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Characterisation of the outdoor public space: a model for assessment

Albano J. G. Martins[1], Ana Vaz Sá[2]
[1]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (albano.jgmartins@fe.up.pt) ORCID 0000-0001-7079-9987
[2]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (vazsa@fe.up.pt) ORCID 0000-0001-9649-1761

Abstract
The aim of the present study is the development of a model for the assessment of construction design solutions for outdoor public spaces, specifically for streets, squares, and parks, sustained by the analysis of the most important criteria in the urban space. Each of these criteria is divided into sub-criteria, that are very relevant in defining the rigour of the respective model, where materials and construction solutions play a very important role in the quality of a given outdoor public space and are decisive in obtaining a good classification. Through the approach of the assessment model, it is possible to define a matrix of relationships between the criteria and the sub-criteria of the analysis, allowing the perception of which sub-criteria have more influence in the assessment of the outdoor public space. The overall result of the assessment of a given outdoor public space is presented on a qualitative scale defined by quality levels, and improvements can be identified to move to a higher quality level.

Author Keywords. Public Space Assessment, Outdoor Public Space, Sustainable Public Space, Urban Design Solutions, Urban Liveability.

Type: Research Article

1. Introduction

The ultimate goal of the study is essentially linked to the interest in developing and deepening knowledge in the scientific field of spatial and environmental planning in order to achieve a more sustainable city.

Cities are sensitive to climate variability and change according to their climate context (Grimmond et al. 2009), so the benefits of outdoor public spaces are a good strategy to improve urban liveability and sustainability, so they can determine its quality.

In this regard, public space is an important part of the urban fabric, and its quality affects the quality of life of residents and the attractiveness of the city as a whole, which is to some extent related to the quality of urban space (Sas-Bojarska and Rembeza 2016), which depends on various parameters analysed in this study.

Assessing construction solutions for designing outdoor public spaces is important to define a model of support and appropriate guidelines to be adopted, which are mainly based on sustainability strategies, namely economic, environmental, and social, and that are aimed at designers and all those involved in the process (Jacquot et al. 2021).

The model presented is an added value in the assessment of outdoor public spaces, with a specific focus on streets, squares, and parks, through a consistent approach that overcomes the subjectivity in this type of studies. Overcoming this subjectivity is achieved in a possible more rigorous analysis with field studies supported by physical parameters as means of evidence.

Through the assessment of a given public space, it is possible to draw some conclusions and thus unveil a whole process of improvement, and it should be noted that the parameters to be considered are now more complex than in the past.

Therefore, it is necessary to consider what type of analytical criteria should be taken into account when assessing a particular outdoor public space, including the construction materials and design strategies used.

In this perspective, it is necessary to develop methodologies for the assessment of these spaces, adapted to the present day, in order to verify their level of effectiveness and efficiency in urban planning and to create new quality outdoor public spaces.

2. An overview of outdoor public space

2.1. Outdoor public space definition

According to Djekic et al. (2018), outdoor public spaces are places where civic, cultural and social activities take place. They are stages of public life and reflect the interaction between physical, social, political and economic realities, and large part of the outdoor public realm belongs to the so-called pedestrian environment.

For Goodsell (2003), the term public space has multiple meanings, depending on the academic discipline, so from an urban planning perspective, it is concerned with creating open physical spaces within cities that function appropriately as places for public use and civic interaction. Essential to a sense of community identity and urban well-being are streets, footpaths, parks, squares, shopping centres, plazas, and coastal beaches.

2.2. Main types of outdoor public spaces

Designing the urban street environment is therefore becoming more visible in planning, as design becomes integrated into programmes to manage growth. It also contributes to the development of design principles which link urban design with the built environment to make cities more liveable (Wey and Wei 2016).

The urban square is a multi-use and multi-dimensional environment where all kinds of activities take place, including those that take place in the square, and should be designed for people of all social classes and incomes (Javadi 2016). Thus, to understand how a square can efficiently serve urban life and improve urban quality, the concept of sustainable squares should be considered.

Urban parks are an important part of the urban ecosystem, as they are essential for improving the quality of life in a society, especially as urbanisation increases (Turan et al. 2015). The outdoor public spaces that were mentioned are summarised through the representation in Figure 1.

Figure 1: Outdoor public spaces in the city of Maia, Portugal
[Google Earth Pro-version 7.3.4.8248]

In this sense, urban green spaces are an extension of the natural, surrounding and urban environment, so well planned and designed outdoor spaces (especially green spaces), have a wide range of positive effects on the city and its inhabitants.

2.3. State of the art

The state of the art will focus on the studies carried out by the scientific community on the characterisation of outdoor public space, which will help to identify the main criteria to be considered in its assessment.

The types of materials used in pavements and roofs can have effects on the albedo and heating of surfaces (Battisti et al. 2018; Kolokotsa et al. 2018), as these surfaces reflect solar radiation or heat the air above them. There are studies that focus on the physical attributes of the pavement materials used and their impact when exposed to high summer temperatures, as well as on the thermal comfort of users of public spaces (Djekic et al. 2018; Galabada and Halwatura 2018).

According to Fabbri et al. (2020), in the built environment, solar radiation acts primarily on horizontal surfaces and on surfaces that are part of the building envelope, whose characteristics influence reflectance.

In addition to the influence of facade surfaces on urban thermal comfort, the visual impact must also be considered (Speroni et al. 2022), as unwanted reflections can affect the visual comfort of pedestrians and car drivers, among others.

Understanding thermal and visual comfort is therefore crucial to designing attractive outdoor spaces and improving the quality of outdoor living. A study by Watanabe et al. (2014) shows how the shadows of buildings and pergolas provide cooler environments than sunlight in summer.

Therefore, an important aspect to be considered is the different social activities related to the use of outdoor public spaces when comparing the summer and winter seasons, where not all summer activities should be abandoned in winter (Pressman 1996). Outdoor public spaces are becoming increasingly important for human well-being in dense urban areas, especially squares that can provide easy access to green spaces (da Silva, Duarte, and Pauleit 2023).

The spatial pattern of green spaces has an important impact on the mitigation of urban heat island, and existing green spaces and bodies of water can play an important role in reducing the intensity of urban heat island, according to (Ghosh and Das 2018).

Contemporary urban space is a bearer of identity, encouraging users to use or enjoy a particular public space that has been deliberately created for them. By providing a place to socialise, urban furniture plays an important role in integrating residents. (Grabiec, Lacka, and Wiza 2022). In this context urban furniture is a complex object influenced by factors including user needs, social structure, urban design, geography, technology, materials and cost (Kaya 2022, cited in Grabiec, Lacka, and Wiza 2022).

Public lighting is another important issue that can be associated with street furniture, although it is a more complex equipment to analyse. According to Pena-Garcia, Hurtado, and Aguilar-Luzon (2015), the primary purpose of public lighting is to ensure the safety of people and property. They also note that the diverse nature of lighting installations, their economic and environmental characteristics and their social costs have led researchers and engineers to question the accuracy of key parameters such as light intensity and colour as indicators of lighting performance. A pertinent study carried out by Fatima, Kumar, and Ieee (2016) addresses the link between vegetation and local bus stops where absence of green infrastructure along the bus stop negatively affects air quality and discomfort for the everyday life of the users. Their findings show that other passive options, such as green roofs and other effective options, are needed to keep the temperature at a comfortable level.

Another important aspect of the outdoor public space is pedestrian crossings and also cycle lanes, so that areas for pedestrian and cyclist traffic should be planned and designed to maximise their safety and comfort during their daily journeys. From that perspective, the attractiveness and comfort of the routes are very important elements involving several factors such as the distance, the slope of the route, the condition of the pavements, the straightness of the route and all other factors that facilitate walking (Monteiro and Campos 2012).

One issue that deserves special attention, mainly for municipalities in large urban areas, is solid waste management in large urban areas, where efficient solid waste management is an essential prerequisite for a clean and safe environment. (Pardini et al. 2018).

In the same vein of sustainable management thinking, but applied to wastewater management, a study by Kalavrouziotis and Arslan-Alaton (2008) looks at water reuse applications around the world, with a particular focus on reuse practices in Mediterranean countries. The main conclusions are that the reuse of biologically treated municipal wastewater and sludge from wastewater treatment plants (WWTPs) should be systematically applied in the Mediterranean countries in the near future. This is because it increases forest areas and at the same time secures new water sources in an attempt to contribute to sustainable environmental protection.

Another issue related to sustainable management is drainage and stormwater management, which must be adapted to the changes in the natural hydrological regime in order to mitigate the negative effects of the new hydrological conditions on rainfall and stormwater runoff and pollution in urban areas (Jusic, Hadzic, and Milisic 2019).

The state of the art presented summarises the developments and strategies to be adopted in the creation of a model for the assessment of construction solutions for the design of public outdoor spaces.

3. Assessment model of construction solutions for outdoor public space design: criteria and sub-criteria for analysis

3.1. Analysis criteria

Given the literature review carried out, it is possible to define 6 groups including 14 analysis criteria to be considered in the assessment of an outdoor public space. The materials and construction solutions used are preponderant in this assessment, and should be optimised by sustainable strategies, which can be also linked to the vernacular concept in urban context. The below Figure 2 represents the defined groups, describing the respective analysis criteria for each one.

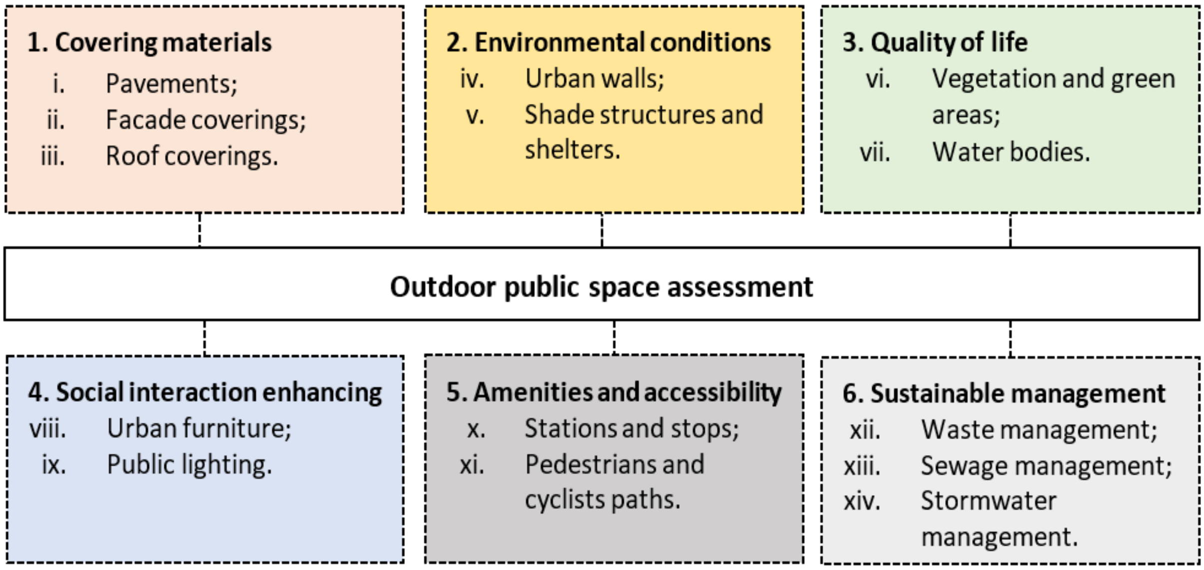

Figure 2: Analysis criteria for outdoor public space assessment

It should be noted that for the analysis of urban furniture, only chairs, benches, tables, and litter bins are considered, the analysis of public lighting, stations and stops being considered separately, as it requires a more careful and rigorous analysis.

For each defined analysis criteria, a weighting (W_i) is attributed, which results from the importance and dominant influence of issues related to urban comfort, safety, and economy, which are considered to be as key elements in the assessment of a certain outdoor public space (e.g., streets, squares and parks).

Table 1 proposes the maximum weightings (W_i) to be adopted for each analysis criteria, according to each type of outdoor public space that was considered in the model.

Analysis criteria	Maximum weightings (Wi)		
	Streets	**Squares**	**Parks**
Pavements (P)	WP= 0,10	WP= 0,13	WP= 0,07
Facade coverings (FC)	WFC= 0,08	WFC= 0,04	WFC= 0,02
Roof coverings (RF)	WRC= 0,07	WRC= 0,03	WRC= 0,01
Covering materials	**25%**	**20%**	**10%**
Urban walls (UW)	WUW= 0,04	WUW= 0,06	WUW= 0,03
Shade structures and shelters (SSS)	WSSS= 0,06	WSSS= 0,09	WSSS= 0,07
Environmental conditions	**10%**	**15%**	**10%**
Vegetation or green areas (VGA)	WVGA= 0,09	WVGA= 0,12	WVGA= 0,15
Water bodies (WB)	WWB= 0,06	WWB= 0,08	WWB= 0,10
Quality of life	**15%**	**20%**	**25%**
Urban furniture (UF)	WUF= 0,04	WUF= 0,09	WUF= 0,12
Public lighting (PL)	WPL= 0,06	WPL= 0,06	WPL= 0,08
Social interaction enhancing	**10%**	**15%**	**20%**
Stations and stops (SS)	WSS= 0,07	WSS= 0,04	WSS= 0,02
Pedestrians and cyclists paths (PCP)	WPCP= 0,08	WPCP= 0,06	WPCP= 0,08
Amenities and accessibility	**15%**	**10%**	**10%**
Waste management (WM)	WWM= 0,10	WWM= 0,09	WWM= 0,12
Sewage management (SM)	WSM= 0,06	WSM= 0,04	WSM= 0,03
Stormwater management (SWM)	WSWM= 0,09	WSWM= 0,07	WSWM= 0,10
Sustainable management	**25%**	**20%**	**25%**

Table 1: Maximum weightings for the analysis criteria

Thus, for the assessment of a given outdoor public space Formula 1 which is presented below, should be used considering the analysis criteria and respective weighting that was previously defined.

$$\sum W_i \leq 1 \tag{1}$$

3.2. Analysis sub-criteria

According to each analysis criteria weighting (W_i), referred to in the previous point, some specific sub-criteria weighting (p_i) can be associated, such as:

a) Visual comfort (p_{vc});
b) Thermal comfort (p_{tc});
c) Acoustic comfort (p_{ac});
d) Olfactory comfort (p_{oc});
e) Runoff (p_{ro});
f) Durability and suitability (p_{ds});
g) Adaptability (p_a);
h) Accessibility (p_{ac});
i) Material combination (p_{mc});
j) Gases, dusts, or particles emission (p_{gdp});
k) Socialisation (p_{so});
l) Safety (p_{st});
m) Plant species (p_{ps});
n) Water supply (p_{ws});
o) Route (p_r);
p) Maintenance (p_m);
q) Cultural identity (p_{ci});
r) Regional or local resources availability (p_{rlr}).

The approach to be used for the analysis sub-criteria mentioned above may be linked with verifications, either at the design stage (calculations, confrontation with related legislation, regulations and standardisation, and simulations using computer applications) or by field surveys, which are necessary for a more accurate assessment.

The weighting correlation established between each sub-criteria and analysis criteria is presented in Formula 2.

$$\sum p_i \leq W_i \tag{2}$$

Consequently, Table 2, Table 3, Table 4, Table 5, Table 6 , Table 7, Table 8, Table 9, Table 10, Table 11, Table 12, Table 13, Table 14, and Table 15 proposes the maximum weightings to be adopted for each analysis sub-criteria (p_i), according to the correlation of each analysis criteria (W_i) and each type of outdoor public space that was considered in the model.

3.2.1. Pavements

Considering pavements are defined 12 analysis sub-criteria, as shown in Table 2. According to the paving material applied, visual comfort and thermal comfort are quite relevant, as colorimetric characteristics and different surface roughness are predominant and should be accounted for in the assessment. From this point of view, considering the values of surface temperature, emissivity and albedo becomes relevant in the connection with the creation of microclimate. For acoustic comfort is considered the noise generated by motor vehicle traffic or other type of traffic.

The runoff is related to the waterproofing of the area according to the paving material applied, which can be estimated through the runoff coefficient. It is important to verify the slope of the area and if the material is monolithic or jointed. Also, another relevant issue to consider is if the paving is applied on a slab (e.g., underground car park), where infiltrations are predictable.

Analysis sub-criteria		Maximum weightings (pi)		
		Streets	Squares	Parks
Pavements (WP)	Visual comfort	pvc= 0,0100	pvc= 0,0140	pvc= 0,0080
	Thermal comfort	ptc= 0,0150	ptc= 0,0180	ptc= 0,0130
	Acoustic comfort	pac= 0,0100	pac= 0,0080	pac= 0,0030
	Runoff	pro= 0,0090	pro= 0,0120	pro= 0,0070
	Durability and suitability	pds= 0,0050	pds= 0,0070	pds= 0,0030
	Adaptability	pa= 0,0050	pa= 0,0070	pa= 0,0030
	Material combination	pmc= 0,0030	pmc= 0,0090	pmc= 0,0040
	Gases, dusts, or particles emission	pgdp= 0,0080	pgdp= 0,0100	pgdp= 0,0050
	Safety	pst= 0,0100	pst= 0,0130	pst= 0,0070
	Maintenance	pm= 0,0100	pm= 0,0130	pm= 0,0070
	Cultural identity	pci= 0,0030	pci= 0,0050	pci= 0,0020
	Regional or local resources availability	prlr= 0,0070	prlr= 0,0100	prlr= 0,0050

Table 2: Maximum weightings for the sub-criteria for pavements analysis

For durability, the rolling resistance value is very important in the analysis, as well as the loads to which the pavement is exposed. Another matter to be considered is the prediction of the physical and chemical behaviour of the material's surface throughout its useful life, according to the environmental aggressions. Suitability contemplates the paving materials according to the purpose of use of the outdoor public space (e.g., adherence and slope of the pavement) and the conditions of universal accessibility (e.g., users with limited or reduced mobility), regarding ramps and staircases. The regional or local climate conditions (solar radiation, rainfall, and wind action) should also be considered. Adaptability allows for the possibility of temporary conversion of spaces (fair or leisure or sporting activities), or even the creation of flowerbeds or planting troughs to integrate different types of vegetation. Climate change is also a major factor to be considered in adaptability.

For the material combination the possibility of integrating other types of paving materials or vegetation in outdoor public space. The chance of the paving material releasing gases, dust, or particles into the atmosphere due to disintegration is another concern to be contemplated in the analysis sub-criteria.

In terms of safety, consideration should be given to the flatness of the surface, its slope, unevenness of the pavement and path markers so that the user can move safely. Involving maintenance, accounting for the costs related with this whole process becomes important.

Regarding cultural identity, the recognition of the construction solution in the culture and tradition of the region (e.g., Portuguese traditional pavement, called calçada portuguesa) is an important issue to contemplate.

As a last analysis sub-criterion for pavements, the possibility of obtaining the necessary resources in the region is also vital for the assessment.

3.2.2. Facade coverings

In order not to repeat comments made previously for similar analysis sub-criteria, from this point onwards only those adopting a different approach resulting from the different analysis criteria will be commented upon.

Concerning facade coverings are defined 10 analysis sub-criteria (Table 3), so starting with suitability, the correlation of the orientation of the facades with the climate constraints of the region (solar radiation, rainfall, and wind action) should be considered. In the case of a facade having vegetation as covering material, it becomes important to certify if the type of vegetation used is adequate.

	Analysis sub-criteria	**Maximum weightings (pi)**		
		Streets	**Squares**	**Parks**
Facade coverings (WFC)	Visual comfort	pvc= 0,0130	pvc= 0,0070	pvc= 0,0040
	Thermal comfort	ptc= 0,0120	ptc= 0,0050	ptc= 0,0025
	Durability and suitability	pds= 0,0050	pds= 0,0020	pds= 0,0009
	Adaptability	pa= 0,0050	pa= 0,0020	pa= 0,0009
	Material combination	pmc= 0,0020	pmc= 0,0010	pmc= 0,0007
	Gases, dusts, or particles emission	pgdp= 0,0080	pgdp= 0,0040	pgdp= 0,0015
	Safety	pst= 0,0130	pst= 0,0070	pst= 0,0037
	Maintenance	pm= 0,0130	pm= 0,0070	pm= 0,0037
	Cultural identity	pci= 0,0030	pci= 0,0020	pci= 0,0008
	Regional or local resources availability	prlr= 0,0060	prlr= 0,0030	prlr= 0,0013

Table 3: Maximum weightings for the sub-criteria for facade coverings analysis

For adaptability the possibility to integrate specific systems into the facade (e.g., innovative technologies or support structures) is relevant, as well as climate change consideration.

About the combination of materials, the possibility of integrating other types of material in the facade or vegetation.

At last, in relation to safety, consider the ways of fixing the cladding and the possibility of any of the cladding elements falling.

3.2.3. Roof coverings

In Table 4 are defined 9 analysis sub-criteria for roof coverings, therefore, in suitability should consider the connection between the geometry and slope of the roof and the climate conditions of the region (solar radiation, rainfall and wind action), as well as the suitability of the type of vegetation used on the roof, if applicable.

	Analysis sub-criteria	Maximum weightings (pi)		
		Streets	Squares	Parks
Roof coverings (WRC)	Thermal comfort	ptc= 0,0100	ptc= 0,0060	ptc= 0,0018
	Durability and suitability	pds= 0,0070	pds= 0,0030	pds= 0,0013
	Adaptability	pa= 0,0070	pa= 0,0030	pa= 0,0013
	Material combination	pmc= 0,0060	pmc= 0,0013	pmc= 0,0004
	Gases, dusts, or particles emission	pgdp= 0,0080	pgdp= 0,0010	pgdp= 0,0003
	Safety	pst= 0,0100	pst= 0,0060	pst= 0,0018
	Maintenance	pm= 0,0100	pm= 0,0060	pm= 0,0018
	Cultural identity	pci= 0,0050	pci= 0,0015	pci= 0,0005
	Regional or local resources availability	prlr= 0,0070	prlr= 0,0022	prlr= 0,0008

Table 4: Maximum weightings for the sub-criteria for roof coverings analysis

Regarding adaptability, the possibility of integrating specific systems on the roof, assessing beforehand the structural constraints of the roof (e.g., innovative technologies or vegetation) and also the eventual possibility of integrating skylights, in order to optimise the incident solar radiation on the roof. Climate change is another relevant factor to consider when weighting the analysis sub-criteria.

As far as the combination of materials is concerned, it should include the possibility of integrating other types of roofing materials or vegetation on the roof.

Finally for roof coverings, as regards safety, safe limits for albedo should be included for air traffic or biodiversity.

3.2.4. Urban walls

About urban walls are defined 10 analysis sub-criteria, as shown in Table 5. In relation to durability, environmental aggressors, and their implication on the physical and chemical behaviour of the material surface throughout its useful life, is also considered, as already seen in other analysis sub-criteria. A relevant issue that should also be accounted for when weighting the durability sub-criteria is the shock resistance of urban walls.

Regarding suitability, the orientation and geometric characteristics of the wall should be considered in accordance with the climate conditions of the region, such as solar radiation, rainfall, and wind action (e.g., openings in the wall, in order to optimise the incident solar radiation).

	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 5: Maximum weightings for the sub-criteria for urban walls analysis

With reference to adaptability, the possibility to integrate specific systems in the wall (e.g., urban furniture or shading structures). A relevant issue concerns the ability of the urban wall also functioning as an acoustic barrier. The adaptability to climate change should not be forgotten when considering this analysis sub-criteria.

Respecting the combination of materials, the possibility of joining other types of materials, such as covering materials or vegetation.

As for safety, consider structural issues such as the thickness, height and crumbling of elements.

Finally, regarding maintenance, consider the associated costs, not forgetting unforeseen situations, such as graffiti vandalism.

3.2.5.Shade structures and shelters

Regarding shade structures and shelters are defined 12 analysis sub-criteria, as shown in Table 6. Initiating with thermal comfort, consider values of solar radiation transmitted to the inner side of the shade structure or shelter, where the user stays. Although not the purpose of shading structures and shelters, according to their design they can also help slightly about noise, such as if there is an airport nearby.

With respect to runoff, consider the rainwater network drainage from the stop, on a practical scope if possible.

In addition to what has already been said about durability and suitability in other analysis sub-criteria, and which fits into these comments, an important issue is the hailstorm, which can damage the shade structure or shelter. From this perspective, shock resistance should also be contemplated.

	Analysis sub-criteria	Maximum weightings (pi)		
		Streets	**Squares**	**Parks**
Shade structures and shelter (WSSS)	Thermal comfort	ptc= 0,0070	ptc= 0,0090	ptc= 0,0080
	Acoustic comfort	pac= 0,0030	pac= 0,0050	pac= 0,0020
	Runoff	pro= 0,0040	pro= 0,0070	pro= 0,0040
	Durability and suitability	pds= 0,0050	pds= 0,0080	pds= 0,0060
	Adaptability	pa= 0,0050	pa= 0,0080	pa= 0,0060
	Material combination	pmc= 0,0040	pmc= 0,0070	pmc= 0,0050
	Gases, dusts, or particles emission	pgdp= 0,0040	pgdp= 0,0070	pgdp= 0,0030
	Socialisation	pso= 0,0050	pso= 0,0080	pso= 0,0070
	Safety	pst= 0,0070	pst= 0,0090	pst= 0,0080
	Maintenance	pm= 0,0070	pm= 0,0090	pm= 0,0080
	Cultural identity	pci= 0,0030	pci= 0,0050	pci= 0,0060
	Regional or local resources availability	prlr= 0,0060	prlr= 0,0080	prlr= 0,0070

Table 6: Maximum weightings for the sub-criteria for shade structures and shelters analysis

As for adaptability, the possibility of integrating specific systems in shading structures and shelters, such as urban furniture or public lighting, is also mentioned, as is the adaptability of this type of structure to climate change. Another very pertinent question about adaptability is the possibility of this type of structure having a temporary or definitive character must be analysed, according to the seasons of the year. In medium and long stays (with a defined interval), the number of seating places in this type of structure enhances the social interaction of users of the outdoor public outdoor, which is also considered as an independent analysis sub-criterion.

In respect of safety, the integrity of the structure when exposed to environmental aggressors (wind and precipitation) and its functionality in safe conditions for users, must be considered.

Lastly, in addition to the costs associated with the maintenance process, damage to structures caused by natural phenomena (e.g., strong wind) must be accounted for.

3.2.6. Vegetation or green areas

In Table 7 are defined 14 analysis sub-criteria for vegetation or green areas, then for visual comfort, the importance of the landscape effect in urban space, such as the balance between vegetation or green areas and built space.

In the matter of thermal comfort, the contribution of vegetation or green areas in mitigating the heat island in urban space through the effect of absorbing energy from solar radiation (e.g., effects on air temperature and relative humidity).

To do with acoustic comfort, vegetation, or green areas as noise attenuating elements (e.g., proximity of airport, motorway, or industrial area), in outdoor public space.

About olfactory comfort, consider the olfactory sensation created by the presence of vegetation or green areas, through pleasant aromas and their contribution to the quality of air in outdoor public space.

For runoff, consider the permeability of the area, given through the runoff coefficient, which is related with the type of sole and slope.

	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 7: Maximum weightings for the sub-criteria for vegetation or green areas analysis

In terms of durability, the behaviour of vegetation or green areas in relation to environmental aggressors should be foreseen, as well as some kind of specific surrounding protection if necessary.

In terms of suitability, consider the number of specimens, geometric arrangement, volume, height, and type of vegetation, given its purpose in the outdoor public space (e.g., shading or barrier against the action of wind). The suitability relative to the seasons of the year should also be considered, namely the climate conditions of the region, such as solar radiation, dust, rainfall, and wind action.

Regarding adaptability, the possibility to integrate specific systems in vegetation or green spaces (e.g., innovative irrigation systems or street furniture) or to convert that space for temporary purpose (e.g., recreational and leisure activities). The consideration of the climate change issue is also quite important.

With reference to socialization, contemplate the potential activities of conviviality and socialization in these green areas.

In terms of safety, consideration should be given to the integrity of vegetation or green areas when exposed to environmental (e.g., falling branch or tree) or misuse. Special attention should be given to vegetation typology, regarding toxicity or allergenicity issues to certain plant species.

About plant species should consider the possibility of harvesting fruits or vegetables in parks or urban gardens, according to the seasons of the year and of a particular region.

The proximity of adequate and sustainable types of water supply (sources and flow rates) for the irrigation of vegetation or green areas (e.g., water harvesting systems) is another important sub-criterion for analysis.

Lastly, maintenance, consider the costs associated with this process, which include felling, pruning, fertilising, and harvesting, if applicable. The cleaning processes of the respective areas should also be foreseen, depending on the type of vegetation (e.g., deciduous, or evergreen trees).

3.2.7. Water bodies

In relation to water bodies are defined 11 analysis sub-criteria, as shown in Table 8. Regarding thermal comfort, consider the optimization of the heat island in the urban space caused by water bodies (e.g., effects on air temperature and relative humidity), as well as the prediction of a significant increase in relative humidity when vegetation or green areas are nearby. About acoustic comfort, the noise level caused by circulating water, such as a water curtain or waterfall, should be considered.

Respecting durability, reflect on the resistance and functionality of infrastructure or structures related to water bodies (e.g., reservoirs and devices), as well as the potential effect caused by environmental aggressors. As for adaptability, the possibility of integrating specific public lighting systems, considering the condition that the type of lighting does not harm nocturnal biodiversity. The issue of climate change (e.g., in a flood situation, foresee if the water body has a mitigating or damaging effect), should also be contemplated in the analysis sub-criterion.

	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 8: Maximum weightings for the sub-criteria for water bodies analysis

For safety, contemplate the inclusion of barriers or guard rails next to the water body, given its typology and depth, as well as considering a possible case of overflow of the water body. Health and hygiene issues should also be considered, being related to water quality and proper treatment (e.g., standing water), as well as foreseeing the possibility of animals or even people bathing or drinking water in these outdoor public spaces.

With respect to water supply, consider the proximity of sustainable water sources, such as water harvesting systems, that include sustainable water circulation technologies, if applicable. About maintenance, the costs associated with this process should include technical installations and cleaning.

At last, regional, or local resources availability is related to the proximity of water lines in the, enabling gravitational water uses.

3.2.8. Urban furniture

With respect to urban furniture are defined 10 analysis sub-criteria, as shown in Table 9. Thermal comfort should consider the contact of the user with the urban furniture (e.g., chair, bench, or table), through the surface temperature of the material.

As to durability, contemplate the resistance and functionality of the furniture in the urban space, as well as the potential effect caused by environmental aggressors. About suitability, the design and ergonomics of urban furniture should be considered, depending on its purpose and placement in the public space (e.g., suitable for all age groups).

In relation to adaptability the possibility of moving urban furniture to another area or changing geometric arrangement. The consideration of the climate change issue is also considered important for this analysis sub-criterion. The possibility of combining other types of materials in urban furniture (e.g., structural or covering material), can be a solution that can optimise its resistance in urban environments.

The consideration of socialising activities (e.g., sitting, talking, or reading) promoted by the use of urban furniture, is also very important in this analysis sub-criterion.

As regards to safety, consider the rigidity of the material, sharp edges, or excessive roughness of the urban furniture so as not to injure the user. Also consider the impossibility of removing the furniture without appropriate tools, thus avoiding disturbances in outdoor public space caused by important events or demonstrations.

With reference to cultural identity, consider whether the material used, or the type of urban furniture reflects the culture and tradition of the region.

Analysis sub-criteria		Maximum weightings (pi)		
		Streets	**Squares**	**Parks**
Urban furniture (WUF)	Thermal comfort	ptc= 0,0030	ptc= 0,0090	ptc= 0,0120
	Durability and suitability	pds= 0,0050	pds= 0,0100	pds= 0,0130
	Adaptability	pa= 0,0020	pa= 0,0050	pa= 0,0100
	Material combination	pmc= 0,0040	pmc= 0,0090	pmc= 0,0120
	Gases, dusts, or particles emission	pgdp= 0,0020	pgdp= 0,0040	pgdp= 0,0070
	Socialisation	pso= 0,0040	pso= 0,0100	pso= 0,0130
	Safety	pst= 0,0060	pst= 0,0120	pst= 0,0140
	Maintenance	pm= 0,0060	pm= 0,0120	pm= 0,0140
	Cultural identity	pci= 0,0030	pci= 0,0090	pci= 0,0120
	Regional or local resources availability	prlr= 0,0050	prlr= 0,0100	prlr= 0,0130

Table 9: Maximum weightings for the sub-criteria for urban furniture analysis

3.2.9. Public lighting

In Table 10 are defined 11 analysis sub-criteria for public lighting, thus for visual comfort, it is important to verify the orientation of the light projection so as not to cause light pollution, neither for the user nor for nocturnal biodiversity (e.g., in the case of a luminaire, consideration of the orientation of the light projection towards the pavement is desirable in order to minimise the light pollution effect – however, the orientation of the light spot of a luminaire at horizon level would be tolerable). Concerning thermal comfort, a relevant issue is to check the temperature in the surroundings or in the proximity of the location of the public lighting (e.g., influence of temperature on the user or on nocturnal biodiversity).

For durability, the consideration of the strength and functionality of the supporting structures and related public lighting equipment is very relevant, as well as contemplating impact protection around the supporting structures of the public lighting. The potential effect caused by environmental aggressors should also be considered. A relevant issue related to suitability is the consideration of the type of construction solution for the support structures and respective equipment, according to the public space where they are placed (e.g., number of luminaires, geometric arrangement, and height), contemplating the working hours of the equipment. The possibility of retrofitting traditional public lighting systems to sustainable and innovative systems (e.g., renewable energy) should be considered in the sub-criterion for analysis of adaptability, as well as the issue of climate change.

	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 10: Maximum weightings for the sub-criteria for public lighting analysis

The combination of materials should consider the possibility of combining other types of materials in public lighting systems, such as reinforcing support structures or even equipment.

Coexistence and socialisation activities can be enhanced by the existence of public lighting in different types of public space, such as walking or doing a sport activity.

Regarding safety, there are a number of issues to consider. In this sense, in relation to support structures for street lighting, consider the correct attachment to the pavement, the rigidity of the material, excessive roughness and whether it contains sharp edges, so as not to injure the user. About the equipment, consider the impossibility of removing lamps or manoeuvring the lighting installations in order to minimise the risks of direct or indirect electrical contact with the user due to some anomaly. Consider the integrity of the installation (e.g., visual inspection of conductor cables or devices, if applicable). The potential effect caused by environmental aggressors and the associated risks should also be taken into account.

Finally, with reference to maintenance, the costs associated with this process reflect the revision of the support structures and equipment, in particular the replacement of lamps or devices.

3.2.10. Stations and stops

Respecting stations and stops are defined 13 analysis sub-criteria (Table 11). Starting with the visual comfort, the verification of the albedo in the surroundings or in the proximity of the stop, resulting from the materials used in its lateral walls, becomes relevant for this analysis sub-criterion. For thermal comfort, consider values of solar radiation transmitted to the interior of the stop, where the user remains. A pertinent issue is to consider the acoustic protection of the stop, in relation to traffic noise in the surroundings or in the vicinity of the stop, this in relation to acoustic comfort. In this sense, pollutants can also be taken into account, related to gas emissions released by the various types of traffic, in the surroundings or near the stop. However, there is also a chance that the materials used in stations and stops may release dust or particles into the atmosphere due to disintegration.

Regarding durability, in addition to the prediction of the physical-chemical behaviour of the material's surface throughout its useful life, the resistance to impact (e.g., integrity of the structure of the stop) should be contemplated. In this sub-criterion of analysis, information technologies relative to transport (e.g., loading or purchase of tickets, etc.) may also be contemplated. For suitability, consideration of the positioning of the stop, in relation to the street, railway, or other, according to the type of public transport. The climate conditions of the region, such as solar radiation, dust, rainfall and wind action, should also be considered.

As to adaptability, the possibility of integrating specific systems into the stop structure (e.g., innovative technology or public lighting), as well as considering also the issue of climate change.

The length of stay and the number of seats at stations and stops promote the social interaction of their users and should therefore be considered under the sub-criterion of socialisation.

At last, in the matter of safety, consider the integrity of the structure of the stop when exposed to environmental aggressors (wind and precipitation) and its functionality in safe conditions for users.

	Analysis sub-criteria	**Maximum weightings (pi)**		
		Streets	**Squares**	**Parks**
Stations and stops (WSS)	Visual comfort	pvc= 0,0050	pvc= 0,0030	pvc= 0,0015
	Thermal comfort	ptc= 0,0070	ptc= 0,0050	ptc= 0,0023
	Acoustic comfort	pac= 0,0040	pac= 0,0020	pac= 0,0007
	Runoff	pro= 0,0040	pro= 0,0020	pro= 0,0010
	Durability and suitability	pd= 0,0060	pd= 0,0030	pd= 0,0023
	Adaptability	pa= 0,0050	pa= 0,0030	pa= 0,0015
	Gases, dusts, or particles emission	pgdp= 0,0050	pgdp= 0,0020	pgdp= 0,0007
	Material combination	pmc= 0,0060	pmc= 0,0030	pmc= 0,0015
	Socialisation	pso= 0,0050	pso= 0,0030	pso= 0,0015
	Safety	pst= 0,0070	pst= 0,0050	pst= 0,0025
	Maintenance	pm= 0,0070	pm= 0,0050	pm= 0,0025
	Cultural identity	pci= 0,0030	pci= 0,0010	pci= 0,0005
	Regional or local resources availability	prlr= 0,0060	prlr= 0,0030	prlr= 0,0015

Table 11: Maximum weightings for the sub-criteria for stations and stops analysis

3.2.11. Pedestrians and cyclists paths

Considering pedestrians and cyclists paths are defined 14 analysis sub-criteria, as shown in the Table 12. Concerning the visual impact, in addition to checking the albedo in the surroundings or close to the runway, also consider the landscape setting along the route (balance between buildings and green spaces). About acoustic comfort, consider the sound absorption value, noise generated by cycling or other traffic on the road, which can be considered "positive" if it allows pedestrians to detect the proximity of a cycling vehicle.

Respecting adaptability, the possibility of changing the type of track or route (e.g., conversion to foot and cycle tracks).

	Analysis sub-criteria	Maximum weightings (pi)		
		Streets	Squares	Parks
Pedestrians and cyclists paths (WPCP)	Visual comfort	pvc= 0,0060	pvc= 0,0040	pvc= 0,0050
	Thermal comfort	ptc= 0,0080	ptc= 0,0060	ptc= 0,0070
	Acoustic comfort	pac= 0,0030	pac= 0,0020	pac= 0,0020
	Runoff	pro= 0,0040	pro= 0,0035	pro= 0,0050
	Durability and suitability	pds= 0,0070	pds= 0,0050	pds= 0,0070
	Adaptability	pa= 0,0040	pa= 0,0040	pa= 0,0040
	Gases, dusts, or particles emission	pgdp= 0,0050	pgdp= 0,0030	pgdp= 0,0040
	Material combination	pmc= 0,0050	pmc= 0,0040	pmc= 0,0050
	Socialisation	pso= 0,0060	pso= 0,0045	pso= 0,0070
	Safety	pst= 0,0080	pst= 0,0060	pst= 0,0080
	Route	pr= 0,0060	pr= 0,0050	pr= 0,0070
	Maintenance	pm= 0,0080	pm= 0,0060	pm= 0,0080
	Cultural identity	pci= 0,0030	pci= 0,0020	pci= 0,0040
	Regional or local resources availability	prlr= 0,0070	prlr= 0,0050	prlr= 0,0070

Table 12: Maximum weightings for the sub-criteria for pedestrians and cyclists paths analysis

With reference to safety, consider the integrity of the pavement when exposed to environmental aggressors (wind and precipitation) and its safe functionality for users. Also consider the safety of pedestrian and cyclist interaction, about potential accidents, in the case of a shared footway (e.g., track dimensioning).

Finally, in connection with the route, check how easy it is for the user to follow the trail, namely, the existence of stop or rest areas, water points (drinking fountains), according to the type of activity to be carried out. Also consider the length and size of the track, as well as the conditions of universal accessibility (e.g., users with limited or reduced mobility).

3.2.12. Waste management

With reference to waste management are defined 10 analysis sub-criteria (Table 13). As regards visual comfort, consider the landscape balance, namely the framing and aesthetic quality of the waste management equipment, according to the type of outdoor public space.

For olfactory comfort, check for the existence of unpleasant smells, around or near the waste collection, separation, or treatment equipment. Also consider the different seasons of the year and the respective aggravation of odours resulting from the increase in air temperature.

Respecting durability, in addition to predicting the physicochemical behaviour of the material used in the waste management equipment (over its lifetime) determined by environmental aggressors, also consider the shock resistance of the waste management equipment. Issues related to suitability are quite relevant, such as contemplating the capacity and number of tanks, depending on the population agglomerations to be served in the surroundings or in the proximity of a certain outdoor public space. Also contemplate the daily frequency of waste disposal or collection, according to the type of waste management equipment (e.g., individual residential door-to-door collection tank or Eco point disposal). Also consider capacity and areas for waste treatment, if applicable (e.g., community composting).

	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 availability	p_{rlr}= 0,0100	p_{rlr}= 0,0090	p_{rlr}= 0,0130

Table 13: Maximum weightings for the sub-criteria for waste management analysis

As for adaptability, consider changing the zoning of the waste management equipment, and also consider the possibility of combining different waste management typologies for the outdoor public space, if possible. The adaptation of the outdoor public space for new container technologies (e.g., capacity sensors for collective containers and user identification sensors for individual containers), is also quite pertinent.

Another relevant sub-criterion is accessibility, which should consider the positioning of the waste management equipment in the public space and the respective route taken by the user to deposit waste, depending on the proximity of the building. It should also consider the ease of waste disposal, according to the type of waste management equipment, as well as the conditions of universal accessibility.

The consideration of situations of vandalism and fire risk near waste management equipment (e.g., recycling bins) are very important in terms of safety.

The costs associated with the maintenance process should include sanitising the waste management equipment and cleaning the surrounding area, as this is a potential approach for all types of animals (e.g., rodents, birds, etc.). Also check the existence of water points and rainwater drainage elements in the area surrounding the waste management equipment.

With a focus on cultural identity, it is important to know if the region has agricultural activity, in order to be an asset in the optimisation of the organic waste recycling process.

Ultimately, consider the existence of community waste management areas in the vicinity and urban waste treatment stations or centres in the region.

3.2.13. Sewage management

In Table 14 are defined 10 analysis sub-criteria for sewage management, so for visual comfort, the consideration of the visual impact of the wastewater collection and treatment system, when implanted in the surroundings or in the proximity of the public space, if applicable (surface tanks, equipment and components), is considered relevant.

As regards acoustic comfort, consider the noise level, coming from the wastewater reception and treatment systems, regarding the surroundings and proximity to public space or neighbouring buildings (e.g., noise level generated by pumping equipment).

	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 availability	p_{rlr}= 0,0060	p_{rlr}= 0,0020	p_{rlr}= 0.0030

Table 14: Maximum weightings for the sub-criteria for sewage management analysis

For durability, the consideration of the useful life of the wastewater reception and treatment systems, depending on their typology (e.g., compact WWTP) is relevant. In relation to suitability, consider the effectiveness and efficiency of the wastewater management solution, taking into account the capacity of the systems and their intended use, as well as the location and area required for the implementation of wastewater collection and treatment systems.

The possibility of converting the wastewater reception and treatment system to a more innovative one, or integrating new technologies (e.g., type of treatment used) should be provided for in the sub-criterion on adaptability.

About safety, it is important to consider the quality of the treated water, depending on its intended use (e.g., washing), and it should not put the health of users or animals at risk. Also consider the possibility of contamination of the public space (e.g., breeding of rodents, flies, etc.)

At last, the maintenance costs shall also cover technical and cleaning aspects of the wastewater collection and treatment systems. Such maintenance must not jeopardise or interrupt the operation of the main drainage systems.

3.2.14. Stormwater management

For stormwater management are defined 10 analysis sub-criteria (Table 15). With reference to durability, consider the service life of stormwater collection and treatment systems, depending on their type, such as storage tanks and devices. In the matter of suitability, in addition to considering the effectiveness and efficiency of the stormwater management solution and the location and area required to implement the systems, also consider the potential contribution to flood control and water conservation.

Regarding adaptability, in addition to considering the possibility of converting the rainwater collection and treatment system to a more innovative one, or the integration of new technologies, consider the possibility of supplying public fire-fighting systems.

Analysis sub-criteria		Maximum weightings (pi)		
		Streets	Squares	Parks
Stormwater management (WSWM)	Visual comfort	pvc= 0,0085	pvc= 0,0065	pvc= 0,0090
	Acoustic comfort	pac= 0,0090	pac= 0,0070	pac= 0,0110
	Olfactory comfort	poc= 0,0100	poc= 0,0085	poc= 0,0115
	Durability and suitability	pd= 0,0095	pd= 0,0080	pd= 0,0100
	Adaptability	pa= 0,0085	pa= 0,0065	pa= 0,0100
	Gases, dusts, or particles emission	pgdp= 0,0100	pgdp= 0,0085	pgdp= 0,0110
	Safety	pst= 0,0110	pst= 0,0090	pst= 0,0120
	Maintenance	pm= 0,0110	pm= 0,0090	pm= 0,0120
	Cultural identity	pci= 0,0045	pci= 0,0030	pci= 0,0050
	Regional or local resources avbl.	prlr= 0,0080	prlr= 0,0040	prlr= 0,0085

Table 15: Maximum weightings for the sub-criteria for stormwater management analysis

Finally, for cultural identity check whether stormwater management solutions reflect the culture and tradition of the region on stormwater harvesting as well as the existence of possible catchment channels in the region or locality.

In this way, the approach to be adopted for the analysis sub-criteria was summarised, which should be considered in the assessment of a certain outdoor public space, given the respective weightings.

4. Results and Discussion

The analysis criteria related to covering materials are considered extremely important in the assessment of outdoor public spaces, with respect to streets and squares, as these types of spaces have significant covering areas that significantly influence issues related to thermal comfort. The analysis of environmental constraints deserves some attention, in the sense that the protective elements of a given outdoor public space can minimise the user's exposure to climate factors. In this way, outdoor public spaces, such as squares, should be given priority in the inclusion of this type of element, as they have large areas, most of which are without any type of protection.

Quality of life plays an important role, since it is certainly healthier and more beneficial for the user to be in an open space, provided that certain environmental conditions are met, where air quality is of great importance, along with the issue of climate change. From this point of view, the use of vegetation or green areas combined with water bodies can help, for instance, to mitigate the heat island effect or even to control flooding. The inclusion of these elements in parks is therefore of great importance when weighing up the quality of life criterion.

Another very important criterion in the assessment of an outdoor public space is the issue of amenities and accessibility, where the presence of stations and stops, as well as the presence of pedestrian and cycle paths, are of great importance in a street layout.

Finally, sustainable maintenance is undoubtedly the most important consideration in the assessment of outdoor public space, combining environmental and economic issues. It takes on greater importance in parks, as this is the most relevant type of outdoor public space in terms of sustainable management, due to the fact that it has a greater surface area associated with its resources, and this can help to optimise waste, sewage and stormwater management.

Through the outdoor public space assessment model presented, it is possible to define a relationship matrix (Table 16) between the criteria and the sub-criteria of analysis. As well as those with the greatest influence in the respective assessment model of the outdoor space, in general, which results from the calculation of the average values of the weighting attributed for the respective sub-criteria of analysis, regarding the 3 types of outdoor public spaces.

Analysis sub-criteria	P	FC	RC	UW	SSS	VGA	WB	UF	PL	SS	PCP	WM	SM	SWM
	Analysis criteria													
Visual comfort	+	+		+					+					
Thermal comfort	+	+	+	+	+	+	+			+	+			
Acoustic comfort						+								
Olfactory comfort												+	+	+
Runoff	+													
Durability and suitability			+	+	+	+	+	+	+	+	+	+	+	+
Adaptability			+	+	+	+	+							
Accessibility														
Material combination										+				
Gases, dusts, or particles emission	+											+	+	+
Socialisation					+			+			+			
Safety	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Plant species														
Water supply						+	+							
Route											+			
Maintenance	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Cultural identity														
Regional or local resources avbl.		+			+	+	+	+	+	+	+	+		

(+): Analysis sub-criteria with the most influence in the respective outdoor public space

Table 16: Relationship matrix between criteria and sub-criteria analysis

Table 16 shows that the outdoor public space assessment model tends to value aspects related to thermal comfort, durability and suitability, safety, maintenance and also the availability of (sustainable) resources at a regional or local level.

Although some weightings of the analysis sub-criteria may seem subjective, they are also supported to some extent by the typology of the public space. In this perspective we have the example of a park, which supposedly has a larger area of vegetation, so its contribution to the dilution of pollutants is higher, while in a street this contribution will be lower. Therefore, the weighting of the emission of gases, dust or particles will be greater in a street, compared to a park.

Another situation that can raise some criticism is the inter-relation of some sub-criteria of analysis, such as the inter-relation between olfactory comfort and the emission of gases, dust or particles, which is considered independently. Olfactory comfort refers only to the release of small smells, which are perceptible in a reduced surrounding area, whereas the emission of gases, dust or particles already focuses on the environmental issue and the pollution load of these emissions.

For an initial model of public space assessment, the weightings attributed are considered balanced, except that in particular or exceptional cases field measurements of some specific physical parameters, as well as the respective simulations in computer applications, become necessary. Therefore, this assessment model of the outdoor urban space should be constantly improved until it reaches high levels of confidence by the users.

Concerning the overall assessment result of the analysis of a given outdoor public space, a qualitative scale is defined, as shown in Figure 3.

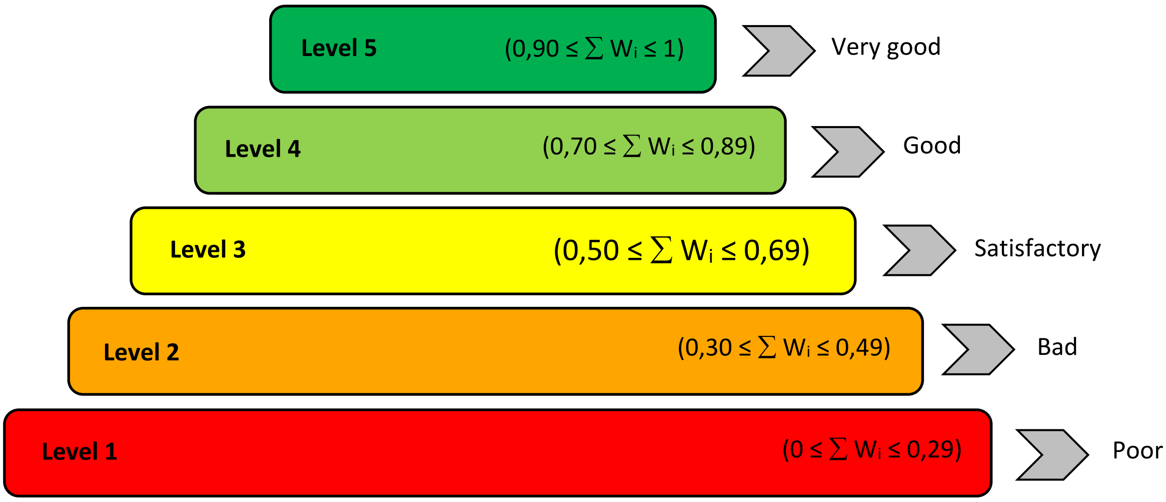

Figure 3: Qualitative scale for outdoor public space assessment

Depending on the level assessed for the public outdoor space it is possible to define potential improvements to reach a more advanced level, either in the design phase or for an intervention phase in the built heritage. For instance, if a level 3 classification is attributed and it is intended to evolve this space to a level 4, through the proposed model it is possible to identify which elements of the public space to intervene, where the analysis sub-criteria work as specific indicators of the improvement changes.

5. Conclusions

The contributions of this study are important in the sense that they help all those involved in the process of assessing construction solutions for the design of outdoor public spaces, as well as raising awareness and assisting in the search for technological solutions and procedures that lead to the sustainability of construction, with the aim of adapting the urban physical heritage to climate conditions.

These construction solutions must contemplate urban bioclimatic aspects, naturally resorting to the use of sustainable materials. Vernacular solutions can also be included, as long as they are applicable in an urban context and can optimize the quality of a given public space.

Although it is understood that the proposed model is already a good basis to support the assessment of construction solutions for outdoor public space design, future studies are necessary, for continuous improvement of the model related to the refinement of the weightings, both for the criteria and the sub-criteria of analysis. This improvement is reflected in the number of assessments made to the respective types of public outdoor space, based on practical experience.

Thus, the proposed model will lead to the definition of guidelines, which can be adopted by municipalities, and which can also serve as a basis for the creation of specific regulations.

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