Cabo Espichel Aqueduct	18 th Setúbal	Public Interest Building	1950	Yes	No	—
Nove Janelas Aqueduct	19 th Ilha de São Miguel	Unclassified	—	No	No	—
Alviela Aqueduct	19 th Lisbon	Unclassified	—	No	No	—

Capital (2020). Besides, the historic cities of Évora, Oporto, Guimarães and Elvas² were recognised as World Heritage Sites (1986, 1996, 2001 and 2012) as well as Sintra Cultural Landscape (1995). These achievements have contributed to the planification and practice of many urban, urban land use or environmental regeneration projects submitted as sustainable indicators of these cities.³ Despite there are cases that evolves towards tourist oversaturation, these plans principally preserve, improve, connect and reactivate the areas they interact with, including cultural heritage ones.

Motivated by the habitual interaction of these regeneration projects with water heritage settings, this research obtains evidence to accurately describe a not much documented urban phenomenon in Portugal, the refurbishment of water heritage protected areas encouraged by European-based regeneration projects. As it has been said, little

research has been formally published in this regard despite the increase in projects. So that, intending to learn from experiences of water heritage regeneration in urban contexts, the article examines and maps four contemporary situations to provide a series of management arguments that validate the practice and update the status of the assets by employing four-case studies design.

2. Structure, sources and methods

The research has been organised in two phases which shape the results and discussion sections.

The first one, the results, provides an updated state of the art for each case study by employing bibliographic research, visiting the areas and analysing the available sources. For this identification of each case, a territorial characterization is provided, then the asset and its protection status are presented and mapped and finally, the

² The city of Elvas and its fortifications are inscribed as a Garrison Border Town.

³ These candidacies are proposed six years before the celebration date and appointed four years in advance. This period is necessary to allow the development of urban projects and new cultural infrastructures.

Table 2 Hyperlinked sources directory employed for the heritage cartography methodology. Source: the authors, 2020.

Direção-Geral do Património Cultural	Pesquisa de Património Imóvel	Atlas do património classificado e em vias de classificação
	Sete Fontes	Decreto nº 16/2011 de 25 de Maio
	Zona de Couros	Aviso nº 15 170/2010 de 30 de Julho
	Água de Prata	Decreto nº 136/1910 de 23 de Junho
	Águas Livres	Aviso nº 12 657/2007 de 6 de Junho Decreto nº 136/1910 de 23 de Junho Portaria nº 1092/1995 de 6 de Setembro Decreto nº 5/2002 de 19 de Fevereiro
Archives	Arquivo Nacional Torre do Tombo	Search portal
	Arquivo Distrital de Évora	Search portal
	Arquivo Distrital de Braga	Archeevo
Refurbishment projects	Arquivo Municipal Alfredo Pimenta	Archeevo
	Câmara Municipal de Lisboa	Corredor Verde Vale de Alcântara
	Câmara Municipal de Évora	UNESCO Policy Monitoring Platform
	Câmara Municipal de Braga	Estudos Arqueológicos e Hidrogeológicos de Sete Fontes
	Câmara Municipal de Guimarães	Proposta de inscrição da Zona de Couros na lista indicativa da UNESCO
Open GIS data	Instituto Hidrográfico Portugal	Dados
	Sistema Nacional de Informação Geográfica	Registo Nacional de Dados Geográficos
	Direcção-Geral do Território	Fototeca, Pesquisa de Secções Cadastrais
	Câmara Municipal de Lisboa	Dados Abertos Lisboa, Geodados
	Câmara Municipal de Braga	GeoPortal WebSIG Público do Município de Braga
	Comunidade Intermunicipal do Alentejo Central	Portal de Informação Geográfica CIMAC
	Universidade Nova de Lisboa	Atlas Cartografia Histórica
	Faculdade de Ciências Sociais e Humanas	
	Universidade de Lisboa	EPIC Webgis Portugal, Green and blue infrastructure research line
	Instituto Superior de Agronomia	

objectives, planning and development status of the regeneration project is documented.⁴

The second part, the discussion, assesses the values of the assets before and after the project's arrival to learn from them and illustrate the landscape changes they have experienced. Using the literature and previously researched, they are classified using a table layout and a series of maps to illustrate the arguments.

As a connecting link between both parts, Geographic Information Systems and particularly QGIS free software has been employed to create nine diagrams, which code graphically the topography, hydrology, land use, infrastructures, accessibility, landmarks and protected areas of each case. With this purpose, two working scales were designed for each case study: one territorial and the other intermediate. The first one complemented the case documentation, it illustrates the relationship of the element and its protected area (ZGP or ZEP) with the hydrography, topography, the other heritage protected areas and the city itself. The second one resulted from overlapping all the data analysed and shows the asset's items and spatial distribution and its connection and involvement with the regeneration project, the architecture and the public

space. As [Table 2](#) arranges and hyperlinks, national, university and municipal Portuguese open data platforms were employed with this purpose, as well as the heritage protection decrees of the assets.

2.1. Criteria for selecting the cases

As seen at [Table 1](#), there are eighteen main Modern-Age waterworks located in Portugal. Out of that classification, fourteen are protected as National Monuments, Public Interest Buildings or Properties, while three of them remain unclassified yet. Moreover, four of them are registered in the UNESCO World Heritage List, whereas two are part of the Tentative one since 2017.

The four cases selected, located in [Fig. 2](#), are the Água de Prata Aqueduct (16th century), the Águas Livres Aqueduct (18th century), the Sete Fontes water-supply system (18th century) and the Zona de Couros industrial area (17th century), placed in Évora, Lisbon, Braga and Guimarães. These paradigmatic waterworks were all previously faded urban areas, which are now good practices' examples, concerned by European or municipal urban regeneration projects. The first three are systems of conveyance and distribution of drinking water while the fourth and last is a water-based industrial infrastructure.

Their selection was based on the asset's differences in origin, settlement and scale, detailed further on. Due to

⁴ Technical reports, maps, news and even conference videos were employed to collect details of the projects, because some of them are current and have been slightly published yet.

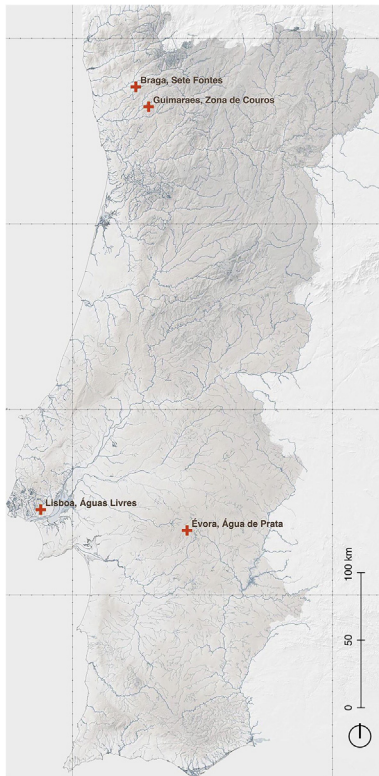


Fig. 2 Case studies location. Scale 1:2.750.000. Source: the authors, 2020.

their disparity, they have developed dissimilar sociohistorical and urban relationships throughout their lifecycles. They have also supplied different areas of influence, a national capital, a district capital or a small town, of which regeneration works of different magnitude have resulted. These dissimilarities allow to represent this urban phenomenon by showing its development at different scales, functions and settlements and perhaps it could motivate the recovery of the rest.

3. Results

3.1. Évora: the presence of the Água de Prata Aqueduct across the new Sphera Castris project

Évora is a medium-sized inland Portuguese city, shown at Fig. 3. It is located on the large plain of Alentejo, between the basins of the rivers Tajo, Guadiana and Sado, 130 km East of Lisbon. It has a relatively elevated water table and is surrounded by several seasonal river basins of irregular water regime. With Roman, Visigoth and Islamic origins, it was conquered in 1165 (Simplicio, 2006).

The construction of the Água de Prata Aqueduct began in 1531 and its final design was completed only six years later, in 1537. As shown by Pereira, Tereno and Monteiro, who have studied the history of this water channel extensively (Monteiro et al., 2015), previous research maintains that King João III ordered it to be rebuilt on the ruins of a Roman duct (Espanca, 1944). It extends 18 km from the springs of Prata and Divor to

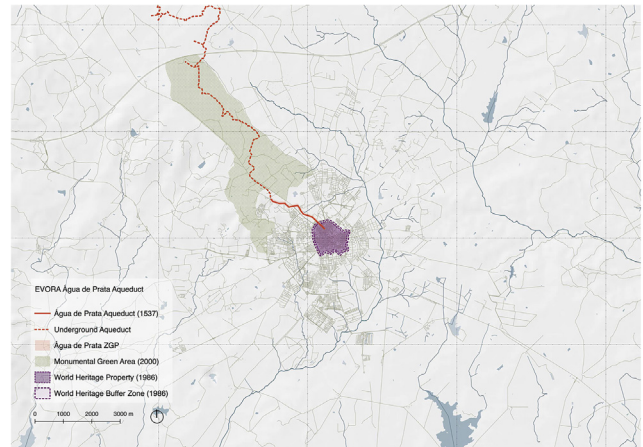


Fig. 3 Évora, Água de Prata Aqueduct and Monumental Green Area cartography. Scale 1:75.000 m. Source: the authors, 2020.

the North, traverses the Alto de São Bento and the Forte de Santo António, crosses the city wall and ends at the Convent of São Francisco in the South-East, as Fig. 4 cartography illustrates. This water supplied the city of Évora for four centuries, from 1537 until 1919 (Monteiro et al., 2019).

It was classified as a National Monument in 1910 while still in use. This protection includes arches, primitive channels, ancient household branches, water sources, reservoirs and fountains in public and private domain (Diário do Governo, 1910). Its urban sections integrated into the historic city centre boundaries, seen in Fig. 5, classified as World Heritage in 1986. Furthermore, part of it is included in the protected surroundings of the Convent of São Bento de Cástris, the Igreja da Cartuxa and the Fort of Santo António. Its Northern route is inside the Monumental Green Zone of Évora, which is a land use restriction factor in the Regulamento do Plano de Urbanização of 2000. It is a predominantly rural area covering over 1000 ha, which includes eight historical recreational estates, in addition to



Fig. 4 Unknown author. Planta da Cidade de Évora, 1750–1790. Source: Biblioteca Nacional de Portugal.



Fig. 5 Évora, Água de Prata Aqueduct's urban stretch. Source: the authors, 2020.

the Aqueduct and the aforementioned assets. For this reason, any intervention in this area must safeguard its prevailing rural character and emphasise the aqueduct's role as a linking element between all the heritage assets in the Zone (Diário da República, 2000). This area also hosts historical traces, such as meadows and Roman cadastral networks, which define a cultural landscape around the city (Batista et al., 2010). Perhaps, the generous boundary of the Monumental Green Zone compensates the lack of a larger protected environment for Água de Prata. Additionally, in 2007, the Percurso Ambiental no motorizado de Água de Prata, showed in Fig. 6, was established. It was part of a district initiative to create routes employing existing infrastructure traces, for leisure time or outdoor sports practice (Câmara Municipal de Évora, 2007). Currently, the Project LIFE Água de Prata (2019) aims to promote works which allow reuse of the Aqueduct for irrigation water distribution.⁵

Anchored in this territory of varied elements, historical origins and strong cultural influence, the Sphera Cástris Southwest Park for Heritage and Arts arose in 2016. This initiative, included in the UNESCO Policy Monitoring Platform,⁶ seeks to create an infrastructure for culture and heritage, as well as production and artistic creation. This centre for arts, science, technology, research, innovation and sustainability plans to cover 5000 square metres. This will include the Convent of São Bento de Cástris and over 40 ha of rural land, subject to the restoration of this 18th-century building and its surroundings. This enhancement of

⁵ It is part of the Estratégia Municipal da Adaptação às Alterações Climáticas of Évora of 2017 and is planned to supply almost 50% of the green areas of the city.

⁶ It is a project of the Direção Regional de Cultura do Alentejo, the Comissão de Coordenação e Desenvolvimento Regional do Alentejo, the Câmara Municipal de Évora and the Universities of Évora, Lisbon, Coimbra, the Algarve, Seville, Granada and Extremadura (Direção Regional de Cultura do Alentejo, 2015).



Fig. 6 Évora, Água de Prata Aqueduct's rural stretch. Source: the authors, 2020.

obsolete heritage aims to increase the growth and competitiveness of the region, creating skilled jobs in the cultural sector (UNESCO, 2016). The construction of this integrated structure, constituted of various areas of activity, will see the creation of a solar park to supply energy to the entire project. It will also contain diverse pilot zones for the study of Mediterranean agriculture and biodiversity and an area for public community gardens (Amendoeira, 2015). Nonetheless, the limited Sphera Cástris Project material published appears to omit its connection to the Aqueduct. This raises questions about the asset's adaptation and involvement in this new project.

3.2. Lisbon: the Alcântara Valley Green Corridor, a new perspective for the Águas Livres Aqueduct

The city of Lisbon is located on the right bank of the Tajo estuary. It is surrounded by numerous small towns which constitute its metropolitan area. To the North, the Sintra and Loures mountain ranges outline this territory, marked by water channels running from North to South. There, the necessary topographic and atmospheric conditions for groundwater concentration are found.

The Águas Livres Aqueduct, started in 1731 and inaugurated in 1748, sources its water from that area. It begins in the Mãe d'Água⁷ Velha in Olival do Santíssimo in Caneças. Then, it follows a stretch of the former Roman Aqueduct of Olissipo (Mascarenhas et al., 2012), towards the Mãe d'Água das Amoreiras reservoir in the parish of Santo Antonio in Lisbon. This main section is 15 km in length. Together with the subsidiary aqueducts, the full network exceeds 60 km, as Fig. 7 maps. Today, its architectural features can be seen throughout the city shaping tanks, reservoirs and the so-called 'chafarices'.⁸ All of them create a network of "urban voids" linked to water (Marat-Mendes, 2007, 2013) and connect an enormous web of assets which extends far beyond the Lisbon Metropolitan area (Marat-Mendes et al., 2015, 2016). Among these

⁷ Natural spring.

⁸ Public fountains with spouts.

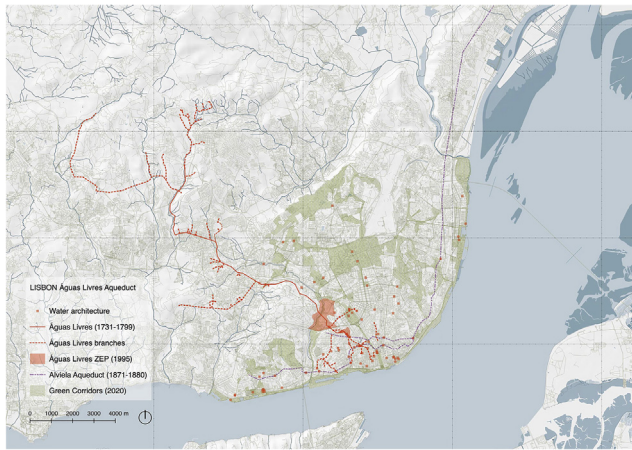


Fig. 7 Lisbon, Águas Livres and Alviela Aqueducts cartography. Scale 1:100.000. Source: the authors, 2020.

are the aforementioned Mãe d'Água das Amoreiras and the Reservatório⁹ do Patriarcal in the Praça do Príncipe Real. However, the arches over the Alcântara Valley represent its most formidable challenge.

The heritage protection of this Aqueduct was implemented in 1910 (*Diário do Governo*, 1910). The perimeter of its ZEP, defined as "el troço entre Campolide e a Avenida do Engenheiro Duarte Pacheco" and the "troço das Amoreiras", was added in 1995 (*Diário da República*, 1995). This initial protection was altered in 2002, by adding its afferent branches and subsidiary aqueducts in over 30 adjacent districts and towns (*Ministério da Cultura*, 2002). Due to its size, the asset is also included in the classification of other 12 assets and 22 adjacent ZGPs and ZEPs. Finally, since 2017, it has been featured on the UNESCO Tentative List, based on its archaeological, documentary, technical, social, ethnographic, historical, cultural-educational¹⁰ and environmental values.

As can be confirmed in the 1871 map at [Fig. 8](#), the Alcântara was an agricultural valley until the 19th century. It was barely urbanized and marked the edge of the city's growth to the West. It is the largest valley in the city of Lisbon, a river basin with slopes exceeding 30% incline which was settled from the 19th century, when it housed textile factories and residential districts for local workers. At the end of that century, the construction of the Lisbon-Sintra train line further accentuated its inaccessibility. Subsequently, with the construction of the Avenida de Ceuta in 1932, the river was completely buried. Since 1962, the construction of the Ponte 25 de Abril has characterised this artery as one of the main access routes to the city ([Anastasia](#), 2019).

Today, the Alcântara Valley Green Corridor is one of the main objectives of the Plano Director Municipal de Lisboa (CML, 2012). The pursuit of environmental improvements,



Fig. 8 Pais, Miguel Carlos Correia. Extract from *Planta Topographica da Cidade de Lisboa*, 1871. Scale: 1:10.000. Source: Biblioteca Nacional de Portugal.

such as the regulation of the water system, the use of recycled water, the recovery and increase of vegetation coverage and ecological continuity is regenerating this traditionally industrial area. Furthermore, a network of pedestrian and cycling paths are connecting the Monsanto Forest Park, the neighbourhoods of Campolide and Alcântara and the Tajo estuary (CML, n.d.). The initiative is over 3 km in length. It is divided into five zones or segments; from North to South: the Parque Urbano da Quinta do Zé Pinto, the area of Bairro da Liberdade - Estação de Campolide, the Águas Livres Aqueduct, the Parque Urbano da Quinta da Bela Flor and the Avenida de Ceuta. Both, the area of Estação de Campolide and the segment relative to the Aqueduct, coincide with the most imposing above-ground section of the infrastructure as it passes through the



Fig. 9 Lisbon, Vale de Alcântara pedestrian bridge. Source: the authors, 2020.

⁹ Reservoir.

¹⁰ The group created by the Mãe d'Água das Amoreiras, the Reservatório do Patriarcal, the arches over the Alcântara Valley and the Estação Elevatória a Vapor dos Barbadinhos conform the Museu da Água de EPAL, established in 1987.



Fig. 10 Lisbon, Vale de Alcântara pedestrian path. Source: the authors, 2020.

Ribeira de Alcântara. The large row of pointed stone arches, showed in Fig. 9, crosses the now piped riverbed which is hidden under road traffic and train tracks. Since 2018, the regeneration project has allowed pedestrians to pass under the arches, Fig. 10, despite its acoustic harshness and visual contrast to the environment. With it, Lisbon promotes accessibility and pedestrian connection in an area previously dominated by motor vehicles and trains. This increases the interaction with the asset, reinforces the Aqueduct's unique value and recovers a historical piece of the territory.

3.3. Braga: the future Parque da Cidade, the resurgence of the Sete Fontes hydraulic system

Braga is the capital of Northern Portugal and the country's third most populous city. It was strategically located during Roman times, seen at Fig. 11, being equidistant from the rivers Minho and Douro and 60 km to the North-East of Porto. The 15th and 16th centuries brought great splendour to this city of Archbishops,¹¹ as Fig. 12 shows. At that time, the population increase caused the new building of numerous public and private fountains (Vieira et al., 2018). Due to this, it was necessary to employ new groundwater abstraction areas. Different hypotheses maintain that in these centuries, the existing aquifers located in the highest areas of the city were reactivated, following the route of the ancient Roman waterways (Ribeiro and Martins, 2012). One of these was the Sete Fontes one, at the foot of the Monte de Pedroso (322 m) in the North-East of the historic centre of Braga.

During the 16th century, the Sete Fontes construction began on a system of subterranean tunnels to collect the water from those springs. First, 3,5 km of stone pipes were built to transport it to the city, as well as storage tanks and fountains for its distribution. In 1704, an early pipeline connected the Sete Fontes aquifer with the Caixa Geral das Águas. Later, between 1744 and 1752, the pipeline was

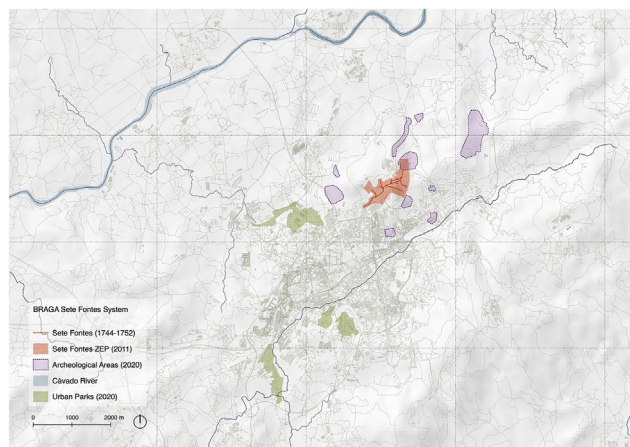


Fig. 11 Braga, Sete Fontes Water System cartography. Scale: 1:55.000. Source: the authors, 2020.

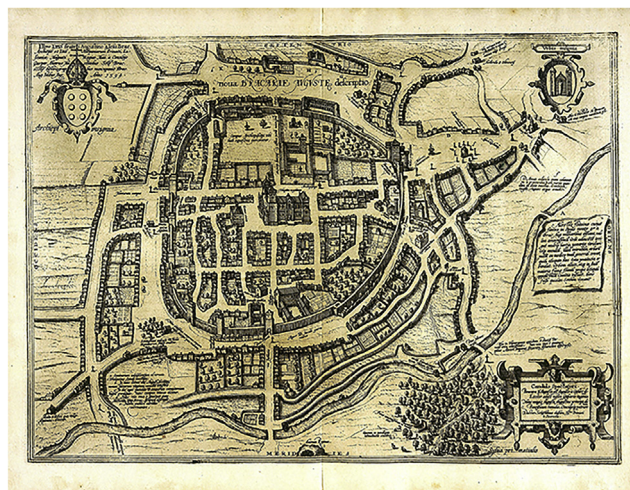


Fig. 12 Noua Bracararum Avgvste description, 1594. Source: Georg Braun; Frans Hogenberg. "Civitates Orbis Terrarum", vol. 5 (Latin ed, Colónia, 1598.).

improved and monumentalised by the Archbishop D. José de Bragança. This was achieved through the construction of new tunnels and the characteristically baroque "chapels",¹² photographed in Fig. 13. As a result of these improvements, Sete Fontes achieved to be the city's primary water supply until 1913. That year, the new water extraction system of the River Cávado was built¹³ (Martins et al., 2012).

Despite being proposed for classification in 1995, it was only declared a National Monument in 2011 (Ministério da Cultura, 2011a) and its ZEP was issued in June of the same year, extending over 66 ha (Ministério da Cultura, 2011b). This classification includes the 3,5 km long system of pipes, 11 galleries, 7 fountains, 3 vents and 5 mines. Out of these, 2,5 km are subterranean galleries and the remainder connecting pipes. Its value lies in the improvements generated in the quality of life, as well as its

¹¹ The diocese of Braga dates from the 3rd century AD.

¹² Rooms with dome ceilings, decorated with a coat of arms. There, the galleries converge and water sedimentation takes place.

¹³ It is now called Ponte do Bico treatment area, placed 6,5 km North of Braga.



Fig. 13 Braga, Sete Fontes “chapels”. Source: the authors, 2020.



Fig. 14 Braga, Sete Fontes stone channel. Source: the authors, 2020.

contribution to the development of baroque architecture and urbanism. Technically, it also took part in the evolution of new hydraulic engineering concepts, later reflected in the quality of Modern-Age urban infrastructures. Today, this sustainable hydraulic resource is still in use¹⁴ and can be found surrounded by a natural environment, as Fig. 14 shows, in the current district of São Victor. However, the area is not easily accessible.

There, the Câmara Municipal de Braga¹⁵ has planned the Project called Parque da Cidade. A Park that focuses on the protection of the area and the infrastructure, including the physical and functional components of this

¹⁴ It is managed by Agere, Empresa de Águas, Efluentes e Resíduos de Braga. According to recent hydrogeological studies it produces 500 m³ per day (Antunes and Gonçalves 2019).

¹⁵ Braga Town Hall.

¹⁶ The dry zone corresponds to the terrains of highest elevation, with less water retention and a prevalence of dryland species, such as the cork oak. The humid zone is located on the grounds of lowest elevation, where run-off water from the basin accumulates and species such as willows and blackberries are prevalent. On the intermediate ground, the transitional ecosystem presents mixed characteristics, with a predominance of oaks.

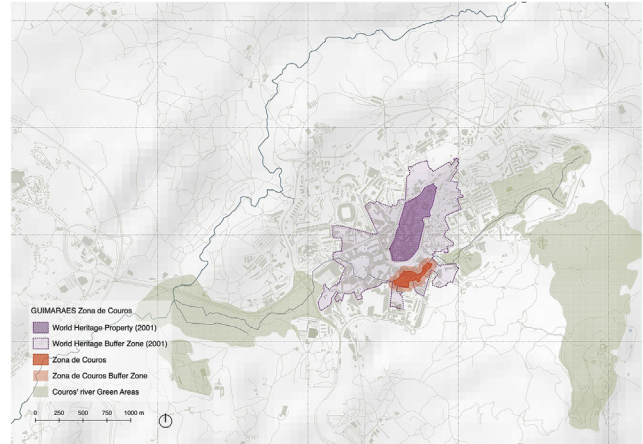


Fig. 15 Guimarães, Zona de Couros location cartography. Scale 1:22.500 Source: the authors, 2020.

hydraulic system. The plan is to preserve it as a natural landscape and include areas of groundwater abstraction and infiltration, in addition to its architectural elements. Among the tools arranged to preserve its natural component, the prior study of the area defines three zones: a dry ecosystem, a humid one and a third transitional one.¹⁶ As a connection to the city, four access points to the area are being considered. They will generate a higher-intensity perimeter of use and two paths parallel to the Monument, which will house lateral rainwater-retention barriers. In the humid area, there will be a natural lake, which will collect seasonal rainfall. It is anticipated that existing vegetation will be entrenched and patches of tree and shrub vegetation will be added. This will create a protective filter for the central core of the park, which is the space bounded by the paths in the main framework of the Monument (Câmara Municipal de Braga, 2019). The project, which was in a period of public discussion from July to November 2020, has been approved and is set to begin within 2021. According to the park preliminary studies, over 15 different landowners can be identified within its area (Câmara Municipal de Braga, 2016). This appears to have generated great debate and has been one of the most significant obstacles to the launch of the project. This is evidenced in the numerous press releases concerning owners' unease about the purchase of the land by the CMB (Cerqueira, 2020; Cunha, 2018). But, despite these difficulties, this Town Hall's initiative aims to protect and domesticate a landscape in danger of being urbanized. The main values of the Parque da Sete Fontes are to encourage the interaction, accessibility, preservation and sense of belonging of this magnificent environment. It tries to protect and update this green part of the city at the same time that it prevents this hydraulic system from natural and physical deterioration.

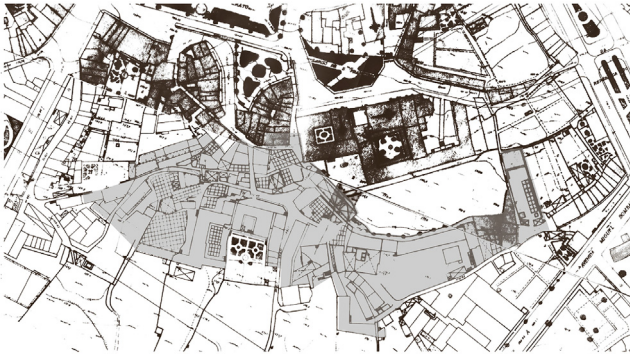


Fig. 16 Unknown author. Guimarães, Zona de Couros location, 1923. Source: Câmara Municipal de Guimarães.

3.4. Guimarães: the improvement program of Zona de Couros, from CampUrbis to the restoration of the Ribeira

The municipality of Guimarães borders Braga to the North and is crossed by the River Ave. This water course gives it a strong industrial character linked to the water availability (Costa and Cordeiro, 2013; Costa, 2012). The city centre was originally located in the Northern bank of a smaller course, called Costa,¹⁷ as can be seen in Fig. 15. The Costa, later called Couros, is a short river of 6,2 km long, that originates in the Serra da Penha, 2 km to the East of the historic centre of Guimarães. It crosses the Parque da Cidade and is then channelled under the urban land. It reappears above ground in the Zona de Couros and, finally, in Lameiras and the Veiga de Creixomil, before flowing into the river Selho (Vieira et al., 2008).

This fortified medieval city prospered thanks to the development of the manufacture and treatment of leather, among other activities. The area of Couros, mapped in Fig. 16, whose main development occurred during the 17th and 18th centuries, is located South of the city foundational monastery of Nossa Senhora da Oliveira. In this neighbourhood, the water channel was used from then until the middle of the 20th century with domestic and industrial purposes, as architectural and infrastructural remains such as mills, tanneries or tanks reveal. Besides, the water was also used for agriculture, as well as for domestic and industrial effluents discharges.

The historical centre of Guimarães has been featured on the UNESCO World Heritage List since 2001. In 2016, a new enlargement including the Zona de Couros was registered as a candidate on the Tentative List (Ramalho and ICOMOS Comissão Nacional Portuguesa, 2017). Currently, the main and specific characteristics of this area can be noticed in its buildings and public spaces, as Fig. 17 exemplifies, which represent an important industrial activity hidden behind its toponymy (GTLICMG, 2007). According to the DGPC catalogue, the area was classified for the first time in 1978, by appointment of the Conjunto das Antigas Fábricas de Curtumes. This was a pioneering recognition of industrial



Fig. 17 Guimarães, Rua de São Francisco. Source: the authors, 2020.



Fig. 18 Guimarães, Centro Ciencia Viva. Source: the authors, 2020.

archaeology in Portugal. Finally, its protection was implemented by including the area in the ZEP of the historical centre of Guimarães, a National Monument, in 2010 (Diário da República, 2010). Despite its hydrological character is an original value of the area, it is in high risk of urban flooding and water contamination, as several publications document (Ferreira and Santos, 2020; Miranda and Ferreira, 2019; Nogueira et al., 2012). Due to this fact, today, one of the main environmental objectives of the Câmara Municipal de Guimarães¹⁸ is the restoration of the Ribeira da Couros, as part of large-scale urban project.

In 2011, a year before Guimarães was named European Capital of Culture, a first project called CampUrbis was conceived. This was a proposal made by the city council and the Universidade do Minho, which aimed to combine the architectural and historical restoration of the area. Its architectural component was focused on the restoration and revitalization of this deteriorated urban area through the concept of "Virtual Campus" or "University without walls". Its objective was to create a city for creativity. Among the urban operations proposed were

¹⁷ The Ribeira da Costa/Couros flows into the river Selho, which is a tributary of the main river Ave.

¹⁸ Guimarães Town Hall.

Table 3 Main characteristics and differences between case studies. Source: the authors, 2021.

	Case 1	Case 2	Case 3	Case 4
City	Évora (District capital)	Lisbon (Nation capital)	Braga (District capital)	Guimarães (Town)
Population	57.000	553.000	194.000	54.000
City extension	11 km ²	100 km ²	12 km ²	4 km ²
Waterworks location	peri-urban	urban	peri-urban	urban
Waterworks typology	Linear (aqueduct)	Linear (aqueduct)	Linear (hydraulic system)	Complex (tanneries complex)
Waterworks function	Irrigation	Cultural facility	Irrigation and water supply	Educational facility
Protected area	2,3 km	117,6 ha	66 ha	3,66 ha
Urban projects area	11,5 ha	16 ha	27,5 ha	5 ha
Urban projects objective	Educational campus	Green corridor	Park	Educational campus
Projects – waterworks relationship	indirect	indirect	direct	direct
Urban projects initiative	European Inter-university	Municipal European Green Capital (2020)	Municipal	Municipal European Capital of Culture (2012)
Urban projects situation	(2016 -) scheduled	(2018–2021) built	(2016-) scheduled	(2011–2021) built
Urban projects estimate	Unavailable	Unavailable	Unavailable	12.000.000 €

restorations, demolitions and new constructions that are currently in development. The completed features are the Centro Ciencia Viva (2010), Fig. 18, located in the old Fábrica Âncora; the Instituto de Design (2011), previously the Fábrica da Ramada; and the Centro Avançado de Formação Pós-Graduada (2012), located in the obsolete Fábrica Freitas e Fernandes. There are also numerous interventions in the public space, such as the improvement of the junction between the streets of Couros, São Francisco, Vila Verde and Largo da Cidade. Moreover, a complex cadastral survey of the physical and ecological areas of the Couros river basin was conducted, with a view to restoring its environment and landscape (Ramísio, 2012; Vieira et al., 2008). The decontamination and the banks regeneration are yet to be completed, creating bordering spaces between the urban land and the riverside (Câmara Municipal de Guimarães, 2020). This ambitious and sensible initiative has increased local interaction with the area. It has also avoided its further deterioration and has transformed it into a new centre. There is no doubt that the necessary natural recovery of the riverbanks will complete this project from an environmental perspective, preventing the disappearance of this urban watercourse.

4. Discussion

While these four heritage areas are affected by urban regeneration projects, there are differences between them. As Table 3 shows as a comparative scheme, there are differences in the typology, layout, magnitude, scope and protected area in each of the cases. In parallel, the projects' objectives can be grouped into those that seek to re-

qualify the infrastructures and their environments avoiding their disappearance (cases 3 and 4), and those that plan urban or peri-urban spaces, but their main objective is not the intervention on the assets (cases 1 and 2). This diversity of objectives derives from the direct (Braga and Guimarães) or indirect (Évora and Lisbon) relationship of the projects on the waterworks. On the other hand, the projects of Évora and Guimarães seek to introduce a new cultural-educational function through the campus, while those of Lisbon and Braga aim to improve the quality of public space without integrating any functional facility. Finally, the phases of the projects make it possible to establish relations with European initiatives such as the European Capital of Culture in Guimarães (2012) or the Green City of Lisbon (2020). Despite the differences, the four projects represent an improvement in the environmental condition and affect the conservation and accessibility of the waterworks in a specific way.

In addition to illustrating the different urban implications of the assets and their environments, mapping as a tool allows showing the main contributions made by the projects, the landscape changes and the difficulties or challenges they face, as shown in Table 4.

In the case of Évora, this vital infrastructure at the urban level, built during the 16th century, currently occupies a boundary between urban and rural land in a large and low-density municipality. As can be seen in Fig. 19, its last section, of 2,3 km long, connects the city centre -World Heritage Property-, with the area of São Bento de Cástris -the Sphera Castris future location-. This graphic proves how the project's outdoor spaces, particularly the solar park, would overlap the arches and the infrastructure's ZGP and break the continuity of the Percurso do Acueducto. On the other hand, it also shows how the assets chained by the

Table 4 Cases studies, pre-existent and currently added values. Source: the authors, 2021.

	Case 1	Case 2	Case 3	Case 4
Waterworks values	Historical Archaeological Architectonical Urban Social	Historical Archaeological Architectonical Urban Social	Historical Archaeological Architectonical Social	Historical Industrial Typological Urban Social
Projects contributions	1. Will improve the accessibility of the area 2. Will stablish a new urban centre	1. Improves the accessibility and connectivity of the area 2. Pedestrianises the area 3. Offers a new perspective of the Aqueduct	1. Will improve the accessibility of the area 2. Will stablish a new green area 3. Will avoid the area urbanisation 4. Will improve the asset's conservation status	1. Allows the cultural visit to assets 2. Stablishes a new urban centre 3. Improves the asset's conservation status
Pre-landscape	Rural meadows landscape	Railway and road	Rural area surrounded by urbanisation	Faded and abandoned urban area
Post-landscape	Agricultural pilot zones, community gardens and solar park	Railway, road and pedestrian green area	Park	New urban campus of culture and education
Projects challenges	1. Risk of water erosion 2. Combining the project with the use of the infrastructure 3. Treatment of the exterior areas, together with the Aqueduct ZGP and <i>Percurso</i>	1. Noise pollution 2. Continuity and utility of the pedestrian corridor	1. Connection with other archaeological areas 2. Combining the project with the use of the infrastructure 3. Accessibility from the city centre 4. Landowners permission	1. Risk of flooding 2. Continuity of the green areas 3. Attractive cultural program

Aqueduct -Zona Verde Monumental, São Bento de Cástris, the Igreja da Cartuxa and the Forte de Santo António should be considered as a whole. Along the path, this infrastructure could work as a physical connector. This landscape joint treatment would develop a new cultural axe that would also bring green areas closer to the city and could be considered an expansion of its World Heritage Protected Area. Although the Sphera Castris Project will improve the accessibility of this part of the Aqueduct bringing there a new educational area, it must refer to its presence in the treatment of its external areas. It should also allow its operation as an irrigation tool and value its architectural and archaeological legacy.

The Aqueduct of Águas Livres in Lisbon, on the other hand, constitutes a vast cultural infrastructure together with the rest of the assets that constitute the Museu da Água, as can be seen in Fig. 20. Its complex above and underground structure crosses the city centre. This graphic proves how the arched structure visually dominates the new Alcântara



Fig. 19 Évora, Sphera Cástris Project and Aqueduct's route cartography. Scale 1:15.500 m. Source: the authors, 2020.

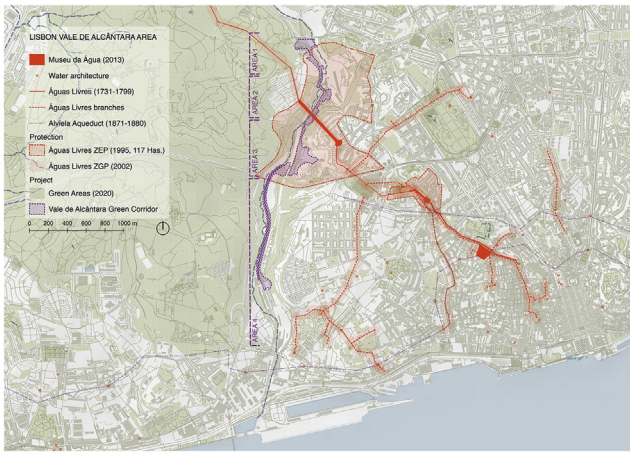


Fig. 20 Lisbon, Vale de Alcântara cartography. Scale 1:22.500. Source: the authors, 2020.

Valley corridor and constitutes its most considerable landmark. This new pedestrian path allows the citizens to contemplate the Monument from a new perspective, valuing its architecture, improving the accessibility and connectivity of this area. However, it also reveals how this arched bridge, whose access is controlled and closed as part of the Museum, could create a second perpendicular level of communication, linking the city with the Northern part of Monsanto Forest Park. On the other hand, noise pollution from this valley caused by traffic impedes the strategy to turn it into a new urban green corridor. Perhaps the increase in pedestrian space, vegetation and new functional claims are necessary for its complete revitalization.

The Braga Project seems to ensure a happy ending after a long and challenging process of protecting and enhancing the hydraulic system of Sete Fontes. After years of complaints by citizens and associations, the Park of Sete Fontes will include, as shown in Fig. 21, the fountains, the mines, the stone pipes, four entrances and pedestrian paths. However, it will be connected to the Archaeological Area of Monte Pedroso to the North but not to the one of Caixa d'Águas Povoado do Bronze to the South. Even though it will not reach the 66 ha of the Sete Fontes ZEP, with an area of



Fig. 21 Braga, Sete Fontes Park cartography. Scale 1:12.500. Source: the authors, 2020.

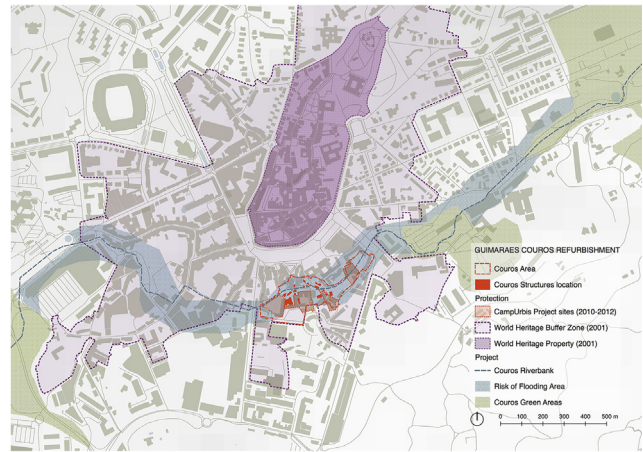


Fig. 22 Guimarães, Zona de Couros cartography. Scale 1:7.500 m. Source: the authors, 2020.

27,5 ha, it will safeguard the beauty and the character of this asset's location, which is already entirely corralled by the urban expansion. Perhaps, for the proper comprehension of the asset and the continuity of its irrigation function, the park should count on educational programs and signposting, to connect this heritage with the rest of the city.

Ultimately, the Couros Area is one of the most complex projects. Its urban location, the flood risk of the area and the density of operations carried out and proposals make it an ambitious regeneration project that, despite being prolonged over the years, supposes a referential urban rehabilitation. As Fig. 22 shows, thirteen groups of leather treatment stone basins still exist and there are four industrial complexes already rehabilitated thanks to the CampUrbis Project. The graphic shows the strong character and the originality of these industrial heritage fragments, which are placed outdoors along the streets and inside the old leather factories complexes. This mapping exercise allows realising the density of heritage assets in this small area of 3,66 ha, where four complexes of 1,25 ha have already been rehabilitated. However, the environmental fragility of the area is a real threat and the recovery of the riverbank to give continuity to the green area is a challenge for this small city in the North of Portugal that has been able to integrate an obsolete industrial fabric into the functional landscape of the current city thanks to the valuation of its architectural and archaeological heritage.

In every case, the diagrams show how the asset works as a linear landmark, connecting the City Centre with the periphery. These linear infrastructures have articulated the territory historically, crossing it and affecting its nature, function and scenography. The four new projects are responsible for preventing these marks from being erased or transformed into isolated assets and reactivate the areas following sustainable purposes.

5. Conclusion

These cases review shows that heritage protection is a determining step because it enhances the cities'

commitment to safeguarding these infrastructures. Nevertheless, it also reinforces that their implication with urban projects results decisive to give a new lifecycle to these obsolete assets. Those projects can be led to guarantee their lifespan and protect their environments, as in the cases of Évora and Braga, or to adapt them as new urban facilities, as achieved in Lisbon and Guimarães. By all means, motivating heritage initiatives by urban renovation projects results crucial in historic cities. They make heritage more accessible and diversify the impact of that urban projects, from economic and social to territorial, cultural and environmental sectors. These experiences focused on water heritage protected areas must be considered to document a growing series of works, learn from them, and transfer the above-mentioned good practices and avoidable errors to other possible locations.

In addition, the method of study and analysis used, through georeferencing and overlapping layers of spatial data information, is a handy and appropriate tool for the challenging and committed management of this typology of large-scale territorial, cultural assets and their landscape. These current cartographic diagrams enhanced the rediscovery of the existing landscapes and showed the areas' main challenges and future opportunities. As the results have developed, using such graphical systems allows to gather the necessary information to glimpse positive and negative aspects and impacts of the projects, improve their urban commitment and connectivity, highlight interferences and opportunities and establish work priorities; while enriching and updating the available information about the assets studied particularly.

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Declaration of competing interest

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