The Rise of E-scooters in Palermo: A SWOT Analysis and Travel Time Study

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Abstract. In recent years, e-scooters became a popular transport mode, mainly covering the "first/last mile" in the trip-chain. The recent pandemic increased the use of these vehicles because it allows social distancing. While e-scooters are already part of the daily landscape in other countries, in Italy, and especially in Sicily, their diffusion has only recently started. Operators have seen demand growth, that created several critical issues referring to vehicle maintenance and vandalism. Although e-scooters tend to be a transport solution with enormous potential, especially in overcrowded cities with increasing private car traffic, several legislative issues need also to be resolved before these can be genuinely successful. This paper shows how to improve strategic planning for e-scooter micro-mobility utilising a SWOT analysis. The paper also identifies four urban poles of attraction and analyses e-scooter suitability in terms of travel time by employing isochrones for 5, 10 and 15 min.

Keywords: E-scooter · Accessibility · Micro-mobility · Sustainable mobility · Smart city · SWOT · Travel time

1 Introduction

Recently, several strategies have been deployed to make urban mobility more sustainable (Madapur et al. 2020). Cities are undergoing continuous transformation, and the latest city models tend to encourage proximity and the use of smart technology (Green 2002).

On the one hand, local governments invest on implementing conventional cycling and walking infrastructure, both temporary and permanent (Campisi et al. 2020a; Hagen and Rynning 2021). On the other hand, national governments encourage the purchase of electric and micro-mobility vehicles (Eccarius and Lu 2020). These actions have been intensified during and in the aftermath of the pandemic (Nikitas et al. 2021b) for raising

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public awareness regarding environmental sustainability and reducing the use of private vehicles, which increased after the pandemic due to the fear of contagion, especially when taking public transport (Arribas-Ibar et al. 2021; Griffiths et al. 2021). However, most big cities are not friendly to their inhabitants, especially vulnerable road users, e.g., children, pedestrians, the disabled, cyclists, the elderly (Broome et al. 2010; Hess 2009; Sundling et al. 2015).

The current infrastructure in most Italian cities is not yet adequate to guarantee safety for pedestrians, cyclists and also micro-mobility users. Several studies are trying to define whether today's cities can keep up with the pace of this new phenomenon and whether there is room for more means of transport (Campisi et al. 2020a; Campisi et al. 2021a). Other studies also highlight the need to analyse better the safety of e-scooters for the users themselves and other road users (Campisi et al. 2021a; Campisi et al. 2021b).

The main reason for this is the lack of a legal framework and rules for important questions about who, where and how can use this new mobility option.

The aim of this work is to demonstrate a dual strategic tool improving the micro-mobility service in the examined area. A first step of evaluation was conducted on the factors that characterise the operation of the existing shared mobility system in the city. Starting from the plausible assumption that e-scooters are mainly used for short-distances and they are considered really competitive for the firtst/last mile of the trip-chain, we estimate which areas can potentially be reached within 10 min from certain focal city areas.

The results lay down the foundations for the relocation and improvement of the service and evaluating some criticalities that have emerged since the start of the shared e-scooter service.

2 Literature Review

The evolution of cities is characterised by a growing urban population and a progressive tendency to pursue smart city models promoting, among others, digital evolution. Several actions have been implemented thanks to planning tools such as a sustainable urban mobility plans (SUMP), taking into account the strategic objectives of Agenda 2030 to improve the quality of life of citizens in urban areas (Campisi et al. 2020c). Studies also show that the 15-min city and smart city models are gaining popularity, especially in European cities (de Valderrama et al. 2020).

While planning focuses on strategies for improving urban spaces, it also promotes new technologies for "smart" transport including electric vehicles (Kougias et al. 2020), autonomous driving (Nikitas et al. 2021a) and e-scooters (Nikiforiadis et al. 2021; Ignaccolo et al. 2022).

Moreover, it helps in promoting multimodality in urban transport leading to efficient use of resources (Campisi et al. 2021d). SUMP evolution, i.e. the planning tools promoted by the EU and used by cities in their policy planning are often related to a fourfold SWOT analysis where the strengths of certain modal choices are defined, taking into account technological developments and vehicle characteristics and business models that may lead to threats to a city's overall mobility and liveability. Some studies in the literature focus on SWOT evaluations related to scooters, often highlighting

some criticalities such as unregulated parking or careless use. Improving micro-mobility services should consider active strategic cooperation between local public authorities, public transport agencies and operators of shared e-scooter services (König et al. 2022; Sundqvist-Andberg et al. 2021). Micro-mobility has become a trend initially in China and the USA and during the last two years also in Europe. It has proved extremely attractive to inhabitants of large cities. Research has shown that more than half of all users see micro-mobility as an acceptable and suitable mode to avoid traffic congestion and stress. Shared e-scooter systems were first introduced in 2017, and in some European countries, the direct purchase and ownership of scooters through discounts and subsidies has also proved successful (Gebhardt et al. 2021; Glavić et al. 2021).

Some studies show that e-scooters can help cities with environmental issues, such as reducing air pollution (Campisi et al. 2021b). At the same time, other works highlight the need to reduce inequalities in access to transport, promote money-saving and improve mobility resilience (Campisi et al. 2021e; Nikiforiadis et al. 2021). Several studies have investigated public opinion regarding e-scooters based on who does not use them, highlighting critical issues in the lack of infrastructure and the absence of a legislative framework (Kostareli et al. 2021; Tsami et al. 2022). A small number of studies focus on the propensity to rent, share or buy scooters (Bieliński and Ważna 2020; Campisi et al. 2021a; Campisi et al. 2020b; Campisi et al. 2020c). A series of surveys have been disseminated in different European contexts to analyse the characteristics of the e-scooter sharing service and the profile of its users (Kostareli et al. 2021; Nikiforiadis et al. 2021; Raptopoulou et al. 2021).

Although the topic of e-scooters in a national context has recently been evaluated, some aspects remain unstudied. For example, the dynamic behaviour of e-scooters is not as systematically studied as that of e-bikes. This could help public administrations to plan the circulation of e-scooters in cities and advise manufacturers to improve their design by including shock absorbers to increase comfort (Boglietti, Ghirardi, Zanoni, Ventura, Barabino, Maternini, and Vetturi, 2022; Ventura, Ghirardi, Vetturi, Maternini and Barabino, 2022).

A report published by The Forum of European Road Safety Research Institutes (2020) compared the situation in 18 European countries regarding e-scooters, aiming to highlight differences in terms of the legal status of the bike, its widespread use, and safety. The majority of the members stated that e-scooters are equated with bicycles. In the Czech Republic, scooters belong to the same category as e-bikes. In some countries, the category depends on speed or maximum power (Haworth 2021). In Finland, for example, a scooter is treated as a pedestrian if it is not travelling at a speed exceeding 15 km/h; otherwise, it is classified as a bicycle. In about half the countries analysed, there is an age limit (in several European countries, scooters can only be ridden by people over the age of 14 and helmets are compulsory for people under 18) for using an e-scooter (Rahimuddin 2020). E-scooters must be ridden on cycle paths in almost all countries, if available. If they are not available, they are expected to be used on the road in Austria, France (if the speed limit for that stretch is not higher than 50 km/h), Germany, Portugal, Sweden and Switzerland (Peci and Ali 2022; Reck and Axhausen 2021). In Italy, users can use both the cycle lane and the road as long as they are in an area with a 30 km/h speed limit, as described below (Fig. 1).



Fig. 1. E-scooter usage characteristics across European countries (data **source**: The Forum of European Road Safety Research Institutes (2020). Figure: authors elaboration)

Only in Germany, e-scooters must have a licence plate. In almost all countries, the irregular parking of e-scooters in public spaces is seen as a safety issue for pedestrians, the elderly, the blind and people with disabilities. In the Netherlands, the parking of e-scooters is not seen as a problem, thanks to the responsibility users showcase in an environment that has a well-established micro-mobility culture. Although e-scooters tend to be a transport solution with enormous potential, especially in overcrowded cities with increasing private car traffic, several legislative issues need to be resolved. In this way it would be ensured that e-scooters are not only fast and cheap, but also safe (Braniš et al. 2020). During the COVID-19 pandemic, e-scooters became more attractive. They promote social distancing and help cities not rely solely on private cars, especially short-distance travel (Campisi et al., 2021a; Li et al. 2022). Special fares have been promoted in some cities for people who start using the service, such as in Braga, Portugal (Dias et al. 2021) and Paris, France (Latinopoulos et al. 2021). The uptake of e-scooters has been also facilitated by the technological advancements (Alevras et al. 2021; Chicco and Diana 2022; Fistola et al. 2022).

2.1 E-scooters in the Italian Context

Urban areas worldwide are experiencing a rapid growth in shared micro-mobility services, mainly due to the introduction of shared bicycles and, more recently, e-scooters. Several studies have been conducted in Europe and, in particular, in Italy. For example, in Turin, research has been carried out by disseminating a questionnaire. The results indicate that both e-bikes and e-scooters are used for short trips, mainly on weekdays in the afternoon (https://www.bird.co/blog/turin-italy-micromobility-helping-red-cross-deliver-food-aid/). The peaks in use suggest that both services mostly meet the demand for non-commuting trips, in line with previous studies in other countries (Nikitas et al. 2016). Furthermore, e-scooter trips are primarily concentrated in the city centre and the vicinity of railway and metro stations, suggesting that, among other purposes, the service is used as a first and last-mile link to public transport (Baek et al. 2021).

A study carried out in the south region of Campany shows how e-scooter sharing can be a particularly effective way for university students to get to their study centres

quickly, avoiding or supplementing the use of local public transport (Fistola et al. 2022). It also stresses the need to create dedicated lanes for urban micro-mobility, which would allow a considerable increase in safety during journeys and help avoid inappropriate behaviour linked to speed, the use of pavements and the inappropriate abandonment of vehicles in the middle of the road (Liu et al. 2019).

In Italy, the spread of micro-mobility can be compared to other European countries. The Italian success was strongly linked to the distribution of economic incentives; demonstrating the promotion of sustainability is still closely linked to economic development principles. Arriving in Italy at the end of 2019, scooter-sharing services achieved unprecedented numbers in the year of the pandemic.

Shared scooters increased from December 2019 to September 2020 from 4,900 to 27,150. It is just one of the numbers indicating the great change in the mobility of Italian cities, between the desire for experimentation and stricter rules. In September 2021, 65,000 light shared vehicles (excluding private ones) were registered, offered by 86 services of micro-mobility. These include 20,000 e-scooters and 45,000 bicycles. The strong growth of e-scooters in Italy was accelerated by the new rules issued in July 2019, which gave Italian municipalities a year to regulate the circulation of e-scooters, segways, hoverboards and monowheels. Milan, Turin, Rimini, Cattolica, Pesaro and Verona were the first cities to join.

The recent Italian legislation in 2021 introduced several changes to the Highway Code, including those concerning the use of e-scooters. Among the innovations introduced by the legislation is the reduction of the maximum speed from 25 to 20 km/h and the obligation to wear a reflective jacket half an hour after sunset or in poor visibility conditions, be equipped with direction indicators and brakes on both wheels. These actions were necessary considering the growing number of accidents caused or suffered by users of e-scooters. If the market for e-scooters continues growing in Italy, this is mainly due to a considerable increase of sharing services in cities.

Ease of use, and quick travel are two main characteristics of e-scooters. A substantial increase in the purchase of e-scooters was recorded in July 2020, thanks to government incentives (i.e. Bonus Mobilità 2020). The most widespread operational model in Italy is that of free-floating. For scooter sharing, the only existing business model is the B2C, with private ownership and private asset management (Foissaud et al. 2022). Campisi et al. (2021a) found that Italians chose to use e-scooters to get around the city quickly in an environmentally friendly way. As shown in Fig. 2, half of the Italians stated that getting around the city quickly and reducing emissions were main motivators to rent an e-scooter. However, only eight per cent of respondents believe that e-scooters are a safe means of transport.

The main benefits of using e-scooters can be summarised as follows:

- Ease and cost-effectiveness
- Reduction of vehicular traffic in the city
- Reduction of emissions and pollution
- Flexibility and potential to fill some gaps in public transport services

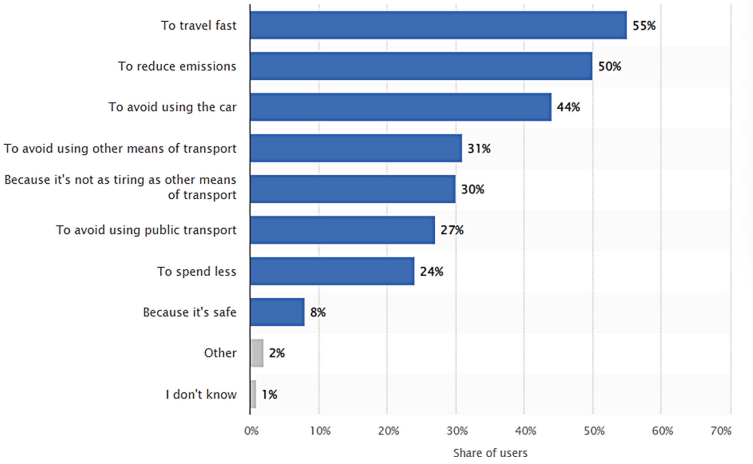

Fig. 2. Main motivators for using e-scooters in Italy. **Source:** Statista (2019)

Instead, there are several critical issues, which include: poor integration of shared micro-mobility within city transport planning; lack of guidelines on parking and dedicated areas, absence of insurance, license plate and vehicle homologation; high accident rate; and dependence on weather conditions.

Starting from these considerations, this work focuses on improving urban planning and mobility strategies in the metropolitan city of Palermo through two steps: a SWOT analysis connected to the spread of micro-mobility and an evaluation based on travel times considering four nodes in the examined city.

3 Methodology

3.1 Case Study Analysis

In recent years, the city of Palermo has been the subject of a study about the development of micro-mobility, as it was the first Sicilian city to have scooter-sharing services. By 2022, more than 20,000 rides had been recorded, and 7,000 new users had been registered. The objective of the local administration, which has been implementing strategies for more sustainable mobility for years, is to bring an integrated and multimodal service to the city, enhancing urban mobility with innovative and ecological means. Several scooter rental companies have entered into agreements with the local administration, and growing demand for transport has emerged, especially after the pandemic.

Although there has been a good take-up of the service, there are unfortunately still some problems related to the planning of the service.

Citizens have repeatedly pointed out to the responsible authorities the inappropriate use of micro-mobility vehicles, which is not limited to their circulation, but also to the release that follows the termination of the rental.

This is often done inappropriately and without respecting the law. The abandonment of these vehicles is becoming an increasingly widespread problem. From the outermost

areas to the city centre, many e-scooters are abandoned on pavements, pedestrian crossings, and parking bays, even in front of essential city monuments. Unfortunately, there was a lot of vandalism in the early days of the sharing services, which initially reduced the number of operating e-scooters.

These phenomena hinder the movement of pedestrians, and cause problems in terms of safety and accessibility.

3.2 SWOT Analysis

The SWOT analysis is a simple and effective strategic planning tool that serves to highlight the characteristics of a project, and the consequent relations with the operational environment in which it is located. It also offers a reference framework for the definition of strategic orientations aimed at achieving a goal.

The SWOT analysis makes possible to think about the objective to be achieved while simultaneously taking internal and external variables into account.

The internal variables are part of the system, where it is possible to intervene, while the external ones do not depend on the organisation. They can be only kept under control to exploit the positive factors and limit the factors that obstruct the achievement of the established objectives. The SWOT analysis is implemented using a matrix divided into four fields in which we have:

- Strengths,
- Weaknesses,
- Opportunities
- Threats

As far as the context of the city of Palermo is concerned, the authors, taking into account the strategies related to the SUMP of the city but also the data of accidents and vandalism recorded by the municipal police in 2021–2022 as well as data from a series of surveys and questionnaires in the literature and related to the case study have developed the SWOT analysis as described in Table 1 below.

Table 1. Main points of SWOT analysis

Strengths	Weakness	Opportunities	Threats
Convenience and compatibility with the 'smart' cities model	Not addressing all age groups	"Smart cities" that will involve all road users	Lack of regulatory framework
Easy to ride	Not easy for family rides (adults and babies)	Sustainable goals	The transition period for cities'

(*continued*)

Table 1. (*continued*)

Strengths	Weakness	Opportunities	Threats
Easy to park	Speed range exceeds pedestrians by 4–5 times	Life quality	Infrastructure to adopt a new transportation model
Eco friendly and silent	Rapid expansion does not allow users time to adapt and comply with safety on the road	Human-friendly cities	Increased risk of non-trained e-scooter users
Enhancing multimodality	Dangerous co-existence with vulnerable road users	No congestion charge	
Suitable for first/last-mile trips	The short life cycle leads to its battery disposal and environmental burden		Lack of use of safety equipment for the users
Low cost for ownership	Operational internal and external costs	Increasing fossil fuel costs	Rise in cost of electricity
		Government subsidy for purchase	Competition in the form of electric hybrids, alternative fuels and hydrogen power cars
Energy saving-achievable in case of a regenerative braking system	Batteries changing is expensive		Presence of non-standard vehicles
			Vandalisms
			Negligence when parking scooters

The SWOT analysis approach is justified on the one hand by the simplicity of implementation and at the same time because it allows one to make an external and internal diagnosis of a phenomenon (mobility of e-scooters) in the area under investigation. The objective is to identify the strengths by highlighting the positive and negative points of the mobility service. By analysing the environment and internal factors, the shared mobility strategy can then be redefined and refined. The SWOT matrix brings together important strategic components, market analyses and evaluation opportunities that are easily readable even by non-experts. The factors defined in the table above make clear that the use of scooters still needs to be studied in terms of both regulations and safety. Although e-scooters are considerdd a useful and environmental-friendly transport mode, attention must be paid to regulating its use and its parking needs. This could ensure less negative implications on pedestrians, who often find scooters as an obstacle. Lastly, the city of Palermo, like many Italian cities, has suffered from phenomena of vandalism,

so greater surveillance and control in urban areas could reduce these phenomena. Businesses, as well as local governments, are subject to many external factors over which they have limited control: relentless technological progress, demographic and social changes through to recent pandemics and wars. Moreover, the external factors to be considered in the analysis change rapidly. SWOT analysis is by nature a static snapshot and is a predictive tool that is limited on its own. Indeed, while the Strengths and Weaknesses presented in the manuscript are correlated with factors that are to some extent certain factors that local decision-makers can control, Opportunities and Threats are neither certain nor under the potential control of local decision-makers. They are by definition beyond their control and increasingly uncertain in a rapidly changing world.

3.3 Travel Time Analysis

E-scooters are one of the fastest ways to travel if you have to travel a mile or less. Generally speaking, walking on flat stretches of the road of 0.5 miles is usually done in 10 min. The same distance is covered in a third of the time if you use an e-scooter (see Table 2). If the journey is repeated over time, the e-scooter saves several hours of travel time each week.

Table 2. Distances and travel time considering walking and e-scoter use

Distance	Walking time (min)	E-scooter travel time (min)
0,5 mile (about 800 m)	10	3
1 mile (about 1600 m)	20	6
3 mile (about 2400 m)	60	18
5 mile (about 4000 m)	100	30
10 mile (about 8000 m)	200	60

Source: ScootMyCommute (2022)

Investigating further the travel times, isochrones and isolines are being drawn. Specifically, isochrones are polygons that enclose areas of the city that can be travelled at the same time with the same transport system. Isolines represent stretches of road and, therefore, the road network that is travelled at specific time-period. Three points (central nodes) in the city of Palermo have been identified and used as a basis for drawing these isochrones and isolines. These points are the following:

- Giulio Cesare main square in front of the railway station and the urban and suburban bus station
- Quattro Canti, the road intersection titled/named Quattro Canti that connected the city's two main arterial roads
- Intersection adjacent to the Teatro Massimo (main city theatre)

These nodes are located along Via Maqueda, one of the oldest streets in the city, full of offices and cultural attractions, defined as a shared space where pedestrians, cyclists and e-scooter users can easily pass. The walking route along Via Maqueda from the junction near Piazza Giulio Cesare to the junction near the Teatro Massimo is about 1.7 km. Under standard conditions, it can be covered on foot in about 19 min and with an e-scooter in about 6 min. This route has a a slight slope, about 3 m total height difference. The e-scooter almost triples the distance that can be covered in a specific time-period. Thus, guaranteeing a movement from Piazza Giulio Cesare to the intersection with Via Notarbartolo, as described in Fig. 3.

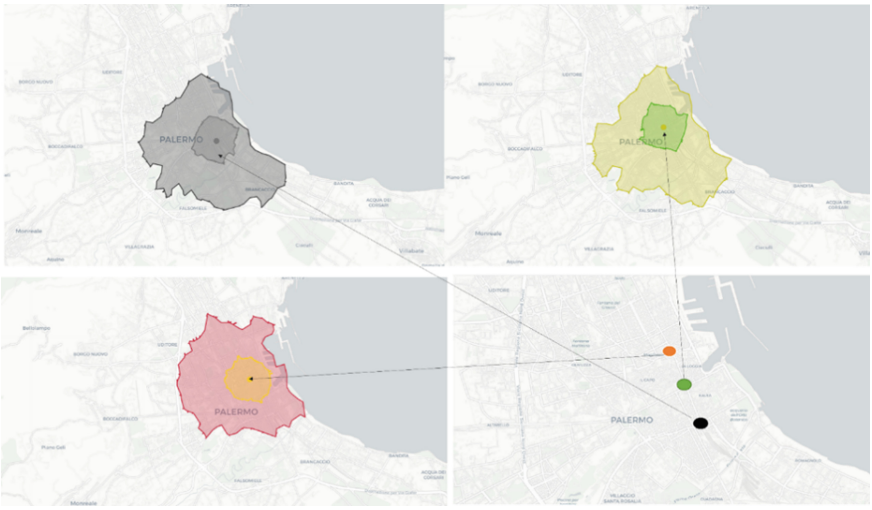

Fig. 3. Isochrones comparison for walking and e-scooter considering 3 three specific nodes of Palermo. **Source**: ISO4APP (2022)

The comparison between walking and e-scooters travel times becomes even clearer through Figs. 4 and 5, where the road network coverage for walking and e-scooters is presented respectively. It is demonstrated that e-scooters can cover a much greater distance comparing with walking in the same time-period.

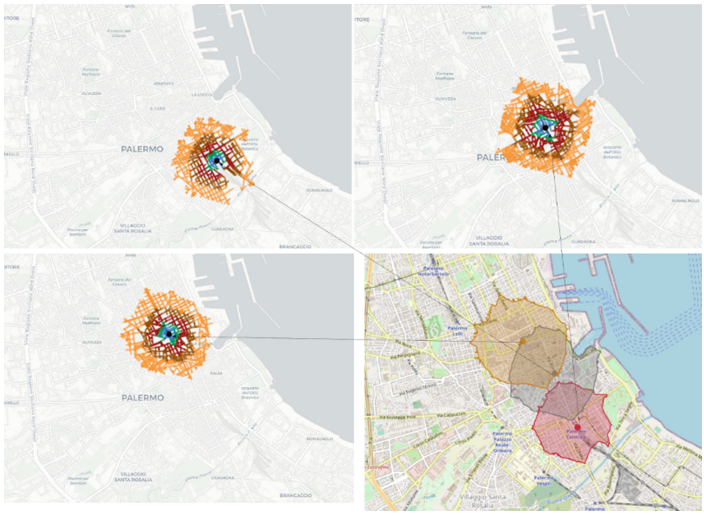

Fig. 4. Isoline street network for walking for three nodes (titled Piazza Giulio Cesare,Quattro canti and the intersection closed to Teatro Massimo) of Palermo. **Source**: ISO4APP (2022)

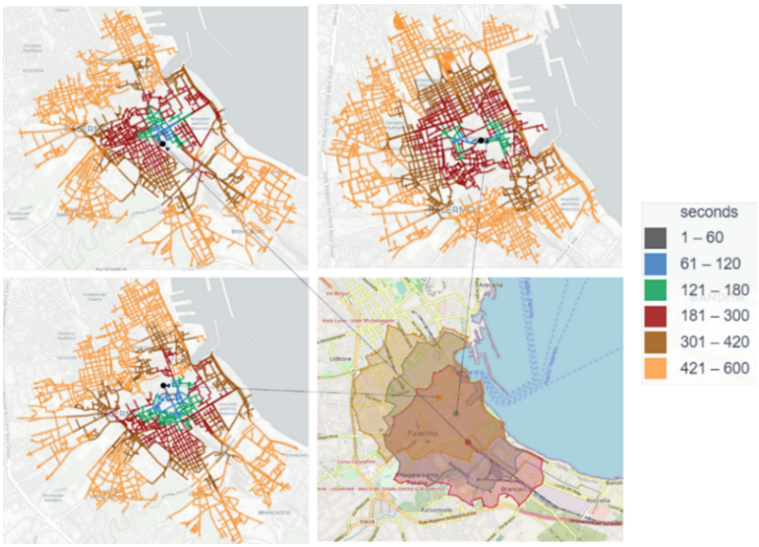

Fig. 5. Isoline street network for e-scooter considering three specific nodes of Palermo. **Source**: ISO4APP (2022)

4 Discussion and Conclusions

According to data processed by the National Observatory on Sharing Mobility, Palermo is the city (among the six analysed: Turin, Milan, Bologna, Rome, Cagliari and Palermo)

that has exceeded the average values of "sharing" in 2019 in all services: scooter sharing, bike-sharing and car-sharing (http://osservatoriosharingmobility.it/).

The data confirms ann evident cultural change in mobility strongly desired by the municipal administration and shared by Palermo's citizens and many tourists who internationally recognise the efficiency and importance of sustainable mobility that in Palermo reaps actual results. Sharing mobility is one of the sustainability strategies foreseen by the Sustainable Urban Mobility Plan of the Municipality of Palermo. The local administration will continue to invest in reducing the use of private vehicles. The next step will be to expand the bike-sharing service, also with private partners, to increase the use of bicycles in urban mobility.

The SWOT analysis revealed the strengths and weaknesses of the current service, and the analysis of the travel time demonstrated the great potential that e-scooters have for attracting a large percentage of daily trips. More specifically, it was shown that e-scooters are capable of serving trips with distances up to 3–4 km from the centre using scooters; thus, potentially reducing the use of private vehicles. Yet, many barriers have to be overcome, as it is identified by the SWOT analysis. A holistic plan is therefore needed for eliminating issues related with safety and irregular use, and finally for providing the appropriate ground for a sustainable transport mode that can greatly contribute in cities' strategic objectives. The present work's key limitation is the lack of attitudinal primary data analysis; an e-survey and/or semi-structured interviews will be administrated shortly as a continuation research task. This paper provides the basis for the definition of an "impact/uncertainty" matrix in which opportunities and threats are assigned according to two parameters: an importance score (this score provides an indication of their potential impact on local economies) and a reasonable score relating to their degree of uncertainty.

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