This is the post-print author's version of the following book chapter:
G. Pellicelli, B. Caselli, C. Garau, V. Torrisi, S. Rossetti (2022). Sustainable Mobility and Accessibility to Essential Services. An Assessment of the San Benedetto Neighbourhood in Cagliari (Italy). In: (a cura di): Gervasi O. Murgante B. Misra S. Rocha A.M.A.C. Garau C. (eds), Computational Science and Its Applications – ICCSA 2022 Workshops. ICCSA 2022. Lecture Notes in Computer Science. vol. 13382, p. 423-438, Cham:Springer, ISBN: 978-3-031-10591-3, Malaga, Spain, July 4-7, 2022, doi: 10.1007/978-3-031-10592-0_31

Sustainable Mobility and Accessibility to Essential Services. An Assessment of the San Benedetto Neighbourhood in Cagliari (Italy)

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Abstract. In line with the leading European directives, i.e. the Sustainable Goals of the 2030 Agenda, concerning urban development and emissions reduction, the authors find in the *15-min city* a model that prioritises active mobility as the main way to reach services within a neighbourhood. The paper is based on the concept of the Smart City (SC), which is defined as a city capable of serving and integrating the demands of individual citizens while concentrating on sustainability and hence on environmentally friendly lifestyles. In this context, the paper highlights pedestrian and bicycle accessibility in relation to essential services, by considering the San Benedetto neighbourhood in the city of Cagliari as a case study. The pedestrian accessibility to essential services is measured in a range of influences based on home-service travel times between 5 and 15 min, using a GIS tool. The contribution aims at identifying action plans for implementing local mobility strategies.

Keywords: GIS · Sustainable mobility · Accessibility · Smart city · Historic centre · Cagliari (Italy)

1 Introduction

According to the European report *Mapping Smart Cities in EU* [1], 248 out of 468 European cities with more than 100,000 inhabitants are considered Smart. Although there is no single definition of a Smart City (SC) [2], some key characteristics can help distinguish it from a simple sustainable city, e.g. the use of new technologies applied to urban and mobility management, to governance and urban transformation [3–8].

This paper is the result of the joint work of the authors. 'Abstract', and 'Discussion and Conclusions' were written jointly by the authors. GP wrote the 'Materials and Methods', 'Case study' and 'Results' sections, BC wrote the 'Introduction', SR wrote the 'Introduction' and the 'Materials and Methods' sections. SR, CG and VT coordinated and supervised the paper.

The European policy framework on SC (Europe 2020 Strategy, adopted in 2010 by the European Commission), provides a clear plan to deal with the economic crisis by increasing European competitiveness through a smart, sustainable, and inclusive growth.

Numerous studies on the SC have been conducted in the field of urban studies, not only for metropolitan cities [9, 10] but also for medium-sized cities. A first classification of medium-sized Smart Cities can be found in the work conducted by the University of Vienna [11], which considers the SC dependent on 6 key axes (mobility, governance, living, people, economy and environment) and proposes a European ranking based on the different degrees of performance in these 6 axes. The report considers 77 medium-sized cities, of which 7 are Italian (section updated in 2014), and 90 larger cities, of which 7 are Italian (section updated in 2015) [12]. In Italy, in recent years, medium-sized cities have adopted increasingly innovative and competitive policies to reach the top positions within the Italian ranking ICity Rank 2019.

According to Garau and Pavan [13] the SC is a city that integrates different ecological, social and technological models using available resources to improve the quality of life of its inhabitants, improve efficiency in the use of environmental resources, build a green and innovation-driven economy, and promote democracy through citizen participation. Indeed, the SC concept, as a technologically advanced urban environment, meets the issue of environmental sustainability. In the last decade, the major Smart Cities in Europe and Italy have voluntary signed the Covenant of Mayors [14] (starting 2008), with the aim of reducing polluting emissions through the drafting of the Sustainable Energy Action Plan (SEAP) and, starting 2015, the Sustainable Energy and Climate Action Plan (SECAP). Indeed, in the main domain of Smart and Sustainable Cities, sustainability and urban resilience need to be prioritised as a central theme, in order to improve the liveability of cities and provide them with the essential tools to adapt to climate change [15–17].

Another relevant issue is undoubtedly sustainable mobility, which is one of the main topics addressed by Goal 11 ‘Sustainable Cities and Communities’ of the 2030 Agenda [18]. Considering that the transportation sector accounts for approximately a quarter of Europe’s greenhouse gas emissions [19], planning for a sustainable urban mobility is indispensable to pursue the objectives of CO2 emission reduction. For this purpose, many Italian cities have implemented Sustainable Urban Mobility Plans (SUMPs), drawn up according to the European guidelines [20, 21].

Within this context, the paper focuses on the issue of sustainable and active mobility (i.e. walking and cycling), analysing and identifying critical aspects related to pedestrian and bicycle accessibility to essential public services, within the conceptual framework of the 15-min city. In particular, the study focuses on the city of Cagliari, which is not included in the European ranking, but which, according to the Italian ICity Rank 2021, it is in 9th place as the smartest city in southern Italy.

The SUMP of Cagliari [22] has been drafted both at the municipal level (from 2018) and in the Metropolitan City (starting in 2019). The main objectives concern the improvement of active mobility, the introduction of road safety measures (e.g. traffic calming solutions), the reduction of road congestion, inclusiveness towards different means of transport and, of course, the reduction of GHG emissions and pollutants. Active mobility, according to the metropolitan SUMP guidelines, will be promoted by

reconnecting and extending existing routes, providing safe home/school/work routes, improving dedicated infrastructure, and encouraging cycling and walking at the social level.

The relationship between the aim of improving sustainability and meeting citizens' needs is expressed through a reconversion of urban spaces and a careful organisation and planning of the neighbourhood unit, rethinking services on the proximity dimension [23, 24]. This vision, rediscovered following the advent of the health emergency, has been embodied in the 15-min city concept centred on the 'walkable distance' from home to nearby amenities and urban spaces [25–29].

Therefore, the study is conducted at the neighbourhood scale, choosing the San Benedetto neighbourhood in Cagliari as a case study, demonstrating which public facilities and green areas, citizens can easily reach by walking or cycling, also thanks to the careful location of bike-sharing stations. Among the analysed public assets, the authors mainly see green areas as crucial, not only as meeting and socialising areas, but also as elements of the ecological-environmental infrastructure functional to climate change adaptation goals.

The remainder of the paper is organised as follows: Sect. 2 presents the analysed case study of the San Benedetto neighbourhood, a central area in the city of Cagliari; Sect. 3 illustrates the applied GIS methodology to map isochrones for assessing pedestrian accessibility levels of essential services; Sect. 4 presents the results of the methodology application in the case study. The section also analyses intermodal opportunities for the district, considering alternative means of transport, such as bike-sharing, cycle paths, and local public transport. Finally, through discussion and concluding remarks, Sect. 5 outlines some possible sustainable mobility strategies that can encourage active mobility within the neighbourhood, also thanks to specific urban policies already undertaken by the municipal administration.

2 Case Study

The chosen research area is located in the San Benedetto neighbourhood, a central district in the municipality of Cagliari, the capital of Sardinia, located in the South of the island (Fig. 1).

The district is affluent in activities and commercial services, and it is characterised by a heterogeneous road system. Via Dante Alighieri is the main street that crosses the neighbourhood from north to south. Piazza San Benedetto is the main square that serves as a roundabout rather than a gathering area. The main streets of S. Benedetto radiate out from that square.

San Benedetto is one of the most densely populated neighbourhoods in the municipality with approximately 8,000 inhabitants (in 2019) and an area of app. 1.15 km^2 (Fig. 2). The study area considered in this paper corresponds to the central part of the district, covering an area of 0.4 km^2.

Fig. 1. Location of the Municipality of Cagliari in relation to the South of Sardinia. Source: Google earth.

Fig. 2. Aerial view of the San Benedetto district in Cagliari. Source: elaboration from Google earth.

Within the neighbourhood, pedestrian spaces have been mapped and, starting from the street graph, cycle paths have been identified. Furthermore, the neighbourhood contains also traffic calming areas such as Restricted Traffic Areas (ZTL) or 30 km/h zones, as further discussed in Sect. 5: these solutions are used in historic city centres and areas close to public services and facilities to encourage slow mobility where there are no adequate spaces or road sections large enough to create new cycle paths. Those areas,

properly equipped with traffic calming measures, are meant to reduce pollution in certain areas of the city and give priority to pedestrians and cyclists without diversifying roadway functions.

Another element that supports slow mobility in the neighbourhood is the presence of bike-sharing stations, as planned in the SUMP of Cagliari. Figure 3 shows the location of these elements, as well as the presence of many local public transport nodes within the neighbourhood.

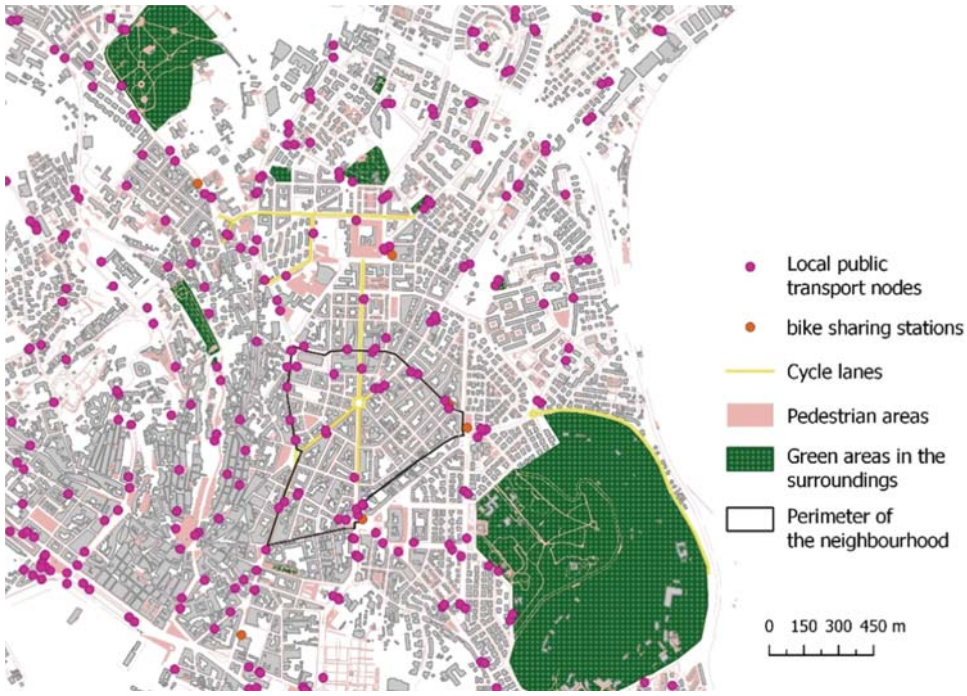

Fig. 3. Slow mobility infrastructures in the studied area: public transport nodes, bike-sharing stations, cycle lanes, pedestrian and green areas. (Color figure online)

3 Materials and Methods

In the proposed study, the accessibility assessment to essential services in the San Benedetto neighbourhood of Cagliari is based on a GIS methodology to map spatial and temporal isochrones for a specific urban area and its road network.

In this sense, isochrones represent an accessibility measure aimed at identifying the area that is within a certain distance or time from a given origin or destination. Starting from a precise spatial point, which corresponds to the location of a public facility, isochrones are created to map the service area, i.e. the area accessible in a given time from each analysed service.

There are many GIS-based methodologies and tools that can be used for this kind of analysis (some of them are described in [30]). Within the context of this paper, an online tool called ISO4app, which determines a specific pedestrian network to reach a service by means of a certain setting, was used.

To map the pedestrian isochrones, it was necessary to set in the online tool some specific key elements such as speed and time factor: an average pedestrian speed of 4 km/h was considered for all the analyses, while the time factor for the service area was modified in relation to each type of analysed service, looking at the travel time that a possible target user may be disposed to walk to reach that specific facility.

In particular, as also highlighted by the Universal Declaration of Human Rights ([31] art. 25–26), despite the fact that wellbeing today has increased their number, the essential services considered in the analysis and their optimal access times are:

- grocery shops, which should be reached within an optimal access time of 5 min from home;
- personal services (pharmacies, polyclinics), which should be reached within an optimal access time of 10 min;
- schools of the first cycle of education (kindergartens, nurseries, primary and secondary schools), which should be optimally reached within an access time of 10 min.

Base maps and data for the analysis were collected from the Territorial Information System of the municipality of Cagliari and from the Geoportal of Sardinia Region (e.g. cartographic data on the street network and on buildings, but also the location of existing public services and of public transport stops). Furthermore, some data were collected also from open data websites, like Open Street Map for the location of certain types of commercial facilities.

4 Results

4.1 Access Time to Grocery Shops, Personal Facilities and Schools

A first step of the analysis focused on the service area of essential services of daily or frequent access for the users: grocery shops, personal care and basic health facilities (pharmacies, medical doctors and polyclinics), and schools (nursery schools; kindergartens; primary and secondary schools).

Starting from the location of each essential service typology in the San Benedetto analysed area and its immediate surroundings (Fig. 4), the pedestrian isochrones for each service were calculated. As it emerges for the analysis, these services are available in the district, and they are easily accessible by foot from almost all the residential buildings located in the district.

Specifically, as shown in Table 1, the 96% of the buildings in S. Benedetto are located within a 5-min isochrone from a grocery shop (Fig. 5). The only two areas of the analysed area in the North-West and South-West that are not contained within the 5-min isochrone, have however a pedestrian access time to grocery shops of less than 15 min.

Fig. 4. Essential services (Grocery shops, personal care, education) within the neighbourhood and in the immediate proximity.

Fig. 5. Pedestrian distance of 5 min to grocery shops

Table 1. Percentage of buildings in the analysed area of S. Benedetto within the 5-min pedestrian isochrone from a grocery shop.

Total number of buildings in the analysed area	Buildings included in the 5-min isochrone from a grocery shop	% of analysed buildings located within 5 min walking from a shop
114	110	96%

Looking at personal care and basic health services, the whole analysed area is well served and included in a 10-min isochrone (Fig. 6a), with the exception of two medical clinics that serve the analysed neighbourhood, but they are not within walking distance (Fig. 6b). Similarly, school services can be reached by each residential building in the neighbourhood and in the close surroundings outside the perimeter (Fig. 7).

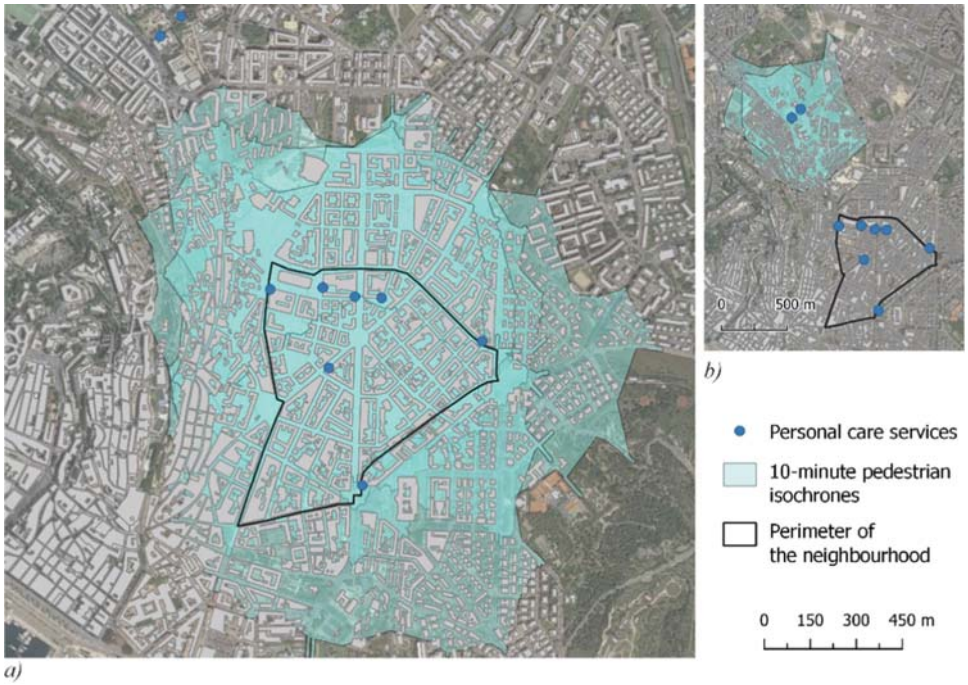

Fig. 6. Pedestrian distance of 10 min to personal care services

Fig. 7. Pedestrian distance of 10 min to first cycle schools

4.2 Accessibility to Public Green Areas

The second step of the analysis focused on accessibility to public green areas, which are probably the only type of public facility which is lacking within San Benedetto district. However, as it emerges from Fig. 8, there are some green areas in the surrounding, and the performed analysis focused on assessing their accessibility levels from the analysed area, checking if they are reachable by foot and by bike, also considering the availability of urban bike lanes and bike-sharing stations.

The most significant public green areas in the surrounding of the San Benedetto neighbourhood are:

- to the north, *Giardino della fermata di Genneruxi* (a green area of app. 1,000 m^2); *Giardini di via Castiglione* (a green area of app. 2,000 m^2); *Parco Giovanni Paolo II* and the adjacent *Parco Lions*, which cover an area of over 20,000 m^2 and include also a restaurant; *Giardino Biasi* of about 2,200 m^2; and *Parco Siro Vannelli* of almost 5,000 m^2. To the north, we also consider the largest urban park, *Parco di Monte Claro*;
- to the South, two adjacent parks: *Parco Martiri delle Foibe* and *Parco delle Rimembranze* of app. 4,000 m^2.
- to the East, a large open space *Parco di Monte Urpinu.*
- to the West, *Giardini pubblici*, an area of app. 16.000 m^2 which also host artworks.

The optimal access time considered to reach a public green facility should be of app. 10 min by foot. San Benedetto neighbourhood is well equipped with pedestrian

facilities and infrastructures and has very good connections with surrounding districts of Cagliari thanks to evenly distributed local public transport stops (Fig. 3). On the contrary, bicycle lanes are scarcely present (Table 2) and cover only 15% of the length of the streets in the district. Outside the district, there are bicycle lanes on the extension of *via Dante Alighieri* and further north on *via dei Giudicati*. With reference to green areas, the cycle path that goes around the *Parco di Monte Urpinu* to the east is of considerable importance.

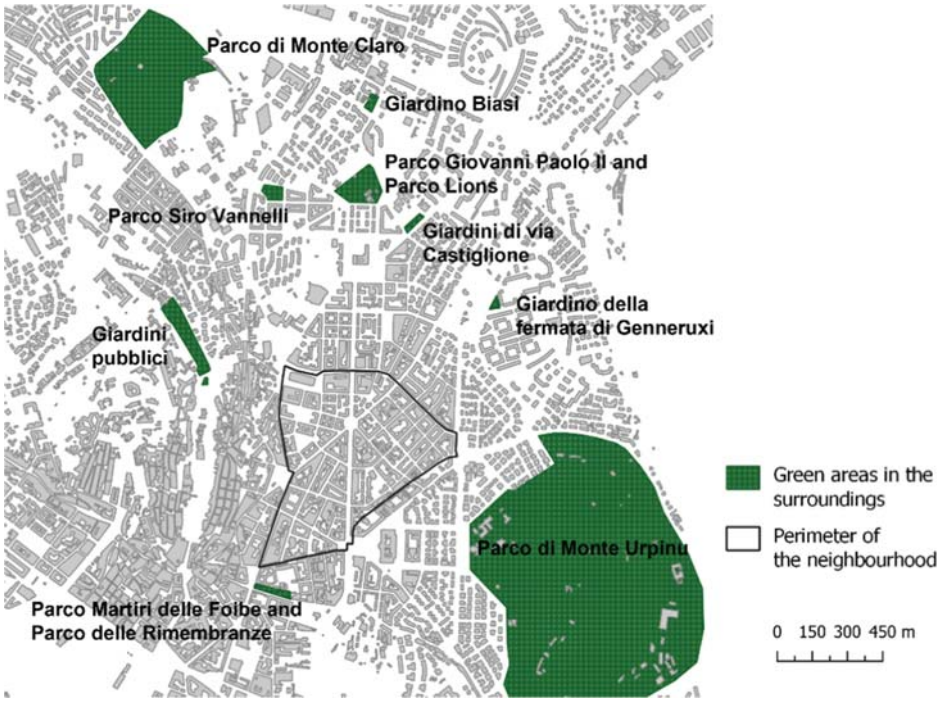

Fig. 8. Location of public green areas in the surrounding of San Benedetto (Color figure online)

Table 2. Presence of cycle lanes along the streets of the analysed San Benedetto area

Total linear meters of streets in the analysed area	Linear meters of cycle lanes	%
9,678 m	1,477 m	15%

The implementation of bike-sharing stations, planned in the ongoing SUMP of Cagliari (2021), provides a good modal choice to move in the area quickly and sustainably. The pedestrian accessibility of the bike-sharing stations shown in Table 3 is easy for about half of the buildings, and less for the rest, although the distances are not too wide (Fig. 9).

Table 3. Accessibility of bike sharing stations by buildings in the neighbourhood

Total number of buildings	Buildings included in the 5-min isochrone from a bike sharing station	% of buildings
114	56	49%

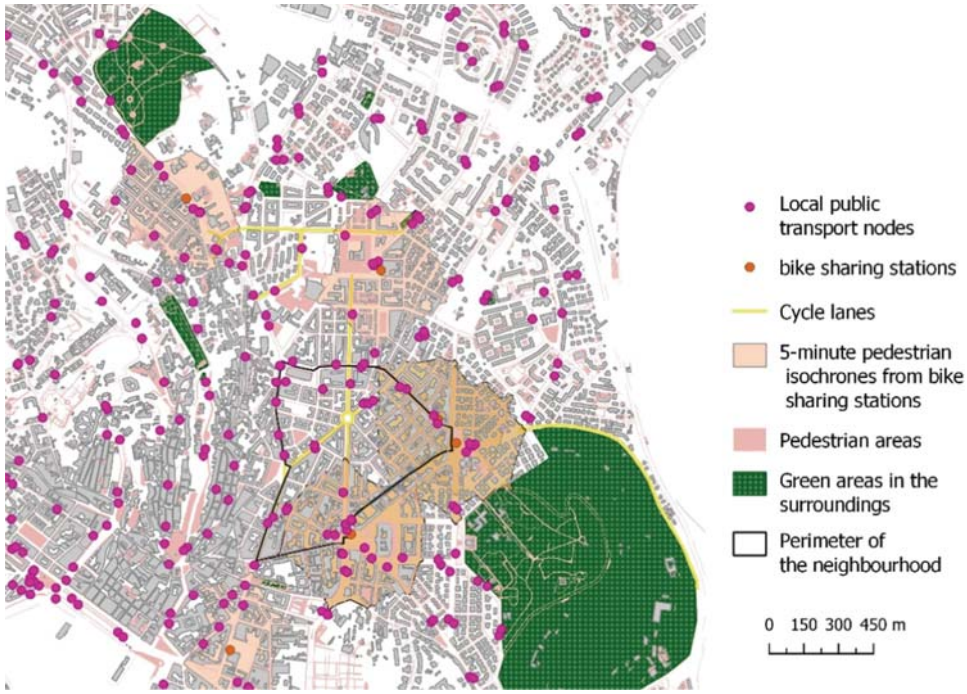

Fig. 9. 5-min pedestrian isochrones from bike sharing facilities in San Benedetto and its surroundings (Color figure online)

Nevertheless, by calculating through the ISO4app tool the isolines starting from the main public green areas in the surroundings of San Benedetto neighbourhood, it was possible to identify the areas covered within 10 min of walking time (Fig. 10). Just from over half of the buildings in the analysed areas, it is possible to reach a green area within a 10-min walk (Table 4).

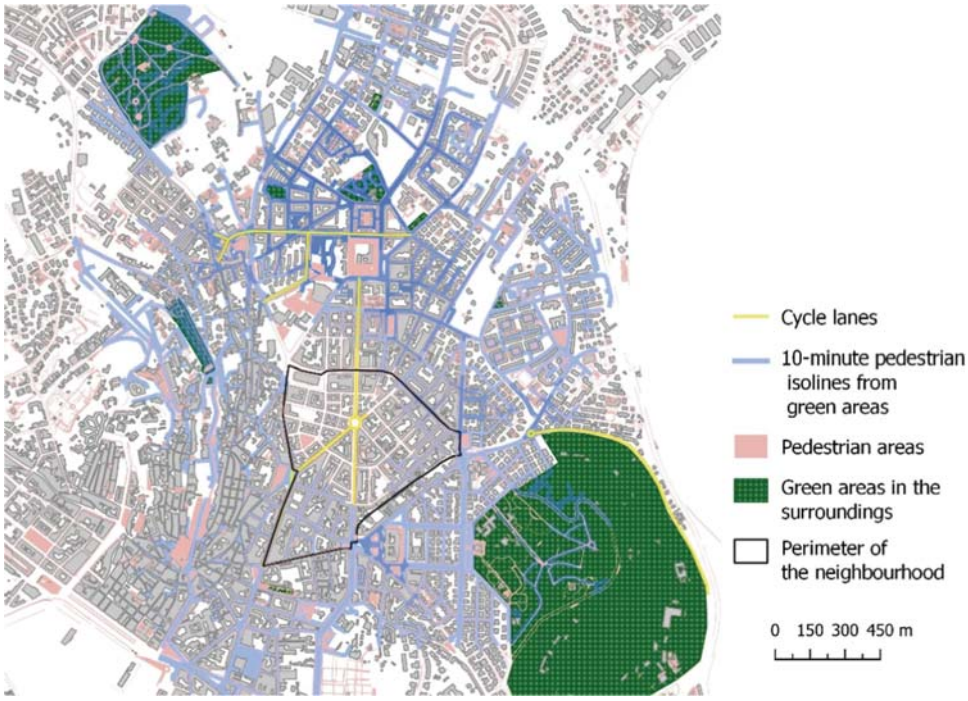

Fig. 10. 10-min pedestrian isolines from the public green areas surrounding the neighbourhood. (Color figure online)

Table 4. Buildings in the neighbourhood from which it is possible to reach a public green area within 10 min.

Total number of buildings in the analysed area	Buildings included in the 10-min isochrone from a green area	% of buildings
114	61	53%

5 Discussion and Conclusions

Today, sustainable mobility should play a leading role of daily movements in the city, both from the energy transition and SC perspective, and cities should aim at enhancing and rediscovering the values of proximity, socialisation, and physical health.

An important element of smart planning is therefore to return to a human-centred vision to focus on citizens in designing urban environments and services able to meet citizens' needs, including the most vulnerable ones [32–35].

Within this framework, the contribution proposed an accessibility study to proximity services for a central district in the city of Cagliari, with the aim of verifying if all residents have the possibility to easily reach essential amenities by foot.

From the data collected and the analysis performed, it emerged that the neighbourhood is very well served and provides high accessibility levels. However, even if the

neighbourhood is well equipped in terms of footpaths and pedestrian infrastructures, high traffic flows are still resulting in a greater potential risk for pedestrians and cyclists. Many areas of the neighbourhood are not included yet in the 30 km/h zones, nor in the Restricted Traffic Zones. Furthermore, bike lanes are only present along the main street and not all buildings have high accessibility (less than 5 min on foot) to the bike sharing facilities.

In accordance with the SUMPs that are being developed in Italy, active mobility could be encouraged and made safer by limiting vehicle traffic and introducing Traffic Calming areas such as the extension of Restricted Traffic Areas (ZTL) or 30 km/h zones in the historic centre [36], as it has already been proposed even in Cagliari at municipal level (Fig. 11).

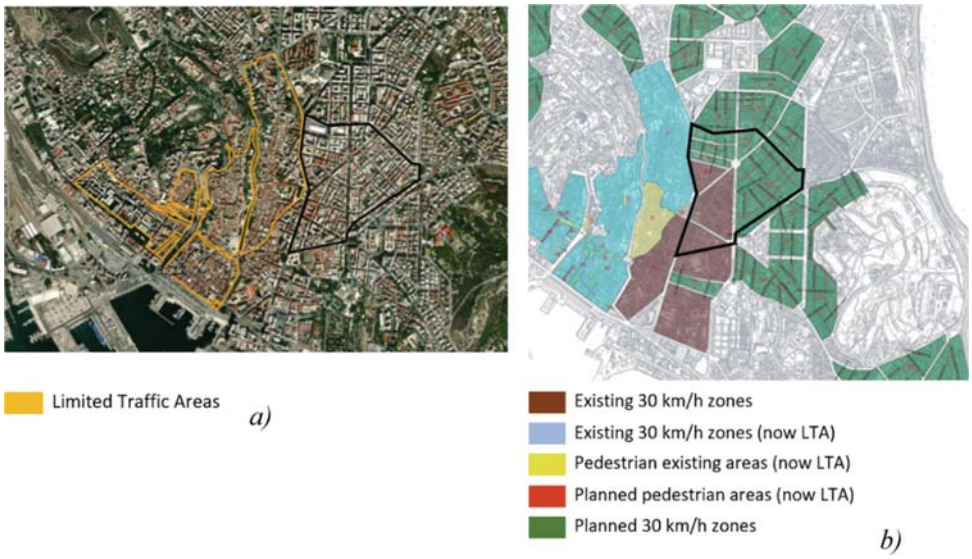

Fig. 11. a) Limited Traffic Areas and b) existing and planned 30 km/h zones. Sources: Municipality of Cagliari Geoportal.

In conclusion, as it emerged from the analysis, the neighbourhood is very rich in services and facilities, and therefore accessibility levels are very high, with the partial exception of pedestrian accessibility to public green areas, whose accessibility is guaranteed in times of more than 10 min walking. An accessibility study like the one proposed may be certainly more effective and highlight more possible accessibility weaknesses in more critical areas that need urban regeneration interventions or that are more peripheral.

A possible development of this work is to link bike-sharing data with the distance to green areas to combine pedestrian mobility with cycling, also taking into consideration the usage patterns and adoption barriers [37]. Further developments of the work may also include a more detailed definition of the isochrones (e.g. by including in the service area the waiting time at road intersection), and a detailed mapping of population distribution within the neighbourhood to assess the exact percentages of inhabitants served within the service areas (as proposed in [25]) .

Acknowledgements. This work started and developed as a result of a project proposal within the doctoral course "Smart and Sustainable Cities (2nd edition)" held at the University of Cagliari (https://dottorati.unica.it/dotticar/smart-and-sustainable-cities-2-Edizione/).

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