# CartujaQanat: Recovering the street life in a climate changing world. Bioclimatic lattices and confinement of air in exterior conditions

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**Abstract**. CartujaQanat represents the necessity to rethink the way our cities are conceived as time passes by and the world evolves. Current and future needs demand up-to-date solutions that combine the knowledge obtained from experience and tradition with innovative research. Cities have the responsibility to contribute to a better environment for their inhabitants while minimizing resource consumption. Passive techniques and bioclimatic solutions have significant benefits for the health and well-being of humans, making them ideal when properly adapted to their suitable climates. Keeping this in mind, CartujaQanat pursues the creation of open-air spaces that provide a comfortable environment in hot and dry weather conditions with minimal negative impacts. Strategies developed for the project utilize water as a heat transfer fluid in open and closed systems to enable the acclimatization of exterior spaces. The project includes the use of physical barriers in the form of bioclimatic lattices that act as a solar screen, enabling natural ventilation and providing a certain level of confinement to the air. These effects are enhanced with the hygrothermal capabilities of water, which is incorporated for direct and indirect evaporative cooling as well as thermally activated elements.

## 1. Introduction

The CartujaQanat project intends to recover street life through a new model of urban governance in the hot climate of Seville. The street is used as a social revitalizer that tries to involve in its transformation citizens along with public and private agents.

The main objective is the renovation of a small urban area in Isla de la Cartuja, next to the Guadalquivir River. This territory was not urbanized until 1992, when the Universal Exposition took place. Since then, different uses have been established in the island, among which educational has a significant role. Examples of this are the Cartuja Scientific and Technological Park (PCT Cartuja) and the University of Seville, this last one being one of the main institutions involved in the CartujaQanat project. However, some areas haven't been redeveloped yet and remain partly unattended, becoming interesting starting points for urban actions such as the one presented in this paper. Once finished, the instructive nature of CartujaQanat is expected to promote the revitalization of the area while encouraging citizens to demand spaces with analogous characteristics in terms of comfort and social benefits.

Within the intervention there are three characteristic elements: an amphitheater, a multipurpose marketplace and a water qanat. The first two are unenclosed buildings at the service of people that are designed to accommodate diverse activities and serve as pioneer examples of mitigation of inclement weather in exterior spaces. The latter, conceived as an open-air channel, is part of a passive acclimatization system designed to mitigate energy demands from these buildings and their users.

CartujaQanat provides a holistic approach towards a conception of urban areas where the focus is set on citizens and their current and future needs, especially with Climate Change affecting many cities due to the Urban Heat Island. To pursue these objectives, bioclimatic techniques are reinterpreted for their implementation in urban spaces. Traditional elements like the Asian qanats are combined with passive cooling techniques to improve comfort conditions in outside areas.

## 2. Methods

Since 2015, the UN Sustainable Development Goals have sought a more desirable future in 17 areas of concern. CartujaQanat aims to contribute to at least three of these topics once built: Sustainable Cities and Communities (No 11), Climate Action (No 13) and Good Health and Well-Being (No 3).

Given the urban nature of the intervention, the project focuses on the application of techniques that have a positive impact in the city and its inhabitants, which is where SDG 11 has a vital importance. Exterior urban areas are becoming increasingly relevant, with citizens claiming these spaces to be dignified and worthy. This topic affects all levels of urbanism, from traffic and pedestrian flows to resting places such as squares and parks. Proper design and a balanced distribution of all activities are inevitably required. When analysing current cities, it is easy to see that well-designed open spaces are generally full of life, even in harsh conditions. It is even more visible when these spaces prove their usefulness, for example providing shading during the summer or shelter during the winter, both of these highly demanded by citizens who want to be able to enjoy their city at its best.

On another note, CartujaQanat is also committed to being conducive towards SDG(s) 13 and 3. Achieving comfortable conditions when the weather is adverse tends to be resource consuming, whether it is for producing heat or reducing the temperature. The ideal situation is to not need to produce energy at all, but because of the obvious difficulty of this task, the best option is to reduce consumption to the minimum, which is achieved by minimizing demands in the first place. Using passive techniques as much as possible has been an important starting point in the design of the project, searching for the most adequate possibilities. In addition, extreme weather conditions can cause several illnesses and, eventually, death, both of which are somewhat frequent in Seville and get increased every year. Creating spaces where people remain unexposed to these problematic situations should be a priority.

The island of Cartuja has previously had experience with bioclimatization of exterior spaces. In the original design in 1992, the aim was to make the most out of the available natural resources, including vegetation, evaporative cooling, shadowing and thermal inertia, in order to create a comfortable micro-climate. Several of the structures originally built for the Expo ’92 remain as they were, while others have been modified or removed. CartujaQanat uses one of the parks from the original project and its elements to perform a renovation that revitalizes the surrounding areas.

For the development of the project it was crucial to understand the weather conditions of Seville, which is located in the South of Spain. The city has a Mediterranean climate modified by the proximity and influence of the Atlantic Ocean. This combination results in mild and rainy winters as well as hot and dry summers, with average maximum temperatures of 35 degrees Celsius during the months of July and August [1]. Prevailing winds, originated in the ocean, blow from the South West following the direction of the Guadalquivir river valley.

If comfort was to be pursued in these conditions, two concepts had to be considered to serve as the base for the constructive development of the project: shading and confinement. Using elements to generate a shaded area is one of the most basic and adequate strategies in hot climates, given that most energy gains originate from solar irradiance. On the other hand, when working with outer spaces, confining the air is key to avoid constant renovation of air when its temperature is above or below comfortable parameters. Aside from generating roofed areas to avoid direct sunlight, a characteristic element is incorporated to the project to contribute to the mitigation of weather: the bioclimatic lattice.

CartujaQanat introduces the lattice as an active element of climate control by combining it with water, creating an evaporative cooling lattice. Lattices can be found in several cultures around the world acting as barriers against the sun while enabling ventilation, mostly in areas with hot and dry weather. This means that the solution achieved can be modified and adapted to satisfy demands in different countries, which confers it a certain level of scalability. The incorporation of water creates a complex system that takes advantage of the sensible and latent heats involved in phase change of water from liquid to vapour and vice versa. The materials used for the fabrication of the lattice need to have a certain level of porosity, which was solved by the utilization of ceramic and concrete.

Water is used as an energy-transferring fluid. During the day, it is utilized to cool down the environment by moistening elements such as the lattice and others. While flowing through the moist lattice, air temperature is lowered by transferring heat to the water, part of which therefore evaporates. Given that water temperature is increased throughout the day, it becomes necessary to lower it. This is done at night at the previously mentioned qanat, when the ambience temperature drops. Water is exposed to the night sky to take advantage of its radiative cooling effect. For the system to function, it is necessary for it to work in cycles on a daily basis.

One of the main concerns in the project was to achieve proper temperature drop in water within the available hours of night sky, which are limited. The surface of exposition needed to be increased for high effectiveness. After considering several options, the optimal solution consisted of spraying it into the qanat. Not only was the qanat surface exposed to the sky, but also the outer surface of every droplet into which water was sprayed. The smaller the droplets, the better efficiency, but also higher evaporation, which meant that a balance had to be achieved.

## 3. Results

The performance of the evaporative cooling effects and their effectiveness have been studied theoretically and experimentally for the project. Firstly, CFD analysis was developed as an approach, which provided positive results towards the objective of the project. This resulted in the verification of these results in an experiment that completed the knowledge and understanding of the system.

Two water basins of equal volumes were built and compared on daily cycles. One of them served as a reference, letting its content stand still, while the other was the active basin through pulverization. During the day, and keeping in mind the weather conditions at the time of the experiment, water was heated in both basins above 25 degrees Celsius, allowing for a proper temperature drop at night. For the experiment, water was sprayed into one of the basins using nozzles with varying levels of pulverization in order to see the cooling capabilities of the different misting effects.

For a complete comparison of the two basins, the study was monitored and measurements were taken for a series of parameters, including temperature, humidity, volume of water flow, spraying height and pressure. In addition, the total volume of evaporated water after each cycle was also analysed in search of the optimal ratio of cooling effectiveness and evaporated water. Figure 1 shows the results obtained during a standard cycle of spraying that took place between the evening and the following morning.