Improving Outdoor Urban Environments: Three Case Studies in Spain

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ABSTRACT

Public life is as intrinsically linked to the physical and material settings as it is to the climatic environment. The physical properties of a space, such as materiality, temperature, or light, can enhance or inhibit people from using and enjoying it. When architects and urban designers deal with the physical properties of a space, and therefore modify its material, thermal, and lighting characteristics, they influence the social environment as well. This paper describes a field study undertaken in Spain. Its aim was to understand the implications of climate-responsive design in urban public spaces over the physical, climatic, and social environment. Three case studies in Spain were selected and the resulting climatic and social environment analyzed. The three structures are: Metropol Parasol in Seville, Ecobulevar in Madrid, and Plaza Pormetzeta in Barakaldo. Each of the three case studies is located in a different climatic region within the Spanish geographical context. The study included on-site measurement of climatic conditions and observations of people behaviour in the public spaces. These were correlated and compared to nearby public spaces to assess the success of the structures in creating lively urban areas. The study suggested that, while climatic conditions play a key role in the success of public spaces, climate-responsive design must also consider other aspects of urban design such as social activities, accessibility, preconceptions of the space, and visual delight.

INTRODUCTION

During the last decade, Spanish cities have witnessed the proliferation of climate-responsive structures, such as canopies or wind towers, in their outdoor public spaces. The main purpose of such structures was to adapt these spaces to existing microclimatic conditions and promote outdoor comfort. In many Spanish cities, staying outdoors in summer at midday can be too uncomfortable and even dangerous. This is due to high temperatures and intense solar radiation that are intensified by the Urban Heat Island effect and climate change. Some studies have analyzed the effects of the structures over the climatic conditions around them (Soutullo et al., 2007). However, no research has addressed their effects on the use of the public space by citizens. What have not been assessed yet are the implications of climate-responsive structures for citizens’ everyday lives. By studying people’s perceptions and reactions to these structures, climate-responsive design could be improved to fulfil its ultimate aim: to promote the use of public spaces. Architects and urban designers should follow an integrative approach to the design of public spaces, one that combines the search for a comfortable environment through climate-responsive design, with a lively social environment that improves the quality of life within cities.

The study described in this paper analyses the resulting climatic and social environment of three climate-responsive structures in Spanish urban public spaces. The three structures are: Metropol Parasol in Seville, Ecobulevar in Madrid, and Plaza Pormetzeta in Barakaldo. Each of the three case studies is located in a different climatic region within the Spanish geographical context. The structures were selected, taking into account the objectives of the design, techniques applied, and location. The study
followed a uniform approach for the three structures. It reviewed and analyzed the original authors’
documents, as well as any other documentation and opinions published in the media. Each of the case
study sites was visited, and one-time on-site measurements of climatic conditions were recorded. In
addition, while climatic temperatures were recorded, interviews with people using the space were carried
out and observations of people’s behavior noted. Measurements were also taken simultaneously in
nearby public spaces, in order to compare and assess the strategies used. The analysis of the case studies
was divided into two groups: climatic environment—temperature, relative humidity, wind speed, and
solar radiation; and the social environment—number of people using the public space and people’s
perceived comfort. Table 1 presents the selected case studies, their location, and the strategies used.

Table 1. Case Studies

<table>
<thead>
<tr>
<th>City</th>
<th>Metropol Parasol</th>
<th>Ecobulevar</th>
<th>Plaza Pormetxeta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographic coordinates</td>
<td>37°22′ N, 5°59′ W</td>
<td>40°23′ N, 3°43′ W</td>
<td>43°17′ N, 2°59′ W</td>
</tr>
<tr>
<td>Climate</td>
<td>Mediterranean</td>
<td>Continental</td>
<td>Oceanic</td>
</tr>
<tr>
<td>Area of the public space</td>
<td>32,605 m²</td>
<td>27,500 m²</td>
<td>27,102 m²</td>
</tr>
<tr>
<td>Technique</td>
<td>Canopy, raised plaza, water fountains, low heat storage materials</td>
<td>Solar shields, wind towers, vegetation, light-colored materials</td>
<td>Canopy, wind shields</td>
</tr>
</tbody>
</table>

Figure 1 Pictures of the three case studies. From left to right: Metropol Parasol in Seville, Ecobulevar in Madrid, and Plaza Pormetxeta in Barakaldo.

CASE STUDY 1: METROPOL PARASOL, SEVILLE

Metropol Parasol is located in the historic center of Seville, in a large void of the dense medieval fabric. The structure consists of an extensive canopy of 150 by 70 meters 25 meters above street level, supported by six gigantic columns. The public space that was the object of study, Plaza Mayor, is located underneath the canopy on a platform raised 5 meters above street level. It has a total surface of 10,600 m² and is approximately 85 m wide and 140 m long. It is furnished with four concrete semi-circular benches, three small fountains on the borders, and a playground. The materials used are clear granite for the pavement, timber for the canopy, and concrete for the structure, which becomes visible at the bases of the pillars. The purpose of the canopy was to create a comfortable environment in the plaza, where people congregate and big public events take place. The canopy protects the space from direct solar radiation, and the plaza is raised above street level to increase air flow. In addition, the selected light tones of the materials are appropriate for reflecting solar radiation. Moreover, the use of fountains, although scarce, helps to decrease air temperature by evaporative cooling.

The construction work of Metropol Parasol started in 2005 but soon encountered technical problems that forced the construction system to change and delayed its completion to April 2011, also doubling its estimated costs. Considering the current economic crisis that Spain, and especially the region of Andalucía, is going through, the delays and cost overruns of the building have resulted in much public controversy. Nevertheless, the project has been widely published in specialized magazines and journals and generally supported by the professional community, which has awarded the structure with several international prizes of architecture.
Climatic Environment

The main issue when dealing with outdoor comfort in Seville is its high temperatures and solar radiation in summer, which are among the highest in Europe. On July 25, 2012, on-site measurements of temperature, humidity, and wind speed were recorded every hour from 10:00 a.m. to 10:00 p.m. at Plaza Mayor. Simultaneously, on-site measurements were taken at Plaza del Cristo Burgos, a highly vegetated park with two playgrounds located 200 meters west of Metropol Parasol. Temperatures recorded at Plaza del Cristo Burgos were very similar to those at Plaza Mayor between 10:00 a.m. and 1:00 p.m. and between 6:00 p.m. and 10:00 p.m. However, between 2:00 p.m. and 5:00 p.m., when the sun is higher, temperatures were cooler in Plaza del Cristo Burgos. Temperatures in both public spaces were also compared to the climatic data registered at the airport meteorological station. Figure 2a shows the comparison among temperatures in these three points of the city. As shown, temperatures at the airport, located in a non-urbanized area outside of the city, are much lower than in the city during the night, indicating the presence of the Urban Heat Island. In addition, spot temperature measurements were taken at different public spaces across the city, where devices such as canopies were in use to improve pedestrian outdoor comfort. Temperature measurements at these Seville public spaces were taken at different times of the day. Figure 2a shows these measurements as dots to compare them to temperatures at Plaza Mayor. It can be inferred from the graph that Plaza Mayor performed better climatically than most of the other spaces, decreasing temperatures and creating a more comfortable urban environment.

![Figure 2a](image)

Social Environment

The number of people present at Plaza Mayor was recorded in parallel to climatic measurements and compared to those at Plaza del Cristo Burgos. As shown in Figure 2b, the number of people at Metropol Parasol was lower than that at Plaza del Cristo Burgos. In addition, Plaza Mayor did not attract as many people as other public spaces of the city where measurements were taken.

A total of 25 interviews were undertaken; questions focused on two topics: the reasons for staying at Plaza Mayor and people’s thermal perceptions. Thermal perception was further evaluated by asking interviewees to compare their thermal comfort with the comfort they expected to have in adjacent streets. According to the results, the main reasons for staying at Metropol Parasol were: first, more comfortable climatic conditions; second, attractiveness of the space; and third, the playground. Moreover, all those interviewed found the environment “warm” or “too warm”, but most of them stated that the temperature at Plaza Mayor was more comfortable than that in adjacent outdoor spaces. In fact, those who perceived a more comfortable climatic environment were those who nominated the attractiveness of the space as the reason to be there, suggesting an influence of the visual environment on thermal perceptions. All those interviewed had a preconceived idea of Metropol Parasol derived from the exhaustive coverage of the building in the local media as well as in the tourist guides and other city information books. In the case of Seville inhabitants, these preconceived ideas were related to its excessive costs.

![Figure 2b](image)
The climatic techniques applied at Metropol Parasol decreased temperatures by over 3°C compared to adjacent open areas. When temperatures were compared to those in other public spaces of the city, Plaza Mayor performed better than many, providing a more comfortable climatic environment. Nevertheless, the public space at Metropol Parasol did not draw as many people as other public spaces. Raising the plaza above the street level resulted in more air flow and decreased temperatures. However, the separation of the space from the street, shops, bars, restaurants, and pedestrian and vehicular flows discouraged people from going there. Lack of benches, activities and attractions left the space empty most of the day. In addition, the fieldwork suggested that the powerful visual environment of Metropol Parasol influenced thermal perception. Preconceived ideas, mainly based on economic and political issues, influenced the assessment of the climatic environment. The experience of the thermal environment could not be isolated from issues such as the visual qualities of the structure and its economic and political implications (Nikolopoulou & Steemers, 2003).

CASE STUDY 2: ECOBULEVAR, MADRID

Located in the suburban development of Vallecas in Madrid, Ecobulevar is the redefinition of an existing 550 m by 50 m boulevard according to two objectives: social and environmental. The design team, Ecosistema Urbano, considered trees to be the perfect tools to achieve both objectives (Ecosistema Urbano, 2004). However, according to the project brief, a tree could take 25 years to satisfy these social and climatic needs. Ecosistema Urbano proposed the construction of three artificial trees that would function climatically and socially from the start. These are composed of cylindrical metallic structures that are around 18 m high with 25 m diameters. Each structure improves climatic conditions using different strategies. The evaporative tree comprises 16 cylindrical wind towers surrounding the principal space formed by a larger cylindrical metallic structure. The wind towers, which are oriented to catch the prevailing winds in the area, inject atomized water to the air flow that passes through them. At the bottom, six nozzles drive the cooled air into the inner space. The second tree, the vegetal tree, is covered by vegetation to provide shadow and decrease temperatures. Finally, the recreational tree is enclosed by an inner screen that, while shading the interior, can be used as a TV screen for different activities. All three trees are located over a modified topography that confines the space and protects it from wind flows.

Climatic Environment

On-site temperature, relative humidity, and wind speed measurements were taken on July 19, 2012 between 12:00 p.m. and 9:00 p.m., both inside and outside the artificial trees. The outdoor temperatures measured on the boulevard that day reached 41 °C, wind flew below 2 m/s, and relative humidity levels remained at around 10%. Figure 5a shows the temperatures that were measured inside each tree and at the street hourly. The temperatures remained lower inside the trees than outside them over the course of the visit (see Figure 5a). The greatest differences were found inside the evaporative tree, which is
surrounded by 16 wind towers. The maximum temperature difference between the interior of this tree and the outdoor temperature equaled 2.4 °C at 4:00 p.m. On average, the evaporative tree created a thermal environment that was 1.42 °C cooler than outside. The average temperature measured inside the vegetal tree was merely 0.42 °C lower than the exterior temperature, and the highest difference registered was 0.6 °C at 6:00 p.m. The recreational tree presented an average temperature of 1.05 degrees lower than the exterior temperature. The peak in thermal difference was recorded at 4:00 p.m., with an environment that was 1.5 °C cooler inside. Inside the artificial trees, air velocity remained lower than outside, with a maximum value of 1.2m/s, while outside the maximum value recorded was 3.0m/s.

Figure 4  (a) Evaporative Tree (b) Vegetal Tree and (c) Recreational Tree

Figure 5  (a) Temperatures measured inside and outside the artificial trees at Ecobulevar and (b) People recorded staying inside and outside the artificial trees at Ecobulevar.

Social Environment

The number of people staying inside each artificial tree and in the space in between them was recorded in parallel to climatic measurements. Due to the high temperatures that day, the number of people staying outdoors was minimal. Figure 4b shows the number of people staying inside each tree and outside along the boulevard. As seen in the graph, the total number of people increased significantly after 6:00 p.m. and reached its peak at 8:00 p.m., with 27 people or groups of people sitting there. Among the artificial trees, the vegetal tree was preferred. It held more people in five out of the six measurements, with a total of 40 people or groups. The evaporative tree, however, hosted only five people or groups during the six hours of fieldwork and remained empty for most of the time. These measurements contrast radically with the climatic measurements that were recorded, where the evaporative tree provided the most comfortable thermal environment and the vegetal tree the less comfortable. The recreational tree remained vacant until 6pm, but was then used by a total of nine people or groups until 9pm. Similarly, the outdoor spaces between the trees were not occupied until
7 pm, when a total of eight people or groups used the seating available there for the next two hours.

In order to understand individual environmental perceptions at Ecobulevar, a total of 25 people were interviewed inside and outside the artificial trees. The interviews followed the same questionnaire as in the previous case study. In this case, the main reasons for staying at Ecobulevar were: first, attractiveness of the space; second, more comfortable climatic conditions; and third, the amenities offered in the space. All of those interviewed found the environment to be “too warm” or “comfortably warm”. People inside the artificial trees were asked how temperatures were comparing to outside. 90% of those who liked the artificial trees stated that the climatic conditions inside them were better than outside. Conversely, 75% of people who found the space inside the artificial trees to be unattractive stated that the climatic conditions inside were equal to those outside.

Findings

The fieldwork revealed that the artificial trees did provide a more comfortable thermal environment than that experienced outside of them, but the effects of the strategies varied, depending on the technique applied. Specifically, the evaporative tree was the most effective for decreasing air temperatures and protecting from solar radiation, while the vegetal tree barely modified the existing climatic conditions. However, when the study analyzed the social performance of the artificial trees, the vegetal tree was the most effective. The number of people staying inside the vegetal tree was considerably higher than those inside the other two trees. Based on the conversations and interviews carried out, people chose the vegetal tree for its facilities, specifically the benches and swings. Moreover, the direct connections between its interior and exterior in all directions and without architectural barriers offered a constant visual and physical relation with the outside, which facilitated the access and use of the tree.

CASE STUDY 3: PLAZA PORMETXETA, BARAKALDO

Plaza Pormetxeta is located in the city of Barakaldo, Spain, which is part of Bilbao’s metropolitan area. The plaza connects the town center with the river through a series of walkways that overcome a 20-meter height difference. These walkways are made of steel plates and paved with hexagonal ceramic tiles. At some points, the steel plates fold over the walkways, providing protection from direct solar radiation. The space between the walkways forms a plaza of 6,500 m² furnished with benches and playgrounds beneath tree-shaped canopies. This space constitutes the public space object of study, as the tree-shaped canopies aim to create a more comfortable space for citizens by providing shade. The canopies, which are called Stone Trees in the project, cover a 750 m² area and are 11.5 meters high. They are constituted by a steel structure of pillars and beams imitating the trunks and branches of a group of trees. On top of the structure, another box structure made of steel holds a metallic mesh and the stones that form the top cover for the canopies. According to the project brief, the Stone Trees “act as an atmospheric device that balances the exuberant natural surroundings” (MTM Arquitectos, 2013).

Climatic Environment

Barakaldo has an oceanic temperate climate with low temperature variations through the year. Summers and winters are both mild seasons with no extreme temperatures. Precipitation is very abundant in Barakaldo, and clouds cover the sky on 330 days per year on average. Moreover, Barakaldo is located in the area with the lowest solar radiation values of Spain, with a mean daily solar global radiation value of 3.54 KWh/ m².

On August 21, 2012, on-site measurements of climatic conditions were taken every hour from 11:00 a.m. to 7:00 p.m. beneath one of the Stone Trees. Climatic conditions were unusually warm, with maximum temperatures around 30°C, covered skies, relative humidity levels around 60%, and low wind flows. The maximum temperature recorded beneath the artificial trees was 27.2°C at 1:00 p.m. and the minimum was 24.8 at 7:00 p.m. The maximum humidity level measured was 65.2 at 6:00 p.m. and the minimum was 58.3 at 11:00 a.m. Wind speeds remained similar during the entire measurement period, with maximums around 2 m/sec. These data were compared with climatic measurements registered in Plaza del Desierto, located 150 m from Plaza Pormetxeta. The design for Plaza del Desierto did not consider any strategy for adapting the space to the local microclimate or for generating a more comfortable thermal environment. Figure 6a shows the temperatures measured in both spaces. As shown, temperatures at Plaza Pormetxeta were consistently lower than those in Plaza del Desierto.
Figure 6  (a) Temperatures measured hourly at Plaza Pormetxeta and Plaza del Desierto on August 21, 2012 and (b) People recorded staying in both public spaces at the time climatic measurements were recorded.

Figure 7  (a) Plaza Pormetxeta (b) Plaza del Desierto

Social Environment

The number of people staying on the plaza, the spaces they occupied, the number of people crossing the space, and the routes they chose were noted. These measurements were recorded simultaneous to climatic measurements. During the nine hours of field study, the total number of stays at Plaza Pormetxeta was 9. Conversely, the number of stays recorded at Plaza del Desierto was significantly higher, reaching 28 by the end of the visit (see Figure 6b). This plaza is surrounded by several cafes, restaurants, and shops that draw citizens to the public space. Although the number of stays in Plaza Pormetxeta was low, it was observed that the number of people that crossed the space was considerably higher. Many people used the pathways to go from the city center to the new urban area by the river and vice versa. But the difficult access to the plaza by labyrinthine pathways and the lack of services and attractions dissuaded people from sitting and remaining there.

Despite the scarce number of people staying under the stone trees at Plaza Pormetxeta, some interviews were carried out to assess the environmental perception of the space. One woman interviewed pointed out that the geometry of the space and the materials used in the construction of the plaza looked dangerous. Specifically, she noted the use of heavy stones suspended on metallic meshes as solar protection as a threatening system that produced an uncomfortable environment. Besides, the enclosed and irregular space formed by the pathways to protect from prevalent winds generated numerous hidden corners and dark spaces, producing a feeling of vulnerability. These statements were also supported by neighbors and the local media (Llamas, 2010).
Findings

On-site measurements proved that Plaza Pormetxeta’s canopies and shields decrease temperatures up to 2 °C on hot days. However, these elements produced other effects such as darkness and threat that dissuaded people from staying at the plaza. Some residents defined the perceived environment as “dark” and “cold,” referring not literally to the thermal environment, but meaning “unfriendly” and “unwelcoming.” As a result, the climatic environment generated influenced negatively the built and the social realm. The public space was rarely used and remained empty for most of the time. People stayed in nearby public spaces and used Plaza Pormetxeta as a pedestrian pathway to move through the city but did not stay there. Consequently, Plaza Pormetxeta did not fulfil its role as a public space for the community.

CONCLUSION

Metropol Parasol in Seville decreased temperatures beneath the canopy, providing a more comfortable climatic environment. However, other spaces, such as Plaza del Cristo Burgos, decreased temperatures further with humbler and simpler techniques such as vegetation. In addition, the Metropol space was not used by citizens as much as other nearby plazas due to its lack of social facilities. Ecobulevar in Madrid generated three different microclimates at three points spread along a boulevard, all of them more comfortable environmentally than that found in nearby public spaces. The vegetal tree was the most popular, although it did not provide the most comfortable climatic environment. Finally, Plaza Pormetxeta offered a less comfortable climatic environment, influencing negatively the social environment and discouraging people from remaining there.

The study suggested that, while a comfortable climatic environment is necessary to generate successful urban public spaces, it needs to be combined with other physical and social aspects of the design. The microclimatic environment of a specific urban space has the potential to attract people to or repel people from it. However, it has to be understood as an integrant of the entire design and needs to be treated together with other requirements of the social environment. In fact, the study indicated that the perception of the climatic environment by citizens is not only determined by its physical properties. A further understanding of the socio-cultural and psychological factors influencing outdoor comfort will help producing successful urban public spaces that foster integration and improve quality of life in cities.

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REFERENCES


