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Article

A methodological approach on disused public properties in the 15-minute city perspective.

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Abstract: Urban accessibility represents one of the great challenges of the contemporary city, which is required to adopt sustainable development models in line with the UN Agenda 2030 objectives, recently confirmed by the health emergency. Urban accessibility and walkability are topics closely related to those aiming at a livable, healthy and inclusive city, based on a system of high-quality public spaces and on a network of services and infrastructures. However, these principles collide with the fragmentation of many urban contexts, built following vehicular accessibility needs. Within this framework, the city of Cagliari represents an interesting case study as it is affected by the disposal of public properties which appear as "enclaves" in the historic urban fabric. This research aims to evaluate if and in which terms the abandoned assets can facilitate the development of the 15-minutes city, as a city reducing the need to move over a certain time and space and therefore granting a more equal access to urban services to a wide range of citizens. This is done by proposing indexes defined as porosity, crossing and attractiveness, which constitute a combined index to improve the pedestrian accessibility in the "central places" of the contemporary city, where the walkability can also become a possible "free choice" for a new healthy lifestyle. These indexes were calculated for the most significant large disused public buildings in the historic center to guide future scenarios towards a 15 minutes city.

Keywords: Public real estate; disused properties; divestment; urban walkability; urban accessibility; Cagliari; Sardinia; Italy.

1. Introduction

Public spaces have always been at the center of reflection and practice of the disciplines that deal with the city and central places. Evaluating these spaces in relation to the new forms assumed by contemporary territories and cities increasingly 'fragmented' by the numerous abandoned buildings - such as large factories, hospitals, etc. - and by the need to reduce the health risk from Covid-19 is not easy and requires nonetheless an interdisciplinary approach. The economic transition process, from the old to the new economy [1], has produced non-negligible effects on the territory, modifying both the productive and the organizational structure of our cities and determining phenomena of dismissal of a significant number of buildings. Since the 1980s, the decommissioning of industrial areas and most of the buildings and large public infrastructures that made up the nineteenth-century city and the first half of the twentieth century, which have now become obsolete, inaugurated the phase of conversion, recalling institutions and organizations directly involved, investors and civil society itself to define enhancement proposals [2-4]. Similarly, central locations have also changed in typology and spatial distribution [5-6]. However, even with the recent health crisis, they continue to invoke "favorable" urban positions. In fact, within and outside these places different practices or actions are defined, such as the relationship with other individuals or things, through the movement that describes directions and tracks or through personal or collective maps. The definition of these

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places [7-8] also takes into account the need to respond to the temporary and permanent changes [9], induced by the health emergency which, in examples such as smart working and, more generally, the distancing between individuals, requires thinking about alternative and flexible uses of existing structures [10]. In this sense, the central places are both meeting places and places of attraction for flows of people oriented by the need to carry out necessary and / or voluntary activities [11].

The review of the studies on central locations is necessary in the light of recent developments. Reconnecting with the Chicago School, we can recall the circular, sector and nucleus models [12], and the debate on the monocentric or polycentric nature of cities returns, never subsided [13-14]. The concept of CBD - Central Business District also refers to the central areas and functions, in what can be defined as the 'center' of the urban area itself., the CBD or central nucleus, represents the highest central location, where the most important activities of a center are concentrated, not only related to retail trade but also extended to professional and administrative activities. These activities, which are referred to for their definition in the works of Bonetti (1975) [15] have undergone and are undergoing considerable changes over time, even more in the current pandemic and post-pandemic moment.

On the basis of these reflections, and without claiming the exhaustiveness of considering the set of higher central activities such as those that are really relevant today, it was decided to focus the attention on some subsets, expandable in future studies. According to Murgante et al. (2020) [16] and as suggested by recent actions aimed at limiting health risk – e.g. distance learning, Smart Working, limitation of access to commercial activities and various services, etc. - the following subsets of central locations can be identified, according to the following synthetic classification proposed by the authors in agreement with Vazzoler and Roveroni (2016) [17]:

- Movement: railway stations and public transport, port, parking;
- Welfare: schools, parks, hospitals, chemist's, churches;
- Trade: food and other.

The Figure 1 represents the main phases of the evolution of central locations in urban environment in relation to the four phases of the industrial revolution.

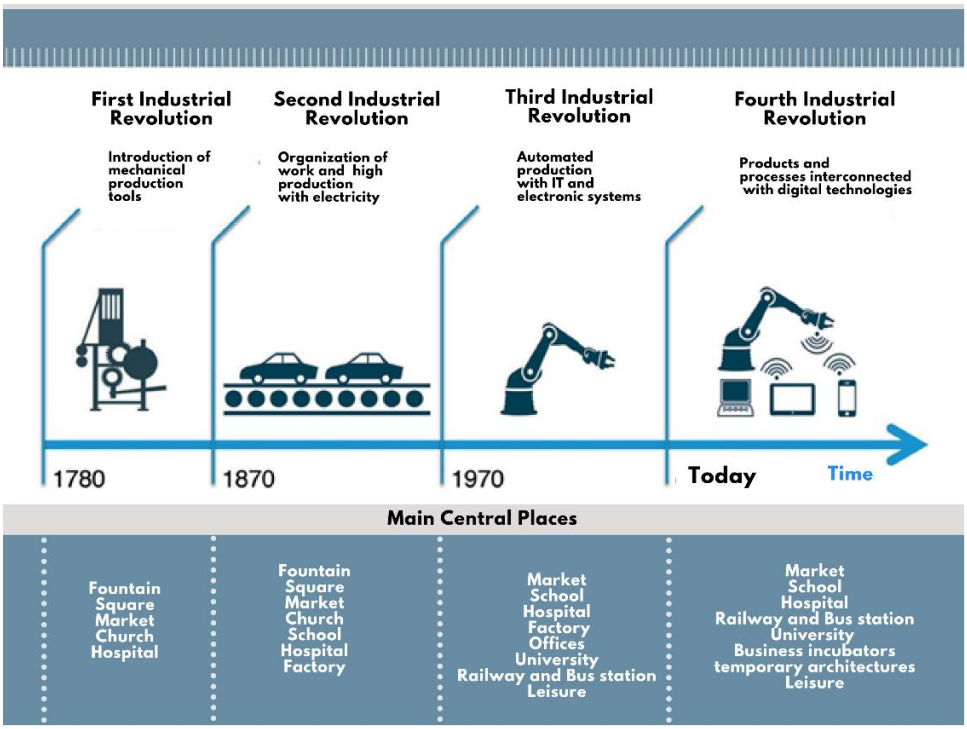

Figure 1. Main phases of the industrial revolution and central places (Author: G. Balletto, 2020, Elaboration from Roland Berger, 2015).

In this sense, the current and tangible condition of the central places of the recent past has been their numerous disposals, with the associated phenomena of the urban enclaves. Many of these divestments are often found incorporated in the urban environment or even in the historic center characterized by a strong materiality and stylistic overlaps [18]. The emerging need to adopt

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sustainable urban development models, based on the protection of the environment and natural resources [19] and the fight against indiscriminate land use [20] have brought attention to the compact city model [21]. This grows internally by recovering abandoned areas to respond to the new demands of the contemporary world - new forms of production and work: industry 4.0, social housing, co-working, smart community and health-wellness. The health crisis is transforming, and will transform, the conception of central places in cities. Indeed, architects and urban planners are looking for new visions [22-26] capable of orienting the urban development of the next future. The spread of the epidemic has in fact put the cities to a severe test, highlighting a series of new criticalities, which can also be overcome through the implementation of innovative strategies to reinvent and readjust abandoned buildings. At first, greater attention to the environment and to the quality of life in general, is followed by a more intense use of innovative technologies to which to delegate the control of the territory [27-28] and at the same time plan a new mobility - individual and public - with a view to smart mobility. Among these is the 15 minutes city [29-32] which derives from the concept of "neighborhood unit", developed for the first time in 1923, as a proposal for an arrangement to build new residential districts.

The current health situation in fact forces us to redesign our lives and the places where we live. Today more than ever, a smart city must be a safe city, ensuring constant analysis of vulnerability and adequacy also in terms of accessibility of services and / or central places. A mix of functions is needed, capable to improve the supply of services and therefore the quality of life, to alleviate the vehicular congestion of the central city - and therefore pollution - and to reduce commuting phenomena. To do this, pedestrian accessibility to central locations facilitated by urban porosity plays a fundamental role, resulting from the recovery of abandoned buildings that currently constitute 'enclaves', which could represent strategic nodes in the 15-minutes city network [33-34], through a renewed sense of common good from anti-commons to commons [35].

The objective of this research is to evaluate if and in what way the disused real estate assets can represent a facilitating element for reaching the 15-minutes city. This was possible by developing suitable indexes, following analyzes on the centrality of the places.

The rest of the paper is organized as follows:

1. Literature review (section 2)
2. The concept of “public city”. Risks and opportunity of divestment (section 3);
3. Methodology and data (section 4);
4. Results and Discussion (section 5);
5. Conclusions and Future Development (section 6).

2. Literature review

The need to contain the spread of the SarsCov-2 virus and, at the same time, to restart the economic system has brought the issues of pedestrianism and urban micro mobility back to the center of the political and scientific debate [36-38]. Among the consequences, we can recall the backlash suffered by public transport [39] and the return to the use of the car, which aggravated the already critical conditions of the urban environment in major cities [40]. Walkability, cycling and micro-mobility are therefore at the center of the new mobility offer, which finds wide collective consensus in the main national and international metropolitan cities [41]. Furthermore, these represent the fastest and cheapest solution - both for the public and the private sector - for urban travel, favoring healthy lifestyles and the distancing of health security.

The new choices on urban mobility go in the direction of improving walkability and encouraging micro-mobility, creating infrastructures for electric vehicles, also in order to improve air quality. In fact, during the lockdown, it was possible to evaluate how bad air quality in the megalopolis - Po Valley, London, Paris, Shanghai and New York etc. - was related to the spread of the virus [16, 42]. The health emergency has brought to light the link between the morphological and functional characteristics of urban contexts and the impacts of public health, opening new scenarios on the theme of 'Urban Health', within the complex phenomena of urbanization and land take that characterize contemporary Italian cities in particular [43-45].

Within this scenario, the fundamental role of public space is confirmed, not only the open one of squares, parks and promenades, but also that of large disused public buildings that await urban regeneration interventions. In this sense, one of the most interesting good practices is the Spanish design "Superblocks" developed in Barcelona: the "Street hierarchy model" [46] which allocates the urban space previously used by cars in areas destined for cycle-foot traffic [47]. Specifically, the objectives of the "Superblocks" model where: regeneration of public spaces; promotion of biodiversity with urban green; promotion of social cohesion; promotion of the circular economy; integration of governance processes and sustainable mobility.

The theory of the "Walkable City" [48-50] is in fact based on the concepts of sustainable mobility such as coherence, continuity, balance, safety, comfort, accessibility, efficiency and attractiveness of places, as key characteristics to promote transport choices capable of promoting correct styles of life [51]. Furthermore, also according to the UN (2020) [52] the promotion of walkability and micro-mobility is necessary in European cities to facilitate the transition towards a sustainable future and better air quality, according to an ASI approach, "Avoid" , "Shift" and "Improve":

- Avoiding the need for transport: planning more compact cities with proximity services;
- Shifting towards other modes of transport: pedestrian and micro-mobility cycle;
- Improving the means of transport: technologically improve means of transport so that they are energy efficient and with low polluting emissions.

In this context it is therefore necessary and crucial to regenerate the public space (outdoor) through the use of qualitative and quantitative standards [53], which represent the urban context and are supportive to promote healthy lifestyles such as walkability. In fact, making cities more pedestrian means improving the network of public spaces (indoor and outdoor), the mix of land use, in order to create healthier, safer, more comfortable and attractive places. Urban walkability thus represents a strictly functional action to achieve more general and common goals for all cities: accessibility, well-being, air quality and urban microclimate [54].

3. The concept of "public city". Risks and opportunity of divestment

The current conception of "public places" is a result of a process of stratification of meanings that took place over time in Western cities [55]. Public places were born with the first human settlements, with the affirmation of a proprietary system that did not exist in primitive society. Since then, they have always been the representation of the value system supported by the ruling power and by the hegemonic classes of each society. Public infrastructures, architecture and open spaces built for institutional, civil and religious functions testify the political and social organization of peoples in different historical moments. This network of the so-called "collective themes" [56] can be understood as the common foundation of the European cities and their democratic society. Over the course of time, this consolidated model evolved in order to respond to the demands of the new economic system based on globalization, which has generated significant changes in the urban structure and organization. Today, the complexity of urban dynamics makes it difficult to classify public places in a univocal way and asks to go beyond the rigid public-private dichotomies [57]. The contemporary city is characterized by hybrid public spaces in terms of form, ownership, functions and uses, users and relationship with the context.

In Italy too this process is clearly manifest in all its phases. The "public city" is no longer identified only with the social housing assets and with the urban planning standards of the 1960s – which are currently being updated [58] -, but consists of a series of functions and services of public interest offered and managed also by the private subject [59]. It is within this renewed conceptual framework that the adaptive reuse of obsolete, abandoned and underutilized buildings and spaces should arise, particularly that belonging to various public entities, within a comprehensive strategy of sustainable development. The public real estate assets can represent an extraordinary opportunity to achieve the main public policies objectives. Among these, a renewed approach to the urban landscape leads to reinterpret public properties as strategic nodes of urban and territorial networks able to ensure better levels of permeability and connectivity [60]. These aspects are progressively becoming fundamental elements of urban governance and planning also in the city of Cagliari.

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Cagliari is an Italian city of over 150,000 inhabitants, located on the southern coast of Sardinia. Capital of the Sardinia Region and an Italian Metropolitan City since 2016, Cagliari has established itself as the most important cultural, economic, political and administrative center of the Island. Its economy is mainly based on the tertiary sector. As too many other cities in Europe and in the world, Cagliari has been affected by phenomena of disposal and potential abandonment of a significant number of public assets. This process testifies the evolution of the urban and economic growth which led to close important public services, industrial and business activities, to optimize the use of buildings thanks to the digital transformation of Public Administration system, but also to divest military and civil defense assets thanks to the general conditions of peace reached globally [61]. The system of buildings, open spaces and green areas belonging to the State, the University and other public bodies and organizations (Figure 2) constitutes a considerable component of the existing city not only in quantitative but also in qualitative terms, by virtue of the historical, cultural, architectural and environmental values recognized, which make this asset an important resource for the future.

Figure 2. The main dismissed public properties in the historic city of Cagliari (Authors: M. Ladu and A. Milesi, 2020) [31].

At the moment, in the historic center there are important public properties such as the former Buoncammino Prison (001 B_ing), the former Tobacco Factory (003 B_ing) and the San Giovanni di Dio Hospital (002 B_ing), true icons of the city of Cagliari [62], for which it is necessary to define new uses. An important aspect to consider is that there is a significant degree of fragmentation of these components of the urban fabric, due not only to their different owners, which determines different types of use and accessibility of spaces, but also to the presence of fences and other physical elements that prevent a connection between them. As a matter of fact, although characterized by big areas compared to the surrounding disused fabric, the main public complexes involved in the process of disposal in the historic city appear as a sequence of "enclaves" rather than as a network of nodes and centralities: the tendency of inhabitants and city users is to circumnavigate, rather than cross. This issue has been faced by the Plan for the historic center of Cagliari drawn up in 2015 [63] and subsequently by the participatory process launched to draft the Metropolitan Strategic Plan (MSP) of the Metropolitan City of Cagliari (MCC), which confirmed the prominent role of public real estate assets for the sustainable development of the city [31].

3.1. Role of public real estate assets in the Metropolitan Strategic Plan

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The participatory process of the MSP drawn up by the Metropolitan City of Cagliari has started in September 2019 in order to face key issues for the future development of the metropolitan area. The debate dedicated to the "Urban Fabric" focused on the concepts of "public city", private city and military enclaves. The stakeholders understood the public city as a system of public buildings, open spaces, green areas and mobility infrastructures which assumes a predominant role in contemporary lifestyles (pre-Covid-19) characterized by a reduction of the private sphere and a growing propensity towards the use of collective, public or semi-public spaces. More generally, it can be said that the public asset represents a cross-cutting theme which will play an important role to pursue the sustainable development objectives.

The list of opportunity and weakness emerged during the discussion was summarized by the authors as follows (Figure 3).

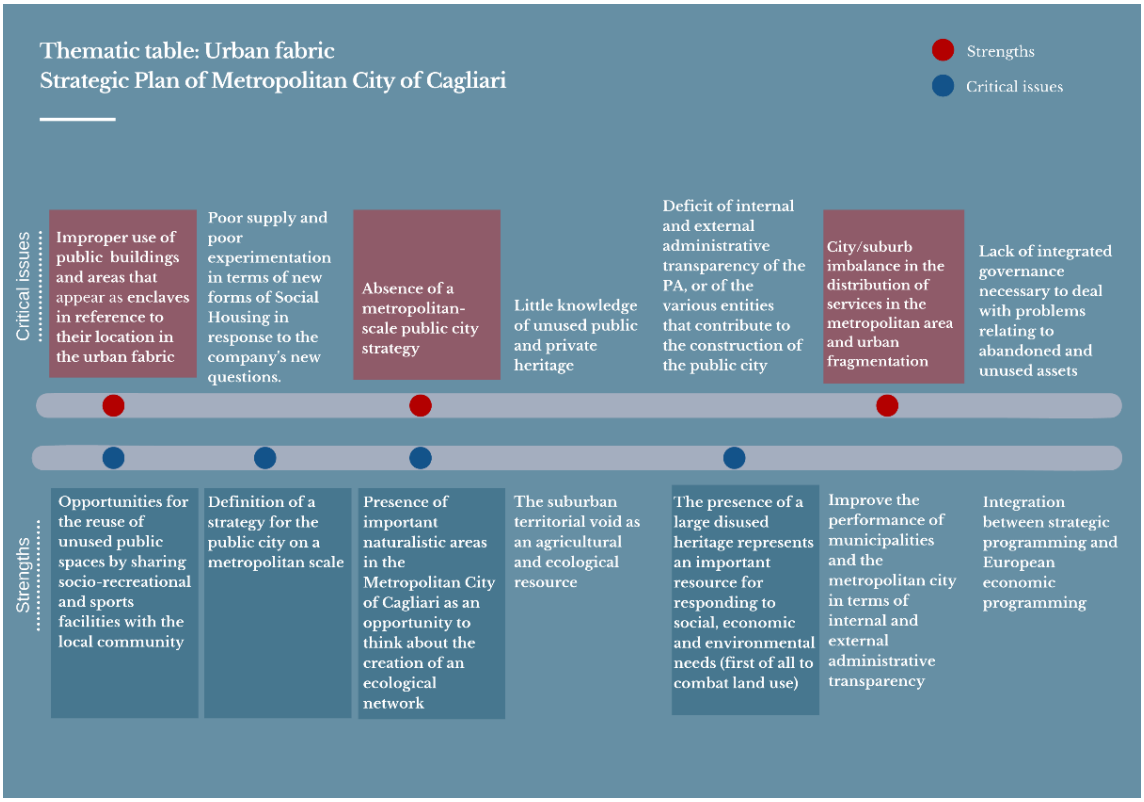

Figure 3. Outcomes by the Thematic Table - Urban Fabric (Authors: G. Balletto, A Milesi, M. Ladu, 2020).

The establishment of the new government body of the MCC is recognized as a great opportunity to integrate the PREM (Public Real Estate Management) issue within more general public policies objectives of social, economic and environmental nature and those of the health city. This, in line with the concept of Walkable city (the 15-minute city theory), but also for defining a strategy for the public city on a metropolitan scale. More specifically, the public assets (buildings and areas) represent an opportunity to improve the provision of socio-recreational and sports facilities, also through new forms of shared management between municipalities, institutions, private investors and citizens. At the same time, high levels of accessibility of the public real estate is essential to pursue sustainable urban development, thus limiting soil consumption.

Within this perspective, the contemporary urban dynamics led authors to develop a research methodology aimed at defining indexes of porosity, crossing and attractiveness, and a composite index referred to the Walkable City.

4. Methodology and data

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4.1. Methodology: porosity, crossing and attractiveness indexes and a composite index

It is important to underline that the methodology adopted was tested on a limited set of data - as the main locations in the study area are considered privileged candidates for redevelopment and revitalization operations -, with the intention, in future research developments, to extend the analysis over the entire urban and metropolitan territory.

The research in particular was based on the development of a set of indexes, considered useful and interesting to evaluate the capacity of a sample of abandoned buildings acting as potential public spaces. In doing so, we proposed a set of indexes based on such a capacity, linking together the concept of centrality and therefore considering the quantity and quality of a set of central services and activities in close proximity to this selected subset.

Distances from places have been considered from the studies on centrality. In this case, the 15-minute walk, corresponding to about 1200 m, considered by several sources to be those necessary to consider an area as having essential services, were used to define 'service' areas around the places.

These service areas were drawn running a 'service area' algorithm from the centroids of the selected locations and expressed in terms of walking distances from the points. Such areas, shaped as irregular polygons drawn from the urban road network on the territory, subsequently serve to collect and count, within them, the data relating to some activities that can be defined as central. Centrality is expressed in the most recent sense of the term. It is worth noting that at the present stage of the research, no distance-decay function was implemented when collecting and counting activities and services from the selected points of origin. This consideration of the central activities located within a defined distance from the selected places, led to reasoning in two different directions. On the one hand, there is the need to focus on evaluating the centrality and diversity (or variety) of activities present. It is, in fact, not sufficient to focus on the plain number of 'central' activities located within a certain distance from the point, but it is also important to focus on the variety and diversity. It is different, from the user perspective, to find an area of the city characterized by a huge number of bank and insurance company branches, what could define a 'financial district', rather than an area characterized by a vibrant mix of differentiated activities [64]. On the other hand, there is the more articulated need to understand the current role of urban voids to bring real interruptions, cracks in the urban territory, and to evaluate, instead, their potential role as central places in the event of their opening.

These aspects constitute one of the main challenges of the city of Cagliari and of contemporary cities in general. For this reason, the authors have proposed specific indicators to support walkability in contexts characterized by urban enclaves. In particular, the proposal of indexes definable as porosity, crossing and attractiveness, and a composite index are functional for the reduction of the urban enclave effect previously described.

It should be noted that the quantitative definition of the indexes refers to the case of the historic center of Cagliari and is the result of the assessment of the context of the Strategic Plan of the Metropolitan City of Cagliari (2020). Particularly important, in the computation of the different indexes, it will be the setup of weights.

Please note that both the single indexes as defined in the following lines (PI, CI and AI) will hold appropriate weights, and also the composite index WBBI will be realized furtherly weighting the previous indexes.

In this regard, the following indexes (Ii) were defined for each public property:

1) Porosity index (PI): It is the weighted coverage ratio, between the building area and the pertinent free land area. The PI was calculated as in the formula:

$$PI = Rc * p_p$$

Where Rc = the ratio, in percentage, between covered area referred to the building, built or buildable, and the land area of reference, and p_P is a weight to be attributed to the ratio Rc, so that:

$$0 \leq p_p \leq 1$$

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In particular, if $Rc \Rightarrow 0$ then the weight $p_p \Rightarrow 1$ according to an inverse relationship and *is* closely related to the conditions of the reference context.

In other words, as *Rc* decreases, the weight p_p increases in order to appreciate the empty surfaces included in the building areas functional to walkability (see case study, paragraph 4.2).

2) Crossing index (CI): The crossing index specifies the level of crossability that characterizes each public property and that allows people to reach different parts of the city. This index, in fact, depends on the architectural morphology of the building, in particular on the number of crossings and paths that connect the various entrances to the property. The CI was calculated as in the formula:

$$CI = Nc * p_c$$

where *Nc* = number of crossings that unfold between two accesses and that allow to relate more urban portions and p_c is a weight to be attributed to the *Nc*, so that $0 \leq p_c \leq 1$

In particular, if $Nc \Rightarrow n$ then the weight $p_c \Rightarrow 1$ *according to a direct relationship and is* closely related to the conditions of the reference context.

In other words, as *Nc* increases, the pc weight increases in order to appreciate the crossings included in the functional areas for walkability (see case study, paragraph 4.2).

3) Attractiveness index (AI), refers to both the number and the variety of central places found within a 15-minute travel range from the analyzed property compendium. Therefore, for the calculation of this index, the Simpson diversity index was taken as a reference, which allows to give weight to the diversity of urban boundary functions. The Simpson diversity index, used in statistics in the case of populations with a finite number (in the case of index D) of elements:

$$AI = D = 1 - log \sum_{j} \frac{Nj(Nj-1)}{N(N-1)} = -log\, \lambda \frac{\sum_j Nj(Nj-1)}{N(N-1)} = -log\, \lambda$$

Where *Nj* indicates the number of j-th "species"

$$N = \sum_{j} Nj \sum_{j} Nj$$

Where λ corresponds to the Simpson concentration index in the case of finite population.

$$\lambda = \frac{\sum_j Nj(Nj-1)}{N(N-1)} \lambda = \frac{\sum_j Nj(Nj-1)}{N(N-1)}$$

The Simpson index finds wide application in Ecology to represent environmental ecological diversity and by analogy it has been transposed to the urban context [64], or to the diversity of central places. Specifically, it referred to the diversity of central locations. These indexes constitute the first set proposed by the authors of a big data set under development, representative in quantitative terms of the intrinsic and extrinsic of walkability of large-scale disused public assets.

4) Walkable Big Buildings Index (WBBI). The indexes PI, CI and AI were integrated by the authors into a composite index Walkable Big Buildings Index (WBBI) experienced in the historic center of the city of Cagliari. In particular, the WBB is the sum of the weighted (p_k)

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indexes (PI, CI, AI), where the sum of weights is 1. To distinguish this index from the others, a one hundred basis was used. The WBBI was calculated as in the formula:

$$\text{WBB} = \sum_{i=1}^{n} \left(I_i * p_k \right) * 100 \quad \text{where} \sum_{k=1}^{n} p_k = 1 \quad \textit{and} \quad I_i = PI, CI, AI, \ldots \textit{where } i=1, 2, 3, ..n$$

In other words, each index I_i is weighted in relation to the intrinsic and extrinsic characteristics of the abandoned buildings and the relative conditions of the reference urban context in order to appreciate the potential (big disused buildings) functional to walkability (see case study, paragraph 4.2). In this sense, the Plans of the historic centers constitute the main reference basis for the evaluation of the context to support the definition of the weights (p_k).

4.2. Data and study area

On the basis of a first survey of the public real estate assets present in the city of Cagliari, with particular reference to its historic center, the authors have undertaken an activity of collecting and processing data relating to the main public buildings that have been abandoned. Among these, the disused public complexes 001 B_ing, 002 B_ing and 003 B_ing were selected, among the most representative in terms of areas - valium and architectural stylistic dimensions. On the other hand, although located within the historic city center, characterized by an articulated system of central places, they limit the reach of the city from 15 minutes due to the persistent 'enclave effect'. It refers to a larger area of the disused building, as a result of the previous and / or subsequent urban infrastructures favored by the past effect of central location of the to-date abandoned buildings (Figure 4).

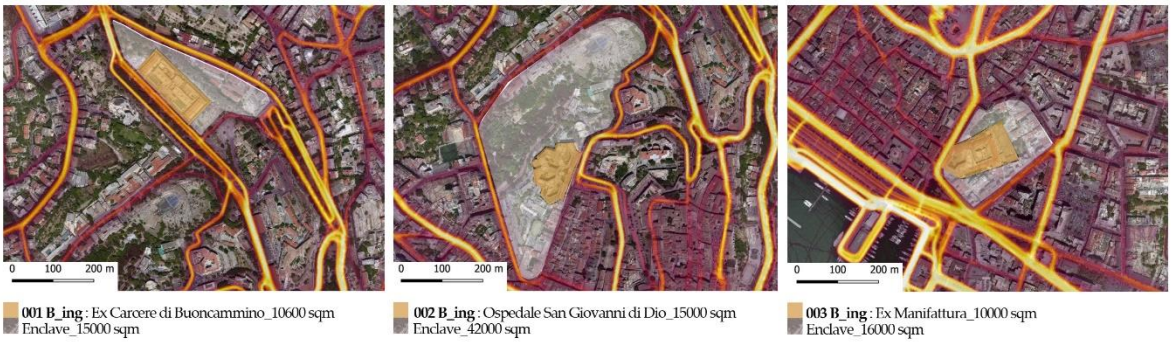

Figure 4. Traces recorded by the smart community - Strava (23.10.2020). (Authors: G. Balletto, M. Ladu, 2020).

This is a serious critical issue, also confirmed by the smart community that animates Strava's digital platform. This platform shows the densest areas, i.e. those most crossed by the community of users of the popular app for sports activities - for example running, cycling, etc. - to testify a 'practicability' walkable in a broad sense. The Figure 4 shows the enclave effect and consequently how a greater and better accessibility of these spaces would facilitate the walkability and therefore the desired goal of the city of 15 minutes confirmed also on the occasion of the health crisis.

The authors then proceeded to identify the central locations within the historic center of Cagliari with reference to the three previously selected real estate compendia, included in the relative 15-minute isochrones. For this evaluation the OSMR1 algorithms and referred to Google maps were used (Figure 5).

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Figure 5. MBR delimiting the 15 min isochrones from building 001 B_ing, 002 B_ing and 003 B_ing.

In particular, the isochrones have been used to define areas where activities are located. The principle used is that of the Minimum Bounding Rectangle (MBR), as the extent of the polygon deriving by most extreme coordinate values of isochrones computed over each location.

The Figure 4 shows the extreme coordinates of the three MBR computed over the relative 15-minutes isochrones for each building.

Within each area, the following central locations have been identified, divided into the three categories previously defined (Table1):

Table 1. Central services reachable in a time of 15 minutes from the main public complexes (001 B_ing, 002 B_ing e 003 B_ing). Source: Google Maps.

Compartment	001B_ing	002 B_ing	003 B_ing

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	Compartment area sqm	15000	42000	16000
	Coverage surface sqm	10600	15000	10000
Central places of movement	railway station			
	LPT	7	30	42
	Port			
Central places of welfare	Schools	12	7	8
	parks/squares	6	5	4
	hospitals	4	1	0
	chemist's	2	10	9
	assistance and worship	12	17	25
Central places of trade	Food	2	7	14
	markets	0	1	1
	bars	2	18	17
	restaurants	0	22	24
	various trade	2	68	75

The authors then proceeded to evaluate the PI, CI and AI and WBBI indexes:

The assessment of PI and CI required the determination of the following weights resulting from the evaluation of the reference urban context of the historic center of Cagliari.

For the three abandoned buildings obtained the following PI after identifying the specific weights:

$0 \leq Rc \leq 0.5$ $p_p = 1$

$0.51 \leq Rc \leq 0.69$ $p_p = 0.5$

$0.70 \leq Rc \leq 0.95$ $p_p = 0.25$

$0.96 \leq Rc \leq 100$ $p_p = 0$

The following PI is therefore derived (Table 2).

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Table 2. PI referred to 001 B_ing, 002 B_ing; 003 B_ing.

Building complex	001 B_ing	002 B_ing	003 B_ing
Rc	0.70	0.35	0.60
p_p	0.25	1	0.20
PI	0.17	0.35	0.30

For the three abandoned buildings the following CI were after obtained with specific weights:

$Nc = 0$ $P_c = 0$
$Nc = 1$ $P_c = 0.15$
$Nc = 2$ $P_c = 0.35$
$Nc > 2$ $P_c = 0.50$

The following CI is therefore derived (Table 3).

Table 3. CI referred to 001 B_ing, 002 B_ing, 003 B_ing.

Building complex	001 B_ing	002 B_ing	003 B_ing
Nc	0	1	1
p_c	0	0.15	0.15
CI	0	0.15	0.15

In particular, for the AI index, the Simpson index was applied, in agreement with Borruso (2006) [65], transposing by analogy a typical index used to represent ecological diversity to the diversity of central locations, as reported in Table 4.

Table 4. Evaluation of AI (Simpson index) referred to 001 B_ing, 002 B_ing, 003 B_ing.

		Simpson's index rating							
		n	n*(n-1)		n	n*(n-1)		n	n*(n-1)
	Building area	001 B_ing			002 B_ing			003 B_ing	
	Compartment area sqm	15.000			42.000			16.000	
	Coverage surface sqm	10.600			15.000			10.000	
Central places of movement	**railway station**	0	0		1	0		1	0
	LPT	7	42		30	870		42	1722
	Port	0	0		0	0		1	0
Central places of welfare	**Schools**	12	132		7	42		8	56
	parks/squares	6	30		5	20		4	12
	Hospitals	4	12		1	0		0	0
	chemist's	2	2		10	90		9	72
	assistance and worship	12	132		17	272		25	600
Central places of trade	**Food**	2	2		7	42		14	182
	Markets	0	0		1	0		1	0
	Bars	2	2		18	306		17	272
	Restaurants	0	0		22	462		24	552
	various trade	2	2		68	4556		75	5550
	Total	49	356	Sum n*(n-1)	187	6660	Sum n*(n-1)	221	9018
	N*(N-1)	2352		N*(N-1)	34782		N*(N-1)	48620	
	D = Sum n*(n-1) / N*(N-1)	0,15		D = Sum n*(n-1) / N*(N-1)	0,19		D = Sum n*(n-1) / N*(N-1)	0,19	
AI	1 – D	0,85		1 – D	0,81		1 – D	0,81	

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Finally, the evaluation of the WBBI required the determination of the weights for each index that composes it. In particular we considered p_k = 0.3 for PI, p_k = 0.4 for CI and p_k = 0.3 for AI (Table 5), justified by the necessary role of 'crossing' to reduce the enclave effect of large abandoned buildings dimension.

Table 5. WBBI referred to 001 B_ing, 002 B_ing, 003 B_ing.

Weights p_k	Building complex	001 B_ing	002 B_ing	003 B_ing
0,3	CI	0	0.15	0.15
0,4	PI	0.17	0.35	0.30
0,3	AI	0.85	0.81	0.81
	WBBI	32.4	51.1	44.3

Below are the summary tables of the calculation of the three indexes, starting from the input data referring to the abandoned real estate complexes selected in the historic urban area, Figure 6.

Figure 6. Input and output data referred to the index calculation PI, CI, AI and combined index (WBBI) for each building complex selected.

The results of the proposed method were presented and discussed in sections 5 and 6.

5. Results and Discussion

In this paper we wanted to represent a first synthesis of ongoing research relating to the identification of functional indexes to improve pedestrian accessibility in the urban area in the desired 15-minute city through PI (Porosity index) , CI (Crossing Index) and AI (Attractiveness index) a combined index WBB index (Walkability Big Building index).

In particular, these indexes make it possible to relate intrinsic elements (PI and CI) with extrinsic elements (AI) of a given decommissioned real estate asset with Big-size dimensional characteristics. This in order to act in the redevelopment of abandoned assets to obtain maximum walkability, knowing that the ideal reference benchmark is given by squares and urban parks. In fact, PI, CI = 1 and AI = 1 (WBBI = 100) occur in an open space, which can be crossed in several directions and with a relative diversified attractiveness.

The assessment of the indexes shows that each abandoned building has the following WBBs: 32.4 for 001 B_ing; 51.1 for 002 B_ing and 44.3 for 003 B_ing. In particular, the lowest WBB (22.4) corresponds to 001 B_ing (former prison) although it has the highest index of AI = 0.85. The highest WBB (51.1) corresponds to 002 B_ing (former hospital) which has the largest enclave. Each WBBI, in fact, must be interpreted in relation to its enclave and in general to the extrinsic characteristics (AI). In doing so, WBBI can support decisions in order to evaluate the intervention priorities aimed at making urban contexts today characterized as enclaves walkable.

In particular, we have intended to evaluate the possibilities of making the 'central places' of the past as ancient factories, hospitals etc. accessible in pedestrian terms in a logic of flexible network, where the "walkability" can renew the quality of life and, at the same time, reduce the health risk from CoViD-19. The vast literature on walkability and abandoned public properties, as well as the

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recent radical changes induced by the health emergency, have prompted the authors to evaluate this first specific set of indexes: porosity, intersection and attractiveness from whose combination the index WBB is derived.

6. Conclusions and Future Development

The analysis of the study context deriving from the evaluations of Metropolitan Strategic Plan of Cagliari, also in light of the current pandemic health emergency, allowed to deepen the role of the disused public properties in the direction of the desired "15 minutes city". The geographic-ecological approach developed led to the proposal of a first set of three indexes PI, CI, AI – related to porosity, crossing and attractivity - and a composite index – WBBI related to walkability - coherent with the complex theoretical framework aggravated by the current health emergency situation. The proposed indexes, and in particular the combined WBB index, respond to the need for analytical frameworks that support decision-making processes [66, 68], identifying and measuring the environmental variables of the urban system that influence individual behavior and collective walking practices.

In particular, the methodological framework addresses the main aspects central to the quality of the walkable public space: the combination of contextualized qualitative and quantitative indicators, and the combination of indicators that measure the intrinsic and extrinsic attributes of disused public building areas, in particular of big dimension and extension. The proposed approach allows to represent the quality of the public space and therefore its potential in the city of 15 minutes.

The methodological framework will be subject to participatory evaluation in the strategic co-planning of the metropolitan city of Cagliari, through decision-making techniques based on the *Analytical Hierarchy Process* (AHP) to involve stakeholders in complex decisions relating to the selection and prioritization of environmental variables and relevant indexes [67]. Finally, the methodological approach proposed can constitute a relevant framework to support the decision-making processes of urban walkability policies [67, 68].

The future development of the methodological framework will address several aspects, hereby highlighted on the limited set of sample buildings and areas analyzed.

One research direction will lead to the tackling the criticalities that emerged during this initial research, particularly in terms of the definition of weights and a broader analysis of the activities to be considered as central. This will be done also incorporating a distance decay correction in the weights being used for the computation of the indexes. The set of the disused buildings considered as potential candidates for reuse will be also broadened so that to cover a wider extension of the urban fabric for a wider social inclusion.

Another direction of research will deal with the application of such method to other already existing and working public buildings and areas in the same city, in order to compare the potential of the reusable buildings and areas to play again a new central, urban role.

A wider extension of the research will deal with the realization of a complete database of the disused buildings and areas in the Metropolitan City of Cagliari, with possible comparison with other urban areas.

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Appendix A

Glossary:
PI = Porosity index. It is the weighted coverage ratio, between the building and the pertinent free land surface
CI = Crossing Index. It specifies the level of crossability that characterizes each public property and that allows people to reach different parts of the city. It depends on the architectural morphology of the project, in particular on the number of crossings and paths that connect the various entrances to the property.
AI = Attractiveness Index. It refers to both the number and variety of central places found within a 15-minute travel range from the analyzed property compendium.
WBBI = Walkability Big Building. It is a combined index given by the sum of the weighted indexes (PI, CI, AI).
MCC = Metropolitan City of Cagliari
PREM = Public Real Estate Management
MSP = Metropolitan Strategic Plan
PHC = Plan of the Historic Center

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