

1 Article

2 Supporting Children's Independent Activities in 3 Smart and Playable Public Places

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8 **Abstract:** The global process of urbanization, and the modification of social interaction determined
9 by the pandemic crisis poses the issue of the place of vulnerable users, and in particular children,
10 within the contemporary city. This research aims to elaborate a theoretical and methodological
11 framework, based on the concepts of affordance and capability, for analyzing the potential of
12 public spaces to enable and support children's independent activities. This potential, or meaningful
13 usefulness, is expressed by the Index of Meaningful Usefulness of public Urban Spaces (I_{UIS}). The
14 latter is calculated via the tool 'Opportunities for Children in Urban Spaces' (OCUS). This
15 methodology is applied to the analysis of significant public spaces within the historic center of the
16 city of Iglesias in Sardinia, Italy. The results reveal adequate usefulness of the selected spaces, while
17 underlining criticalities related to intrinsic spatial and physical attributes. The application to the
18 case study confirms the validity of the theoretical and methodological framework embodied in the
19 OCUS tool for supporting urban design and planning by orienting place-shaping processes
20 towards the acknowledgement of children's needs.

21 **Keywords:** public space; smart-city; children; affordance; Sardinia

23 1 Introduction

24 Global trends towards urbanization [1], and the related triumph of the city [2], intersect global
25 phenomena, including the climatic and the pandemic crisis [3,4], emphasizing the centrality of the
26 urban realm as the crucible of the human condition in the Anthropocene [5]. Within this perspective,
27 the ways in which the spatial, material and social structures of the city affect individual and
28 collective practices emerge as a global issue. Thus, the development of a theoretical and
29 methodological framework for assessing opportunities for people's practices across public spaces [6]
30 is central to orient place-shaping processes, particularly within the smart city paradigm and the
31 smart growth model [7]. The former, in fact, prefigures the prototype of a city that integrates ICTs
32 and data collection and analysis into governance practices to address in a systematic way the issues
33 of the contemporary city, while responding to citizens' expectations of transparency and
34 accountability. On the other side, smart growth underlines the relevance of density, diversity of
35 land uses, walkability and transit oriented development in terms of the sustainability of urban
36 settlements. A further relevant issue concerns the ways in which the articulation of public open
37 spaces can enable co-presence and functional proximity, while ensuring social distancing in the
38 post-pandemic era.

39 In particular, the place of children's developmental needs [8] within the power relationships
40 that orient place-shaping processes [9] has emerged as a global issue. Today, over a billion children
41 are growing up in cities [10]. The possibility of engaging significantly with the public space affects
42 children's bodily, emotional, social, and cognitive development while influencing their conduct and
43 affective relations as adults [11–13]. Despite the increasing relevance of this topic within different
44 disciplinary fields [14], existing methods and techniques for the analysis of public space quality from
45 children's points of view present several limitations including: i) reduction of children's experience

46 of the environment to distinct behaviors; ii) partial recognition of impacts of outdoor practices on
47 children's wellbeing; iii) failure to understand the effect of configurational factors on children's
48 behavior; iv) failure to recognize the relational character of opportunities embodied into the built
49 environment; Within this perspective, the authors build on the paradigm of soft-physical
50 determinism, and on the inherent relationship between place quality and place value [5,6] to
51 elaborate a theoretical and methodological framework for identifying and assessing the attributes of
52 the environment that affect children's outdoor independent activities. With respect to the four issues
53 emerging from the existing literature this research investigates four aspects: i) firstly the concepts of
54 Children independent activities (CIAs) in relation to the multi-dimensional character of children's
55 experience of public open spaces (POS) are analyzed. Consequently, the concept of meaningful
56 usefulness of a place is introduced. Secondly, the concept of capability [15] and affordance [16–18]
57 are studied. Consequently, usefulness is operationalized in terms of a set of qualitative and
58 quantitative indicators that measure site-specific and contextual factors. These indicators are
59 organized into the Opportunities for Children in Urban Spaces (OCUS) tool and are summarized by
60 the synthetic Index of meaningful usefulness of individual public spaces (IUIS). This article presents
61 results from a research [14,19–21] on the availability of POS to children's outdoor practices. This
62 research focuses on the definition of the methodological framework, and on the investigation of its
63 usability with respect to: i) test of techniques for the conduction of focus groups; ii) definition of the
64 layout of the OCUS tool, and verification of indicators in terms of availability of input data,
65 computational simplicity and speed, replicability, flexibility, and cost; iii) definition of techniques for
66 the results validation and testing in terms of computational simplicity and speed, reliability, and
67 cost.

68 The proposed methodology is applied to the assessment of significant urban spaces within the
69 historic district of the city of Iglesias in Sardinia (Italy). The city of Iglesias is selected as a case-study
70 for its conditions of demographic and socio-economic crisis. The paper is divided into six sections.
71 After the Introduction, a review of literature concerning children's experiences of outdoor spaces
72 elucidates the theoretical framework by defining the concepts of capability, affordance, and
73 meaningful usefulness. Next, the methodological framework and the case study are described. The
74 results of the application of the audit tool to the case study are presented in section 4, and the
75 findings are discussed in section 5. Finally, the conclusion discusses the relevance and the limitations
76 of this research and outlines its future development.

77 2 Literature review

78 The issue of the child-friendliness of the built environment is emerging as a relevant aspect of
79 the discourse on the Contemporary city. The impact on children's cognitive, physical and social
80 development of independent outdoor practices is the focus of studies across different disciplines.
81 Within this discourse different approaches can be recognized: i) Exploratory research, focusing on
82 the clear definition of research questions related to children's outdoor activities [22] ii) Explanatory
83 studies, focused on cause-effect relationship between built environment factors and outdoor
84 practices, combine the analysis of individual behavior, based on qualitative and quantitative
85 methods, and the measurement of built environment variables via spatial analysis techniques or
86 surveys [23–27]; iii) descriptive research, based on qualitative and quantitative techniques, focus on
87 the description of individual practices and perceptions related to the public space [28–30]. Within
88 this perspective, the collection of data related to individual behaviors and perceptions include both
89 qualitative and quantitative methods; qualitative techniques include focus groups, cognitive
90 mapping activity diaries, Surveys conducted through PPGIS tools, systematic direct observation and
91 interviews; on the other hand quantitative techniques are based on the utilization of accelerometers
92 and GPS devices. Several issues emerge from the existing literature concerning four aspects: i) the
93 reduction of children's interaction and dwelling with the material and social environment to specific
94 actions; ii) the non-exhaustive conceptualization of wellbeing, and of positive effects of children's
95 independent activities; iii) the non-recognition of the effects of extrinsic configurational properties of
96 the spatial layout on individual and group activities; iv) the failure to recognize the relational

97 character of opportunities and the significance of the plurality and diversity of opportunities as a
98 central determinant of children's behaviour.

99 More precisely, a relevant proportion of existing studies focus on a specific behavior, thus
100 overlooking the plural, multidimensional character of children-environment transactions and the
101 intimate connection among children's interactions with the material and social environment. Three
102 tendencies emerge: The first tendency include explanatory and descriptive studies focused on
103 children's active travel and independent mobility, [24–27]. Independent mobility is also
104 conceptualized as a proxy to physical activity [22]. The second tendency include descriptive and
105 exploratory studies focused on play and outdoor activities [11,31–34]. Lastly, the third tendency
106 includes descriptive studies focusing on physical activity and health as the resultant of both
107 independent mobility and outdoor play [26,28,35,36]. On the other side, descriptive and exploratory
108 studies building on the concept of affordance and affective relation, recognize and investigate the
109 plurality and interplay of children's functional, social and emotional interactions with the built
110 environment [12,23,37–40]. A relevant contribution is represented by the Bullerby model [41–43].
111 The latter operationalizes the child-friendliness of an urban environment as the resultant of the
112 number and diversity of positive and actualized possibilities, or affordances, and of the degree of
113 independent mobility.

114 Furthermore, existing studies tend to conceptualize wellbeing and, consequently, effects of
115 children's experience of public open spaces, primarily in terms of bodily health cognitive
116 development and socialization. In particular the meta-analytic review conducted by Sharmin and
117 Kamruzzaman [25] on 13 studies underlines a prevailing conceptualization of well-being in terms of
118 health, within explanatory research aimed at investigating the relationship between built
119 environment and independent mobility. On the other hand, Descriptive and explanatory studies
120 that recognize the plurality of children's interactions with the physical and social environment refer
121 to benefits of outdoor practices in terms of creativity and responsibility [44], agency and
122 development of tactics [12] and learning [38]. Furthermore, Chawla's literature review on benefits of
123 nature contact for children [11] introduces a comprehensive formulation, based on the concept of
124 capability, of positive effects of children's encounter with the natural environment.. Within this
125 perspective, well-being is conceptualized as the full development of fundamental human faculties.
126 A further issue emerging from the literature review regards the failure to ground environmental
127 properties in the relationship between attributes of the public spaces and individual abilities. Within
128 this perspective, in fact, a component of the built environment incorporates an opportunity for
129 action only if its attributes fit the abilities of the user or of a specific group of users [17,18,23]. The
130 relational quality of opportunities reflects an accurate account of places experience as mediated by
131 processes of perception-action and a conceptualization of spaces and environmental elements
132 relative to a specific individual and to a specific individual's activities [18]. Finally, with respect to
133 the effect of configurational properties of spaces on children's practices, existing studies tend to
134 focus on the effect of local properties of the spatial layout on active travel, independent mobility and
135 physical activity. Local configurational properties include connectivity [36], intersection density
136 [22,25,26,45]. Consequently, the effect of large-scale topological properties of the urban layout on the
137 accessibility of spaces and on patterns of natural movement, co-presence and of sense of privacy and
138 territoriality [46–49] are largely unexplored. In order to address the criticalities emerging from the
139 literature review, the concepts of Children's independent activities, usefulness, capability and
140 affordance are presented in the sub-sequent section.

141 2.1. *A Theoretical framework: concepts of usefulness, capability and affordance*

142 This paper focuses on the construction of a methodological framework for assessing the extent
143 to which the spatial, social, and material attributes of public spaces are conducive to children's
144 independent outdoor activities (CIAs). CIAs are herein defined as the complex of children's
145 practices carried out without adult supervision. These include independent mobility, or the freedom
146 and/or ability of children to travel across an urban space, play [33] and creative acts of claiming,
147 interpreting, and appropriating spaces [50].

148 The potential of public open spaces (POSS) to enable children's independent activities is here
149 referred to as usefulness. This concept hence reflects the conceptualization of child-friendliness as
150 the potential of the public open space to support intense engagement with the environment.
151 Nevertheless, while the concept of child-friendliness, as observed by Whitzman et al. [22], is
152 encompassed within a social and health planning perspective, the concept of meaningful usefulness
153 is introduced to focus the discourse on child-friendly cities on attributes of the built environment
154 incorporating opportunities for children's independent activities. Children's independent outdoor
155 activities are eminently related to positive effects on their well-being [11,13,24,28,30,51]. In general
156 terms, the benefits of outdoor activities can be re-conceptualised through the capability approach. In
157 Sen's words [15], a capability can be defined as the ability of an individual to achieve a specific
158 functioning – a 'doing' or 'being' part of the state of that person –deemed as valuable. Martha
159 Nussbaum [52–54], underlines the necessity of individuating a list of capabilities central to good
160 human life. According to Nussbaum, these central capabilities include life; bodily health; bodily
161 integrity; affiliation; practical reason; play; senses, imagination, and thought; emotions; connection
162 to nature; and control over one's environment [53]. Within this perspective, well-being can be
163 conceptualized as the full achievement and exercise of fundamental human faculties; hence the
164 concept of capability is central to the comprehensive conceptualization of the effects of outdoor
165 independent activities on children's well-being [15].

166 Furthermore, the concept of capability implies the availability of different opportunities, as a
167 factor influencing the set of alternative attainable functionings that constitutes the capability set [15].
168 In this respect, the external opportunities are conceptualized through the affordance theory.
169 Affordances can be defined as the functional, emotional, and social opportunities and constraints
170 incorporated into a setting in relation to a specific individual or to a specific category of individuals
171 [17,18,43,55,56]. Affordances thus incorporate relations between the abilities of a specific group of
172 individuals and the attributes of the environment. Hence, affordances are relational [18,57]. This
173 characteristic emphasizes the relevance of the affordance concept within a theoretical framework for
174 interpreting the ways in which the built environment affects the behavior of a specific group of
175 individuals. Specific functional, emotional and social affordances, affecting patterns of children's
176 activities are identified by Heft [17], Lerstrup and Van Den Bosch [37], Kyttä [23], and Broeberg et al.
177 [38]. These categories, and the attributes of variation and uniqueness, size and gradation, novelty
178 and change, and abundance of environmental features, constitute the foundation of the layout of the
179 OCUS tool, which is described in the following sections.

180 Lastly, a further class of opportunities influencing children's independent activities is
181 systematized through the concept of accessibility. According to Moore [58], both the diversity of
182 resources, described via the functional, social and contextual affordances dimensions, and the access
183 to resources define the quality of children's environment [6,38,58,59]. In particular, the
184 movement-related component of accessibility is related to the configuration of urban space.
185 Configuration refers to the topological properties of a spatial structure and can be defined as a set of
186 relationships among parts, all of which interdepend in a citywide structure [46,48,60–63].

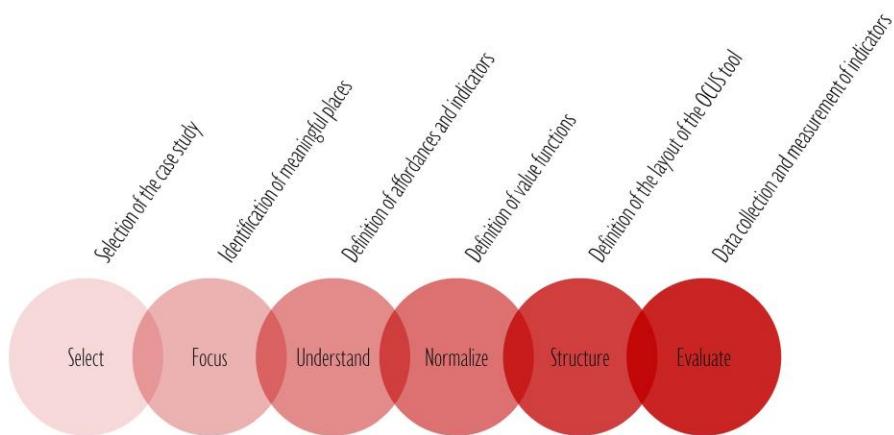
187 These concepts constitute the theoretical model encompassing a methodology for the
188 assessment of the usefulness of the public space. Within this model, the meaningful usefulness of a
189 setting is determined by the accessibility conditions and by environmental features and amenities [9]
190 that, in relation with children's characteristics, produce functional, social, and emotional
191 affordances. The meaningful usefulness of public spaces, in turn affects children's well-being by
192 encompassing the external conditions shaping their central capabilities [53]. In particular, the
193 opportunities for children's engagement with the built environment are related to bodily health,
194 bodily integrity, or the ability to move freely from place to place, sense, imagination and thought,
195 emotion, herein defined as the ability to develop attachment to things and people, affiliation, play
196 and control over one's environment [11,50,52,53,64].

197 In the following section, the Methodological framework for assessing the meaningful
198 usefulness of public spaces, the "Opportunities for Children in Urban Spaces" tool is described.

199 **3 Methodology**

200 The Opportunities for Children in Urban Spaces (OCUS) tool is envisioned as an audit tool that
201 integrates quantitative and qualitative indicators for measuring the conditions of access to open
202 public spaces and the availability, quality, and variety of functional, emotional, and social
203 affordances, that are determined by the conditions of the built environment at different scales (see
204 Table 1). The OCUS tool combines the analysis of primary data collected during on-site explorations
205 as well as secondary data collected from territorial informative systems (Sardinia Regional
206 Informative Territorial Service, Open Street Map) and from Internet-based street level imagery
207 services (Google Street View) and territorial imagery services (Google Maps, Google Earth, Bing
208 Maps). The audit tool incorporates a methodological framework organized on six stages (see Figure
209 1).

Process



210

211 **Figure 1.** The seven stages of the analytical process

212 The first stage is characterization of the case study, consisting in the definition of the area of
213 study and of the group of users in relation to which the meaningful usefulness of a public space is
214 assessed. The second stage is a focus group, involving children, for individuating meaningful places
215 and transactions with spaces and elements of the public space. The third stage is the individuation of
216 environmental features associated with specific affordances and the individuation of indicators
217 according to criteria of objectivity; relevance); measurability and reproducibility; validity;
218 representativeness, comparability over time, applicability, and understanding [14]. The fourth stage
219 is that of definition of use-value functions and quality thresholds for normalizing and aggregating
220 single indicators. The fifth stage is that of definition of the layout of the Audit tool and of a function
221 for summarizing the single indicators into a synthetic Index of Meaningful Usefulness of public
222 Urban Spaces (IUIS). The sixth stage is that of data collection, measurement of single indicators, and
223 evaluation of the meaningful usefulness of the significant public spaces within the area of study via
224 the determination of the value of the IUIS Index.

225 Primarily, the developmental character incorporated in the concept of affordance compels the
226 definition of the group of users considered. The recent research focuses on children attending
227 secondary school and aged between 11 and 14 years. According to Shaw et al. and Carver et al.
228 [27,65], this range is consistent with existing studies on children's experiences of place and reflects
229 sensible variations in children's levels of independent mobility. In particular, age and school level
230 together emerge as relevant correlates of children's levels of independent mobility, and, particularly,
231 major progresses in children's independence coincide with the transition from primary to secondary
232 school. Furthermore, at age 14, the majority of children are allowed to cross major roads, travel

233 alone on local buses, and independently go to school and to relevant places within walking distance
 234 from home.

235 The definition of the case study was based on a focus group involving 24 children, 12 boys and
 236 12 girls, aged 11 to 14 years, from a secondary school located in Iglesias, Sardinia, Italy, the
 237 Comprehensive Institute "Eleonora d'Arborea". In particular, five participants were aged between
 238 10 and 11 years, 12 were aged 12 years, and 7 were aged between 13 and 14 years. All participants
 239 resided in Iglesias. The involvement of 24 children was based on the saturation principle and on
 240 the phenomenological approach, known in literature on qualitative research [14,21,66–69].

241 The subject of the focus group was locating on a map of the city of Iglesias significant
 242 functional, emotional, and social affordances. The objective was twofold. On one hand, the objective
 243 concerned the individuation of meaningful places, or spaces imbued with behavioural,
 244 psychological, and symbolic meaning [40]. On the other hand, the focus group was aimed at
 245 underlining situations and activities valued by children as meaningful; these preliminary findings
 246 were used to revise the taxonomy of elements of the public space incorporated into the audit tool.

247 The focus group was part of a workshop for children between the ages of 11 and 14 on sensory
 248 territorial explorations. The aim was to promote and develop children's abilities to describe the
 249 landscape of their everyday practices, and to investigate children's experience of public space, in
 250 order to increase awareness among decision-makers and the general public of children's right to
 251 mobility within a city. The format of the workshop was elaborated in the context of the regional
 252 program "Tutti a Iscol@". The Comprehensive Institute "Eleonora d'Arborea" was the first to
 253 volunteer to be involved in the workshop. According to the program regulations, a group of 24
 254 children was selected by the teaching staff, among those interested in the proposed activity. The
 255 criteria for the selection of the final group included knowledge of basic principles of photography,
 256 degree of command in the use of apps for editing images and texts.

257 Environmental features and attributes associated with functional, emotional, and social
 258 affordances are then individuated according to the existing literature on children's independent
 259 mobility and place experience, as illustrated in Table 1. Primarily, functional affordances are related
 260 to specific site-specific features: hence, the functional affordances of walking, running, cycling, and
 261 playing ball are related to the presence of flat, void, relatively smooth surfaces. Likewise, the
 262 affordances of hiding, prospect, and sitting in are associated with the availability of enclosed spaces,
 263 hence of a space bounded on three sides or covered by a ceiling of height not superior than 2.50
 264 metres. Finally, rigid features include non-movable features (including trees, retaining walls,
 265 benches, and stairs) that afford sitting-on, jumping-on/over/down-from, running around, hiding
 266 behind, or building on [14,17,19,37].

267 **Table 1.** Indicators incorporated into the OCUS tool.

Affordance	Environmental features	Indicator
Functional affordances		
Walking, running, cycling, playing ball	Open ground	Ind. potential appropriation of open grounds (presence, size, quantity, variety)
Rolling/ sliding/running down, rolling objects down, jumping down, jumping over, sitting in	Sloping Terrain	Ind. potential appropriation of sloping terrains (presence, gradation, quantity, variety)
Hiding, as frame, microclimate	Repaired space	Ind. potential appropriation of repaired spaces (presence, quantity, variety)
Sitting-on, jumping, running	Rigid features	Ind. potential transaction with

around, hiding behind, Climbing, balancing-on, hanging by arms, hanging in legs		rigid features (presence, quantity, variety)
Drawing, scratching, throwing, hammering, batting, building	Loose objects	Ind. potential manipulation of Loose objects (presence, quantity, variety)
Splashing, pouring, floating objects, drinking	Water	Availability of Water (presence, quantity, variety, size)
Following, catching, caring for	Nature situations	Presence of vegetation, animals, insects, birds
Emotional affordances		
Feeling safe	Natural control of the pos	Eyes on the pos
Pleasant place	Conspicuousness	Imageability of the POS
Quiet	Acoustic Environment	Quality of the acoustic environment
Clean public space	Maintenance of POS	Cleanliness of surfaces, equipment
Luminous	Illumination	Ind. Of potential usability of the POS during night hours
Social affordances		
Meeting friends	Meeting places	Through-movement potential (Local syntactic choice (Normalized angular choice, R400)
Privacy/Control	Sense of privacy and territoriality	Topological step depth from segments of natural movement
Being with adults	Intergenerational activities	Presence of intergenerational activities
Make new friends	Anchor places	Presence of anchor places within a 400 m buffer (Sports facilities, Educational institutions, shopping malls, formal sites for play)
Lively	Presence of people	Index of liveliness of the public space (Presence of outdoor activities/Dining outside)
Accessibility		
Access	Access for pedestrian movement	Angular Integration R400
Access by walking alone or with friends	Accessible pedestrian network	Category of contiguous pedestrian facilities
Dealing with vehicular traffic	Priority of vulnerable	Barrier effect (Main entrance or

	users and soft mobility modes	worst condition)	
	Access by cycling alone or with friends	Accessible Bicycle facilities	Category of contiguous bicycle facilities

268

269 Emotional and social affordances as well as accessibility conditions are associated with both
 270 site-specific attributes and with large-scale factors related to the configuration of the urban structure,
 271 to density, and to land-use patterns. For instance, the emotional affordance of feeling safe is
 272 associated with the natural surveillance of the public space [70], which in turn depends on the
 273 perception of social incivilities, configurational aspects of the urban structure influencing pedestrian
 274 movement, and compositional aspects of a public space. Natural surveillance is thus operationalized
 275 in terms of sub-indicators assessing the visibility of the nearest buildings, the interactivity of facades
 276 and residential density [71,72], the presence of signs of neglect, and/or the evidence of antisocial
 277 practices [24]. Moreover, the compositional aspects include prospect, or the ability to see into a place
 278 where someone can be hiding, and boundedness, defined as the degree of enclosure of a space that
 279 limits the possibility to escape [73]. Finally, configurational aspects refer to local normalized angular
 280 choice [47], or the probability that a space comprises the shortest paths among all pairs of spaces in
 281 the urban structure.

282

283 The affordance of being in a pleasant place is associated with the conspicuousness of a space,
 284 which is operationalized via the indicator imageability of the public space. The latter aggregates
 285 sub-indicators that assess the presence of unique elements - including public art, ruins,
 286 geological/vegetation formation [9] - the visibility of major landscape features [74], the articulation of
 287 edges [20]- related to the heterogeneity of spatial conditions along the boundaries of a space - and
 288 the complexity and density of retail activities and services. The latter refers to the number of store
 289 frontages per 100 metres of linear extension of facades delimiting a particular public space.
 290 According to Gehl [71], in vibrant public spaces, retail activities frontages are between 5 and 6
 metres wide, thus corresponding to between 15 and 20 interactive façades in 100 metres.

291

292 The affordance of meeting friends is associated with the significance of a space as a meeting
 293 place, according to its through-movement potential, and the possibility of making new friends is
 294 associated with the proximity of anchor places, hence of primary functions determining the
 295 concentration of users, including educational institutions and sport and recreational facilities.
 296 Furthermore, the sense of privacy and territoriality is associated with the proximity of public spaces
 297 to the primary lines of pedestrian movement. In fact, according to Hillier [46], children tend to
 298 concentrate in the most integrated spaces distinct from spaces of adults' natural movement. Finally,
 299 the conditions of accessibility of a space are associated with its potential to attract movement,
 prioritise vulnerable users, and to connect with comfortable pedestrian and bicycle facilities.

300

301 Finally, with respect to the indicators assessing built environment correlates of independent
 302 access to public space, the indicator 'R400 angular integration' measures the to-movement potential
 303 of a space, or its potential as a destination. This potential is conceptualized as the resultant of the
 304 proximity of a space to all other segments, within a radius of 400 metres, in terms of the sum of
 305 angular changes that are made on each route. Selecting a set of spaces within a 400 metres radius, in
 particular, is instrumental to the analysis of patterns of pedestrian movement [48].

306

307 The qualitative and quantitative indicators and sub-indicators are organized into four
 308 categories: i) functional opportunities, ii) social opportunities, iii) emotional/contextual
 opportunities, and iv) independent accessibility opportunities.

309

310 The individual indicators are then normalized by assigning a score ranging from 0 to 4, as
 311 illustrated in Table 2, where 0 indicates a poor condition, 1 equals inadequate, 2 adequate, 3
 312 corresponds to a fair/good condition and 4 indicates an optimal condition. The score varies
 313 according to the level of performance established, for each indicator, according to a qualitative or to
 314 a quantitative scale. In particular, for quantitative indicators, levels of performance correspond to
 bands of values, determined by subdividing in equal intervals a range defined by the minimum and

315 maximum values observed in the area of study or based on threshold values derived from the
 316 literature (see Table 2).

317 **Table 2.** Examples of indicators and scoring procedures.

Indicator	Type	Measurement	Scale	Score
Quantitative	Sub-indicator 1 (S ₁) Size (L ₁ and/or L ₂)	70 m ≥ L ₁ and L ₂ > 25 m	4	
		100 m ≥ L ₁ and/or L ₂ > 70 m	3	
		25 m ≥ L ₁ and L ₂ > 15 m	3	
		15 m ≥ L ₁ and/or L ₂ > 6 m	2	
		(L ₁ and/or L ₂) > 100 m	1	
		6 m ≥ (L ₁ and/or L ₂)	0	
	Sub-indicator 2 (S ₂) Quantity	= 0 region of open ground	0	
		= 1 OR 2 reg. open ground	2	
		> 2 regions of open ground	4	
Ind. potential appropriation of open grounds	Sub-indicator 3 (S ₃) Regularity	Rectangular shape	4	
		Triangular, T- or L-shape	2	
		Linear shape	1	
		Not regular shape	0	
	Sub-indicator 4 (S ₄) Availability	Restrictions on Access	0.1	
		Constraints on uses	0.2	
		Competition for space	0.3	
		Time/coupling constraints	0.5	
		Manicured spaces	0.8	
		Available	1	
To-movement potential, Angular Integration R=400m	Quantitative	Total	[(S ₁ +S ₂ +S ₃)/4]* S ₄	0-4
			First Band	4
			Second Band	3
			Third Band	2
			Four Band	1
			Fifth Band	0
	Quantitative	Presence of an element x within a n-meters radius	Present (R100m)	4
			Present (R200m)	3
			Present (R400m)	2
			Absent	0
		N of topological steps	Td = 1	4
Topological step depth from	Quantitative		2 ≤ Td ≤ 3; Td = 0	2

segments of natural movement	$3 \leq Td \leq 10$	1
	$10 < Td$	0

318

319 With respect to the functional opportunities dimension, in particular, each indicator is
 320 determined by first calculating the mean of the values of sub-indicators measuring the quantity,
 321 variety and uniqueness, regularity, and size and gradation of a specific class of environmental
 322 features, and then by weighting the result according to a sub-indicator that expresses an availability
 323 measure. This availability-related sub-indicator is conceptualized as a factor ranging from 0.1 to 1
 324 where values close to 0.1 indicate limited availability of affordances and values close to 1 reflect
 325 opportunities for children to freely actualize potential affordances. Hence, the availability-related
 326 sub-indicator expresses to what extent socio-cultural constructs (including norms, habits,
 327 conceptualizations, and shared values) or physical constraints inhibit children's independent
 328 activities. More specifically, constraints include restrictions on accessibility, regulations preventing
 329 specific activities, conflicts among children's practices and adults' activities, time or coupling
 330 constraints determined by adults' control of specific facilities or amenities, and the manicuring of
 331 spaces [11,44]. Furthermore, regarding indicators that measure configurational properties, in case a
 332 space is intersected by several segments, the value of the configurational variable equals the value
 333 calculated for the most integrated segment, if the longest dimension of the considered space is less
 334 than 70 metres; otherwise, the value of the indicator related to the configurational variable is equal to
 335 the mean of the values calculated for all the segments that intersect the considered space. The
 336 70-metre measure is derived from Gehl [71] and is indicated as a relevant social distance that
 337 influences the significance and content of interactions among individuals.

338 For each affordance category, the relative single indicators are then aggregated into a synthetic
 339 index. Hence a functional affordances index (I_f), a social affordances index (I_s), an emotional
 340 affordances index (I_e) and an independent accessibility index (I_a) are computed. Each index is
 341 calculated dividing the sum of the values determined for the relative individual indicators by a
 342 potential value, which is determined as the sum of the maximum values assignable to each indicator.
 343 Hence, each index is expressed by a value ranging from 0 to 1, where values close to 0 equal
 344 marginal quality of the public space and values close to 1 indicate good to optimal conditions in
 345 terms of opportunities for children's independent practices (see in detail Table 3).

346
347

Table 3. Examples of determination of the Index of Meaningful Usefulness of public Urban Spaces (I_{UIS}) and the Index of Meaningful Usefulness of public Urban Spaces modified (I_{UISm})

Index	Measurement	Scale	Rating
I_{UIS}	$\frac{[(\sum I_{fi} + \sum I_{ej} + \sum I_{sk}) / P_{f+e+s}] * I_a}{(P_{f+e+s} = 68)}$	$1.00 \geq I_{UIS} \geq 0.85$	Optimal
		$0.84 \geq I_{UIS} \geq 0.75$	Good
		$0.74 \geq I_{UIS} \geq 0.65$	Fair
		$0.64 \geq I_{UIS} \geq 0.55$	Adequate
		$0.54 \geq I_{UIS} \geq 0.35$	Inadequate
		$0.34 \geq I_{UIS} \geq 0.15$	Poor
		$0.14 \geq I_{UIS} \geq 0.00$	Null
$I_f; I_e; I_s; I_a$	$(\sum I_{ij}) / P_j$	$1.00 \geq I \geq 0.85$	Optimal
	$P_f = 28$	$0.84 \geq I \geq 0.75$	Good
	$P_e = 20$	$0.74 \geq I \geq 0.65$	Fair
	$P_s = 20$	$0.64 \geq I \geq 0.55$	Adequate
	$P_a = 16$		

0.54 ≥ I ≥ 0.35	Inadequate
0.34 ≥ I ≥ 0.15	Poor
0.14 ≥ I ≥ 0.00	Null

348

349 Next, the Index of Meaningful Usefulness of public Urban Spaces (IUIS) is calculated (Table 3)
350 in two steps. Primarily, the sum of the values assigned to single indicators included in the functional,
351 emotional, and social affordances categories is divided by their potential maximum value. Then, the
352 resulting value is multiplied by the value of the Independent accessibility Index. The result is a value
353 ranging from 0 to 1. The IUIS index, thus, synthetically expresses the usefulness of a space as the
354 resultant of the quantity, quality, and variety of opportunities for significant experiences
355 incorporated into environmental features, mediated by the possibility of perceiving and actualizing
356 potential affordances. The latter in turn is related to conditions for frequent and independent access
357 to a specific public space.

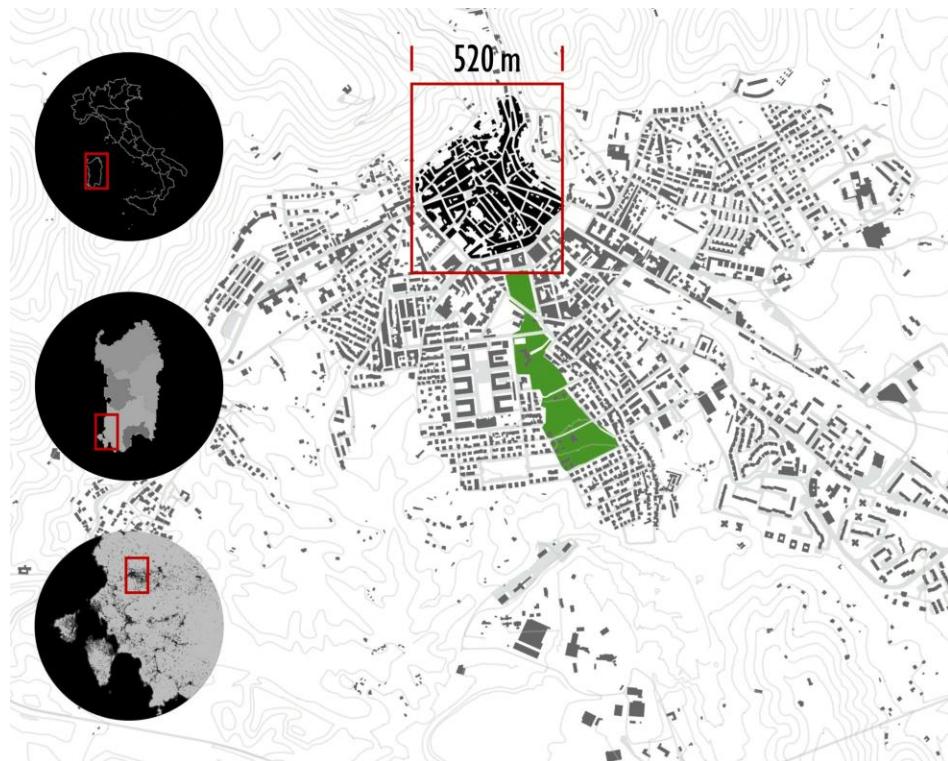
358 For the IUIS index, values close to 1 refer to optimal levels of meaningful usefulness of the
359 public space and values close to 0 refer to marginal levels of inclusivity of a setting from children's
360 perspective (see in detail Table 3).

361 This article focuses on the presentation of OCUS procedure, and on the investigation of its
362 usability via its application to a set of public spaces across the historic centre of the city of Iglesias.
363 Further clarifications on the criteria for the selection and characterization of the case study are
364 presented in the initial paragraph of the succeeding section.

365 3.1. Selection of the case study

366 The proposed methodology was applied to the assessment of meaningful urban spaces within
367 the historic district of the city of Iglesias in Sardinia (Italy) (Figure2). The city of Iglesias was selected
368 as a case study for its particular demographic and socio-economic conditions, including the modest
369 percentage of residents aged between 11 and 14 years, depopulation, and stagnant economy. In fact,
370 regarding the first issue, children aged between 11 and 14 years represent the 2.8 % of the population
371 compared to a national average of 3.7%, a regional average of 3.3% and to a value for the city of
372 Cagliari of 2.8% [75].

373



374

375 **Figure 2.** Selection of the area of study

376 The trend toward depopulation was confirmed by the loss of 929 inhabitants in the time span
377 2014-2019 - from 27444 to 26515 inhabitants -, equal to a decrease of 3.4% , while economic
378 stagnation was underlined by the gap in terms of GDP per capita with the national and regional
379 average. In fact, for the city of Iglesias the GDP per capita was equal to 19200 euros per year,
380 compared to a national average of 26000 euros per year, a regional average of 20600 euros per year,
381 and a value of 25681 euros per year for the city of Cagliari, which represents the administrative
382 center of the Sardinia Region [76-78]. Building on the examples of Sidney, Rotterdam, and
383 Vancouver [79,80], interventions aimed at increasing the inclusivity, liveliness, and usefulness of
384 public spaces from the point of view of children are instrumental in making cities attractive to
385 families, attracting and retaining a skilled workforce, and, thus, driving a local economy and
386 reversing trends toward depopulation.

387 The OCUS tool was been applied to the analysis of nine public open spaces within the historic
388 district of the city of Iglesias, selected during the workshop of territorial sensory exploration. In a
389 first stage of the Workshop, children were presented with a map of the city of Iglesias and asked to
390 locate meaningful places in terms of actualized affordances. Then, once the set of meaningful places
391 was established, five itineraries of sensory exploration were defined. Each itinerary investigated a
392 specific theme related to a specific functional, symbolic, or behavioural value attributed by children
393 to the public space. The five themes were: i) food, ii) meeting places, iii) transitory spaces, iv) space
394 of memory, and v) boundary spaces. Spaces incorporating different values were then selected and
395 analyzed via the OCUS tool. These spaces included to Quintino Sella Square, Via Giacomo Matteotti,
396 Via Cagliari, Lamarmora Square, Pichi Square, Municipio Square, Collegio Square, and San
397 Francesco Square (Figures 3 and 4).

398 The historic districts of Iglesias, furthermore, are characterized by a compact structure and
399 present several characters conducive to child-friendliness: mixed uses, a continuous network of
400 pedestrian areas and limited traffic routes, an integrated spatial structure, pedestrian accessibility,
401 and diversity in terms of retail, cultural, and commercial offerings including a theatre, libraries,
402 accommodation structures, restaurants, caf  s, and shops. In the following section, the results of the

403 application of the OCUS tool are presented, and the meaningful usefulness of the selected public
404 spaces is analysed.



405

406 **Figure 3.** Meaningful places within the historic district of the City of Iglesias, Sardinia, Italy.



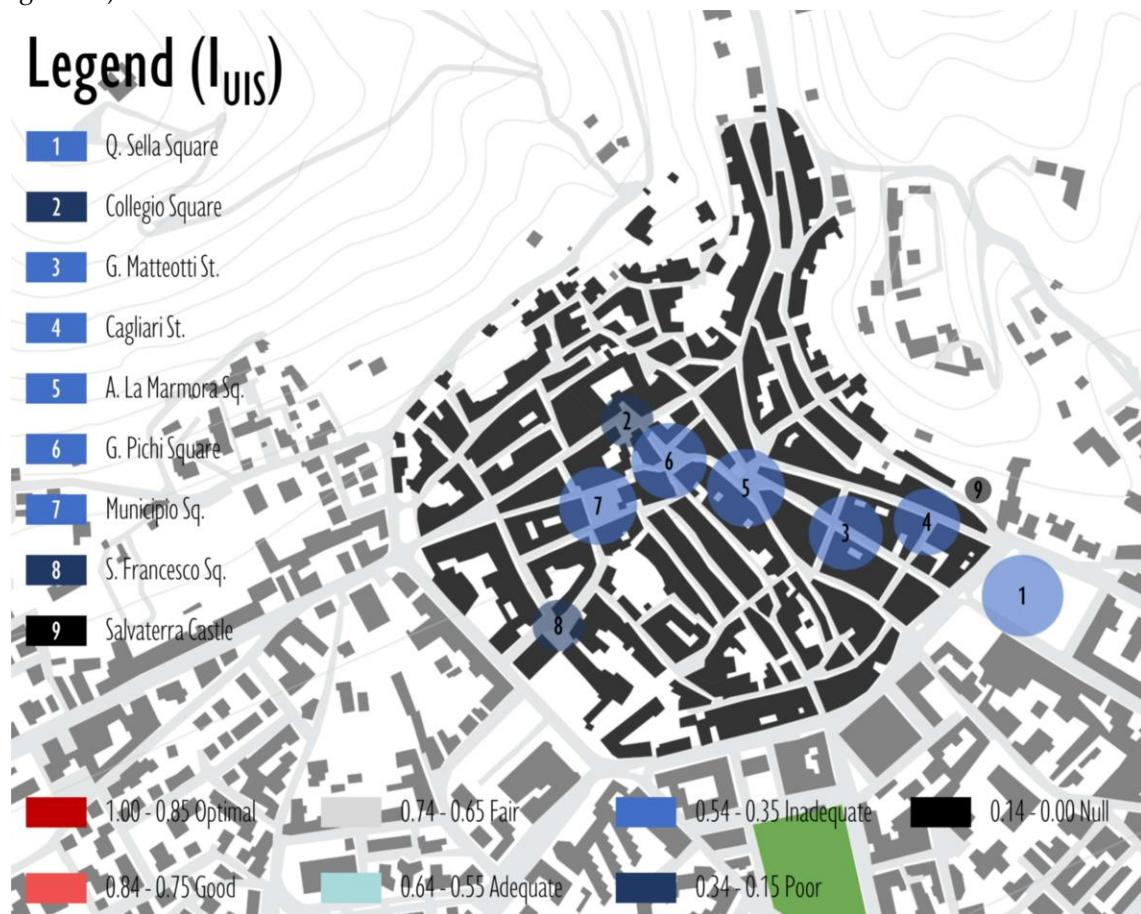
407

408 **Figure 4.** Q. Sella Square, G. Matteotti Street, Cagliari Street, La Marmora Square and Salvaterra
409 Castle.

410

411 4 Results

412 The application of the Tool to the case study, as illustrated in Table 4, reveals that the
 413 meaningful usefulness of the selected places is marginal for Collegio Square (IUIS equal to 0.28), San
 414 Francesco Square (IUIS = 0.27), and Salvaterra Castle (IUIS = 0.06) and modest for the remaining
 415 spaces, with values of IUIS ranging from 0.35 for Cagliari Street to 0.43 for Quintino Sella Square.
 416 (Figures 5).

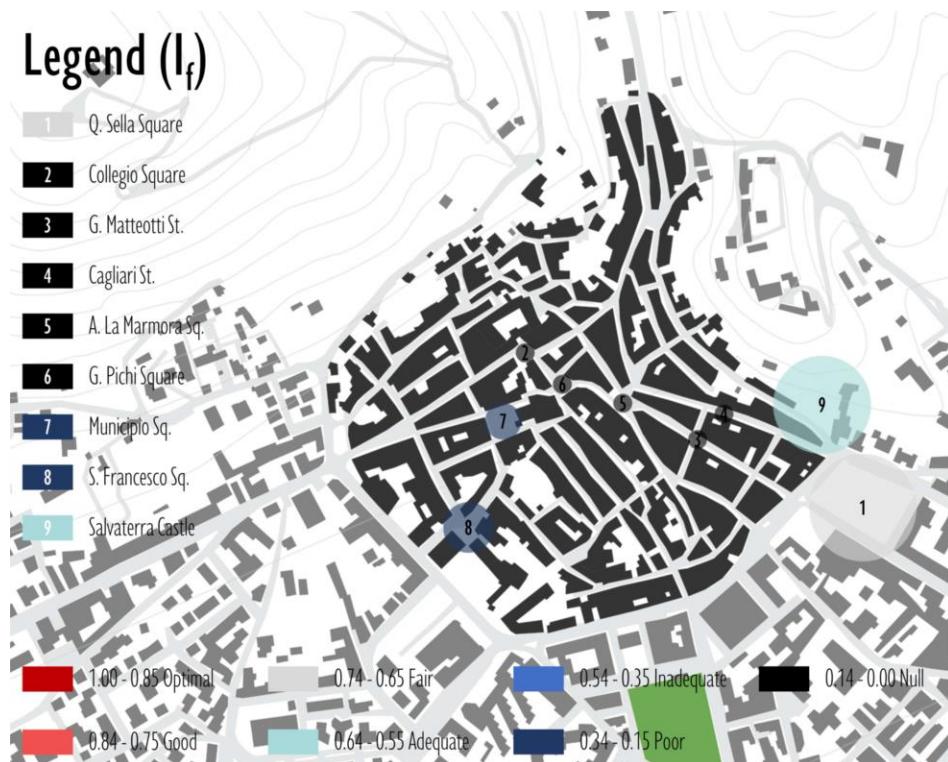


417

418 **Figure 5.** Distribution of values of the IUIS Index across the meaningful places within the historic
 419 district of the City of Iglesias, Sardinia, Italy.

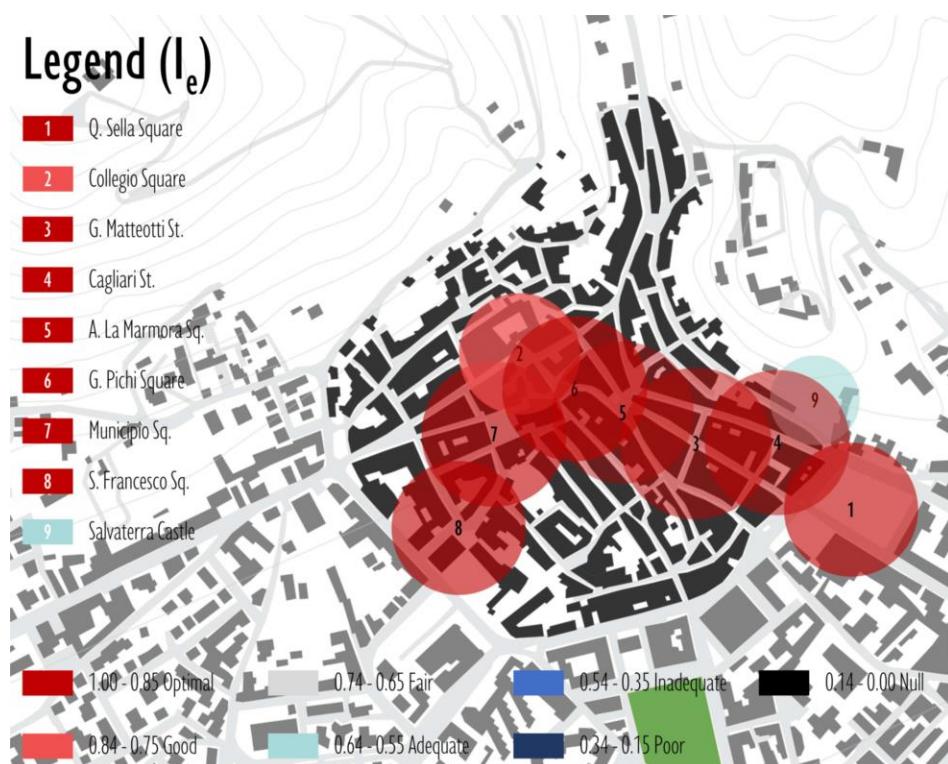
420 In particular, the modest levels of meaningful usefulness are influenced by the limited
 421 availability, quantity, and diversity of functional affordances incorporated in the built environment.
 422 In fact, with regard to the index of functional affordances, as illustrated in Figure 6, the usefulness of
 423 the public spaces is assessed as fair for Q. Sella Square (I_f equal to 0.68), adequate for Salvaterra
 424 Castle (I_f equal to 0.62), poor for Municipio Square and San Francesco Square (I_f equal respectively to
 425 0.23 and to 0.32), and null for the remaining places (I_f ranging from 0.03 for Collegio Square to 0.09
 426 for Via Cagliari). A different situation is observed regarding emotional and social affordances. In
 427 particular, the values calculated for the index of emotional affordances range from 0.57 for
 428 Salvaterra Castle to 0.96 for Via G. Matteotti, thus denoting levels of usefulness, in terms of
 429 opportunities for meaningful emotional experiences, ranging from adequate to optimal (Table 4)
 430 (Figure 7). In particular, conditions determining the perceived safety of public spaces were assessed
 431 as optimal for Q. Sella Square, La Marmora Square, and G. Matteotti Street; as good for Municipio
 432 Square, Collegio Square, Pichi Square, and Cagliari Street; as fair for San Francesco Square; and as
 433 poor for Salvaterra Castle. Likewise, the selected public spaces incorporate opportunities for social
 434 interactions to a great extent in the cases of Collegio Square, La Marmora Square, Pichi Square, and
 435 Municipio Square (I_s equal, respectively, to 0.85, 0.85, 0.85 and 0.8). Adequate levels of usefulness, in
 436 terms of social affordances, were also observed in Q. Sella Square, G. Matteotti Street, and Cagliari

437 Street (I_s equal to 0.75). On the other hand, a scarcity of opportunities for significant social
 438 interactions was observed in San Francesco Square (0.45) and in proximity of Salvaterra Castle ($I_s =$
 439 0.10) (see in detail Table 4 and Figure 8).



440

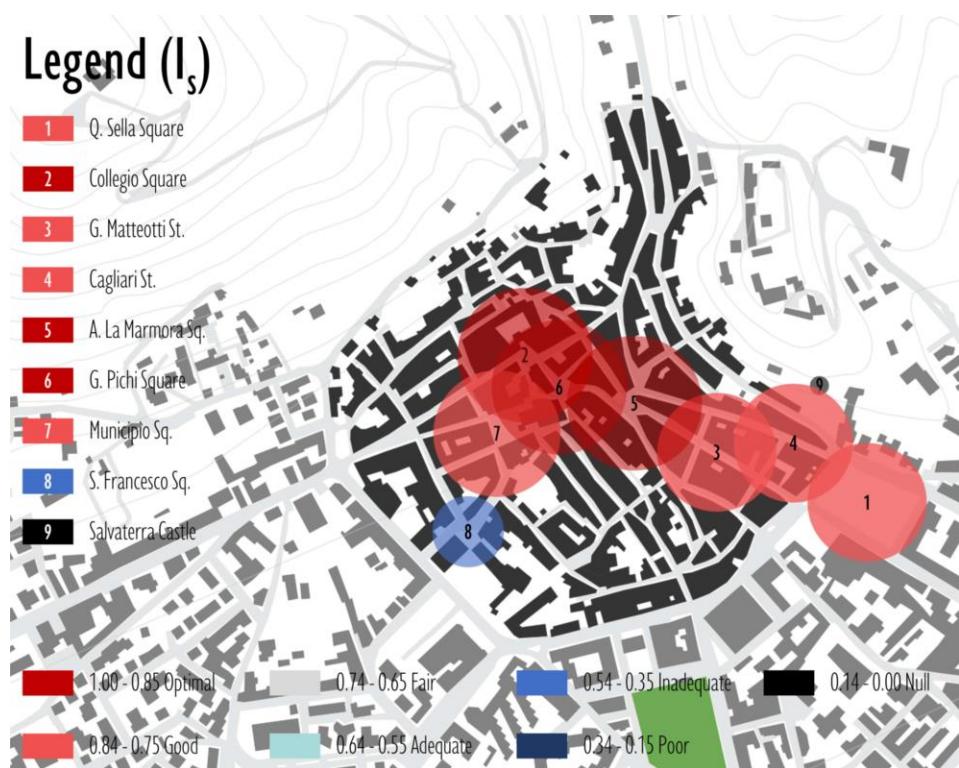
441 **Figure 6.** Distribution of values of the If Index across the meaningful places within the historic
 442 district of the City of Iglesias, Sardinia, Italy.



443

444 **Figure 7.** Distribution of values of the Ie Index across the meaningful places within the historic
 445 district of the City of Iglesias, Sardinia, Italy.

446



447

Figure 8. Distribution of values of the I_s Index across the meaningful places within the historic district of the City of Iglesias, Sardinia, Italy.

449

Finally, the Index of independent accessibility (I_a) reveals that children's possibilities for autonomously and safely accessing the public space are high in the cases of G. Matteotti Street, La Marmora Square, Pichi Square, Municipio Square, and Cagliari Street (I_a respectively equal to 0.75; 0.75; 0.75; 0.69; 0.67); adequate for Q Sella Square and Collegio Square (I_a equal, respectively, to 0.57 and 0.56); modest for San Francesco Square (I_a = 0.52); and marginal for Salvaterra Castle (I_a = 0.14) (Table 4) (Figure 9).

455

In particular, the priority of vulnerable users, measured by the Barrier effect indicator, is maximum for G. Matteotti Street, Cagliari Street, La Marmora Square, Pichi Square, and Municipio Square (measures ranging from 0.94 to 1); high for Collegio Square (0.75) and San Francesco Square (0.81); medium in the proximity of Salvaterra Castle (0.56); and limited for Q. Sella Square (0.53).

459

Moreover, the to-movement potential of a space, hence its potential to emerge as a destination, measured by the Angular Integration within a 400 metres radius (R_{400} AI), is significant for Collegio Square, G. Matteotti Street, La Marmora Square, and Pichi Square (R_{400} AI values superior than 127.54); good for Q. Sella Square, Cagliari Street, Municipio Square, and San Francesco Square (R_{400} AI values ranging from 96.43 to 127.53); and scarce for Salvaterra Castle (R_{400} AI values inferior than 34.21).

465

466

Table 4. Values of the I_{UIS} , I_f , I_e , I_s and I_a indexes for the selected area of study

	Q. Sella Square	Collegio Square	G. Matteotti Street	Cagliari Street	La Marmora Square	G. Pichi Square	Municipio Square	S. Francesco Square	Salvaterra Castle
Ind. appropriation of open grounds	3.00	0.67	1.67	2.00	0.67	1.33	3.00	2.00	1.33
Ind. appr. of repaired spaces	4.00	0.00	0.00	2.00	2.00	0.00	2.00	2.00	2.00
Index of Functional affordances I_f	0.68	0.03	0.05	0.09	0.06	0.04	0.23	0.32	0.62
Ind. Eyes on the POS	3.60	3.20	3.50	3.10	3.40	3.00	3.30	2.90	1.00
Cleanliness of surfaces,	4.00	2.00	4.00	4.00	4.00	4.00	4.00	4.00	0.00
Index of Emotional affordances I_e	0.85	0.77	0.96	0.92	0.90	0.92	0.92	0.85	0.57
Normalized angular choice, R400	3.00	4.00	3.00	3.00	4.00	4.00	3.00	3.00	1.00
Presence of anchor places	2.00	3.00	2.00	2.00	3.00	3.00	3.00	4.00	0.00
index of Social affordances I_s	0.75	0.85	0.75	0.75	0.85	0.85	0.80	0.45	0.10
Angular Integration R400	3.00	4.00	4.00	3.00	4.00	4.00	3.00	3.00	0.00
Barrier effect	2.13	3.00	4.00	3.75	4.00	4.00	4.00	3.25	2.25
Index of independent Accessibility I_a	0.57	0.56	0.75	0.67	0.75	0.75	0.69	0.52	0.14
I_{UIS}	0.43	0.28	0.39	0.35	0.41	0.40	0.41	0.27	0.06



467

Figure 9. Distribution of values of the I_a Index across the meaningful places within the historic district of the City of Iglesias, Sardinia, Italy.

468

A thorough discussion on the results obtained from the analysis of the public space is presented in the subsequent section.

469

470

471

472

473 5 Discussion

474 The results presented in the previous section reveal a set of criticalities both at the scale of the
475 single setting and of the system of public space. An emerging issue concerns the spatial and physical
476 attributes of individual spaces [40]. The geometry, size, and organization of spaces limit the quantity
477 and variety of the functional affordances. Thus, the absence of repaired spaces limits children's
478 possibilities of retiring, hiding, or being on their own. Second, both the irregular shape and limited
479 extension of regions of open grounds and the lack of morphological variety reduce opportunities for
480 physical activities, such as running, cycling, skating, and for structured group activities including
481 playing ball. Furthermore, the lack of rigid elements reduces opportunities for informal play
482 activities, including jumping, climbing on, running around, balancing acts, and for sitting and
483 resting. A further aspect, emerging from the values of the Index of functional affordances calculated
484 for Q. Sella Square and Salvaterra Castle, is the evident association between the complexity of
485 vegetal formations and the increase in the quantity and variety of functional affordances. In fact,
486 treed areas afford different types of activities, including climbing-on, hiding behind, refuge,
487 balancing acts, utilization and manipulation of loose objects, and observation [17,37,81]. These
488 different activities generate significant nature situations, which in turn shape the psychological traits
489 of human-nature connections, [81], while significantly contributing to the development of central
490 capabilities [82]. A related aspect concerns the availability of potential affordances. In fact, adults'
491 control over and ownership of public space, implemented through manicuring of spaces,
492 occupation, regulations, and time or coupling constraints, reduce the likelihood of children
493 perceiving and actualizing the potential affordances [12,14,22]. Further issues are related to the
494 configurations of networks of pedestrian spaces and the organization of road spaces. The
495 interference and conflict between pedestrian movements and traffic flows - determined by
496 conditions of adjacency and overlap of surfaces for vehicular mobility and pedestrian spaces,
497 geometrical and functional characters of crosswalks, inadequate visibility, and lack of measures of
498 traffic control - produce a barrier effect that negatively affects opportunities for children's access to
499 and appropriation of meaningful places. Moreover, the absence of a diffuse and continuous network
500 of bicycle paths emerges as an additional constraint to children's agency and independent mobility.
501 These factors reflect an organization of public space that reduces the total space available to children
502 within the city, both in physical and in symbolic terms: public space spatializes, through strategies of
503 segregation into controlled environments, the marginalization of children's needs and of their right
504 to participate in the city's life. This phenomenon further increases children's psychological distance
505 from the adults [8].

506 In particular, complexity emerges as a fundamental compositional aspect of public space.
507 Complexity refers to the density of differences within a structure or a space, and thus depends on the
508 variety of morphological, material, and functional characteristics and on the arrangement of the
509 elements of a space [74,83–85]. Hence, complexity is related to visual richness, imageability, and the
510 quantity and variety of possible meaningful actions, thus increasing both the functional and
511 emotional affordances incorporated into a public space.

512 These considerations call for an integrated urban design strategy, aiming to enhance the
513 intrinsic, local attributes of public open spaces, particularly their complexity and the continuity and
514 connectivity of walkable surfaces, hence reinforcing the usefulness, accessibility and attractivity of
515 the public space from children's perspective. This strategy actualizes the shift from a tokenistic
516 approach to the issue of the child friendliness of the contemporary city, to a citizenship approach
517 [22] to place-shaping processes [86]; the latter acknowledges the impact of opportunities for
518 independent mobility and outdoor activities, encompassed in the usefulness of public open spaces,
519 on children's well-being. Lastly, the robustness and predictiveness of the methodological
520 framework should be verified through a validation stage, based on the comparison between
521 estimated levels of public space usefulness and users' actual patterns of activities, preferences and
522 attitudes towards specific settings. In particular, the validation stage is central to underline three
523 distinct aspects: i) discrepancies, between an expert evaluator and a child, in the perception of the
524 activities, social interactions and emotional experiences afforded by specific environmental features;

525 ii) the relative importance attributed by children to specific affordances; iii) the adaptation of
526 children to specific constraints determined by the spatial, material and social conditions of the public
527 space. For instance, the values of the Iuis Index are relevantly influenced by contextual factors,
528 including proximity to anchor places, choice or through-movement potential, and integration. Yet,
529 contextual factors could be less relevant, from children's perspective, than micro-scale specific
530 factors related to compositional, functional, and social attributes.

531 In conclusion, the findings of the presented study and a perspective for the development of the
532 research are outlined in the sub-sequent paragraph.
533

534 6 Conclusions

535 This paper describes a research that builds on the notion of soft physical determinism to
536 investigate the extent to which the built environment affects children's independent activities and
537 support their well-being. In particular this article aims to present and to illustrate the usability of a
538 methodological framework for the assessment of the usefulness of the public space. This study
539 contributes to the literature on child-friendly cities in three ways. Firstly, authors derive from
540 different disciplinary fields the concepts of affordance and capability which are still largely
541 neglected within the field of urban planning. Yet, as argued in the literature review section, they are
542 central categories for conceptualizing opportunities for experience embodied into the built
543 environment and the ways in which the latter affects children's well-being. Secondly, this study
544 introduces the conceptualization of the quality of the Public space as the resultant of both its intrinsic
545 social, morphological and material characteristics and of its extrinsic properties determined by
546 land-use distribution and by the topology of the urban layout.

547 Consequently, the third relevant aspect of this study is the utilization of space syntax
548 techniques to analyze the impact of configurational properties of centrality on the quality of the
549 public space from children's perspective. Thus, the proposed methodological framework
550 operationalizes the combined influence of intrinsic and extrinsic variables on the usefulness of the
551 public space by integrating qualitative indicators, quantitative indicators and Syntactic measures
552 within a multi-criteria analysis framework.

553 The OCUS tool can support different stages of the planning process, particularly i) the
554 individuation of criticalities of individual spaces; ii) the evaluation of alternative scenarios of urban
555 regeneration at different scales, in terms of their impact on children's opportunities to
556 meaningfully engage with public spaces; iii) monitoring of interventions of regeneration via the
557 comparison of levels of meaningful usefulness over time.

558 On the other hand, the research reveals three limitations, related to: i) the need to consider the
559 effect of specific local context-related factors - including cultural constructs and parents'
560 socio-economic status - and individual aspects -including abilities, interests and needs, age, and
561 gender - on children's patterns of activities across the public space; ii) the limited participation of
562 children in the workshop of sensory territorial explorations (25%); iii) the pertinence of comparing
563 public spaces different in terms of scale, function, and morphology.

564 As a result, the future development of the OCUS tool should focus on three aspects. The first is
565 the utilization of techniques of consensus building during the stakeholder sessions, structured to
566 involve panels of children, experts, and parents. The objective would be achieving a convergence of
567 opinions among the stakeholders about the relative importance of environmental features, so as to
568 weight accordingly the indicators. Furthermore, stakeholders sessions should focus on the extent to
569 which the pandemic crisis, while affecting patterns and modes of social interactions and individual
570 practices, redefines the notion of useful places and, thus, requires the modification of the set of
571 criteria for the analysis of built environment quality. The second aspect is the utilization of PPGIS
572 methodologies to support the individuation of meaningful places, through the mapping of
573 significant, actualised affordances, and to support the stage of the validation of the results obtained
574 via the OCUS tool.

575 More precisely, the utilization of Public Participatory GIS (PPGIS) techniques [23,39], aims to: i)
576 increase participation, and reach a wider range of potential users; ii) use a wide range of standard
577 question types and location based question types; iii) collect and categorize reliable location based
578 data in a simple and cost effective way, through integrated analysis tool; iv) improve the
579 understandability of data visualization.

580 The third aspect incorporates both the definition of a taxonomy of public spaces based on
581 morphology, scale, and function, and the determination of an optimal level of meaningful usefulness
582 specific for each category. As a consequence, the future development of the research will aim to
583 enhance the effectiveness of the OCUS methodology in orienting the planning process and the
584 decision-making process through the acknowledgement of children's needs and interests. According
585 to the objectives and theoretical premises embodied in the smart city paradigm, the objective is the
586 creation of a flexible, simple, cost-effective tool for supporting the implementation of strategies of
587 urban renewal and urban regeneration aimed at building sustainable cities and communities,
588 reducing segregation and spatial inequalities via the re-configuration of public space.
589

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616

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