

# THE USE OF CANALS FOR WATER SUPPLY IN ANCIENT CITY OF COIMBRA AND ON THE BOTANICAL GARDEN OF THE UNIVERSITY

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## Abstract

Shaped by humans to meet their demands, cities are artificial, complex ecosystems, subject to environmental challenges that have significant implications for human health, life quality and the city's economy.

Cities developed and expanded in places where natural and environmental conditions were favorable, and they can only continue to thrive as long as they safeguard the natural resources that are the drivers of wealth and quality of life for their citizens.

People living in cities value parks and green areas for their amenity and facilities, as well as for the presence of nature in urban environments, but parks and green spots remain invisible assets. Climate changes and continual urban expansion are challenges that increase the need to control surface water drainage to manage flooding and its impact on communities.

The Botanical Garden of the University of Coimbra (BGUC) dates back to 1772 and it was built to study botany and its application to medical and pharmacy studies.

From the start of its construction, the water supply for irrigation was a concern. Over the years, it has been secured from a natural spring water source leading to the garden and distributes the inside through a system of small reservoirs and canals.

## Keywords

Coimbra Botanical Garden; Low Impact Development, Sustainable water management; water supply using canals.

## 1. Introduction

Water was one of the most important aspects of life in ancient cultures. In Greek mythology, one of the most ancient and powerful divinities was Neptune, the god of the sea. In India, the Ganges River was considered sacred from historical accounts over 3000 years old. To the Egyptians, the Nile River was the political, economic, and life-sustaining centre.

Ancient civilizations' respect for water is a consequence of their absolute need for it. Still today, water sustains life in many ways.

Since the beginning of early cultures, man not only uses natural water resources as it appears in nature, but also improved its use by artificial methods. Based on observations of nature, they constructed small and large storage basins for a temporary transfer of water from a period of abundance to one with scarcity.

As cities grew, they required larger amounts of clean water for their citizens and even cities built near this sources of water, require means to provide it to people's home. Canals and ditches were employed to transport water for irrigation and drinking.

Over centuries, these water supply systems were improved and the Romans were, probably the

initiators of the construction of the modern water supply systems using aqueducts and channels to carry water by gravity from one place to another. The Romans built thousands of kilometres of aqueducts throughout the Roman Empire. Remains of these aqueducts are still visible today.

## 2. Water supply to the ancient town

The provision of water in the city of Coimbra early raised several conflicts centred on water disputes between the religious orders, who wanted more generous quantities for the parks and gardens of their monasteries and also the people who needed it to satisfy their most basic needs. Coimbra is located in a very hilly region, with an upper town, the most ancient one, and a lower town, near Mondego River, with a very low elevation.

At Figure 1, location of some of the most important and ancient water sources, aqueducts and cisterns can be seen drawn on actual urban plant.

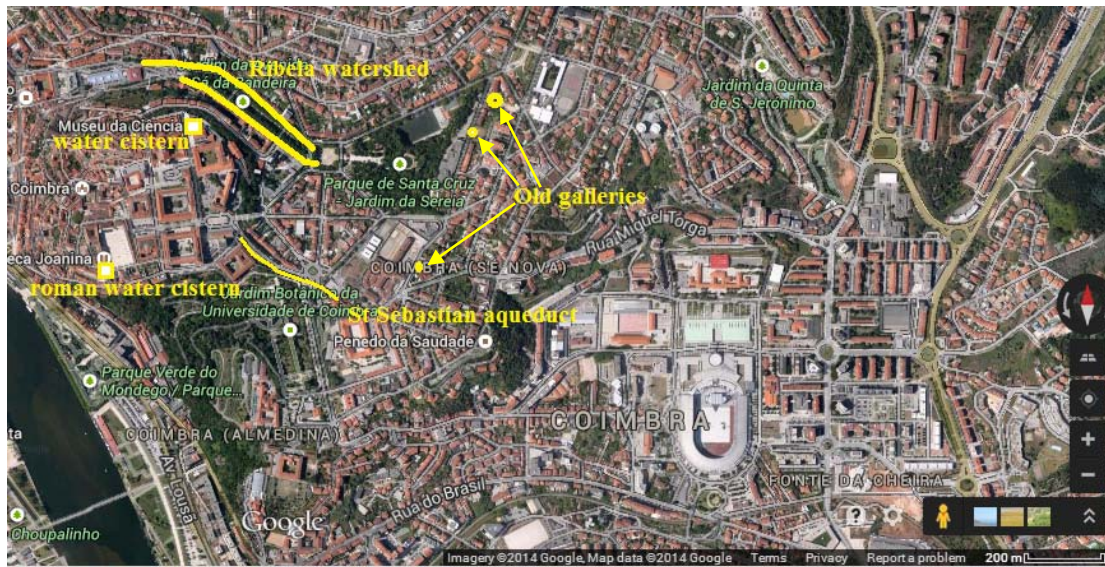


Figure 1 – Location of ancient water sources in actual urban plant, using Google maps.

### 2.1 The water supply to the upper town

In figure 2 it can be observed an ancient topographic plan of Coimbra city with its most probable water supplying system to the upper town.

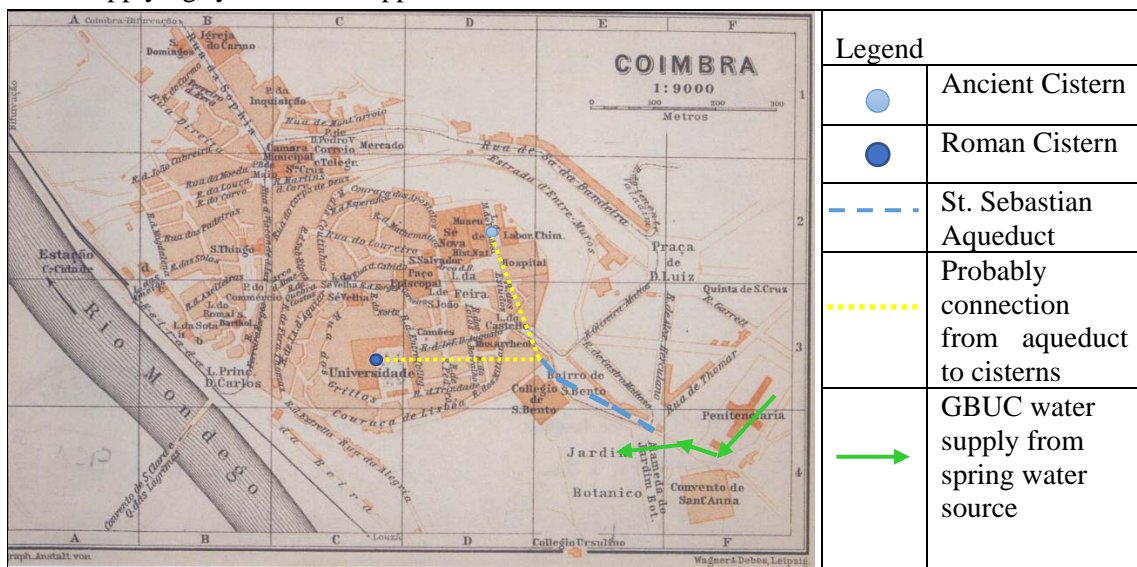


Figure 2 – Topographic plan of Coimbra, 1901 (Coimbra, 2006)

## 2.2 The water supply to Botanical Garden of the University of Coimbra

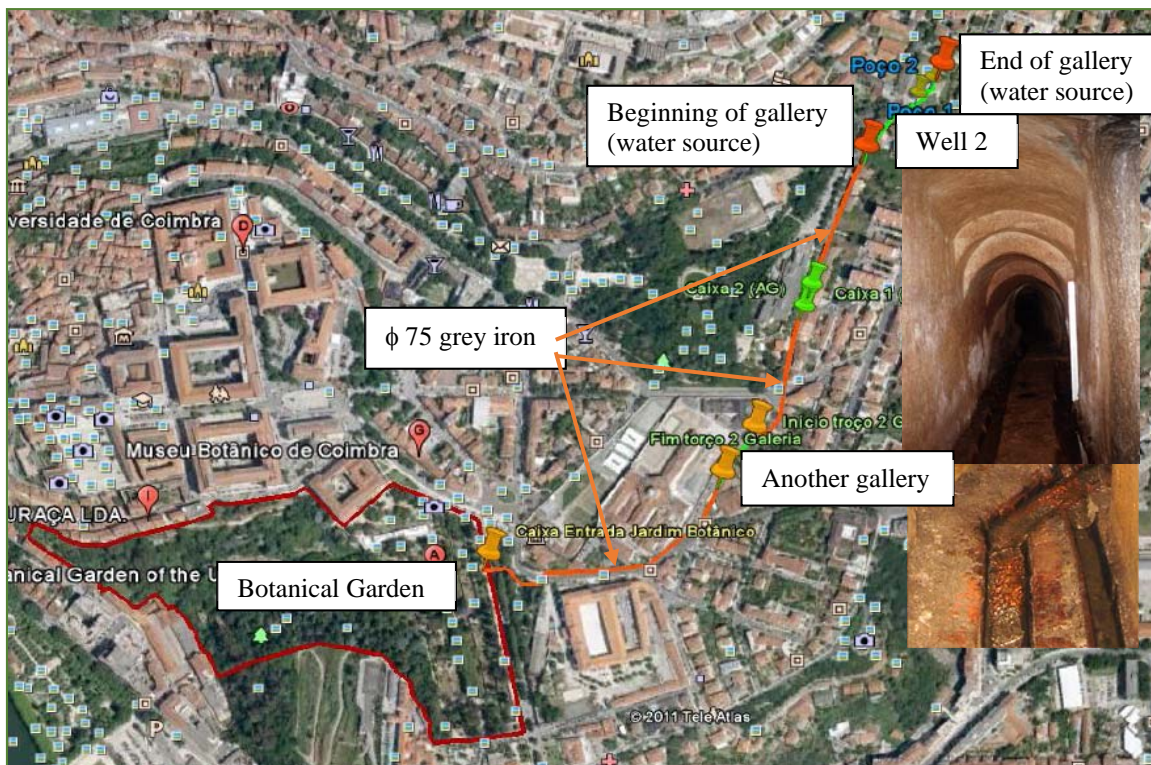
Botanical Garden of the University of Coimbra (BGUC) dates back to 1774 and it was built as an “laboratory” for the study of botany and its application to medical and pharmacy studies (HENRIQUES, 1876).

It occupies a total area of 13 ha and is divided into two fundamentally different parts: the area open to visitors – formal garden, which is on various levels and where there is a harmonious mingling of trees, shrubs and all kinds of small plants, framed by diverse architectural structures and occupying an area of around 5 ha; and the wooded area, mostly consisting of mixed forest, where abundant exotic species have adapted perfectly.

In geological terms, the district of Coimbra is situated between the Hesperian (or Iberian) Massif, consisting of Precambrian Paeleozoic formations and the western Meso-Cenozoic sediment deposits (Tavares, 1999).

The Botanical Garden is in a zone of dolomite marl and Triassic red sandstone. In hydrogeological terms it is characterized by compact formations of variable low permeability, although it may be raised where there is fracturing.

The water needed for irrigation is mainly comes from a water source about 1000 m away and is conducted to the Botanical Gardens via gallery sections (a semi-circular channel section, 8 cm in height and 12 cm wide, showed in Figure 3) and pipes ( $\phi$  75 mm in cast gray iron) in a free surface flow.

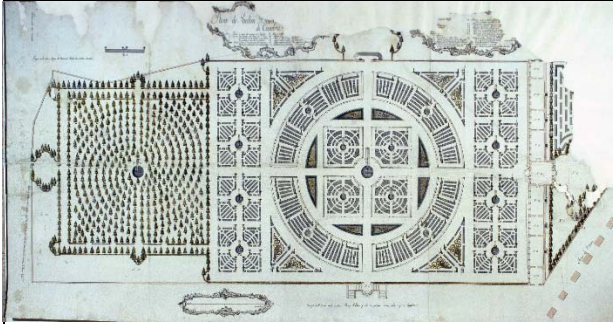


**Figure 3:** University of Coimbra Botanical Garden spring water collector, with origin on old Quinta da Rainha - general layout with water sources (using Google Earth).

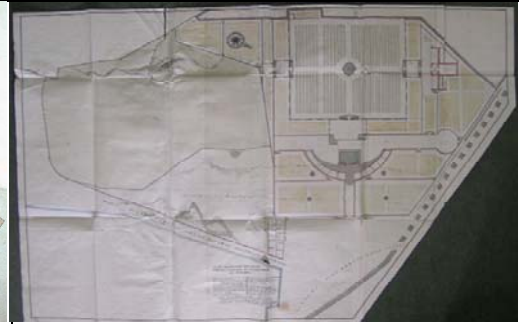
Water is an essential aspect for the existence of the Botanical Garden. To overcome this need the Marquis of Pombal, Prime Minister of Portugal, promotor of its construction and the reform of university education, wrote in a letter to the rector in 1772, about the selection of the site location,

that "... the introduction of water into that land, derived from the castello, is a very easy thing." (ALMEIDA, 1937).

In Figure 4 we can see a draft made by William ELDSSEN (1773), probably the first project for the garden, rejected by Marquis of Pombal, (PAIVA et al, 1989) and in Figure 5 a draft of the plan proposed by Manoel Macamboa in 1795.



**Figure 4:** Plan for the Botanical Garden made by William Eldsen, 1773

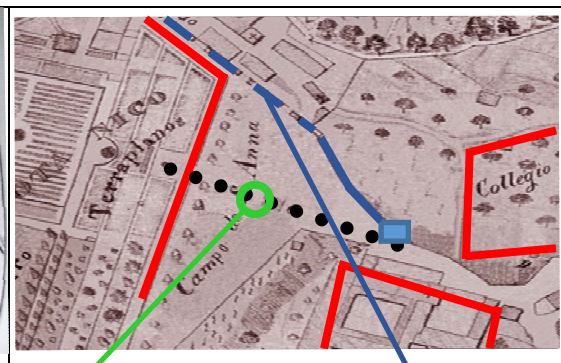
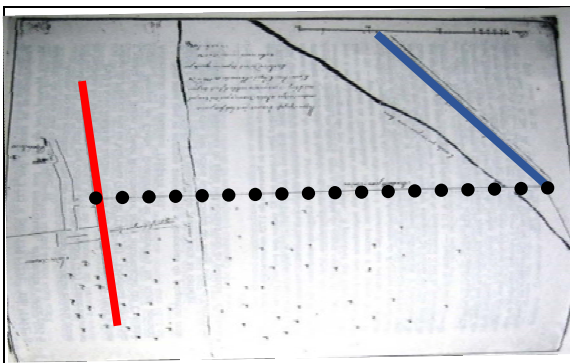


**Figure 5:** Plan of the Botanical Garden made by Macamboa, 1795

However, water supply never has ceased to be a complex and important question to its directors. Indeed, in the local of the Botanical Garden was built, the water never was easily driven from the castle. Just to the presente a large number of studies and long works were undertaken to introduce water into the garden.

At Figure 6 a draft of aqueduct proposed by Macamboa is presented as well as it implantion in a map of the region of these period.

Figures and photos of old and actual aspects of these constructions executed at this period can be seen in Figure 7.



**Figure 6 –** Draft of the aqueduct being built to bring water to the Botanical Garden, 1781.



**Figure 7 –** Sant'Ana spring and St. Sebastian Aqueduct

### 3. Conclusions

Although the infrastructure built for about 2 centuries need of upkeep and maintenance, its implementation is sustainable both from an economic as environmental aspect because they use low-cost water driven by gravity and free surface flow and untreated water, preventing its consummation from the public network system.

The GBUC contribute to enhancing air quality, reduce temperatures and the damping effect of floods, it promotes an decrease in the flow coefficient, reduces the impact of water droplets and the effects of erosion, increases infiltration and recharge aquifers and offer habitats for biodiversity, which plays a significant role in improving life in the city and for their citizens and presents a very great environmental benefits.

The most actual methodology to governor city development is usually designated Low Impact Development (LID) or also blue-green approach and the BGUC can be considerate in this approach.

### 4. Acknowledges

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