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Applying a model for assessing construction solutions for outdoor public spaces: the case study of a city square in Maia, Portugal

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Abstract

The application of an effective and efficient model for assessing construction design solutions for outdoor public spaces is currently necessary for cities to obtain high-quality urban spaces, be it a street, a square or a park. The characteristics of a given outdoor public space are defined by the appropriate choice of materials and construction techniques used, which must tend towards sustainable solutions. It is, therefore, imperative that these places are attractive in terms of urban comfort, safe to use and economically viable throughout their useful life. The assessment model presented in this case study applies to the design of new outdoor public spaces and the renewal of urban space and serves to test and further develop the analysis and calculation methodology. As a main result, the square has been classified as a "good quality" outdoor public space, which is reflected in level 4 according to the proposed scale. Therefore, specific improvement indicators are provided to further improve this space and reach the maximum level.

1. Introduction

The improvement of the quality of the urban environment is a very pertinent and topical issue, both because of the greater concentration of inhabitants in cities as a result of the process of rural-urban migration (Bjerke and Mellander 2022; Mouratidis 2021).

Thus, the need to revitalise urban centres has become an emerging consequence, not forgetting the less important issue of climate change and the consequent adaptability of outdoor public spaces.

Outdoor public spaces play an essential role in shaping urban daily life, being the main focus for social interaction and various activities (Mouratidis 2018; Zakariya, Harun, and Mansor 2014), depending on the type of outdoor urban space, i.e., whether it is a street, a square or a park.

In this sense, the characteristics of a given outdoor public space become essential, such as its geometry, orientation, dimensions, relationship with its surroundings (e.g., buildings), and the existence of elements that characterise that space and define its identity.

In general, the role of construction materials, building solutions, the presence of vegetation or even street furniture must be adapted to a particular type of space according to the proposed purpose (Lee, Sohn, and Yang 2014; Tsitoura, Michailidou, and Tsoutsos 2017).

Therefore, to guarantee perfect functionality for the user, both in terms of urban comfort and safety, the activities associated with a given urban space must be planned, highlighting the fact that they are greatly influenced by the microclimate and specificities of urban spatial configurations (Lachapelle et al. 2023; Chen and Ng 2012; Jiakun Liu, Ettema, and Helbich 2023).

As such, the following stand out: entertainment activities, sports activities, and even certain types of outdoor cultural activities, which also reflect the cultural identity of the region or place. From this perspective, public spaces should be more attractive so that people can carry out their activities comfortably and safely while interacting or just have a moment to pause or wait when seated.

Trying to ensure that a particular construction solution is the most effective and efficient is a difficult task, especially when climate variables are involved (Pietrapertosa et al. 2019; Heinzlef et al. 2020; Sijakovic and Peric 2021).

There must be an almost perfect balance in terms of the impact that each type of construction solution will have on the overall performance of the outdoor space, and the aim of maximising the urban quality of each type of space must never be compromised.

2. Presentation of the city square

2.1. Location

The outdoor public space that will be analysed is a city square located in Maia (Figure 1), Portugal, known as Dr José Vieira de Carvalho Square, an emblematic space and the city's epicentre. It should be noted that this square has undergone several interventions over the decades, in line with urban growth and its needs. The geographical coordinates are as follows: 41°13'58.68"N 8°37'20.51"W.

Figure 1: Dr. José Vieira de Carvalho Square in the city of Maia, Portugal [Google Earth Pro-version 7.3.6.9345]

As well as being a city promenade, the square is in an urban area with the main public services, cultural facilities, sports facilities, shops, and a complete transport network. Of particular note is the *Forum Maia* station of the *Metro do Porto*, on one of the streets (Padre António street) converging with the square, as well as the private Maia Hospital. It is, therefore, an area of great urban quality and is considered the heart and postcard of the city. All this results from a recent journey that has transformed a very rural community with serious and profound structural backwardness into a community that now has development and quality of life indices at the level of the best in the European Union.

2.2. Square characterisation

Firstly, it's worth mentioning that the square can host various types of activities throughout the year and various types of events, which can be linked to seasonal festivities. In general, what characterises this square is a large open space where two of the city's most important buildings are located, one being the stone-fronted City Hall and the other the 92m high *Lidador* Tower, with its glazed façade (Figure 2), which houses the municipal services.

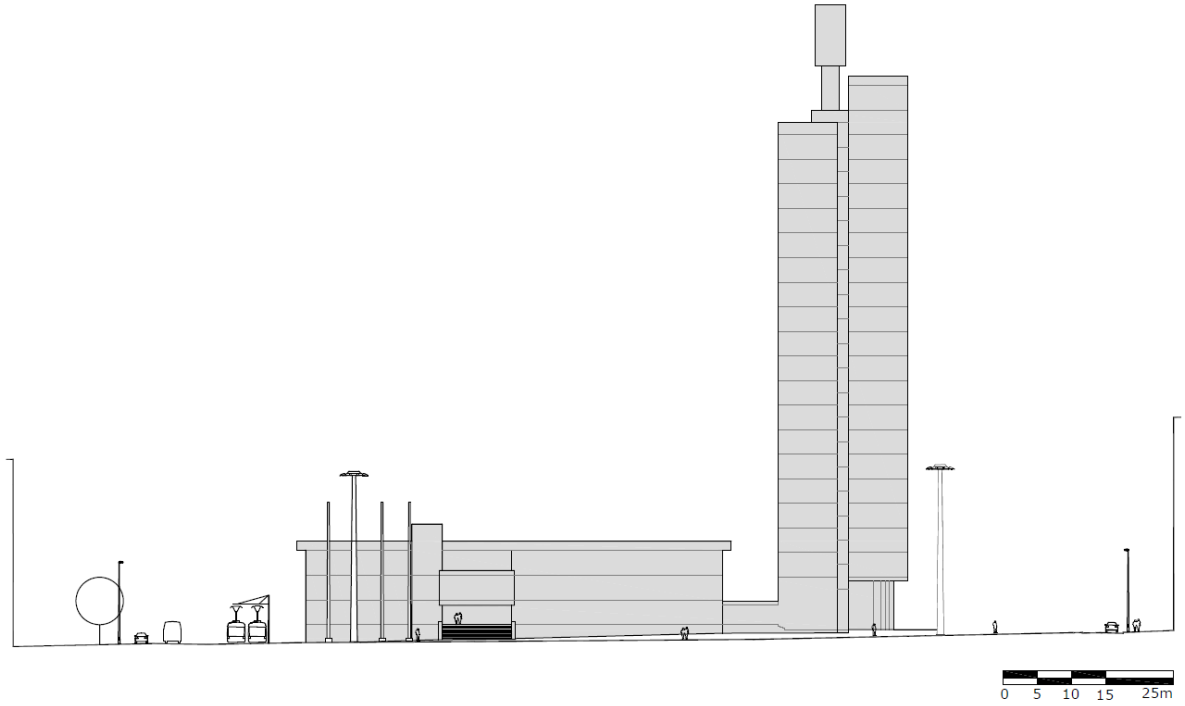

Figure 2: Front elevation of the square [Maia City Council Architectural Drawings, Version 0.1 of February 2022]

The square's paving comprises light-coloured granite slabs (grey), as are the boundary kerbs. The main square area considered for assessment measures 6750.45m^2 and its delimitation is shown in Figure 3. There is no relevant vegetation or green areas in this delimited area, as there is only one flowerbed to the north-west of the square, in a boundary zone, measuring 40.98m^2. As far as the central area is concerned, there are only mobile modular flowerbeds with a quadrilateral geometry, which occupy an area of 138.55m^2 of the square (Figure 1 and Figure 3). It should also be noted that there are no urban walls of any kind, nor any shading structures or shelters, even of a temporary nature.

Regarding street furniture, there is no equipment of this type in the square's central area, except for the sculptures present (which are not included in the assessment of the square's construction solutions). However, the area is still delimited for assessment, but on the periphery of the square with a converging street to the west of the square, there are simple

stone benches. Within the square area, there are three sculptures, namely the equestrian statue of the *Lidador* (Portuguese aristocrat and knight by the name of Gonçalo Mendes da Maia), the statue of Dr Vieira de Carvalho (late former mayor of Maia), and finally, the Corten steel sculpture, called ZMORK, which pays homage to the city's entrepreneurship.

As far as lighting is concerned, the square is lit by symmetrically placed lampposts explicitly oriented towards the centre of the square.

Around the main area of the square, there are mostly medium-sized buildings with different façades and roofs, and there is a triangular fountain that measures 165.89m^2 (Figure 3) in one of the streets converging to the east, which is also considered for assessment.

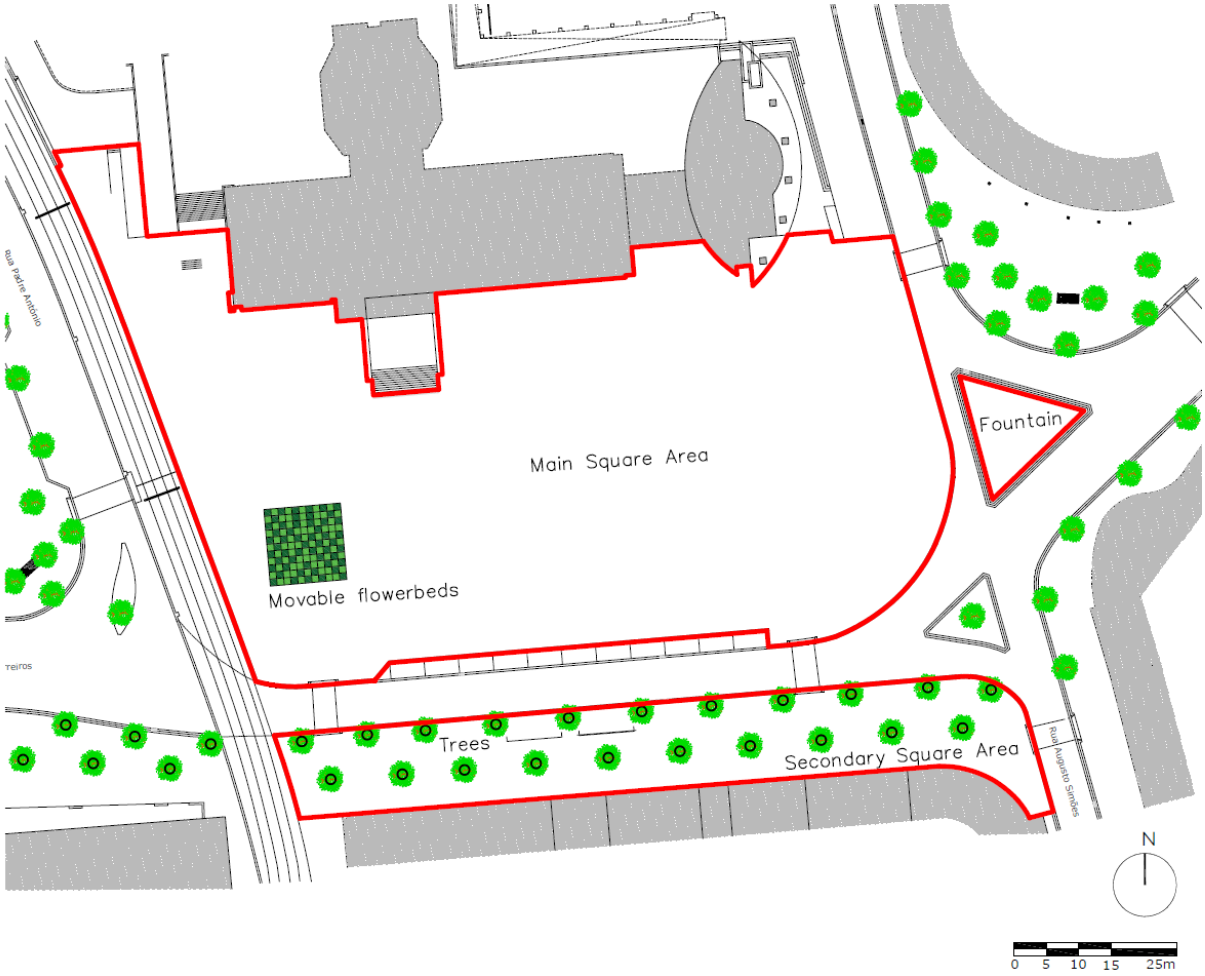

Figure 3: The plan of the square with the red lines delimiting the assessment zones, the green zones referring to the trees and the movable flowerbeds and the grey zones referring to the buildings in the surroundings [Adapted from the Maia City Council Architectural Drawings, Version 0.1 of February 2022]

To the south, a secondary area of the square was considered, covering 1553.60m^2 and characterised by small trees, street furniture, and commercial and residential buildings (Figure 3). Bus stations are also located in this area, and it should be noted that there are no pedestrian or cycle routes on the converging roads.

Finally, the sustainable management of this urban space is characterised by conventional systems and is not considered innovative in terms of waste management or wastewater and stormwater drainage systems.

3. Materials and Methods

The proposed methodology is built on the authors' comprehensive literature review of specialised topics, ultimately informing its development. This includes defining the groups and establishing the maximum weightings for the analysis criteria and sub-criteria specific to a particular type of outdoor public space.

When developing the model, the authors also considered preliminary analyses of various outdoor public spaces, such as streets, squares, and parks. It is important to note that this case study builds on previous research, specifically focusing on the characterisation of outdoor public spaces.

Based on this, the methodology is designed to assess three types of outdoor public spaces: squares, streets, and parks. The assessment considers six main groups and 14 analysis criteria distributed across each group, as shown in Figure 4. According to each analysis criterion, specific analysis sub-criteria are also defined.

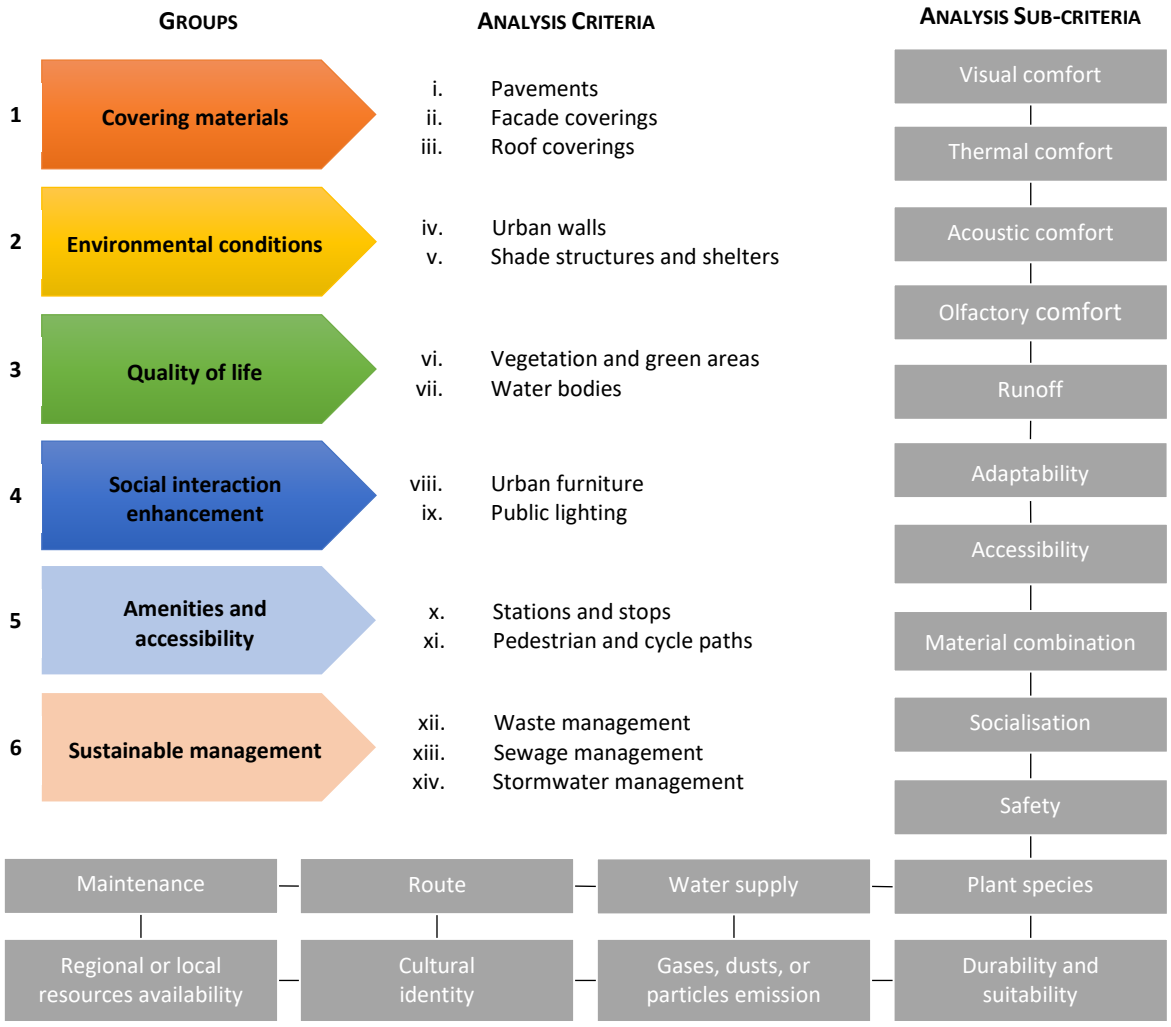

Figure 4: Methodology to assess outdoor public spaces

Regarding the analysis criteria, a specific weighting is defined for each one, which is intrinsically linked to three essential aspects that strongly influence the quality of outdoor public spaces: urban comfort, safety, and economy. Table 1 shows the maximum weighting given to each analysis criterion for use in the respective score calculation for a given type of outdoor urban space.

Analysis criteria	Maximum weightings ($W_{i\,max}$)		
	Streets	Squares	Parks
Covering materials			
Pavements (P)	W_P= 0,10	W_P= 0,13	W_P= 0,07
Façade coverings (FC)	W_{FC}= 0,08	W_{FC}= 0,04	W_{FC}= 0,02
Roof coverings (RF)	W_{RC}= 0,07	W_{RC}= 0,03	W_{RC}= 0,01
	0,25	**0,20**	**0,10**
Environmental conditions			
Urban walls (UW)	W_{UW}= 0,04	W_{UW}= 0,06	W_{UW}= 0,03
Shade structures and shelters (SSS)	W_{SSS}= 0,06	W_{SSS}= 0,09	W_{SSS}= 0,07
	0,10	**0,15**	**0,10**
Quality of life			
Vegetation or green areas (VGA)	W_{VGA}= 0,09	W_{VGA}= 0,12	W_{VGA}= 0,15
Water bodies (WB)	W_{WB}= 0,06	W_{WB}= 0,08	W_{WB}= 0,10
	0,15	**0,20**	**0,25**
Social interaction enhancement			
Urban furniture (UF)	W_{UF}= 0,04	W_{UF}= 0,09	W_{UF}= 0,12
Public lighting (PL)	W_{PL}= 0,06	W_{PL}= 0,06	W_{PL}= 0,08
	0,10	**0,15**	**0,20**
Amenities and accessibility			
Stations and stops (SS)	W_{SS}= 0,07	W_{SS}= 0,04	W_{SS}= 0,02
Pedestrian and cycle paths (PCP)	W_{PCP}= 0,08	W_{PCP}= 0,06	W_{PCP}= 0,08
	0,15	**0,10**	**0,10**
Sustainable management			
Waste management (WM)	W_{WM}= 0,10	W_{WM}= 0,09	W_{WM}= 0,12
Sewage management (SM)	W_{SM}= 0,06	W_{SM}= 0,04	W_{SM}= 0,03
Stormwater management (SWM)	W_{SWM}= 0,09	W_{SWM}= 0,07	W_{SWM}= 0,10
	0,25	**0,20**	**0,25**

Table 1: Maximum weightings for the analysis criteria (Martins and Sá 2023)

In this sense, the maximum weighting of the analysis criteria proposed is directly related to the maximum weightings assigned to the specific analysis sub-criteria shown in Figure 4. The approach used for the analysis sub-criteria can be combined with controls, either in the design phase (computations, comparisons with related laws, regulations and standards, and simulations using computer tools) or in the field.

Formula 1 shows the weighting correlation between the analysis sub-criteria and the corresponding analysis criteria:

$$\sum p_i \leq W_{i\,max} \quad (1)$$

where p_i refers to the weighting of each specific analysis sub-criterion, and W_i refers to the maximum weighting for a given analysis criterion. Martins and Sá (2023) define the maximum weighting for the analysis sub-criteria according to the respective analysis criterion and depending on whether the outdoor public space is a street, a square or a park (see Appendix A). In this study, general considerations are also made on how to proceed with the assessment of the sub-criteria of analysis.

Therefore, considering the analysis criteria and their respective weightings, the classification to be given to a given outdoor public space is determined by Formula 2:

$$\sum W_i \leq 1 \quad (2)$$

As a result of the overall assessment of analysing a given outdoor public space, a qualitative scale is defined, as shown in Figure 5.

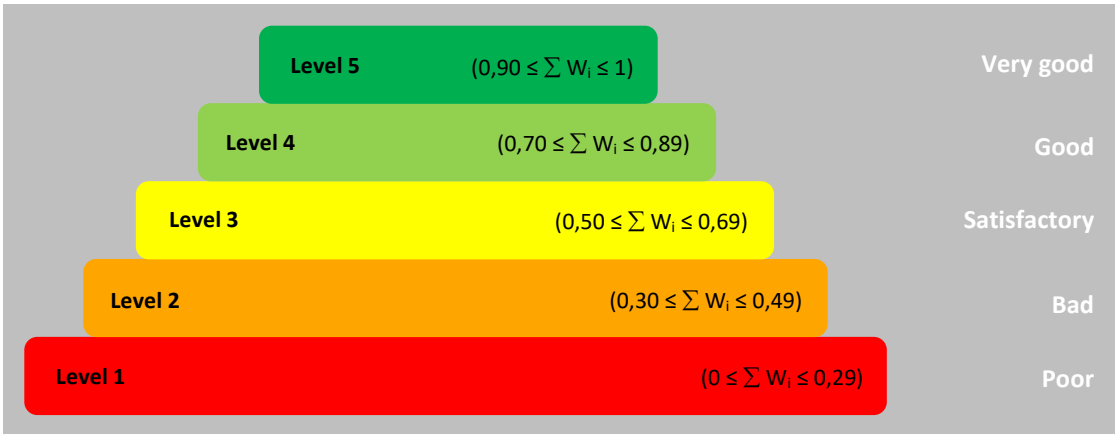

Figure 5: Outdoor Public Space Quality Scale

Thus, for the assessment of a given outdoor public space, which is presented below, should be used considering the analysis criteria and respective weighting that was previously defined.

4. Square assessment considerations

The assessment of outdoor public spaces is carried out using a Microsoft Excel spreadsheet-based application specially designed for this purpose. The application is called AM-SSP3 (version 0.3) and has undergone improvements based on research carried out. The spreadsheets can be filled in intuitively, although instructions are given on making the relevant inputs for each sub-criterion of the analysis or possible adjustments, i.e., depending on the characteristics of the outdoor public space being analysed.

The scores for the sub-criteria analysed were based on an analysis support, which included direct observation in the field, data collection and processing (e.g. measurements) and some calculation.

4.1. Covering materials: pavements, facade coverings, and roof coverings

One of the main considerations that had a major impact on the assessment of the pavements used in the main and secondary square areas was the issue of visual and thermal comfort for users since these are considerable open spaces, especially the main square area.

Regarding facade coverings, buildings within the square and those that establish a close relationship with the streets converging with the square were considered. One of the buildings that stands out for its concern and influence on the visual comfort of pedestrians is the *Lidador* Tower inside the square, with its glazed façade.

The roof coverings of the buildings in the vicinity of the square are preponderant for urban thermal comfort in this surrounding area, and their consideration is very relevant concerning the creation of the microclimate (Berardi 2016; Lalosevic et al. 2018; Peng and Jim 2013). In this sense, the colourimetric characteristics and the different surface roughness are predominant and are considered in the assessment.

4.2. Environmental conditions urban walls, shade structures and shelters:

Urban walls are not present either inside or along the perimeter of the square, so this criterion was not applicable in the assessment. However, they could be a valuable bioclimatic architectural element in an urban context and an innovation to be explored in the square,

guaranteeing good thermal and visual comfort for pedestrians while emphasising the protection these architectural elements offer pedestrians from the wind.

Concerning shade structures and shelters, these criteria were also not applicable in the assessment of the square, although, like urban walls, their existence would be an asset in terms of protecting pedestrians, considering exposure to environmental agents.

4.3. Quality of life: vegetation or green areas, and water bodies

In the square's central area, the green areas are minimal, with small plots that tend to fill the emptiness of the vast area of stone paving, through flowerbeds arranged in particular areas of the square, either permanent or with movable characteristics.

From this point of view, vegetation or green spaces play a major role in the landscape effect of the urban space, in other words, balancing the built environment (Tian, Jim, and Wang 2014; Zhu, Li, and Chen 2023).

As for the bodies of water, the existing triangular fountain is not directly connected to the square, but rather inside the streets that converge on the square. However, it was considered pertinent to include it in the square assessment, as its proximity to it justifies it.

4.4. Social interaction enhancement: urban furniture and public lighting

Only chairs, benches, tables, and small rubbish bins are included in the analysis of urban furniture. The stone benches are located at the edge of the square (to the north-west), which requires special attention regarding graffiti vandalism. The three sculptures inside the square also contribute to the city's cultural identity, as they are full of great symbolism, although they are not the focus of the square's assessment.

The analysis of public lighting is considered separately because it requires a more careful and rigorous analysis. It should be emphasised that good lighting in the square makes the place more attractive, which makes all the difference in encouraging pedestrians to visit this type of urban space more regularly at night, thus improving social interaction and also making this type of urban space safer (Pan and Du 2021; Rakonjac et al. 2022).

4.5. Amenities and accessibility: stations and stops, and pedestrian and cycle paths

The square is connected to bus stops to the south, and it is worth emphasising the presence of shops in this area, which also add value to the city's facilities. However, the assessment of the square refers to the building solutions of the public space.

As far as pedestrian and cycle routes, there are no urban facilities of this type, i.e., neither individual nor combined, so these criteria did not apply to the square assessment.

4.6. Sustainable management: waste management, sewage management, and stormwater management

Concerning sustainable management, there is no waste management equipment on the outskirts of the square for collecting and sorting waste, regardless of load capacity or size, so this criterion did not apply to the square's assessment.

Although it has not been classified, it is essential to mention that a sustainable waste management centre within the municipality of Maia is located around 5.7 kilometres from the square (*LIPOR II*, Maia Centre).

Regarding wastewater management, a conventional public wastewater drainage network covers the entire area, converging with the square. It should also be noted that there are three wastewater treatment plants in the municipality of Maia, of which *Ponte de Moreira* WWTP (4 kilometres from the square), *Parada* WWTP (5.8 kilometres from the square), and *Cambados* WWTP (7.6 kilometres from the square).

Lastly, in terms of stormwater management, the rainwater drainage system used in the square consists of a system of holes applied to the paving slabs, distributed throughout the square, to collect rainwater and direct it to the conventional main drainage network. The same rainwater collection system is used next to the access staircase to the Maia Town Hall building.

As a final note, the considerations presented on the square assessment make it possible to clarify the foundations of the assessment and deepen the understanding of the results obtained.

5. Results

The full results of the assessment of the building solutions of the square for all analysis criteria and sub-criteria are shown in Table 2.

It is important to note that four of the analysis criteria did not apply to the square's construction solutions (urban walls, shade structures and shelters, pedestrian and cycle paths, and waste management), so it was necessary to redistribute the maximum weightings of the analysis criteria, as shown in Figure 6. The redistribution of the weighting of the analysis criteria was carried out in the AM-SSP3 application, version 0.3, based on the Microsoft Excel spreadsheet.

No. of $W_{i\ not\ applicable}$=	4
$\sum W_{i\ not\ applicable}$=	0,30
No. of $W_{i\ applicable}$=	10
r=	0,03

SQUARES		$W_{i\ max}$		$RW_{i\ max}$		VC_i
Pavements	W_P=	0,13	RW_P=	0,16	VC_P=	1,23
Façade coverings	W_{FC}=	0,04	RW_{FC}=	0,07	VC_{FC}=	1,75
Roof coverings	W_{RF}=	0,03	RW_{RF}=	0,06	VC_{RF}=	2,00
Urban walls	W_{UW}=	N/A	RW_{UW}=	0,00	VC_{UW}=	0,00
Shade structures and shelters	W_{SSS}=	N/A	RW_{SSS}=	0,00	VC_{SSS}=	0,00
Vegetation or green areas	W_{VGA}=	0,12	RW_{VGA}=	0,15	VC_{VGA}=	1,25
Water bodies	W_{WB}=	0,08	RW_{WB}=	0,11	VC_{WB}=	1,38
Urban furniture	W_{UF}=	0,09	RW_{UF}=	0,12	VC_{UF}=	1,33
Public lighting	W_{PL}=	0,06	RW_{PL}=	0,09	VC_{PL}=	1,50
Stations and stops	W_{SS}=	0,04	RW_{SS}=	0,07	VC_{SS}=	1,75
Pedestrian and cycle paths	W_{PCP}=	N/A	RW_{PCP}=	0,00	VC_{PCP}=	0,00
Waste management	W_{WM}=	N/A	RW_{WM}=	0,00	VC_{WM}=	0,00
Sewage management	W_{SM}=	0,04	RW_{SM}=	0,07	VC_{SM}=	1,75
Stormwater management	W_{SWM}=	0,07	RW_{SWM}=	0,10	VC_{SWM}=	1,43

*If an analysis criterion is not applicable write N/A in the specific cell;
**The weighting redistribution for the non-applicable analysis criterion is equal to zero;
***The variation coefficient for an analysis criterion that is not applicable is considered to be zero.

Figure 6: Weighting redistribution for the analysis criteria [Microsoft Excel spreadsheet-based application, AM-SSP3, version 0.3]

Table 2 also presents the weights that each group had in assessing the square, also counted as a percentage, and finally, the total quantitative assessment of the square, with a result of 0.77 that was converted into a qualitative scale, which translated into a “good quality” outdoor urban space, according to the defined scale in Figure 5.

		Analysis criteria (W_i)													
		Covering materials			Environmental conditions		Quality of life		Social interaction enhancement		Amenities and accessibility		Sustainable management		
		P	FC	RC	UW	SSS	VGA	WB	UF	PL	SS	PCP	WM	SM	SWM
Analysis sub-criteria (p_i)	Visual comfort	0,0080	0,0050	–	N/A	–	0,0035	0,0060	–	0,0050	0,0025	N/A	N/A	0,0030	0,0065
	Thermal comfort	0,0160	0,0040	0,0055	N/A	N/A	0,0060	0,0080	0,0045	0,0050	0,0040	N/A	–	–	–
	Acoustic comfort	0,0070	–	–	–	N/A	0,0040	0,0045	–	–	0,0015	N/A	–	0,0035	0,0070
	Olfactory comfort	–	–	–	–	–	0,0035	–	–	–	–	–	N/A	0,0050	0,0085
	Runoff	0,0070	–	–	–	N/A	0,0030	–	–	–	0,0012	N/A	–	–	–
	Durability and suitability	0,0060	0,0015	0,0025	N/A	N/A	0,0055	0,0070	0,0085	0,0050	0,0025	N/A	N/A	0,0040	0,0070
	Adaptability	0,0070	0,0015	0,0020	N/A	N/A	0,0070	0,0065	0,0025	0,0040	0,0025	N/A	N/A	0,0025	0,0038
	Accessibility	–	–	–	–	–	–	–	–	–	–	–	N/A	–	–
	Material combination	0,0060	0,0007	0,0011	N/A	N/A	–	–	0,0010	0,0020	0,0020	N/A	–	–	–
	Gases, dusts, or particles emission	0,0090	0,0030	0,0009	N/A	N/A	–	–	0,0035	0,0018	0,0010	N/A	N/A	0,0045	0,0080
	Socialisation	–	–	–	–	N/A	0,0045	0,0010	0,0070	0,0050	0,0025	N/A	–	–	–
	Safety	0,0110	0,0060	0,0050	N/A	N/A	0,0110	0,0045	0,0110	0,0065	0,0040	N/A	N/A	0,0055	0,0085
	Plant species	–	–	–	–	–	0,0040	–	–	–	–	–	–	–	–
	Water supply	–	–	–	–	–	0,0045	0,0040	–	–	–	–	–	–	–
	Route	–	–	–	–	–	–	–	–	–	–	N/A	–	–	–
	Maintenance	0,0100	0,0050	0,0040	N/A	N/A	0,0100	0,0070	0,0100	0,0060	0,0045	N/A	N/A	0,0050	0,0080
	Cultural identity	0,0050	0,0015	0,0005	N/A	N/A	0,0050	0,0030	0,0090	0,0025	0,0007	N/A	N/A	0,0008	0,0025
	Regional or local resources availability	0,0100	0,0025	0,0015	N/A	N/A	0,0075	0,0050	0,0100	0,0040	0,0020	N/A	N/A	0,0020	0,0025
	$\sum p_i = W_i$	0,10	0,03	0,02	N/A	N/A	0,08	0,06	0,07	0,05	0,03	N/A	N/A	0,04	0,06
	$*RW_i$	0,12	0,05	0,04	N/A	N/A	0,10	0,08	0,09	0,08	0,05	N/A	N/A	0,07	0,09
		21%			–		18%		17%		5%		16%		
		$\sum W_i = 0,77$													

$*RW_i$ refers to the redistribution of the weighting for the analysis criteria

Table 2: Results of the weightings of the assessment criteria and sub-criteria

6. Discussion

6.1. Covering materials: pavements, facade coverings, and roof coverings

Covering materials are considered extremely important when assessing outdoor public spaces (Doulos, Santamouris, and Livada 2004; Rosso et al. 2018), mainly when there are vast areas of pavements, façades and roofs that will directly or indirectly influence urban comfort, namely visual, thermal and acoustic comfort. The sub-criterion of thermal comfort, which is common to all covering materials, will certainly have a significant influence on the overall thermal comfort of this outdoor public space. The paving material used in the square and the area to the south received high scores. The choice of stone for this outdoor public space is most suitable, as it met most of the sub-criteria analysed. This includes maximum points for adaptability, cultural identity, and the availability of regional or local resources. Nevertheless, the deterioration in the square cannot be overlooked, particularly the cracks in some of the paving slabs due to some settlements, which could jeopardise the safety of pedestrians or other users (Figure 7). However, these states of disrepair are due to events of all kinds, so the construction technique combined with the size of the stone slabs may not serve this purpose of use beyond pedestrian circulation. Settlement caused by concentrated loads is evident, and it is important to emphasise that issues related to poor pavement drainage can increase these pathologies.

Figure 7: Cracks in the stone floor slabs

As far as facades are concerned, the glass facade of the *Lidador* Tower is a highlight, although it is an emblematic piece of architecture for the city. On the other hand, according to Suk, Schiler, and Kensek (2017), it can harm the visual comfort of pedestrians travelling through the square or even road traffic on the converging streets. In addition to visual comfort, it can also enhance the creation of an urban heat island, generating thermal discomfort for pedestrians and other users during the summer. A possible suggestion to mitigate this situation would be to combine it with another type of facade material with a lower level of reflectivity, given the solar radiation reflected towards the worst areas of the square.

However, the score given to the facades of the buildings in and around the square is considered good, except for the highlight mentioned above.

In the case of building roofs, the analogy can be made with the use of materials that reflect or absorb more solar radiation, although the main issue here is the thermal comfort that these roofs can improve by creating an urban microclimate. One of the sub-criteria of analysis that was penalised was cultural identity, as this issue should not be overlooked, where traditional or vernacular materials could provide good performance in an urban context (Matar, Palaiologou, and Richards 2023), as well as for the building, where the selection of these materials should be well considered, in order to optimise both urban thermal comfort, not forgetting the connection to the building, to optimise the thermal comfort of the building.

6.2. Environmental conditions: urban walls, shade structures and shelters

The adverse environmental conditions related to climate change and the need to adapt outdoor public space to these constraints mean that certain types of architectural elements are necessary to optimise the quality of a given urban space (Ou and Lin 2023; Watanabe et al. 2014).

Although the assessment of urban walls was not applicable, it is important to briefly mention this important architectural element, which would certainly be an asset to the square and to the urban comfort of its users.

Adjusting the vast unprotected area of the square to adverse environmental conditions makes perfect sense, so solar radiation, rainfall and wind circulation must be accounted for in this type of outdoor public space. Architectural elements such as urban walls and shade structures or shelters end up providing greater comfort for their users, emphasising that these elements can also form part of the cultural identity of the local squares and the region in general.

The temporary or permanent nature of a given architectural element will naturally be determined by the aggressiveness of the climate conditions, considering its orientation and layout in the urban space and its structural resistance, among others, as provided for in the assessment sub-criteria.

An example is the inclusion of small sections of wall, which can be connected to benches, arranged around the square in such a way as to compensate for winds blowing from the north-west. The shading structures or shelters could be temporary to protect pedestrians from excessive solar radiation in the summer (Figure 9) without making any changes to the square. If these shade structures and shelters were permanent, it would be necessary to create strategic corridors in the square, considering all these climate conditions. Due to the extensive area of the square, the creation of corridors makes perfect sense and makes the route more comfortable for its users.

6.3. Quality of life: vegetation or green areas, and water bodies

The quality of life in cities is related to various factors, particularly those linked to ideal environmental conditions (Tanguay, Rajaonson, and Bilodeau 2023). In this sense, air quality, ideal temperature, and relative humidity are preponderant in the different types of outdoor urban spaces, where all the city's dynamics take place and bring the city to life in the urban fabric.

The focus of this assessment criterion focuses on maximising the use of public space at ground level in an urban context, i.e., unrelated to the building, where vegetation and green spaces are dedicated to the user, with all the environmental benefits that naturally come from this.

In terms of thermal comfort, vegetation and green spaces help to mitigate the urban heat island effect by absorbing energy from solar radiation (Balany et al. 2020; AboElata 2016; J.

Liu, Ma, and Li 2011), with impact on air temperature and relative humidity. Vegetation or green spaces can also act as noise-attenuating elements in the outdoor public space (Jang, Kim, and Jeon 2015), as well as creating an olfactory sensation through the release of pleasant aromas, thus contributing to the air quality in the outdoor public space (Deshmukh et al. 2019; Janhäll 2015)

In accordance with Ghosh and Das (2018) bodies of water end up fulfilling the same mission, offering all these benefits, but it should be noted that the combination of these architectural elements with vegetation and green areas must be well considered (Zhou et al. 2023), since it can eventually increase the relative humidity excessively, making it uncomfortable for the user.

Nowadays, with all the climate change issues, it is precisely when squares should reflect a place of continuity of dynamics, life, and the heart of the city that they should include considerable areas of greenery.

Regarding the square under study, and in terms of proportionality of areas, small green areas compensate for a vast area of open pavement that could be used to achieve higher levels of attractiveness. Particularly noteworthy are the movable flowerbeds within the main square area, as shown in Figure 8, which can be moved according to the needs of the space, providing design flexibility.

Figure 8: Movable flowerbeds in the main square area

The secondary square area has a higher level of attractiveness, with small trees that make the space much more attractive and welcoming, plus all the above benefits for vegetation and green areas, naturally focusing on air quality and the possibility of creating shaded areas in the summer.

In general, given the scores given, the following sub-criteria need to be improved: visual comfort, thermal comfort, acoustic comfort, olfactory comfort, runoff, and water supply, to improve the space of the square.

In this context, it is appropriate to present another scenario for the square, where a harmonious balance between green areas and paved areas is established, as shown in Figure 9. This proposal can serve as a basis for future studies of the square.

Figure 9: Possible scenario for future studies of the square [Adapted from the Maia City Council Architectural Drawings, Version 0.1 of February 2022]

The fountain considered in the assessment of the square is located on the converging streets (Figure 3), but its orientation is considered appropriate, as it is close to the square and, together with the south-easterly winds, can contribute to an increase in relative humidity, which can optimise the thermal comfort of the square. This fountain makes a difference and creates very positive visual comfort.

At last, about the score given to the water body, the sub-criterion of visual comfort stands out with the highest score, to the detriment of the sub-criteria with the lowest scores: socialisation, safety, and water supply, given that this equipment is outside the square area, i.e., within the converging streets, more specifically at a fork.

6.4. Social interaction enhancement: urban furniture and public lighting

Social interaction results from various factors present in urban furniture (Allahdadi 2017; Bolkaner, Inançoglu, and Asilsoy 2019), enhancing the presence of users in each place for rest, conversation or even leisure, or even to carry out certain specific activities that only good street lighting makes possible.

There are only two benches in the large square area, and they are located on the periphery of the square, one of them next to the town hall building to the west and the other next to the street that converges with the Forum Maia station.

It should be emphasised that in a longitudinal pedestrian circulation stretch of approximately 110m, no benches can serve as a resting point, which is significant for the senior age group. On the other hand, the secondary square area, which gives continuity to the pedestrian circulation dynamic, has four benches and two litter bins, which adequately serve this space.

One of the issues that is of interest in the use of street furniture, with a focus on benches, is thermal comfort in terms of direct contact with the user in the harshest seasons of the year, such as winter.

Vandalism of street furniture is a pertinent issue, particularly graffiti, which has been occurring (Figure 10), and can cause significant increases in the cost of maintaining this type of furniture, although the maintenance plan may provide for such unforeseen events, among others.

Figure 10: Graffiti vandalism on urban furniture

Regarding the score given, the sub-criterion of thermal comfort needs improvement in the sense that the material of the benches is stone, which, from the point of view of the winter season, can generate thermal discomfort for the user. The issue of combining materials would be worth considering to overcome discomfort contact when using the benches for a long time.

Otherwise, the use of stone is in keeping with cultural identity, as well as the possibility of obtaining this building material in the region, and for this reason, it received top marks in these two sub-criteria. Through the analysis carried out, the criterion for analysing street furniture received a fair score.

Good street lighting creates a unique nocturnal atmosphere in a given outdoor public space (Nasar and Bokharaei 2017a, 2017b), where squares are certainly areas of excellence, and should not only be attractive, but also inspire confidence in terms of safety and security.

In the case of the main square area only has two lampposts inside (Figure 2), each with three floodlights, which sufficiently serve the area to be lit and its adjacent areas. From a visual comfort perspective, the orientation of the light projection is critical so as not to cause light

pollution (Pothukuchi 2021), either for pedestrians or for nocturnal biodiversity, so the orientation of the light projection must be well designed. Thermal comfort ends up being somewhat associated with visual comfort, in that excessive heating of the floodlights can alter the behaviour of nocturnal biodiversity in the sense of increasing the temperature in the vicinity.

In the secondary square area, there are two more lampposts (Figure 12) with one floodlight each, but these are only directed towards the converging street. At the far end of this same area, there are 17 tree pits, with one floor spotlight for each tree pit (Figure 11). However, the lighting in the whole area is considered poor for night-time users, as the spotlights are designed to demarcate the tree area.

Figure 11: Installation of floodlights in the tree pits

The sub-criterion of thermal comfort scored maximum points, while the sub-criterion of the material combination needs attention, emphasising the use of sustainable construction materials for the lampposts. In addition, the criterion for analysing public lighting is considered to have scored well.

6.5. Amenities and accessibility: stations and stops, and pedestrian and cycle paths

Amenities and accessibility in a city must also be assessed from the point of view of construction design solutions. In any case, it is clear that the presence of commercial establishments also determines the entire structure of the road network and accessibility, thereby moulding the urban fabric, as shown in Figure 12. In the secondary square area, which is seen as an extension of the main area, there are two bus stops (Figure 12), which are well-sized, and which serve a wide range of users. It should be noted that they are covered and have side walls, so that the user is somewhat protected from the weather, considering the length of time spent at the stop.

Another pertinent issue regarding urban comfort is considering the acoustic protection of the bus stop, about traffic noise in the surroundings or the vicinity of the square or converging streets.

Figure 12: Secondary square area with bus stops and shops

As an aside, the location of the bus stops could be on the periphery of the main square area, that is destined for car parking, as seen in Figure 12. It would be a much safer space for pedestrians to get on and off the bus, it wouldn't reduce the area of the square, it wouldn't create traffic congestion by temporarily immobilising the buses and, finally, it would free up the secondary square area where the bus stops are currently located. Freeing up this area would certainly make it much more attractive for pedestrians to use. One of the sub-criteria that needs to be improved is gases, dusts, or particles emission, which is related to the gas emissions released by the various types of traffic in the vicinity or near the bus stop, and which is understood to be heavy because it encompasses all types of traffic on the street. From this perspective, car traffic, apart from public transport of course, should be kept away from this location, hence the suggestion to remove the car park in order to change the location of the bus stop (Figure 9). This penalty in the overall assessment of the bus stop assessment criterion only reduced the score a little, but the score achieved was considered good in any case.

Concerning the sub-criterion of pedestrian and cycle paths, this did not apply to the assessment, although part of the streets in the municipality are already covered with a network of this type. There is still no public equipment of this type in the square and converging streets, but there is potential for this type of equipment, and the route and converging streets should be well studied.

6.6. Sustainable management: waste management, sewage management, and stormwater management

Currently, sustainable management is of central importance in any city, where complexity increases with the number of inhabitants (De Matteis et al. 2021), so coming up with an effective and efficient system is difficult, as there must be a balance between environmental, economic and, of course, social issues.

As for the square's main and secondary areas, no waste management equipment could be perfectly integrated, preserving its size and appropriate aesthetics.

It should be stated that this sub-criterion emphasises the collection and separation of waste for subsequent recycling, and not just the existence of simple rubbish bins, which were previously included in the assessment of the urban furniture sub-criterion.

Nevertheless, the nearest small urban eco point module is around 100m from the centre of the square, which is considered excessive; in addition to the fact that this equipment is intended and designed in terms of waste volumes for the inhabitants of the street, the waste management sub-criterion was therefore not applicable.

Concerning wastewater management, this was assessed based on a conventional drainage system through a network of public collectors, which is then received and treated at the municipality's wastewater treatment plants (WWTP). Based on this system, the score given to the wastewater management criterion is considered good, with the sub-criteria of visual comfort, acoustic comfort, olfactory comfort and regional or local resources availability receiving top marks. The maximum score given for regional or local resources availability is justified by the three water treatment plants in the municipality, which have advanced water treatment technologies.

Although the system assessed is considered effective, combining it with other types of more sustainable solutions would be preferable, but in such a way as not to jeopardise the operation of the main network. For instance, in general terms, the possibility of integrating effective and efficient technologies, which could be applied to watering agricultural land, vegetation, or green areas (Kalavrouziotis and Arslan-Alaton 2008). Compact wastewater treatment plants could be a possibility, as they optimise and assist in the reuse of the municipality's wastewater.

Even though this analysis criterion has been discussed on deep and complex issues, it is understood that the existing network fulfils its intended functions effectively, hence the good rating, with the following criteria getting top marks: visual comfort, acoustic comfort, olfactory comfort and regional or local resources availability.

At last, about stormwater management, the same line of reasoning is followed (e.g., for irrigation or washing), or even its potential reuse for firefighting, being collected through effective systems (Martins Vaz, Ghisi, and Souza 2023). As Jusic, Hadzic, and Milisic (2019) mention, other potential innovative technology solutions could be associated with creating Bioretention Basins or Bioswales.

However, the analysis goes beyond analysing the rainwater drainage system through the public collector, i.e., upstream, focusing on the effectiveness and efficiency of the water collection devices along the main and secondary square areas. From this perspective, and focusing on the main area of the square, the adequacy could be better, as the solution designed is through a system of holes in the paving slabs, and the drainage is insufficient given the large area of the square. The sub-criteria with the highest scores were visual and acoustic comfort. In general, the stormwater management criterion scored well.

7. Conclusions

Through the assessment of this square, it can be concluded that this type of methodology provides good indicators for improving outdoor urban spaces, as each sub-criteria analysed allows to get to the bottom of each relevant issue in selecting the best building materials and technologies. Even though the score of 0.77 refers to a level 4 of quality for this outdoor public space, which was considered “good”, lessons can be learnt to improve the construction solutions of the square to reach a level 5, which is the maximum level of quality proposed in this study.

To achieve this level of quality excellence, improvements would have to be made mainly to the vegetation and the paving in the main area of the square. To further optimise this space, including shading structures or shelters would be a possibility to be studied so that the main square area is not so unprotected in terms of its use. From this point of view, passageways or corridors should be planned along the square, maintaining a spatial balance between the open paved area, the green areas, and the possible addition of street furniture.

This tool can be applied to urban renewal and design, allowing it to support creating municipal guidelines or specific regulations. In essence, this model will help in the search for the best construction solutions for outdoor public space, always sensitising designers and all those involved in this process to preferably opt for sustainable construction in an urban context, using traditional or vernacular solutions that are linked to the bioclimatic concept. Urban heritage can be adapted to climate conditions, but this requires exact indicators to fine-tune these solutions in outdoor public spaces.

As future studies, in addition to the innovative sustainable solutions best suited to the urban space, it is necessary to create a mix of contemporary and traditional solutions that define the cultural identity of a particular region or location and that can mitigate the adverse effects of climate change.

Appendix A

*Maximum weightings for the sub-criteria analysis (*Martins and Sá 2023*)*

	Analysis sub-criteria	Maximum weightings (p_i)		
		Streets	**Squares**	**Parks**
Pavements (W_P)	Visual comfort	p_{vc}= 0,0100	p_{vc}= 0,0140	p_{vc}= 0,0080
	Thermal comfort	p_{tc}= 0,0150	p_{tc}= 0,0180	p_{tc}= 0,0130
	Acoustic comfort	p_{ac}= 0,0100	p_{ac}= 0,0080	p_{ac}= 0,0030
	Runoff	p_{ro}= 0,0090	p_{ro}= 0,0120	p_{ro}= 0,0070
	Durability and suitability	p_{ds}= 0,0050	p_{ds}= 0,0070	p_{ds}= 0,0030
	Adaptability	p_{a}= 0,0050	p_{a}= 0,0070	p_{a}= 0,0030
	Material combination	p_{mc}= 0,0030	p_{mc}= 0,0090	p_{mc}= 0,0040
	Gases, dusts, or particles emission	p_{gdp}= 0,0080	p_{gdp}= 0,0100	p_{gdp}= 0,0050
	Safety	p_{st}= 0,0100	p_{st}= 0,0130	p_{st}= 0,0070
	Maintenance	p_{m}= 0,0100	p_{m}= 0,0130	p_{m}= 0,0070
	Cultural identity	p_{ci}= 0,0030	p_{ci}= 0,0050	p_{ci}= 0,0020
	Regional or local resources availability	p_{rlr}= 0,0070	p_{rlr}= 0,0100	p_{rlr}= 0,0050

Table A1: Maximum weightings for the sub-criteria for pavements analysis

	Analysis sub-criteria	Maximum weightings (p_i)		
		Streets	**Squares**	**Parks**
Facade coverings (W_{FC})	Visual comfort	p_{vc}= 0,0130	p_{vc}= 0,0070	p_{vc}= 0,0040
	Thermal comfort	p_{tc}= 0,0120	p_{tc}= 0,0050	p_{tc}= 0,0025
	Durability and suitability	p_{ds}= 0,0050	p_{ds}= 0,0020	p_{ds}= 0,0009
	Adaptability	p_{a}= 0,0050	p_{a}= 0,0020	p_{a}= 0,0009
	Material combination	p_{mc}= 0,0020	p_{mc}= 0,0010	p_{mc}= 0,0007
	Gases, dusts, or particles emission	p_{gdp}= 0,0080	p_{gdp}= 0,0040	p_{gdp}= 0,0015
	Safety	p_{st}= 0,0130	p_{st}= 0,0070	p_{st}= 0,0037
	Maintenance	p_{m}= 0,0130	p_{m}= 0,0070	p_{m}= 0,0037
	Cultural identity	p_{ci}= 0,0030	p_{ci}= 0,0020	p_{ci}= 0,0008
	Regional or local resources availability	p_{rlr}= 0,0060	p_{rlr}= 0,0030	p_{rlr}= 0,0013

Table A2: Maximum weightings for the sub-criteria for facade coverings analysis

Analysis sub-criteria		Maximum weightings (p_i)		
		Streets	**Squares**	**Parks**
Roof coverings (W_{RC})	Thermal comfort	p_{tc}= 0,0100	p_{tc}= 0,0060	p_{tc}= 0,0018
	Durability and suitability	p_{ds}= 0,0070	p_{ds}= 0,0030	p_{ds}= 0,0013
	Adaptability	p_a= 0,0070	p_a= 0,0030	p_a= 0,0013
	Material combination	p_{mc}= 0,0060	p_{mc}= 0,0013	p_{mc}= 0,0004
	Gases, dusts, or particles emission	p_{gdp}= 0,0080	p_{gdp}= 0,0010	p_{gdp}= 0,0003
	Safety	p_{st}= 0,0100	p_{st}= 0,0060	p_{st}= 0,0018
	Maintenance	p_m= 0,0100	p_m= 0,0060	p_m= 0,0018
	Cultural identity	p_{ci}= 0,0050	p_{ci}= 0,0015	p_{ci}= 0,0005
	Regional or local resources availability	p_{rlr}= 0,0070	p_{rlr}= 0,0022	p_{rlr}= 0,0008

Table A3: Maximum weightings for the sub-criteria for roof coverings analysis

Analysis sub-criteria		Maximum weightings (p_i)		
		Streets	**Squares**	**Parks**
Urban walls (W_{UW})	Visual comfort	p_{vc}= 0,0070	p_{vc}= 0,0100	p_{vc}= 0,0050
	Thermal comfort	p_{tc}= 0,0050	p_{tc}= 0,0080	p_{tc}= 0,0040
	Durability and suitability	p_{ds}= 0,0020	p_{ds}= 0,0050	p_{ds}= 0,0025
	Adaptability	p_a= 0,0020	p_a= 0,0050	p_a= 0,0025
	Material combination	p_{mc}= 0,0010	p_{mc}= 0,0020	p_{mc}= 0,0010
	Gases, dusts, or particles emission	p_{gdp}= 0,0040	p_{gdp}= 0,0030	p_{gdp}= 0,0015
	Safety	p_{st}= 0,0070	p_{st}= 0,0100	p_{st}= 0,0050
	Maintenance	p_m= 0,0070	p_m= 0,0100	p_m= 0,0050
	Cultural identity	p_{ci}= 0,0020	p_{ci}= 0,0030	p_{ci}= 0,0015
	Regional or local resources availability	p_{rlr}= 0,0030	p_{rlr}= 0,0040	p_{rlr}= 0,0020

Table A4: Maximum weightings for the sub-criteria for urban walls analysis

Analysis sub-criteria		Maximum weightings (p_i)		
		Streets	**Squares**	**Parks**
Shade structures and shelter (W_{SSS})	Thermal comfort	p_{tc}= 0,0070	p_{tc}= 0,0090	p_{tc}= 0,0080
	Acoustic comfort	p_{ac}= 0,0030	p_{ac}= 0,0050	p_{ac}= 0,0020
	Runoff	p_{ro}= 0,0040	p_{ro}= 0,0070	p_{ro}= 0,0040
	Durability and suitability	p_{ds}= 0,0050	p_{ds}= 0,0080	p_{ds}= 0,0060
	Adaptability	p_a= 0,0050	p_a= 0,0080	p_a= 0,0060
	Material combination	p_{mc}= 0,0040	p_{mc}= 0,0070	p_{mc}= 0,0050
	Gases, dusts, or particles emission	p_{gdp}= 0,0040	p_{gdp}= 0,0070	p_{gdp}= 0,0030
	Socialisation	p_{so}= 0,0050	p_{so}= 0,0080	p_{so}= 0,0070
	Safety	p_{st}= 0,0070	p_{st}= 0,0090	p_{st}= 0,0080
	Maintenance	p_m= 0,0070	p_m= 0,0090	p_m= 0,0080
	Cultural identity	p_{ci}= 0,0030	p_{ci}= 0,0050	p_{ci}= 0,0060
	Regional or local resources avail.	p_{rlr}= 0,0060	p_{rlr}= 0,0080	p_{rlr}= 0,0070

Table A5: Maximum weightings for the sub-criteria for shade structures and shelters analysis

	Analysis sub-criteria	Maximum weightings (p_i)		
		Streets	Squares	Parks
Vegetation or green areas (W_{VGA})	Visual comfort	p_{vc}= 0,0040	p_{vc}= 0,0070	p_{vc}= 0,0090
	Thermal comfort	p_{tc}= 0,0100	p_{tc}= 0,0120	p_{tc}= 0,0140
	Acoustic comfort	p_{ac}= 0,0060	p_{ac}= 0,0080	p_{ac}= 0,0110
	Olfactory comfort	p_{oc}= 0,0050	p_{oc}= 0,0070	p_{oc}= 0,0110
	Runoff	p_{ro}= 0.0040	p_{ro}= 0,0060	p_{ro}= 0,0070
	Durability and suitability	p_{ds}= 0,0070	p_{ds}= 0,0090	p_{ds}= 0,0100
	Adaptability	p_a= 0,0070	p_a= 0,0090	p_a= 0,0100
	Socialisation	p_{so}= 0,0050	p_{so}= 0,0070	p_{so}= 0,0110
	Safety	p_{st}= 0,0100	p_{st}= 0,0120	p_{st}= 0,0140
	Plant species	p_{ps}= 0,0040	p_{ps}= 0,0060	p_{ps}= 0,0100
	Water supply	p_{ws}= 0,0060	p_{ws}= 0,0090	p_{ws}= 0,0110
	Maintenance	p_m= 0,0100	p_m= 0,0120	p_m= 0,0140
	Cultural identity	p_{ci}= 0,0050	p_{ci}= 0,0070	p_{ci}= 0,0080
	Regional or local resources availability	p_{rlr}= 0,0070	p_{rlr}= 0,0090	p_{rlr}= 0,0100

Table A6: Maximum weightings for the sub-criteria for vegetation or green areas
nalysis

	Analysis sub-criteria	Maximum weightings (p_i)		
		Streets	Squares	Parks
Water bodies (W_{WB})	Visual comfort	p_{vc}= 0,0040	p_{vc}= 0,0060	p_{vc}= 0,0070
	Thermal comfort	p_{tc}= 0,0070	p_{tc}= 0,0090	p_{tc}= 0,0110
	Acoustic comfort	p_{ac}= 0,0030	p_{ac}= 0,0050	p_{ac}= 0,0060
	Durability and suitability	p_{ds}= 0,0060	p_{ds}= 0,0080	p_{ds}= 0,0100
	Adaptability	p_a= 0,0060	p_a= 0,0080	p_a= 0,0100
	Socialisation	p_{so}= 0,0050	p_{so}= 0,0060	p_{so}= 0,0080
	Safety	p_{st}= 0,0070	p_{st}= 0,0090	p_{st}= 0,0110
	Water supply	p_{ws}= 0,0060	p_{ws}= 0,0080	p_{ws}= 0,0100
	Maintenance	p_m= 0,0070	p_m= 0,0090	p_m= 0,0110
	Cultural identity	p_{ci}= 0,0030	p_{ci}= 0,0040	p_{ci}= 0,0060
	Regional or local resources availability	p_{rlr}= 0,0060	p_{rlr}= 0,0080	p_{rlr}= 0,0100

Table A7: Maximum weightings for the sub-criteria for water bodies analysis

	Analysis sub-criteria	Maximum weightings (p_i)		
		Streets	Squares	Parks
Urban furniture (W_{UF})	Thermal comfort	p_{tc}= 0,0030	p_{tc}= 0,0090	p_{tc}= 0,0120
	Durability and suitability	p_{ds}= 0,0050	p_{ds}= 0,0100	p_{ds}= 0,0130
	Adaptability	p_a= 0,0020	p_a= 0,0050	p_a= 0,0100
	Material combination	p_{mc}= 0,0040	p_{mc}= 0,0090	p_{mc}= 0,0120
	Gases, dusts, or particles emission	p_{gdp}= 0,0020	p_{gdp}= 0,0040	p_{gdp}= 0,0070
	Socialisation	p_{so}= 0,0040	p_{so}= 0,0100	p_{so}= 0,0130
	Safety	p_{st}= 0,0060	p_{st}= 0,0120	p_{st}= 0,0140
	Maintenance	p_m= 0,0060	p_m= 0,0120	p_m= 0,0140
	Cultural identity	p_{ci}= 0,0030	p_{ci}= 0,0090	p_{ci}= 0,0120
	Regional or local resources availability	p_{rlr}= 0,0050	p_{rlr}= 0,0100	p_{rlr}= 0,0130

Table A8: Maximum weightings for the sub-criteria for urban furniture analysis

	Analysis sub-criteria	Maximum weightings (p_i)		
		Streets	Squares	Parks
Public lighting (W_{PL})	Visual comfort	p_{vc}= 0,0070	p_{vc}= 0,0070	p_{vc}= 0,0090
	Thermal comfort	p_{tc}= 0,0050	p_{tc}= 0,0050	p_{tc}= 0,0060
	Durability and suitability	p_d= 0,0060	p_d= 0,0060	p_d= 0,0080
	Adaptability	p_a= 0,0050	p_a= 0,0050	p_a= 0,0060
	Gases, dusts, or particles emission	p_{gdp}=0,0030	p_{gdp}=0,0020	p_{gdp}= 0,0040
	Material combination	p_{mc}= 0,0050	p_{mc}= 0,0050	p_{mc}= 0,0070
	Socialisation	p_{so}= 0,0050	p_{so}= 0,0060	p_{so}= 0,0080
	Safety	p_{st}= 0,0070	p_{st}= 0,0070	p_{st}= 0,0090
	Maintenance	p_m= 0,0070	p_m= 0,0070	p_m= 0,0090
	Cultural identity	p_{ci}= 0,0040	p_{ci}= 0,0040	p_{ci}= 0,0060
	Regional or local resources availability	p_{rlr}= 0,0060	p_{rlr}= 0,0060	p_{rlr}= 0,0080

Table A9: Maximum weightings for the sub-criteria for public lighting analysis

	Analysis sub-criteria	Maximum weightings (p_i)		
		Streets	Squares	Parks
Stations and stops (W_{SS})	Visual comfort	p_{vc}= 0,0050	p_{vc}= 0,0030	p_{vc}= 0,0015
	Thermal comfort	p_{tc}= 0,0070	p_{tc}= 0,0050	p_{tc}= 0,0023
	Acoustic comfort	p_{ac}= 0,0040	p_{ac}= 0,0020	p_{ac}= 0,0007
	Runoff	p_{ro}= 0,0040	p_{ro}= 0,0020	p_{ro}= 0,0010
	Durability and suitability	p_d= 0,0060	p_d= 0,0030	p_d= 0,0023
	Adaptability	p_a= 0,0050	p_a= 0,0030	p_a= 0,0015
	Gases, dusts, or particles emission	p_{gdp}= 0,0050	p_{gdp}= 0,0020	p_{gdp}= 0,0007
	Material combination	p_{mc}= 0,0060	p_{mc}= 0,0030	p_{mc}= 0,0015
	Socialisation	p_{so}= 0,0050	p_{so}= 0,0030	p_{so}= 0,0015
	Safety	p_{st}= 0,0070	p_{st}= 0,0050	p_{st}= 0,0025
	Maintenance	p_m= 0,0070	p_m= 0,0050	p_m= 0,0025
	Cultural identity	p_{ci}= 0,0030	p_{ci}= 0,0010	p_{ci}= 0,0005
	Regional or local resources availability	p_{rlr}= 0,0060	p_{rlr}= 0,0030	p_{rlr}= 0,0015

Table A10: Maximum weightings for the sub-criteria for stations and stops analysis

	Analysis sub-criteria	Maximum weightings (p_i)		
		Streets	Squares	Parks
Pedestrians and cyclists paths (W_{PCP})	Visual comfort	p_{vc}= 0,0060	p_{vc}= 0,0040	p_{vc}= 0,0050
	Thermal comfort	p_{tc}= 0,0080	p_{tc}= 0,0060	p_{tc}= 0,0070
	Acoustic comfort	p_{ac}= 0,0030	p_{ac}= 0,0020	p_{ac}= 0,0020
	Runoff	p_{ro}= 0,0040	p_{ro}= 0,0035	p_{ro}= 0,0050
	Durability and suitability	p_{ds}= 0,0070	p_{ds}= 0,0050	p_{ds}= 0,0070
	Adaptability	p_a= 0,0040	p_a= 0,0040	p_a= 0,0040
	Gases, dusts, or particles emission	p_{gdp}= 0,0050	p_{gdp}= 0,0030	p_{gdp}= 0,0040
	Material combination	p_{mc}= 0,0050	p_{mc}= 0,0040	p_{mc}= 0,0050
	Socialisation	p_{so}= 0,0060	p_{so}= 0,0045	p_{so}= 0,0070
	Safety	p_{st}= 0,0080	p_{st}= 0,0060	p_{st}= 0,0080
	Route	p_r= 0,0060	p_r= 0,0050	p_r= 0,0070
	Maintenance	p_m= 0,0080	p_m= 0,0060	p_m= 0,0080
	Cultural identity	p_{ci}= 0,0030	p_{ci}= 0,0020	p_{ci}= 0,0040
	Regional or local resources availability	p_{rlr}= 0,0070	p_{rlr}= 0,0050	p_{rlr}= 0,0070

Table A11: Maximum weightings for the sub-criteria for pedestrians and cyclists paths analysis

Analysis sub-criteria		Maximum weightings (p_i)		
		Streets	**Squares**	**Parks**
Waste management (W_{WM})	Visual comfort	p_{vc}= 0,0070	p_{vc}= 0,0070	p_{vc}= 0,0090
	Olfactory comfort	p_{oc}= 0,0120	p_{oc}= 0,0110	p_{oc}= 0,0120
	Durability and suitability	p_{ds}= 0,0100	p_{ds}= 0,0090	p_{ds}= 0,0130
	Adaptability	p_a= 0,0090	p_a= 0,0080	p_a= 0,0120
	Accessibility	p_{ac}= 0,0090	p_{ac}= 0,0080	p_{ac}= 0,0130
	Gases, dusts, or particles emission	p_{gdp}= 0,0110	p_{gdp}= 0,0090	p_{gdp}= 0,0110
	Safety	p_{st}= 0,0120	p_{st}= 0,0110	p_{st}= 0,0140
	Maintenance	p_m= 0,0120	p_m= 0,0110	p_m= 0,0140
	Cultural identity	p_{ci}= 0,0080	p_{ci}= 0,0070	p_{ci}= 0,0090
	Regional or local resources avail.	p_{rlr}= 0,0100	p_{rlr}= 0,0090	p_{rlr}= 0,0130

Table A12: Maximum weightings for the sub-criteria for waste management analysis

Analysis sub-criteria		Maximum weightings (p_i)		
		Streets	**Squares**	**Parks**
Sewage management (W_{SW})	Visual comfort	p_{vc}= 0,0040	p_{vc}= 0,0030	p_{vc}= 0,0020
	Acoustic comfort	p_{ac}= 0,0050	p_{ac}= 0,0035	p_{ac}= 0,0030
	Olfactory comfort	p_{oc}= 0,0070	p_{oc}= 0,0050	p_{oc}= 0,0035
	Durability and suitability	p_d= 0,0060	p_d= 0,0045	p_d= 0,0030
	Adaptability	p_a= 0,0050	p_a= 0,0040	p_a= 0,0025
	Gases, dusts, or particles emission	p_{gdp}= 0,0070	p_{gdp}= 0,0050	p_{gdp}= 0,0030
	Safety	p_{st}= 0,0080	p_{st}= 0,0060	p_{st}= 0,0040
	Maintenance	p_m= 0,0080	p_m= 0,0060	p_m=0,0040
	Cultural identity	p_{ci}= 0,0040	p_{ci}= 0,0010	p_{ci}= 0,0020
	Regional or local resources avail.	p_{rlr}= 0,0060	p_{rlr}= 0,0020	p_{rlr}= 0.0030

Table A13: Maximum weightings for the sub-criteria for sewage management analysis

Analysis sub-criteria		Maximum weightings (p_i)		
		Streets	**Squares**	**Parks**
Stormwater management (W_{SWM})	Visual comfort	p_{vc}= 0,0085	p_{vc}= 0,0065	p_{vc}= 0,0090
	Acoustic comfort	p_{ac}= 0,0090	p_{ac}= 0,0070	p_{ac}= 0,0110
	Olfactory comfort	p_{oc}= 0,0100	p_{oc}= 0,0085	p_{oc}= 0,0115
	Durability and suitability	p_d= 0,0095	p_d= 0,0080	p_d= 0,0100
	Adaptability	p_a= 0,0085	p_a= 0,0065	p_a= 0,0100
	Gases, dusts, or particles emission	p_{gdp}= 0,0100	p_{gdp}= 0,0085	p_{gdp}= 0,0110
	Safety	p_{st}= 0,0110	p_{st}= 0,0090	p_{st}= 0,0120
	Maintenance	p_m= 0,0110	p_m= 0,0090	p_m= 0,0120
	Cultural identity	p_{ci}= 0,0045	p_{ci}= 0,0030	p_{ci}= 0,0050
	Regional or local resources avbl.	p_{rlr}= 0,0080	p_{rlr}= 0,0040	p_{rlr}= 0,0085

Table A14: Maximum weightings for the sub-criteria for stormwater management analysis

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