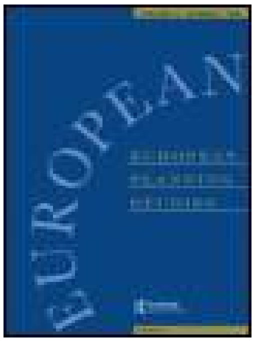

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Assessment of open spaces in inland medium-sized cities of eastern Andalusia (Spain) through complementary approaches: spatial-configurational analysis and decision support

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ABSTRACT
The benefits of urban open spaces for improving the quality of life and sustainability in cities are widely recognized. The functions they perform within the framework established by urban planning, as well as their metrics, are now more complex than in the past. It is convenient to develop methodologies for the evaluation of these spaces adapted to the present time to check their level of efficiency, which is useful in urban planning for the establishment of new urban open spaces. The aim of this study is to classify such spaces through a methodology that integrates spatial analysis, configuration analysis, and decision support so as to understand their complexity from a more advanced analytical perspective. In order to do this, a prior exploration of specific literature is carried out, which allows the characterization of the functions of urban open spaces by means of the corresponding analysis variables in a weighted manner. The integrated combination of these advanced tools is a step forward in achieving consistent and detailed results for urban open spaces. They perform their functions best in dense, central, equipped, accessible, connected, and easily walkable urban environments. In addition, future recommendations are provided.

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Urban planning; decision support; urban morphology; spatial configuration; medium-sized city; urban open spaces

Introduction

In contemporary urban development, marked by a renewed focus of attention on human social needs and the active conservation of nature, the planned functions of urban open spaces (UOS) are essential. The attention paid to these spaces and the success of their implementation depend to a large extent on the urban policies of each geographical area as well as their transformation over time. It has been suggested that modern urban planning starts with nineteenth-century regularism and reaches up to the current emerging sustainable planning, with the consequent evolution of its approaches, measures, and standards (Baycan-Levent & Nijkamp, 2009; Ståhle, 2010).

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The climate change challenges that sustainable planning faces are very technical and require the management of very specific data derived from natural sciences and climate that traditional planning instruments cannot solve. Therefore, attempts to understand this new complexity must be made through different approaches and perspectives of information. Innovations introduced by this type of planning include: indicator-based assessment of the elements needed to achieve sustainability (open spaces, among others), decision-making support, the development of social capital, and the use of more complex metrics and analysis tools (Campos-Sánchez, Abarca-Álvarez, & Domíngues, 2018; Shen, Jorge Ochoa, Shah, & Zhang, 2011).

In this context, with respect to the analysis of UOS, the usefulness of various tools has been demonstrated since the 1990s, including: (i) geographic information systems (GIS), systems for integrating spatial data from various sources by overlapping both georeferenced graphic layers and attributes, from which accurate quantitative data can be extracted (Yeh, 2005); (ii) decision support systems (DSS), effective tools for the incorporation and integration of complex problems and decision support, reducing indeterminacy and improvization (Ayeni, 1998); and (iii) configuration analysis, as reflected in space syntax (SS) theories and methods (Hillier & Hanson, 1984) closely related to urban morphology, social variables, and pedestrian mobility.

There are studies that use hierarchical multi-criteria analytical decision support tools such as AHP (Analytic Hierarchy Process) (Saaty, 1982) to evaluate different aspects of UOS, such as the functions they perform or their degree of desirability by the population (He & Zhu, 2017; Orak, Zandvakili, Roshan, & Abkenar, 2016). Many other studies use spatial configuration analysis to measure or even predict the influence of green spaces on pedestrian movement (Marcus & Colding, 2011; Ståhle, 2010), as well as other aspects related to health (Knöll, Neuheuser, Li, & Rudolph-Cleff, 2015; Sarkar, Gallacher, & Webster, 2013) or safety (Reis, Lay, Muniz, & Ambrosini, 2005). Taking a step further, research has been conducted that integrates AHP and GIS to plan UOS spatial distribution according to factors of different levels of importance (Yannan, Deping, & Wang, 2009), or that combines GIS and the SS variables to measure accessibility to these spaces (e.g. Abubakar & Aina, 2006).

Some of these studies also interpret the data using traditional statistical methods (Kim, 2008; Ståhle, 2005). The problem with these methods is that they are limited to average values and partial results, which sometimes leads to a simplification of reality and affects the determination of the final results (Serra-Coch, Chastel, Campos, & Coch, 2018). Some works that complement these methods with GIS and SS tools in the study of open spaces stand out (Koohsari, Kaczynski, Giles-Corti, & Karakiewicz, 2013; Koohsari, Karakiewicz, & Kaczynski, 2012; Kothencz & Blaschke, 2017). However, there is a lack of work that integrates spatial analysis, configurational analysis, and decision support tools that represent a step forward in obtaining, detailing, and interpreting specific multilevel results in this field.

On the other hand, in order to evaluate UOS, it is common to carry out data collection through methods such as population surveys, monitoring, direct observations, or questionnaires addressed to expert panels. As a complementary but not substitutive measure to the previous ones, a systematic review of specific literature is useful in order to extract and select the relevant information on the subject matter of the case study (Campos-Sánchez, 2017; Valenzuela & Talavera, 2015).

The aim of this work is to design and experimentally verify a useful and exploratory methodology to check the extent to which the UOS of the case study fulfil the urban planning functions assigned to them (Figure 1). To this end, it focuses on two of its main planned functions, which are spatially characterized and evaluated. By means of an AHP process, both the functions and the variables involved are weighted according to their relative importance, as defined in the reviewed literature. Finally, in order to validate the methodology, a global and categorical ranking of these spaces is obtained, which is useful to the decision-making processes of the urban planning in view of its implementation.

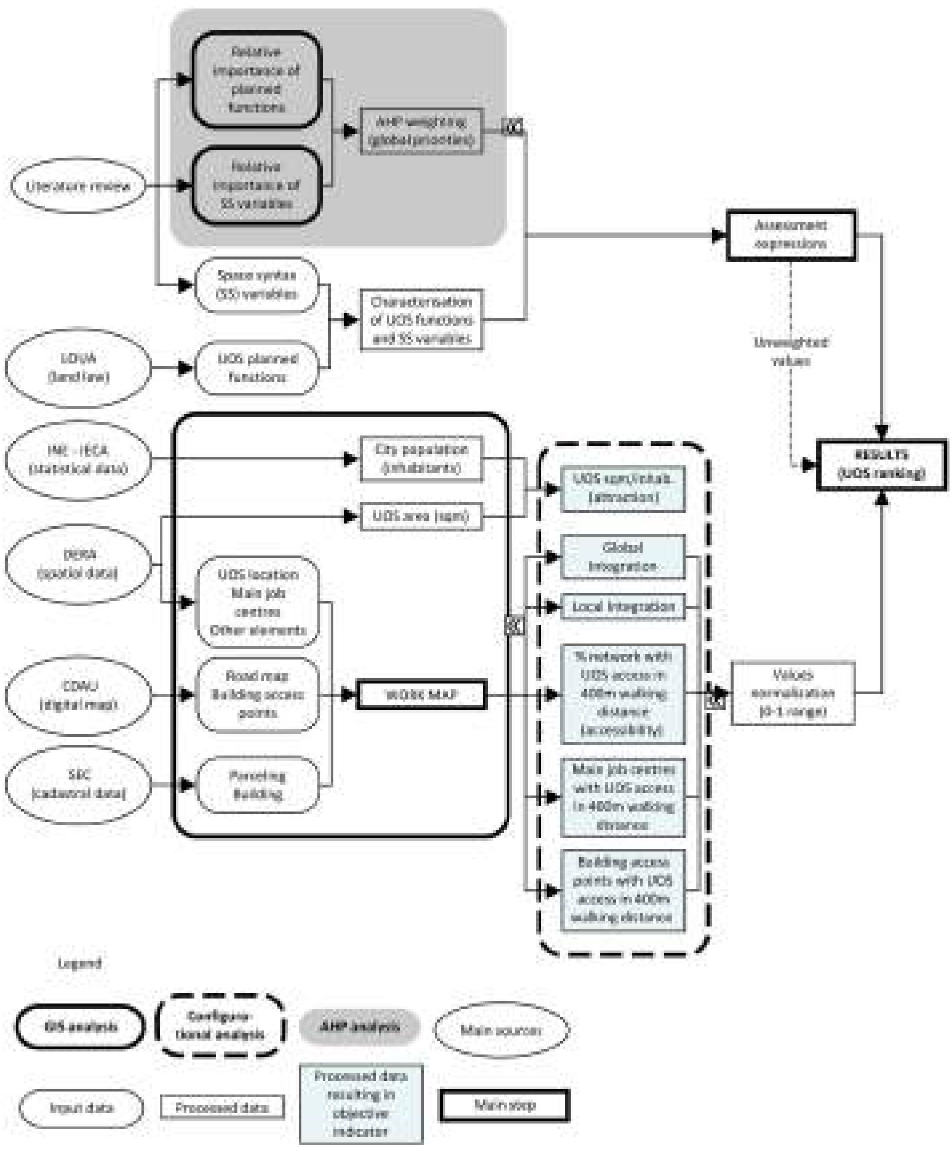


Figure 1. The workflow of the applied methodology. Source: Prepared by the authors (PbA).

Materials and methods

Phase 1. Weighting of functions and variables. This phase is carried out in order to determine the weight of each category in the assessment process. It is obtained by applying an AHP model. In its initial phase, this technique requires a comparison by pairs of criteria, according to hierarchical level, based on the Saaty numerical scale (1–9). The ratio between the relative importances of each pair of criteria is used as a reference for selecting the value of the comparative scale. The relative importance can be obtained from the frequency with which each criterion is used in impact research. To this end, specialized literature is explored through systematic searches of the Web of Science and Google Scholar databases over a recent period (2000–2018).

Phase 2. Construction of function indicator. In order to verify the validity of the methodology, the evaluation is completed for two of its main planned functions: equidistribution (city level) and social cohesion (UOS level). These are characterized by the assignment of the corresponding analysis variables. Both categories are assessed on a weighted basis. The process is based on the exploration of specialized literature in the field of spatial configuration and urban design.

Phase 3. Classification of urban open spaces. Once the functions of the example have been characterized and weighted, they are quantified by analysis in order to obtain the corresponding score for each open space, both globally and by variable. For this purpose, the values obtained are normalized to the 0–1 range. The final result of the evaluation is a comparative ranking of the UOS. The process is multi-scalar and multivariable, since in the assessment calculations are made at the city and open space levels. The following steps are taken and the following sources of knowledge and analysis tools are managed:

(1) Work city map production: (i) from the DERA (Spatial Reference Data of Andalusia), vectorial information is obtained, including the delimitation of the main urban centre, location of open spaces, topographical relief, hydrology, infrastructures, and services. From the services data, a layer is built with the main job centres; (ii) the CDAU (Unified Digital Street Map of Andalusia) provides the urban road digital layer and the building access points; (iii) the SEC (Cadastre Electronic Headquarter) provides information on land parcelling and building.
(2) Spatial and proximity configuration analysis. A segment city map is produced and processed (CDAU), which is the spatial network on which the analysis is carried out. The access segments to each UOS are determined, which will constitute the origin-elements of the calculations in relation to the destination elements (residential access, job centres, catchment areas, etc.). The calculation values correspond to those of the optimum access segment. Calculations are made for a 400-meter real metric distance or approximately five minutes of continuous walking.

The analysis tools used in the research are as follows: (i) calculations, tools, and spatial databases have been integrated into an GIS open source: QGIS (V.2.18.13); (ii) multivariable and proximity analyses have been carried out using Place Syntax Tool (PST) (Ståhle, 2005), Depthmap and SS-Toolkit; and (iii) AHP analysis for weighting has been carried out using an AHP Online System (https://bpmsg.com/ahp-online-system/). In addition, case study urban and regional planning were consulted, including PGOU (Urban

Development Plan), POTA (Territorial Plan of Andalusia), and the LOUA (Regional Urban Planning Law), in order to contextualize them normatively and theoretically.

Case study

Andalusia is the second largest region of Spain. Medium-sized cities (MSCs) constitute an important system of networked cities in the territorial organization of the region. MSCs represent an intermediate urban category between capital and smaller cities (JA, 2006). The eastern Andalusian zone presents socioeconomic disadvantages compared to the western zone, as do the inland MSCs compared to the metropolitan or coastal MSCs. However, the former show certain richer environmental and social cohesion conditions compared to the latter, a circumstance partly due to their open spaces (Pérez-Campaña, 2015; Campos-Sánchez & Abarca-Álvarez, 2013; Garrido Cumbrera, Rodríguez Mateos, & López Lara, 2016). Therefore, the assessment and improvement of the UOS can help inland MSCs habitability and development. This leads to the achievement of the territorial balance between both urban categories and the eastern and western regional areas, which is a main goal of territorial planning (JA, 2006). According to data from the IEA (Statistical Institute of Andalusia), the total number of MSCs in the case study is nine (Figure 2). Each has a municipal population between 20.000 and 50.000 (Merinero & Lara, 2011).

In addition, due to their strategic site and historical context, these cities have a close relationship with their geographical framework, which has strongly conditioned their urban form (Cano García, 2008). They are 'agrocities' affected by diverse urban transformation throughout their history, e.g.: demolition of walls, religious uses expropriations that gave rise to gardens and orchards within the inner city; the democracy arrival in the 1970s, the land laws and the urban planning modernization from the second half of the twentieth century, which involved the provision of community services land use; the construction of tree-lined promenades between city and train station; and other green spaces linked to agricultural activity. These transformations have led case study cities to show a long list of diverse green spaces. Therefore, these cities are of interest as experimental 'urban laboratories' of the methodology research.

The work focuses on UOS where optional activities (e.g. recreational, leisure, sport) can be carried out together with social functions, rather than those where purely necessary uses (e.g. transport, mobility, supply) are performed (Gehl, 2010). The former consists of public spaces such as: parks, gardens, boulevards, playgrounds and sport fields. The latter consists

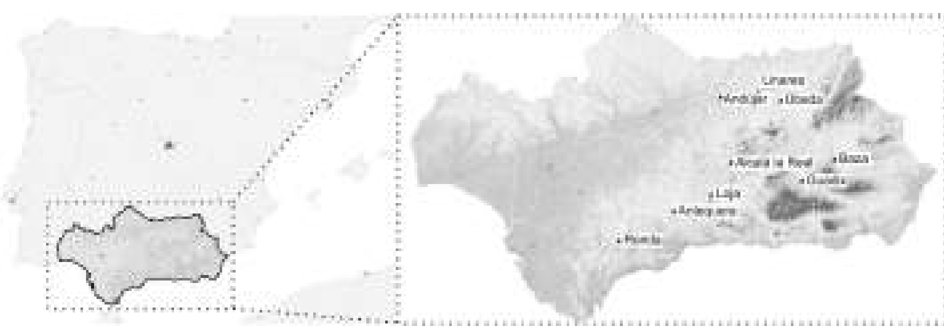


Figure 2. Case study location. Source: PbA.

mainly of public streets with sidewalks and pedestrian paths. Hence, this research focuses on the former. In order to verify whether or not these spaces fulfil their functions and are potentially attractive to citizens, key factors that have to do with pedestrian movement and social activity are assessed.

The LOUA established that the PGOUs must literally ensure the coherence, functionality, and accessibility of urban public uses (e.g. UOS) and equipment, as well as their balanced distribution. In addition, the location of urban public uses and equipment must be established in such a way to promote their suitable articulation and to address social integration and cohesion in the city. Therefore, the planned functions of UOS are: coherence, functionality, equidistribution, articulation, and social cohesion.

Phase 1. Weighting of both functions and variables

The following tables shows the relative importance with which the UOS functions in urban planning (criteria) as well as the configurational variables of the urban space (sub-criteria) are attended by the specialized literature. They are adapted to the Saaty numerical scale and a pair comparison is made at each hierarchical level. The set is processed using an AHP matrix to determine the weight of each term, which will be used to weight the function indicator in the next methodological step.

According to Table 1, the relative importance of the UOS functions in the case study is as follows: accessibility (44% of references: 29% dealing with distribution or access and 15% with the area or ratio available), functionality (62%), articulation (15%), and social cohesion (32%). According to Table 2, the relative importance of the SS variables is: global integration (59%), local integration (62%), choice (14%), connectivity (17%), VGA (38%), and others (35%). In addition, about 31% of references relate to residents and 10% to job centres.

Within the AHP model, the relative importance ratios are taken as references in order to choose the numerical comparison value (1–9) between pairs of both criteria and sub-criteria. This gives the weighting coefficients for each hierarchy level (Figure 3, Table 3). Continuing with the analytical model, a final hierarchical level (alternative pair comparison) is used to roughly assess which UOS (alternative) best fits each criterion and sub-criterion. In our case, this last step is replaced by the more precise analysis carried out in Phase 3.

Phase 2. Construction of the function indicator

The UOS planned functions selected as examples in the case study are contextualized below. Subsequently, they are characterized by the assignment of related spatial variables that allow their quantification. The resulting indicators respond to Equations (1) and (2).

Equidistribution

Accessibility or ease of reaching a destination, as well as attraction, have traditionally been the standard measures of open space. Both by definition respond to the available surface area of open space (attraction) within a given metric distance (accessibility). In our case study, we took into account all those UOS with a minimum value

Table 1. Relative importance of the UOS functions.

References	Keywords	Equi-distribution	Functionality	Articulation	Social Cohesion
Bajaj and Kumar (2017)	distribution, sustainability	x			
Baycan-Levent and Nijkamp (2009)	planning, policies, success, comparison, cases study		x		
Chiesura (2004)	motivation, perception, social, welfare				x
Cruz et al. (2017)	planning, metropolitan areas, connectivity, ambiental, landscape		x	x	
Douglas, Lennon, and Scott (2017)	health, welfare		x		
Fei et al. (2009)	hazards, planning, function		x		
Feria and Santiago (2009)	ecology, planning, metropolitan areas		x		
Fu (2013)	ecology, planning, continuity		x	x	
Haaland and van den Bosch (2015)	compactness, quality, density, supply	x+	x		
He and Zhu (2017)	evaluation, functions, ecology, AHP decision support		x		
Hooper, Boruff, Beesley, Badland, and Giles-Corti (2018)	location, quantity, access, size	x+			
Hwang (2016)	supply, residents, quality of life	x+			x
Jia et al. (2009)	decision support, method	x			
Johar and Omar (2010)	ecology, planning, quality, sustainability	+	x		
Kim (2008)	private, pleasure, building, offices	+			x
Kim and Yang (2014)	behaviour, public property, private property, Privately Owned Public Space	x+	x		
Lee, Jordan, and Horsley (2015)	functionality, health, challenges		x		
Lee and Jang (2017)	urban uses, functions, monitoring		x		
Lennon, Douglas, and Scott (2017)	health, welfare		x		
Lindholst, Caspersen, and Konijnendijk van den Bosch (2015)	mapping, planning, use value		x		
Orak et al. (2016)	desirability, ambiental, uses, density, distribution, employment, AHP	x	x		x
Niemelä et al. (2010)	ecosystem services, networks, sustainability, planning		x		
Pulighe, Fava, and Lupia (2016)	mapping, ecosystem				x
Qiu and Nielsen (2015)	landscape, perception, mapping, urban use		x		
Semenzato, Sievänen, de Oliveira, Soares, and Spaeth (2011)	physical activity, design, planning, environment	x+	x		
Teimouri and Yigitcanlar (2018)	network, continuity, supply, distribution	x+	x		
Vasilevska, Vranic, and Marinkovic (2014)	planning, segregation, housing, access	x		x	x
Wandani, Utami, and Ramadhan (2015)	functionality, social, ecological, cultural		x		x
Wang (2009)	planning, spatial patterns, development			x	
Wright Wendel, Zarger, and Mihelcic (2012)	access, urban use, barriers, inequality	x	x		x
Wu, Liu, Yu, and Peng (2018)	residential density, distribution, location, mobile communications	x			x
Yannan et al. (2009)	spatial analysis, AHP decision support, planning, GIS	x		x	
Yung, Conejos, and Chan (2016)	access, elderly people, planning				x

Notes: (1) Equidistribution function: (x) = distribution, access; (+) = area, supply, provisioning. (2) By definition, in this case, the 'coherence' function is subsumed under 'functionality'.
Source: PbA.

Table 2. Relative importance of spatial configuration variables.

References	Keywords	Global Int	Local Int	Choice	Connectivity	VGA	Others
Abbasi, Alalouch, and Bramley (2016)	user, accessibility, observation, policy, quality, degraded					x	
Abubakar and Aina (2006)	accessibility, services, uses	x	x	x	x		
Baran, Rodríguez, and Khattak (2008)	walkability, New Urbanism, suburbs, design, neighborhood	x	x				x+
Dou and Zhan (2011)	shelter, accessibility, emergency		x				
Foltête and Piombini (2007)	landscape, environment, uses, views		x				*
Hanson and Zako (2007)	behaviour, livability, residential, morphology	x					x
Hao, Kang, and Krijnders (2015)	birds, sound, urban morphology, visibility					x	
Kang (2015)	accessibility, centrality, uses, walkability	x	x				x
Knöll et al. (2015)	spatial, stress, users, environment, health	x	x		x	x	
Koohsari, Karakiewicz, et al. (2012)	proximity, attraction, perception, configuration, uses, residents, correlation		x				x+
Koohsari, Kaczynski, et al. (2013)	proximity, distance, walkability		x				
Legeby (2010)	segregation, social cohesion, residents, urban morphology	x	x	x			+*
Listerborn (2000)	configuration, women, fear, spatial	x				x	x+
Mahmoud and Omar (2015)	parks, design, planting, vegetation	x				x	x
Marcus and Colding (2011)	urban morphology, social, ecology, resilience	x	x				+
Ebrahimpour-Masoumi (2012)	urban growth, comparision, east, west	x	x		x		
Önder and Gigi (2010)	history, culture, continuity, spatial	x	x				
Raford and Ragland (2004)	pedestrian, hazard, contact, traffic	x					+
Ratti (2004)	metrics, topology, geometry, problems		x				
Reis et al. (2005)	safety, urbanization, children, teenagers, visual		x			x	x+
Saito, Said, and Shinozaki (2017)	landscape, conservation, heritage, urban heat, neighborhood		x			x	
Sarkar et al. (2013)	body mass index, environment, uses, location				x		*
Setola (2009)	hospital, flow rates, design, emergency, social, health			x		x	x
Ståhle (2005)	compactness, parks, suburbs, questionnaires	x	x				x
Ståhle (2010)	attraction, use value, proximity, supply	x					+
Talavera (2012)	accessibility, attraction, catchment area	x	x		x	x	
Wang, Qing, and Qizhi (2007)	image, city, movement, weighting	x	x			x	
Wei, Qian, Tao, Hu, and Ou (2018)	rapid urbanization, network, infrastructure, landscape, connectivity	x		x			
Zhai and Baran (2016)	parks, route, walkability, elderly people, observations					x	x+

Note: Others (other variables): (+) = residents, building; (*) = job centres.
Source: PbA.

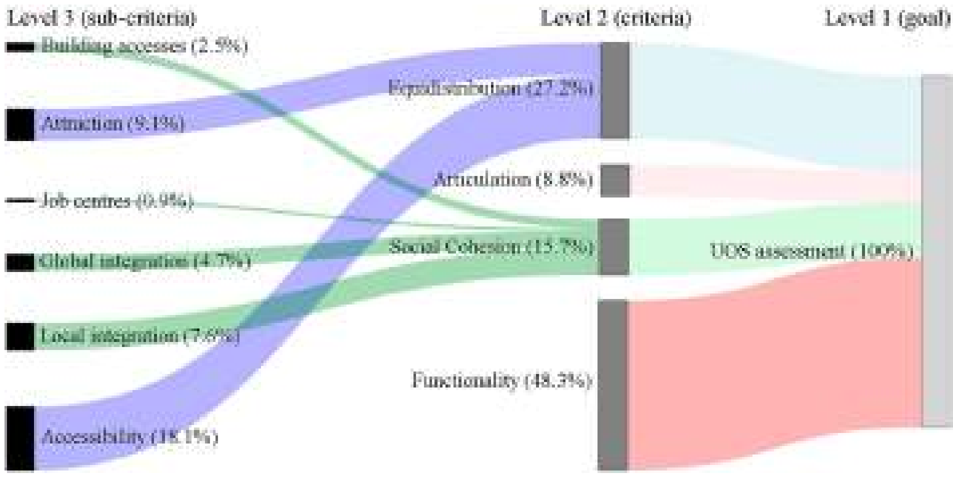


Figure 3. Hierarchical decision scheme with priorities breakdown. Source: PbA based on a Sankey diagram.

of attraction >0.5 Has, as established in this respect by one of the five main indicators of the First Generation of European Indicators. This is a measure of attraction that has previously used in urban planning as a reference for the identification of local open spaces (Ståhle, 2010), such as those investigated in this work.

The accessibility value adopted is 400 metres of maximum pedestrian distance to reach a UOS. This is a comfortable walking distance (WD) for pedestrians and inclusive for sectors of the population with limited and reduced mobility. It is currently widely used in the area of the intermediate scale (Gómez, 2013; Van Herzele & Wiedemann, 2003) such as neighborhoods or districts. It consists of a reasonable distance of accessibility for our case study, considering that the maximum length of MSCs does not usually exceed two or three kilometres. Therefore, the study of accessibility will determine which zones of the city have access to that UOS, i.e. equidistribution (Table 4).

The equidistribution variable is assessed at the city level (Table 5). Therefore, the sum of the following measures of attraction and accessibility is adopted as an indicator of this function: (a) Sqm UOS/inhabitant, and (b) % of urban network segments with access to one (or more) UOS (Figures 4–7), i.e. segments within its 400 m radius catchment area.

Table 3. Weighting coefficients and AHP global priorities.

Level 1	Level 2	W	Level 3	W	GPs (%)
Urban Open Spaces (UOS) assessment	Equidistribution	0.272	Attraction (Sqm /Inhabitants)	0.333	9.1
			Accessibility ($r = 400$ m)	0.667	18.1
	Articulation			0.088	8.8
	Social cohesion	0.157	Global integration ($r = 400$ m)	0.298	4.7
			Local integration ($r = 400$ m)	0.486	7.6
			Building accesses ($r = 400$ m)	0.159	2.5
			Job centres ($r = 400$ m)	0.057	0.9
	Functionality			0.483	48.3

Notes: Level n = hierarchical level; GP = global priority; W = weight. CR (Consistency Index) = 0.5% (<10% = consistent matrix). GPs considered in the application example are highlighted.
Source: PbA.

Table 4. MSCs' general data and equidistribution conditions.

MSCs	S (Sq km)	N	UOS Area (Sqm)	Seg.	% UOS P_{400}	% 1UOS P_{400}	% 2UOS P_{400}	% +3UOS P_{400}	E_n	% UOS E_{400}	A_n	% UOS A_{400}
Alcalá la Real	1.90	5	74,312	1325	59	39	16	5	49	61	4669	67
Andújar	3.24	7	162,786	2117	74	57	16	1	77	65	6276	69
Antequera	4.13	6	197,671	2680	41	25	11	5	74	39	7387	36
Baza	2.79	3	49,324	3430	30	30	0	0	50	38	6503	27
Guadix	2.70	5	130,300	2998	45	29	14	3	57	44	3753	37
Linares	7.12	12	262,193	3152	45	25	14	6	104	72	10,611	41
Loja	1.47	3	42,073	2142	28	28	0	0	44	14	4085	15
Ronda	3.87	8	136,437	1774	69	42	23	4	65	62	5649	56
Úbeda	4.47	6	222,620	2042	45	38	7	0	70	31	8039	40

Notes: Data obtained per urban core analyzed: S = total area; N = total number (TN) of UOS; Seg. = TN of segments; A_n = TN of building access points; E_n = TN of main job centres. The rest of the measures are calculated for catchment areas of 400m-WD around the UOS: % nUOS-P_{400} = percentage of segments with accessibility to nUOS; %UOS-E_{400} = percentage of main job centres around the UOS; %-UOS-A_{400} = percentage of building access points around the UOS.
Source: PbA.

The resulting values are normalized (0–1) and weighted according to AHP priorities.

$$E_i = \sum_i f[(S_i, P_{400})\text{Normalized}]GP_E \quad (1)$$

where E_i = UOS equidistribution in a city i; S_i = Sqm UOS/inhabitant; P_{400} = % of urban network with access to one UOS within 400 m-WD; GP_E = equidistribution GP according to the AHP model (Table 3).

Social cohesion

Social cohesion is proposed as a solution to social segregation, which normally refers to residential segregation. In the urban context, this issue has a direct impact on spatial segregation, i.e. the built environment form facilitates (cohesion) or hinders (segregation) the way people share public space (Legeby & Marcus, 2011). Spatial segregation (and thus also social) comes from limited access to residents and to job opportunities based on the urban space morphology (Hanson, 2000; Legeby, 2010). The properties of configurational analysis relate to both movement and co-presence patterns with social implications. For this reason, in order to capture the society-space relationship, accessibility network measures must be assessed in relation to geometric representations of the space system under study (Hillier & Vaughan, 2007).

From a spatial configuration point of view, an open space can be integrated locally and within a larger urban system at the same time (Hillier, 1996). Local integration (LIn) represents a scale of movement within the neighborhood. It is the ideal factor for measuring this type of scale (Ratti, 2004). Instead, global integration (GIn) represents a scale of movement between neighborhoods. The evaluation of global measures makes sense in our case study since they are fully walkable cities with reasonable physical effort (Campos-Sánchez & Abarca-Álvarez, 2013). We could say that integration, a kind of centrality, measures the 'destination potential' of each segment within a given metric radius. In our case study, we found that the higher the integration value of the access segments to each UOS, the greater the likelihood that people moving within that radius will end up in it, i.e. the UOS will enjoy greater accessibility.

Table 5. Multivariable analysis and UOS ranking.

	Equidist. (E_i)		Social cohesion (C_i)				Normalized values (0–1)						Scores and Ranking		
UOS	Sqm/Inh	% UOS $\boldsymbol{P}_{400}$	A_{400}	E_{400}	GIn	LIn	Sqm/Inh	% UOS $\boldsymbol{P}_{400}$	A_{400}	E_{400}	GIn	LIn	Rk	Total (P)	Rk (P)
AD1	4.50	74	207	1	220	37	0.5	1.0	0.1	0.1	0.0	0.1	6	0.238	6
AD2			67	0	227	29			0.0	0.0	0.0	0.0	7	0.227	7
AD3			412	10	372	67			0.3	0.7	0.9	0.5	4	0.321	4
AD4			611	12	358	72			0.5	0.9	0.8	0.6	3	0.330	3
AD5			1077	6	357	104			1.0	0.4	0.8	1.0	1	0.369	1
AD6			344	1	314	58			0.3	0.1	0.6	0.4	5	0.294	5
AD7			610	14	389	69			0.5	1.0	1.0	0.5	2	0.333	2
AR1	4.45	59	830	3	257	58	0.5	0.7	0.7	0.2	0.4	0.3	3	0.233	3
AR2			224	4	304	44			0.0	0.2	0.7	0.0	4	0.207	4
AR3			725	3	322	79			0.6	0.2	0.8	0.6	2	0.272	2
AR4			1117	18	349	100			1.0	1.0	1.0	1.0	1	0.329	1
AR5			472	0	201	46			0.3	0.0	0.0	0.0	5	0.180	5
AT1	5.51	41	590	2	294	53	0.7	0.3	0.8	0.2	0.1	0.2	3	0.160	3
AT2			403	2	331	50			0.4	0.2	0.4	0.1	4	0.156	5
AT3			677	6	319	54			1.0	0.5	0.3	0.2	2	0.177	2
AT4			197	3	376	47			0.0	0.2	0.8	0.0	5	0.157	4
AT5			420	13	406	78			0.5	1.0	1.0	1.0	1	0.263	1
AT6			505	0	282	57			0.6	0.0	0.0	0.3	6	0.156	6
BZ1	2.41	30	731	10	441	127	0.0	0.0	1.0	1.0	0.6	1.0	1	0.138	1
BZ2			100	0	359	25			0.0	0.0	0.0	0.0	3	0.000	3
BZ3			642	9	489	109			0.9	0.9	1.0	0.8	2	0.138	2
GX1	6.93	45	656	12	483	144	1.0	0.4	1.0	0.8	1.0	1.0	1	0.319	1
GX2			385	15	407	85			0.5	1.0	0.6	0.4	2	0.244	2
GX3			325	11	418	72			0.4	0.7	0.7	0.3	3	0.235	3
GX4			220	2	378	70			0.2	0.1	0.5	0.3	4	0.216	4
GX5			121	1	290	40			0.0	0.0	0.0	0.0	5	0.163	5
LN1	4.46	45	779	8	565	80	0.5	0.4	1.0	0.3	0.7	0.9	3	0.247	2
LN2			378	6	457	63			0.5	0.2	0.4	0.6	7	0.197	7
LN3			548	18	570	69			0.7	0.7	0.7	0.7	4	0.228	5
LN4			382	13	577	74			0.5	0.5	0.7	0.8	5	0.229	3
LN5			47	2	338	14			0.0	0.0	0.0	0.0	12	0.118	12
LN6			127	1	419	42			0.1	0.0	0.2	0.4	10	0.160	10
LN7			34	1	413	27			0.0	0.0	0.2	0.2	11	0.143	11

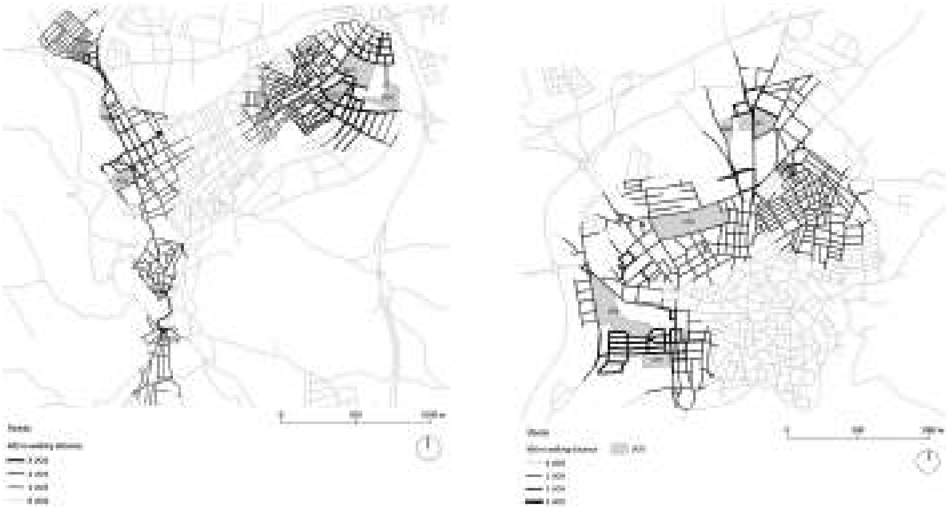
(*Continued*)

Table 5. Continued.

	Equidist. (E_i)		Social cohesion (C_i)				Normalized values (0–1)						Scores and Ranking		
UOS	Sqm/Inh	% UOS P_{400}	A_{400}	E_{400}	GIn	LIn	Sqm/Inh	% UOS P_{400}	A_{400}	E_{400}	GIn	LIn	Rk	Total (P)	Rk (P)
LN8			111	6	527	47			0.1	0.2	0.6	0.4	8	0.181	8
LN9			223	5	437	39			0.3	0.2	0.3	0.3	9	0.164	9
LN10			567	1	576	73			0.7	0.0	0.7	0.8	6	0.229	4
LN11			787	24	504	59			1.0	1.0	0.5	0.6	1	0.221	6
LN13			523	9	664	90			0.6	0.3	1.0	1.0	2	0.259	1
LJ1	2.68	28	139	0	231	46	0.1	0.0	0.1	0.0	0.9	0.5	2	0.092	2
LJ2			113	1	180	28			0.0	0.2	0.0	0.0	3	0.011	3
LJ3			326	5	240	64			1.0	1.0	1.0	1.0	1	0.166	1
RD1	4.31	69	304	13	172	44	0.4	0.9	0.1	1.0	0.1	0.0	5	0.216	8
RD2			357	3	227	59			0.2	0.1	0.5	0.2	6	0.244	5
RD3			801	5	234	117			1.0	0.3	0.6	1.0	2	0.331	1
RD4			241	2	196	28			0.0	0.0	0.3	0.2	8	0.229	6
RD5			514	4	199	81			0.5	0.2	0.3	0.5	3	0.266	3
RD6			724	13	290	79			0.9	1.0	1.0	0.5	1	0.316	2
RD7			478	2	154	59			0.4	0.0	0.0	0.2	7	0.225	7
RD8			281	4	272	57			0.1	0.2	0.9	0.2	4	0.261	4
UB1	6.66	45	194	1	394	36	0.9	0.4	0.1	0.2	0.7	0.2	5	0.207	5
UB2			72	0	356	26			0.0	0.0	0.3	0.0	6	0.168	6
UB3			727	4	329	63			0.6	0.7	0.0	0.8	4	0.236	4
UB4			160	6	429	45			0.1	1.0	1.0	0.4	3	0.243	3
UB5			1130	2	355	71			1.0	0.3	0.3	1.0	1	0.272	1
UB6			421	6	402	53			0.3	1.0	0.7	0.6	2	0.249	2

Notes: (1) Calculations based on the existing data according to DERA and INE for the main urban core; (2) The 'winner' UOS are highlighted in each case; (3) In the event of a tie, the highest ranking was awarded to the UOS with the most scores equal to 1 or the fewest scores equal to 0; (4) Rk = unweighted ranking; Rk (P) = weighted ranking; (5) LN12 was removed from the table as it is considered to be an interstitial space within a fully industrial use area; (6) AD = Andújar, AR = Alcalá la Real, AT = Antequera, BZ = Baza, GX = Guadix, LN = Linares, LJ = Loja, RD = Ronda, UB = Úbeda.

Source: PbA.



Figures 4 and 5. Analysis of the % nUOS-P_{400} variable in Ronda (left) and Úbeda (right). Source: PbA.

Therefore, the UOS social cohesion potential is as follows:

$$C_i = \sum_i f[(\text{GIn},\ \text{LIn},\ A_{400}, E_{400})\text{Normalized}]GP_S \quad (2)$$

where C_i = UOS social cohesion potential; A_{400} = number of building access points; E_{400} = number of main job centres; GP_S = AHP social cohesion global priority (Table 3). GIn variable is calculated for the whole city while the rest is applied locally, within a 400 m-WD (Figure 8).

Phase 3. Classification of urban open spaces

Table 5 shows the results of the whole evaluation process. This allows the case study UOS to be classified according to a preferential ranking in terms of fulfilling the example functions within the framework of current urban planning.

Figures 6 and 7. Analysis of the % nUOS-P_{400} variable in Antequera (left) and Guadix (right). Source: PbA.

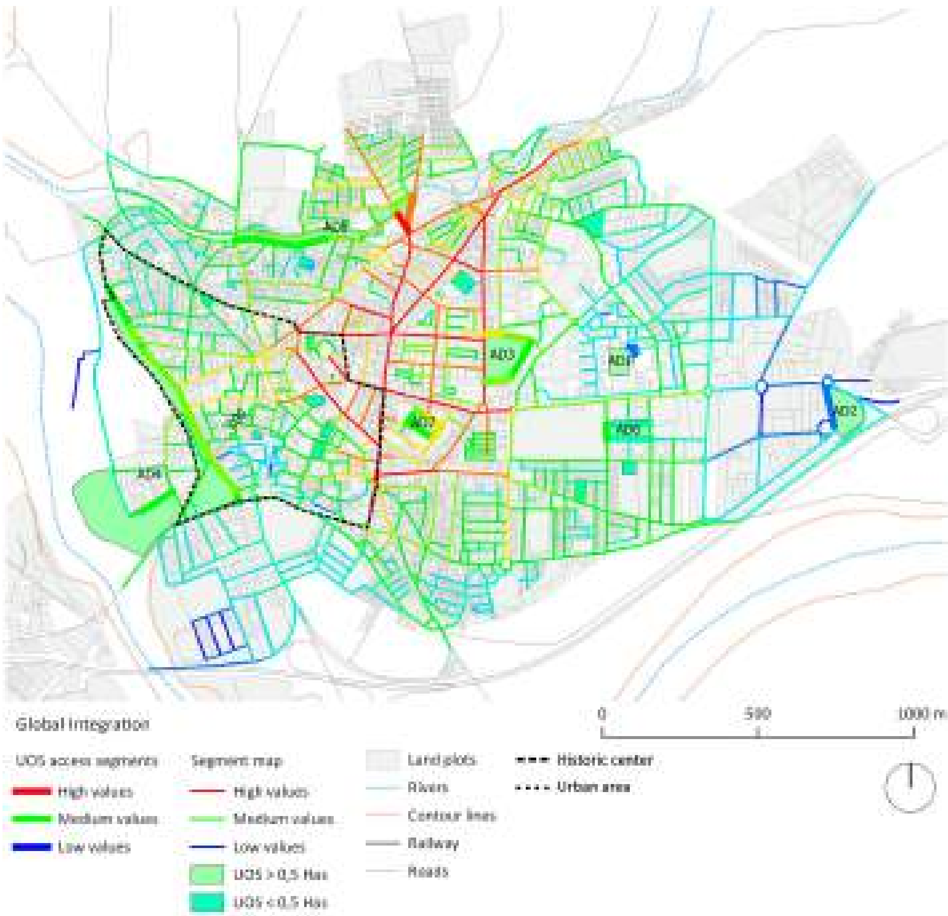


Figure 8. Analysis of the GIn variable in Andújar. Source: PbA.
Note: The UOS access segments have greater thickness than the rest.

Discussion

Table 1 shows the complexity of the functions that UOS must perform in cities according to the objectives of urban planning (Maruani & Amit-Cohen, 2007). It is confirmed that these functions do not all have the same relative importance. In our case, almost half of the reviewed references consider the functionality function (open space as support for the performance of activities) as the most important criterion that UOS must meet. On the other hand, less than a tenth refer to urban articulation from an exclusively morphological point of view. This last circumstance shows a certain distance between the current academic world and the theories of the late nineteenth century and some episodes of the twentieth century, which conceived open spaces as a central issue of urban form (Solá-Morales, 1994).

Table 2 lists the recent literature on the spatial configuration of UOS and their measurement using SS variables. There are some references that clearly highlight the importance of some variables over others (Raford & Ragland, 2004; Ratti, 2004), but most focus only on their applicability. The 'integration' variable is confirmed as the most important of all SS variables, with a study frequency of around two thirds of the total number of references consulted. It should also be mentioned that the frequency with which the reviewed literature refers to the residents of the respective fields of study is three times higher than the frequency of references to job centres.

Finally, the compilation and comparison of the relative importance of both the functions and the characterization and measurement variables of the UOS is performed in Table 3 through an AHP model, which is used to weigh the analysis results in each case. Table 5 shows the differences between weighted and unweighted urban open spaces classification. When weighted classification, all cases (AT, LN, RD) show a high number of instances.

According to Table 4, the size-range factor of cities seems to be one of the most influential parameters for reaching the highest values of the assessed variables. Such is the case of Linares, which is the largest MSC with the largest number and area of UOS, E_n and A_n, as well as the one with the largest number of main job centres close to the UOS. Andújar, however, is the city with the greatest accessibility to its open spaces (% UOS-P_{400}) and, in proportion (Table 5), the best equidistribution of UOS. So, we could say that Linares could be the best city to work in and Andújar could be the best city to live in, which is a possible scenario for commuters due to the relatively close proximity of one city to the other and the good communications between them. This circumstance allows us to verify certain evidence of territorial networks between some of these cities (Feria, 1987), resembling territories close to the 'city-region' concept (Secchi, 2004), although to weak degree.

Some particularities of the case study are listed as follows. (i) In general, the larger the area of open space, the more attractive it is. This is because, in addition to other functions, it has more possibilities to host certain activities that would not take place in other smaller spaces (Van Herzele & Wiedemann, 2003). However, there is not direct relationship between: (a) the open space size and (b) both the residential density and the number of job centres in proximity to each other. This has more to do with the open space location in the city. (ii) At the equidistribution level, Ronda (Figure 4) shows 'two cities in one': to the east we find the historical area, which has good conditions of global integration, while to the west there is an area of new urban growth with a lower number of main job centres. Between them, the central zone lacks open spaces >0.5 ha. (iii) The low level access to the buildings and job centres of both the UB1 and UB2 areas (Úbeda) stands out (Figure 5) due to the existence of large plots with predominantly industrial use, which are not very permeable between these areas and the main urban areas.

Finally, Table 5 compiles the results of the exploratory multivariable analysis. This makes it possible to classify the UOS according to a comparative ranking. This shows the position occupied by each of them in terms of the performance of equidistribution and social cohesion functions in each city. In this sense, the 'winners' open spaces are usually located: (i) in growth areas close to the historic centre but mainly outside of it; (ii) next to main and structuring streets; (iii) within urban fabrics of a certain regularity and medium block size; and (iv) within predominantly residential use areas. On the other hand, the 'losers' are often located: (i) within the outermost areas of urban growth; (ii) in residual positions; (iii) in areas of low density and weak urbanization; (iv) close to secondary roads; and (v) within predominantly non-residential use areas.

Conclusions

It has been demonstrated that it is possible to evaluate urban open spaces within the spatial configuration and the urban planning framework. The novelty of this work is the application of a methodology that integrates complex theories and analysis techniques (GIS, SS, AHP) with the same purpose. This allows progress to be made in detailing the information obtained, which is essential to address more complex current urban challenges related to open spaces. Likewise, the systematic examination of impact research in the study field was validated as an exploratory and complementary methodology for obtaining useful data, which allowed both the spatial characterization and weighting of the UOS planned functions.

The importance of urban morphology to the conditions that determine the functions of these spaces is verified. The classification of the UOS by ranking allows urban planning to identify which elements and aspects should be considered to manage the available economic and human resources strategically. The improvement of open spaces and their built environment could not only increase the habitability of cities but also help their socioeconomic and competitive development through the specialization of functions and the construction of territorial networks (Aguado-Moralejo, Barrutia, & Echebarria, 2013; Garrido Cumbrera et al., 2016; JA, 2006).

The results show that there is a lack of UOS equidistribution in the case study. To solve this problem several small UOS equally distributed by each city avoiding residual locations (e.g. Andújar) are preferable than a few large of them located in monofunctional districts (e.g. Antequera), which leads to a lack of use by citizens. On the other hand, more than half of the sample presents low or unbalanced ratio between both of these variables, which is an indicator of certain functional segregation. Likewise, the highest values of the driven indicators generally correspond to cities of the province of Jaén, while the lowest correspond to those of Granada. The cities of Málaga are in the average.

It is noted that the urban areas with the greatest potential for mixed land uses are the historic centre and the surroundings neighbourhoods. In them, the combination of centrality, residential density, job centres and accessible UOS should lead to vibrant and environmentally comfortable cities, improving their habitability. This can be a key factor in urban and regional planning in order to design urban renewal strategies, solve functional segregation impact problems and take a step forward in territorial development and balance.

There are UOS that show limited street network accessibility. This is because any of the following reasons: (i) they are located next to large non-residential uses and non-permeable plots that block UOS network connectivity (e.g. Andújar); (ii) UOS accesses are far from most streets (e.g. Úbeda). Additionally, it is of interest the fact that some of these large plots are of public use. Therefore, they would have street permeability potential if suitable planning arrangements were taken. Likewise, it is also interesting the urban articulation potential showed by some UOS when locating between different urban fragments such as districts or neighbourhoods.

The proximity between residential density and job centres within walkable and comfortable areas through the presence of accessible open spaces of suitable size is desirable and sustainable. For this reason, in general terms, the best distributed and socially cohesive UOS are those located in areas of spatial centrality and pedestrian presence, well connected to the main street network, free of barriers, and with a good number of access points in their perimeter.

In the work, some but not all of the UOS functions have been characterized and assessed according to a current urban planning framework. So that the analysis of other functions could be carried out in future research. Another important consideration has to do with the observation of periurban rural and agricultural areas of landscape value next to the case study cities (Pérez-Campaña, 2015). The study of the potential of these areas as possible open spaces serving citizens is of great interest.

It should be noted that the multivariable analysis carried out is theoretical and exploratory. It has not been verified through direct observations or similar to check whether indeed the winner spaces are the most appreciated by citizens and multifunctional in reality, and the loser spaces are just the opposite. The indicators used cannot logically cover all the situations to which the challenges and opportunities of the public space respond. A future development line of this work could add new observations and analysis to the study carried out in order to contrast the results obtained.

Disclosure statement

No potential conflict of interest was reported by the authors.

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