The 15-minute City Model: Assessment of the Socio-Economic and Environmental Impacts Associated with the Location of Essential Amenities

Dino Molinaro[1], Valentina Santarsiero[1,2], Lucia Saganeiti[3(✉)], and Beniamino Murgante[1]

[1] School of Engineering, University of Basilicata, Viale dell'Ateneo Lucano 10, 85100 Potenza, Italy
[2] CNR IGAG, Area della ricerca di Roma 1, strada provinciale 35d, 9, 00010 Montelibretti (RM), Italy
[3] Department of Civil, Construction-Architectural and Environmental Engineering – DICEAA, University of L'Aquila, Via G. Gronchi, 18, 67100 L'Aquila, Italy
lucia.saganeiti@univaq.it

Abstract. The 15-minute city is a way of strategically and ecologically planning the amenities and spaces of an urban area. This model based on sustainable urban planning, built on the concept of proximity of amenities, facilitates the commuting and brings an environmental advantage in terms of reduction of greenhouse gas emissions from vehicular traffic. The application of this city model becomes critical in areas characterized by settlement dispersion.

In fact, there are several socio-economic and environmental impacts linked to a dispersed location of essential amenities in non-compact urban contexts. For example, the economic cost of travelling, the time taken to reach essential amenities which are often decentralized in peripheral districts of cities, the pollution generated by the widespread use of private means of transport, determined by inefficient mass transport systems. This research aims to analyze the socio-economic and environmental impact of context characterized by peripherality, settlement dispersion and lack of essential amenities. The study area focuses on the Italian Municipalities of Terni, Matera, Pisa and Trento where the 15-minute city model has not been pursued in the urban planning process. The work carried out highlights the distinction that exists between the different cities, showing how the provision and location of essential amenities, considered as a fundamental parameter for the study, improves the quality of life.

Keywords: Sustainable City · Urban Sprawl · Accessibility · 15-minute city

1 Introduction

The concept of the 15-minute city was introduced in 2016 by Carlos Moreno [1–3], who proposes a new idea of proximity within cities, oriented towards sustainable development and referring to the theory of chrono-urbanism, which takes into account not only space

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but also the temporal dimension when designing cities. According to this model, an urban context with a high degree of liveability is one in which all different types of amenities and socializing places are ideally within a 15-min walk or cycle ride from their residence. The aim of this innovative approach to planning is to positively influence the pace of life in cities, reconnecting people with their surroundings and eliminating unnecessary travel by polluting and energy-intensive means.

The positive effects of the 15-minute city model were tested and adopted during the pandemic, due to smart working and total lockdown rules to control and contain the spread of the virus. What it proposes, in fact, is a sort of return to the vitality of neighborhoods, promoting the frequenting of the streets 'down home' with many benefits, starting from a re-appropriation of one's own vital time, thanks to the drastic reduction of hours wasted in long journeys, traffic jams within the metropolis [4, 5].

In this context, the model of the 15-minute city could represent a long-term objective for cities in post-pandemic recovery. The solutions linked to cycle-pedestrian mobility and the redevelopment of open spaces should, however, be evaluated not only from a purely quantitative point of view, but also by the presence of amenities (already existing or to be built) that guarantee an attractiveness and a level of use appropriate to the places, linked to the temporality of the functions they can accommodate.

The implementation of this city model becomes problematic in areas characterized by urban sprawl and settlement dispersion [6, 7]. The spread of sprawl, in areas already affected by demographic and social imbalances, determines high costs for the population. There are several elements that characterize the impact in socio-economic and environmental terms; socio-economic impacts refer both to the economic cost of travel, and to the time taken to reach essential amenities often concentrated in central districts. In environmental terms, however, reference is made to the pollution generated by the extensive use of private means of transport, in turn determined by the difficulty of articulate functional mass transport systems in areas where the low population density generates weak demand [8]. Currently, compact development remains the most sustainable form of the high-density city [9]. From a spatial point of view, the level of peripherality of territories with respect to urban centers, home to a wide range of amenities, profoundly influences the quality of life of citizens and the level of social inclusion. Peripheral areas force the people living in them to bear high time and monetary costs to access central ones [8]. When describing the distribution of travel determined by the demand for the use of basic amenities, it also emerges that the terms accessibility and mobility are used interchangeably. It is necessary, however, to distinguish the two notions, pointing out, in particular, how the concept of accessibility, with reference to a service, is declined in the possibility of reaching it and in the manner in which this is reached by the user [10]. The objective of this research concerns the evaluation of costs resulting from the effects of the urban sprinkling phenomenon, i.e. the dispersed and low-density city. By classifying the amenities of primary necessity and assessing the demand for amenities through the division into travel isochrones, the case studies of the cities of Matera, Terni, Pisa and Trento will be compared.

2 Material and Method

2.1 Study Area

The research focused on the study of four Italian municipalities with similar socio-demographic and morphological characteristics: Matera, Terni, Pisa and Trento (Fig. 1).



Fig. 1. Territorial Framework.

The city of Matera is located in the eastern part of the Basilicata region at 401 m above sea level and is the largest municipality in the region with its 392.09 km^2. It is the second most populous municipality in the region with its 59824 inhabitants, 4.9% of whom are foreigners, and a population density of 152.58 inhabitants/km^2. It is also known as the 'City of the Sassi', precisely because of the peculiarity and uniqueness of its historical center, characterized by ancient settlements excavated in calcarenite, close to the gorge carved by the Gravina stream. Since 1993, UNESCO has declared the Sassi district a World Heritage Site. In 1952, the law for the displacement of the Sassi was passed and the city began to expand into new neighborhoods; the neighborhoods created

in the 1950s had as their main characteristics large common green spaces and buildings with few floors, to reproduce the Sassi's social life models as much as possible. An initial phase of orderly expansion that perfectly followed Piccinato's first urban planning instrument was followed, in the 1990s, by a phase of disorderly expansion, resulting in neighborhoods characterized by the morphological and typological inhomogeneity of the built fabric, a lack of green spaces, undersized roadways and an absence of urbanization works [11]. Terni is located 130 m above sea level in the region of Umbria with a large land area of 212.43 km^2, the resident population is about 106844 inhabitants of which 12.2% are foreigners. The population density is 502.96 inhabitants/km^2. The territory is mainly mountainous, the hilly areas cover an area of about 31.6%. The city of Terni has a modern structure, due to post-war reconstruction; it has had a strong urban expansion, developing on four axes arranged radially around the central core. One of the city's problems is the poor connection of the suburbs with the urban center. The city of Pisa lies a few kilometers from the mouth of the river Arno, in the north of the region of Tuscany, in a flat area called Valdarno Inferiore, at 4 m above sea level, and extends over an area of 185.18 km^2, with a population density of 485.08 inhabitants/km^2 and a total of 89828 inhabitants; 14% of these are foreigners. The urban fabric has an 'oil spot' configuration, in which the settlement system expands uniformly around the compact historical center, delimited by the city walls. A peculiar characteristic of the city is the presence of the so-called 'Pisan gardens', private green areas that are quite extensive but not very accessible as they are separated from the urban fabric by stone walls. As they are separated from the urban fabric by brick or stone walls. The greatest modern urban revolution took place in the 1970s when the suburbs began to develop to the west and in the early 1980s when they began to develop to the east, taking the modern suburbs of foreign cities as a model.

Trento, with an area of 157.88 km^2, is located in the central part of Trentino-Alto Adige at 194 m above sea level. It has a population of approximately 118632 inhabitants and a population density that is not characteristic of compact cities due to its vastness extension, amounting to 751.41 inhabitants/km^2. The municipal population is mainly concentrated in the city, but there are numerous scattered centers or suburbs, which are quite different from one another and still retain their own rural and cultural identity. The four study cities are classified differently in the mapping of the SNAI (National Strategy for Inner Areas) [12]. The Map of Inner Areas updated to 2020 classifies the cities of Pisa, Trento and Terni as a Pole and Matera as an Intermediate Municipality. This classification system defines service poles as those municipalities with an articulated upper secondary school offer (at least one high school - scientific or classical - and at least one technical and professional institute), at least one hospital with an emergency room and intensive care units, a railway station of at least silver type. Neighboring municipalities are defined according to the distance from the municipalities service pole. The Municipality of Matera is considered an intermediate municipality as it does not have a silver category station.

2.2 Methodology

The dataset used for the analysis of population movements, in relation to the amenities available in all cities, consists of open data, including information on resident population, location of amenities and reason and mode of travel. Resident population data were obtained from the European Copernicus website by accessing the Urban Atlas project in the Land Monitoring Service section [13].

Spatial information in vector format dating back to 2018 was used, taking into account the polygons falling within the surveyed territory. The vector files were processed using the opensource software QGIS, filtering out geometries with a population value greater than zero; they were then switched from areal to point information, generating the centroid of each polygon. The data concerning the essential amenities present in the various territorial contexts were obtained from the information present within the OpenStreetMap map using the QuickOSM plugin. Only amenities belonging to the categories health, economy and finance, education and sport and leisure were selected. The database obtained was supplemented with other amenities obtained from geolocation by photointerpretation on Google Maps. Data from the 18th Audimob Report on the Mobility of Italians [14] were used for the analysis of trips, in particular information on the distribution of trips by motivation and the percentage of transport used according to the size of cities by number of residents.

The endowment of essential amenities is a fundamental parameter against which to assess the quality of life in a specific territory. It can also be understood as a deficit assessment, i.e. the absence of minimum requirements for the supply of essential amenities with reference to the urban functions exercised by each territorial unit [15, 16]. The main categories of amenities examined for each study area were extracted from Google My Maps using the Points of Interest export function. The service points were imported into the GIS environment and reclassified into 10 main categories, each consisting of subcategories as follows (Table 1):

Table 1. List of amenities and equipment.

REFERNCE CODE	TYPE OF SERVICE
CM	Commerce
CU	Culture and Art
ED	Education
HE	Health
S	Services
FS	Financial Services
PS	Public Services
SA	Safety
SF	Sport and free time
TR	Tourism

The analysis of the road traffic in the four territories was carried out using the ORS Tools plugin (openrouteservice routing, isochrones and matrix calculations for QGIS), which is able to generate isochrones, i.e. the location of points having equal distance, spatial or temporal, with respect to a fixed point entered as input. The distance between the initial point of departure and the points of arrival is not linear but, by setting a value in metres or minutes in the plugin, is calculated as a function of the possible real routes that can be travelled within the OpenStreetMap road network. In this research it was chosen to use as a starting point, a point belonging to the center of each individual city, symbolically identifying it with the town hall. A spatial interval between two consecutive isochrones of 2000 m was set, with the option of selecting the fastest route. Starting from the information available in the dataset, the elements of the vector files of population and amenities were re-processed by associating to each element the information relative to the isochronous band to which it belongs. This operation made it possible to obtain the total population and amenities data in each band.

The analysis of the movements for each portion of the population was carried out using the statistical data on mobility for the year 2018 [14]. From the available statistical data, the trips made by the population residing in the band under consideration were evaluated. In a corresponding approach, the distribution of amenities across the territory was determined by calculating the number of amenities located in each isochronous range.

It was assumed that 5.1% of all trips were for study purposes and 32.7% for sport and leisure. For the categories health and economy and finance, the percentage value of trips for family management (34.4%) was taken into account. The remaining part of work-related trips (30.8%) was not taken into account in the study-related trips because it is considered that work-related trips are influenced by different factors than the other amenities considered.

In order to obtain the movements of the population to reach amenities, a demand model was used to derive the population data from URBAN ATLAS [13], amenities and displacement referred to each isochrone.

In each isochrone band the satisfaction of the demand for the service considered was verified, if the demand was not considered satisfied according to the presence of at least one element belonging to the category of service requested, for example in the case of the absence of amenities, the hypothesis of a displacement towards the contiguous isochrone band closest to the center was assumed, iterating the procedure until the condition was verified by proceeding towards the city center.

Subsequently, in order to estimate the costs and the production of C02 resulting from trips from one isochrone to another, generated by the absence of amenities, and in order to analyses the consumption resulting from these trips, the total distance travelled was analyzed using the number of trips that occur with the passage between two adjacent isochrones whose distance is fixed at 2 km.

The total distance travelled on a daily basis is thus the sum of the number of trips made by each inhabitant as a function of the number of isochrones crossed. The analysis of the CO2 production estimate was carried out by multiplying the total distance travelled, determined for each city, by the coefficient of CO2 emissions expressed in Kg/Km, taken from the *terraup.it* website [17], choosing as the route a mixed path, entering the

best-selling car models in Italy (Fiat Panda, Fiat 500, Fiat Punto, Jeep Renegade and Volkswagen Golf) [18]. The fuel price was set at the average price for the month of July/August 2022 of €1.859/liter for diesel and €1.869/liter for petrol, choosing an urban route. The evaluation of the management costs of a private car was carried out using the ACI 2022 Tables [19] which provide, for each car model, a mileage reimbursement coefficient which takes into account all management costs (fuel costs, wear mechanics, ordinary and extraordinary maintenance, insurance costs and ownership tax). The coefficient relating to each of the 5 car models taken into consideration was chosen by multiplying it by the distance traveled in both cities. The values of CO2 production, fuel consumption and running costs, obtained for each car model, were averaged to obtain the daily value and, subsequently, the monthly and annual value.

3 Results and Discussions

The reconstruction of the essential amenities has made it possible to create a complete database of all the essential amenities present in the investigated municipalities. This database and the related Service Charters provide an initial overview of the location and distribution of amenities in the investigated cities. Comparing the demographic trends of the Italian resident population from 2009 to 2019, the cities of Matera and Terni show a slight decrease in population, while the cities of Trento and Pisa show an opposite trend and show a small increase in the resident population (Fig. 2).

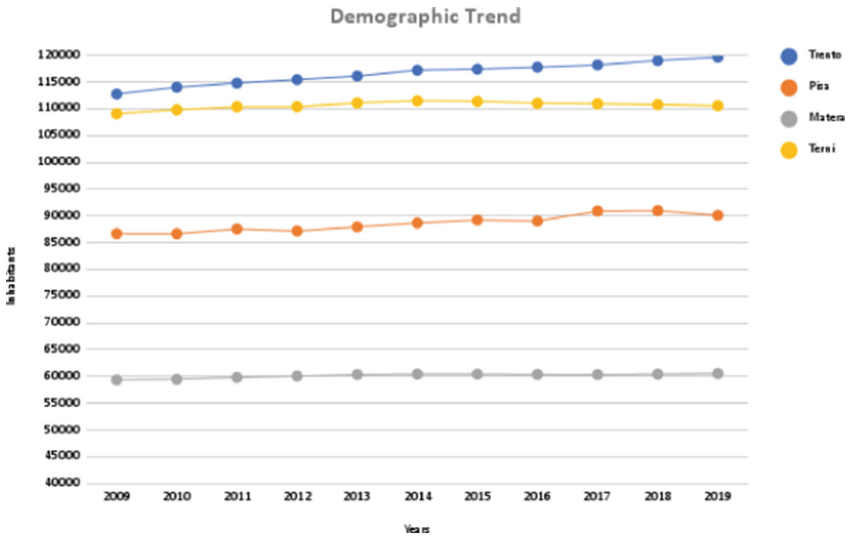


Fig. 2. Demographic trend.

The identification of the amenities has highlighted, in addition to the difference in positioning on the territory, a different assortment in the different isochrone bands. The data relating to the first band (0–2000 m) are substantially similar for all categories of amenities (Fig. 3).

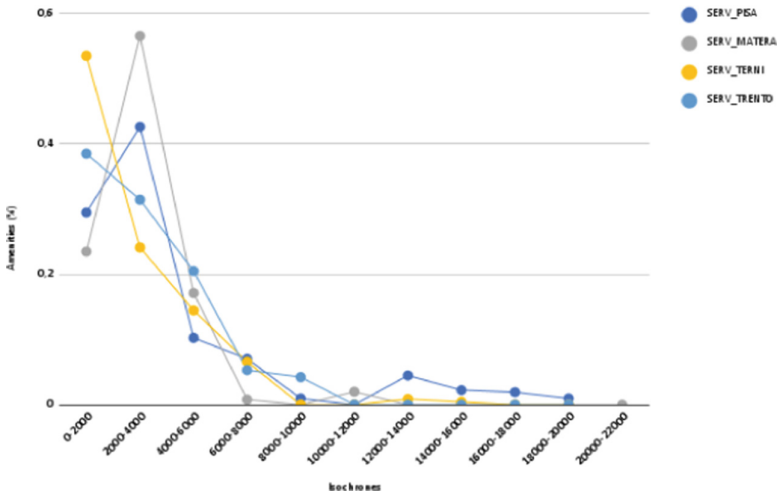


Fig. 3. Distribution of amenities divided into ranges of isochrones.

The analysis of the displacements was carried out for each isochronous band starting from the contained population value. For each type of service, the fraction of the total movements that take place to reach that category of service was calculated and, subsequently, the methods with which the movement takes place were specified.

The evaluation of journeys with private vehicles was possible by knowing the value of total kilometers travelled, and the percentages of the methods with which journeys with own means of transport take place on average, i.e. with cars and motorcycle.

There is a clear correlation between the kilometers traveled and the number of users moving between the cities of Trento and Terni. Completely different scenarios emerge for the cities of Matera and Pisa.

For the city of Matera we note a large number of people who need to move to access amenities, but traveling shorter distances, because the kilometric data obtained is not high, otherwise it happens in the city of Pisa, because the number of population it moves does not differ much from that of Matera, but the kilometers traveled are about three times (Fig. 4).

Using the online service offered by the terraup.it site and the ACI tables, the CO2 production value in kg, the cost of fuel consumption and the cost of car management were obtained from the kilometers travelled. Obtained the results relating to the calculation of the kilometers traveled in each city, the monetary cost of the journeys and the production of CO2 were calculated. These two variables are considered the main consequences of the demand for mobility determined by the imbalances in the distribution of amenities and which produce the more significant externalities, in economic and environmental terms, for the resident population.

The results obtained from the experimented methodology refer only to travel to reach amenities, as the purpose of this analysis is to highlight in which city the environmental and monetary costs referable to the travel demand generated by the distribution of population and amenities are higher.

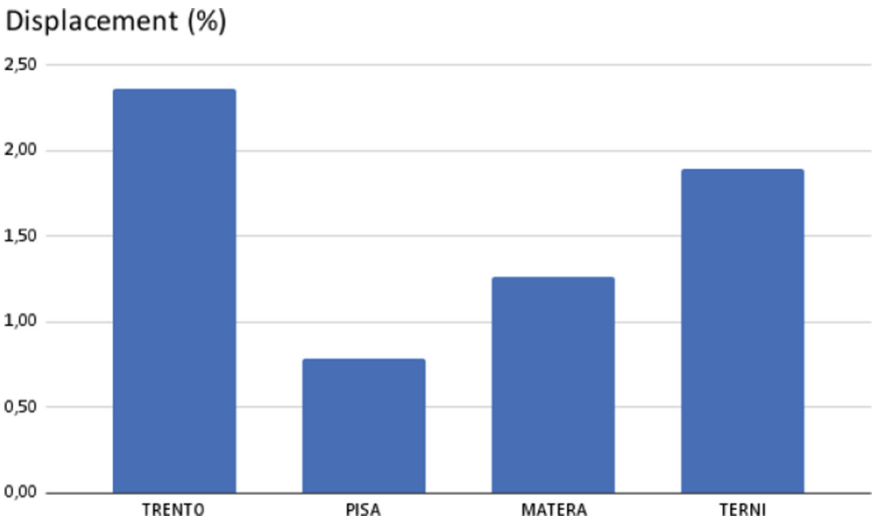


Fig. 4. Percentage of displacement.

In Fig. 4, it can be seen, in percentage terms, the population that moves to reach amenities, it is noted that only 0.20% of the population of Trento needs to move to reach an essential service. For Pisa and Matera, the percentage of the population that moves is similar, while in the case of the Municipality of Terni, 7.52% of the population has to move to reach a service.

The small percentage of the population that travels by car to reach amenities in the city of Trento is the result of a constant revision of planning tools, starting from the master plan drawn up in the 1960s up to the most recent one updated to 2022. Conformation of the territory has constituted a fundamental determinant of the planning action, orienting the concentration of the urban settlement along the valleys, where the amenities are also located, limiting the urban settlements on the slopes of the surrounding mountains and in particular by equipping the industrial area of amenities.

In clear contrast Terni: one of the first industrial cities in Italy, whose industrial revolution has distorted the appearance of the city. In fact, it expands by relocating the city center, in fact it emerges that most of the amenities present in the area are located in the city center, to the south-east of the territory, while a large number of the population resides in the peripheral areas without essential amenities.

The city of Matera has had an evolution from an urban point of view from the second half of the twentieth century, when the Sassi were declared unusable due to poor sanitary conditions and consequently displaced, the city was planned with the limitations due to Gravina. In the nineties the scenario changes, new built-up areas are born which expand the city in a very disorderly way. The city center has a good range of amenities, lacking instead in the northern part of the city where, however, part of the population is concentrated; therefore 3.54% of the population is destined to move towards the city center to reach essential amenities. Data similar to that of the city of Matera, we have for Pisa, the amenities are more present in the center of the city, in this case in the upper

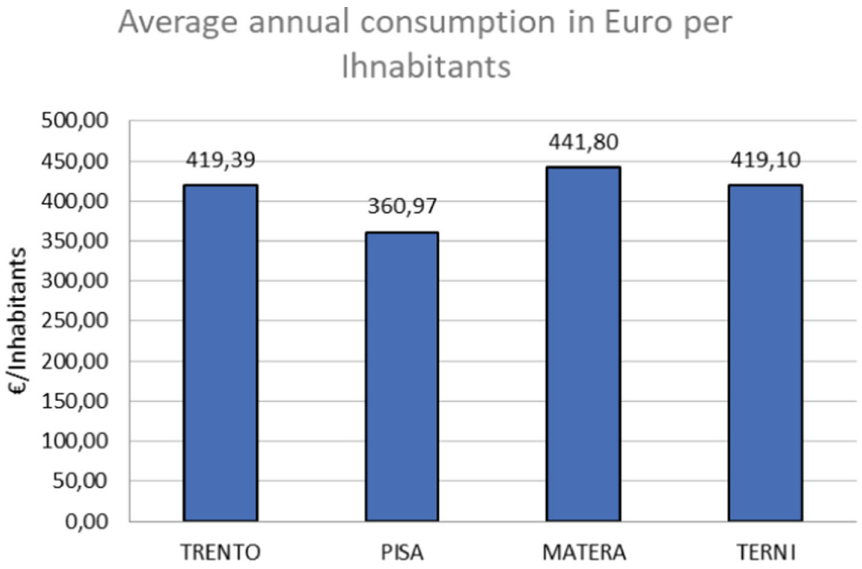


Fig. 5. Average annual cost in euro.

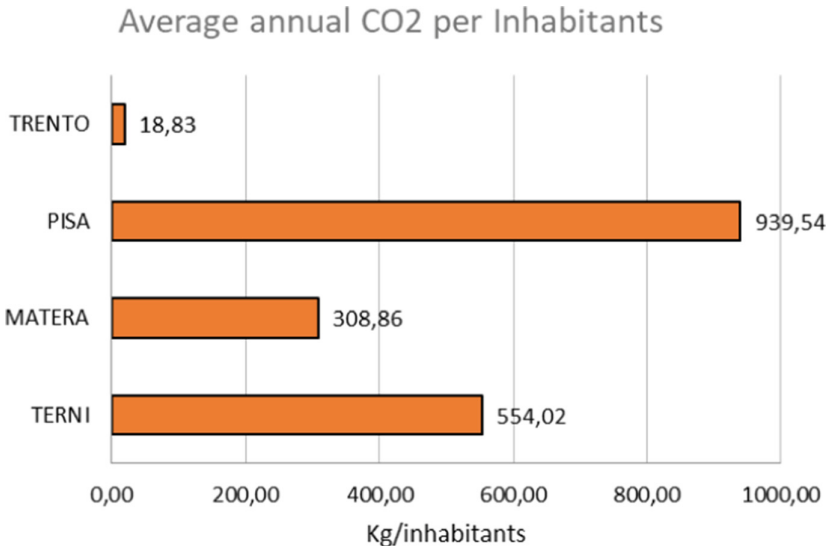


Fig. 6. Average annual production of CO2 per inhabitant.

part, while the area of the Pisan coast records a scarcity of amenities, but a high presence of population; a similar scenario can be found in the southern quadrant of the city.

Examining the costs distributed over the entire population, it can be seen that the city of Terni has the highest cost and emission values. On the contrary, by dividing the costs only on the portion of the population that travels to access basic amenities, we note that in the Municipality of Pisa, a user who travels to access a basic service spends

around 240 euros a year and produces about 815 kg of CO2; these data are closely linked to the percentage of the population that moves (Fig. 6), for this reason the per capita consumption and production of CO2 for the city of Terni are low, because the population that moves is high (Fig. 5).

4 Conclusions

This research represents the main elements of a first experiment based on the study of four cities. The first goal of this work was to create a methodology to link the two localized data, through displacements; secondly, however, the objective has shifted towards the calculation of costs and the production of CO2 due to travel; in order to mark the impact that poor territorial planning causes both economically and on the environment; with the future goal of integrating processing and improving traditional methodologies.

The cities of Trento, Pisa, Matera and Terni, referring to the definition of livable city, defined in the introduction, cannot be considered livable cities, due to the lack of essential amenities in the isochrone zones furthest from the city center. The 15-minute city model loses its validity due to the low population density and the fragmentation of the peripheral areas; these characteristics limit the possibility of a reconfiguration of the service system that satisfies the requirement of proximity, and that favors the use of alternative forms of mobility to the car to access the functions.

The work carried out highlights the distinction that exists between the different cities, showing how the provision and location of essential services, considered as a fundamental parameter for the study, improves the quality of life.

References

1. Allam, Z., Bibri, S.E., Chabaud, D., Moreno, C.: The theoretical, practical, and technological foundations of the 15-minute city model: proximity and its environmental, social and economic benefits for sustainability. Energies **15**, 6042 (2022)
2. Caragliu, A.A.: La città dei 15 minuti: Una moda di gran richiamo mediatico? ARCIPELAGOMILANO **17**, 1–8 (2022)
3. Balletto, G., Ladu, M., Milesi, A., Borruso, G.: A methodological approach on disused public properties in the 15-minute city perspective. Sustainability **13**, 593 (2021)
4. Roberts, D.: How to make a city livable during lockdown. Vox (2020)
5. Abdelfattah, L., Deponte, D., Fossa, G.: The 15-minute city: interpreting the model to bring out urban resiliencies. Transp. Res. Proc. **60**, 330–337 (2022)
6. Saganeiti, L., Favale, A., Pilogallo, A., Scorza, F., Murgante, B.: Assessing urban fragmentation at regional scale using sprinkling indexes. Sustainability **10**, 3274 (2018). https://doi.org/10.3390/su10093274
7. Saganeiti, L., Mustafa, A., Teller, J., Murgante, B.: Modeling urban sprinkling with cellular automata. Sustain. Cities Soc. **65**, 102586 (2021). https://doi.org/10.1016/J.SCS.2020.102586
8. Manganelli, B., Murgante, B., Saganeiti, L.: The social cost of urban sprinkling. Sustainability **12**, 2236 (2020). https://doi.org/10.3390/su12062236
9. Thomas, L., Cousins, W.: A new compact city form: concepts in practice. In: Compact City: A Sustainable Urban Form, pp. 328–338 (1996)
10. Ferrario, M.: L'accessibilità alle opportunità urbane: uffici postali e altri servizi della città di Milano (2019)

11. Santarsiero, V., Nolè, G., Lanorte, A., Tucci, B., Cillis, G., Murgante, B.: Remote Sensing and Spatial Analysis for Land-Take Assessment in Basilicata Region (Southern Italy) (2022). https://doi.org/10.3390/rs14071692
12. Bacci, E., Cotella, G., Vitale Brovarone, E.: La sfida dell'accessibilità nelle aree interne: riflessioni a partire dalla Valle Arroscia. TERRITORIO, pp. 77–85 (2021). https://doi.org/10.3280/TR2021-096007
13. Urban Atlas 2018 - Copernicus Land Monitoring Services. https://land.copernicus.eu/local/urban-atlas/urban-atlas-2018
14. 17° Rapporto sulla mobilità degli Italiani. https://www.isfort.it/progetti/17-rapporto-audimob-sullamobilita-%0Adegli-italiani/
15. Santarsiero, V., Nolè, G., Scorza, F., Murgante, B.: Geographic information and socio-economic indicators: a reading of recent territorial processes in the test area of Basilicata region. In: Calabrò, F., Della Spina, L., Piñeira Mantiñán, M.J. (eds.) NMP 2022. LNNS, vol. 482, pp. 2104–2111. Springer, Cham (2022). https://doi.org/10.1007/978-3-031-06825-6_202
16. Santarsiero, V., Nolè, G., Scorza, F., Murgante, B.: Evaluation of spatial variables related to the provision of essential services in the Basilicata region. In: Gervasi, O., Murgante, B., Hendrix, E.M.T., Taniar, D., Apduhan, B.O. (eds.) ICCSA 2022. LNCS, vol. 13376, pp. 344–353. Springer, Cham (2022). https://doi.org/10.1007/978-3-031-10450-3_29
17. Terraup. https://terraup.it/confronta_auto
18. Al Volante. https://www.alvolante.it/
19. Tabelle Aci. https://www.missionline.it/mission-fleet-post/tabelle-aci-2022/