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And then there were three: GIS-based analysis of the new three-operator-only e-scooter sharing system of Rome, Italy

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Abstract

In recent years, electric scooters (e-scooters) have rapidly spread all over the world, becoming a new major paradigm of micro-mobility. Their success can be mainly attributed to their easiness of riding and parking, providing an agile, cheap and sustainable option for last-mile trips. Following this success, many e-scooter sharing companies started to operate in many cities. However, the rapid diffusion of these sharing services has not only brought evident benefits, but also critical issues: a substantial part of the users has soon shown a tendency to ride and park mindless of road rules, causing safety risks for riders and pedestrians and reducing urban decorum. Consequently, municipalities have introduced bans, fines and stricter regulations. In this work, we study the reformed e-sharing scooter system of Rome, the Italian capital city, following the introduction of new regulations in 2023, after the end of the experimental phase started in 2019. Major changes have been a) reducing the number of operators to only three, b) limiting the size of fleets (decreasing the total number of deployed e-scooter by 40%), c) extending services to outer districts of the city. All the changes were aimed to favour a closer control of the sharing services, safer rides and more well-ordered parking, plus a fairer access to services also in suburbs. In our GIS-based study, we focus on identifying and analyzing the service coverage in this new Rome setting, in terms of the geofences defined by the operators. After having spatially identified the service areas, we analyze their new features, especially in terms of the new fairer distribution over the territory. We also analyze how service areas and geofences have evolved over time, in order to reflect modifications and updates in the regulations passed by the municipality.

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1. Introduction

Electric scooters (e-scooters) have nowadays become a common sight in the streets of major cities all over the world. Their impressive diffusion as vehicles has been facilitated by their simpleness of buying, keeping and maintenance and by their agility through urban traffic, which allow to easily ride and park them. These highlighted (desirable) features have been so appreciated that, in some recent works, it has been pointed out that e-scooter riding has been able to consistently substitute walking and biking in some cities, besides reducing the resort on cars (Laa and Leth, 2020; Sanders et al., 2020; Turon et al., 2021). For a comprehensive introduction to e-scooter systems, we refer to the surveys (Gössling, 2020; Orozco et al., 2023; Turoń and Tóth, 2023).

The success of e-scooters has soon been accompanied by the creation of many sharing companies in many countries: similarly to more traditional sharing mobility services like bike- and car-sharing, a shared e-scooter can be spontaneously rented by a user by unlocking it through a smartphone application and paying a plain time-based fee. Canonically, shared e-scooter systems are of free-floating type, meaning that a user may pick up and drop off an e-scooter at any location within the a geographical area (service area) by a sharing company.

It is interesting to note that the easiness of use that characterizes e-scooters has clearly represented a big advantage, but, at the same time, has also originated critical issues: riders have revealed to be prone to ride in spite of road rules, creating a new source of road accidents, and to park wildly, leading to reduction of urban decorum (see e.g., Carrese et al. 2021a; Kazemzadeh et al. 2023; Latinopoulos et al. 2021; Wallgren et al. 2023). This has induced local authorities to take steps against e-scooters, by introducing stricter regulations and even full bans, as happened in Paris, France (The Guardian, 2023). In order to tackle such issues, a number of solutions have been proposed in literature, such as better managing the overall flows of e-scooters by acting on the definition of the boundaries of the services areas (geofencing - e.g., Liazos et al. 2023; Nikiforiadis et al. 2023), identifying reserved parking lots for contrasting wild parking by means of mathematical optimization (e.g., Colovic et al. 2024; Nardin and D'Andreagiovanni 2024), promoting refined regulations (e.g., Ignaccolo et al. 2022; Sobrino et al. 2021), employing and optimally scheduling the activities of agents having the specific task of correcting wild parking (so called "beautificators", see Carrese et al. 2021a), also assisted by unmanned aerial vehicles (Carrese et al., 2021b).

A typical e-scooter sharing company allows to rent, ride and park the vehicles of its fleet within the boundaries of a well-defined area (the *service area)*, defined through an operation of geofencing: exploiting the Global Positioning System (GPS), virtual boundaries are set to spatially limit the operations of e-scooters to just a portion of the city where sharing services are provided; then, using a Geographic Information System (GIS) software, a map is created and provided to users on the smartphone application of the sharing service (canonically as a coloured polygon), in order to show where the users can find and use the shared vehicles. Commonly, distinct e-scooter operators define distinct service areas, reflecting their own specific business objectives (e.g., concentrating services in downtown areas or having a more widely distributed fleet that is available also in suburban areas).

The study that we present in this work is primarily aimed at providing an analysis of the service areas of the e-scooter sharing companies that operates in the Italian capital city of Rome in April 2024. In 2023, the city of Rome has been interested by a major revision of the regulations concerning shared e-scooters, which now allow the presence of just three operators in contrast to the previous absence of a cap on the number of operators. Furthermore, the revision has tried to induce a larger coverage of suburban areas, which were previously greatly neglected.

Our main objective is to highlight the evolution of the service coverage, highlighting differences with respect to our spatial analysis dating back to 2021, when, though a higher number of six operators were active in Rome, the coverage was much more limited and concentrated in the historical center (see D'Andreagiovanni et al. 2022).

We remark that operating GIS-based analysis of e-scooter service areas is not a novelty, as done in works by Moran (2021), Moran et al. (2020), Straub and Gajda (2021), which have have considered a number of cities in Austria, Poland and the USA. However, to our best knowledge, the new service areas of Rome have not yet been studied and their evolution over time has not yet been analyzed. More in detail, the major original contributions of our work are:

- providing a visualization of the service areas of the only three companies that have won the right to to operate in Rome through a public tender, deriving the maps of their intersection and union, and discussing their features, by highlighting their surface and analyzing how they distribute over the territory of Rome;

- reviewing the regulations of Rome that affect e-scooter sharing services, highlighting differences with respect to the first set of regulations passed in 2019;
- providing a discussion about the evolution of service coverage and regulations of Rome and deriving a number of conclusions that could inspire future work.

The remainder of this paper is organized as follows: in Section 2, we depict and analyzes the service areas of the escooter sharing companies; in Section 3, we survey the main novelties of Rome's e-scooter regulation, then discussing conclusions and possible research paths to beat in the conclusive Section 4.

2. Service Area Analysis

Our primary aim is to rigorously identify through a GIS software the service areas offered by each of the three companies that currently operate in Rome. This is not a trivial task, since, to our best knowledge, the companies do not put openly at disposal their maps through a GIS geospatial vector data format. Due to this lack of open data that can be freely accessed and processed, our spatial analysis first required us to draw by hand the polygons associated with the service areas through the software QGIS (2021). Similarly to Moran et al. (2020), we have drawn the sides of each polygon on a street-by-street basis, using as reference the visualization of the service areas in the official online apps of each company (available on April 30th, 2024). The availability of service areas rendered as GIS map layers allowed us to compute the intersection and union of the set of polygons and to derive other data that are not immediately available. Such data can be used as basis for deriving additional facts with respect to a simple fragmented observation of the distinct maps on the companies' smartphone applications. As a matter of course, since the QGIS polygons of the service areas have been drawn by hand, some slight discrepancies with respect to the maps visualized in the applications can be present. Tackling the issue of hand drawing would be straightforward if the sharing operators freely uploaded their maps on some public open data portal in a suitable geospatial data format. However, as also pointed out in discussions with sharing mobility professionals, we must also recognize the fact that, running a profit-oriented business, the operators may have a legitimate interest of not fully and openly share their geospatial data.

The companies that are currently operative in Rome are three, namely BIRD (2021), DOTT (2021), LIME (2021), in compliance with the cap introduced by the new regulations. With respect to 2021, three companies have thus ceased to operate, relocating their vehicles to other (European) cities where they still continue to operate. Interestingly, among these disappeared companies, there is also the company WIND that used to offer the largest and more peripheral service area in the 2021 Rome's scenario.

As first step, it is natural to compare the overall extension of the territory of Rome to the extension of the area in which e-scooter sharing services of at least one operator are available (we will refer to this area as *global service area)*. We provide a visualization of this comparison in Figure 1. It is very interesting to report that the global service area has been impressively enlarged: in 2021, it spread over about 134 square kilometers (km^2), whereas now in 2024 it has practically doubled its extent, spreading over about 244 km^2. Furthermore, while in 2021 it was exclusively located in an inner area of Rome that privileged the coverage of the central historical districts and of more downtown residential, administrative and business districts, in 2024 the coverage extends well beyond the limits of the "Grande Raccordo Anulare", a six-lane ring-shaped highway with a radius of about 20 km that encircles the more urban part of the city. A large area coinciding with more suburban and peripheral residential areas characterized by lower income is thus now covered with service.

It is then natural to analyze more closely the single service areas of the companies. A comparison between the situation of 2021 and that of 2024 is provided in Table 1 and in Figures 2, 3, 4. In Table 1, we report the extent of the areas (*Total Service Area*) of each company in 2021 and 2024, showing also the variation in extent both in absolute (*Delta*) and percentage value (*Delta%*). All the three companies have greatly enlarged their areas, all bringing them at levels that guarantee a comparable surface of coverage of more than 230 km^2. The enlargement appears much higher for the company BIRD (an increase of more than 400%), which previously ran the smallest coverage, mostly concentrated in the historical center of Rome. From the maps, it can be noted that the three companies now cover areas of comparable size that include similar districts: the focus seems to have been on guaranteeing a fairer access to peripheral areas, which were previously excluded and to include (narrow) corridors along the subway lines also beyond the limits of the GRA ring highway. This looks in contrast to the scenario of 2021, in which all the companies

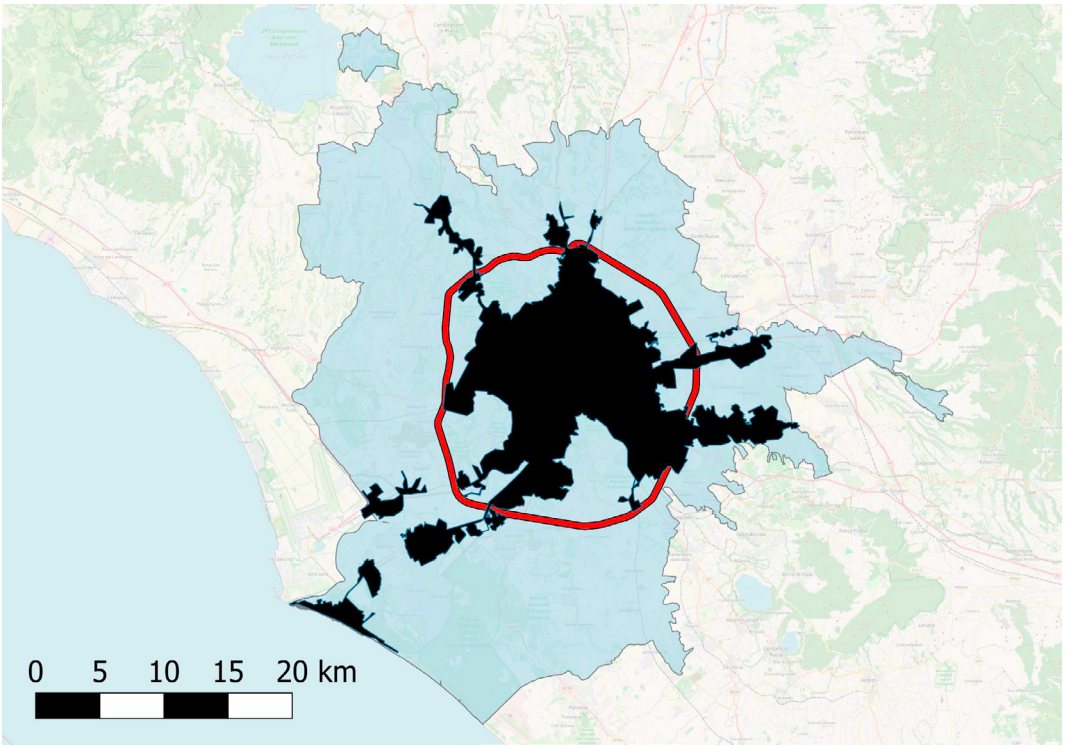


Fig. 1: Territory of Rome with highlighted the area where at least one e-scooter sharing company operates

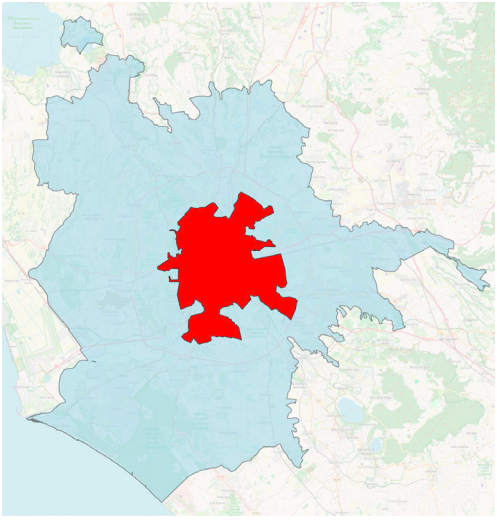
covered the historical center, while the coverage of semi-peripheral district was less homogeneous (some areas were covered by only one company). As a sign of a fairer and more homogeneous coverage, it is also interesting to look at the intersection of the service areas, namely the portion of territory in which all the companies operate (Fig. 3): the intersection is now way larger, covering about 191 km^2 and extending well beyond central districts and including also Ostia, a district located on the coast which could be considered a small town on its own independent from Rome.

Table 1: Surface of the e-scooter service areas.

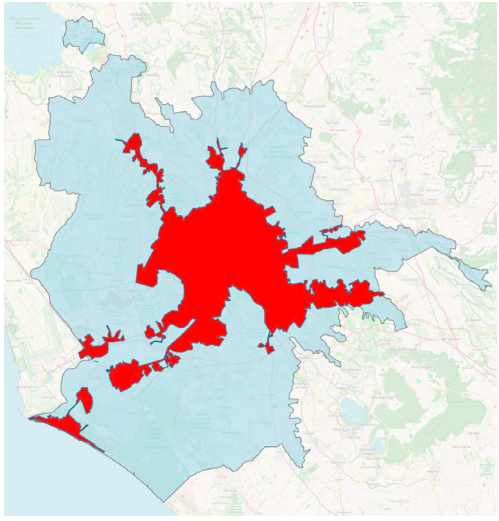
Company	**Total Service Area (2021)** (km^2)	**Total Service Area (2024)** (km^2)	**Delta** (km^2)	**Delta %**
BIRD	46	235	+189	+411
DOTT	77	254	+177	+230
LIME	60	236	+176	+293
UNION	133	274	+141	+106
INTERSECTION	33	191	+158	+479

3. Overview of Regulation

In the Italian regulation of micromobility based on e-scooters, a milestone has been represented by the two 2018-2019 national laws (L. 30.12.2018, 2018) and (L. 27.12.19, 2019) that have created the legal framework for allowing e-scooters to circulate on the streets, fixing the features that they must fulfill (e.g., power limits, maximum speed, required safety devices) and allowing municipalities to start to experiment the deployment of e-scooter sharing services in their territory. These laws have left a substantial freedom to municipalities to define their own local road rules for

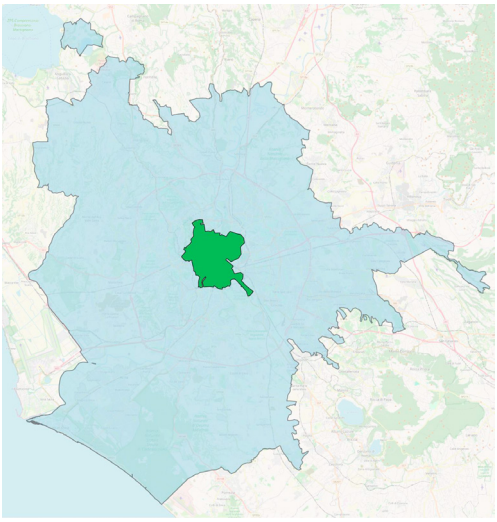


(a) Union of the service areas (2021)

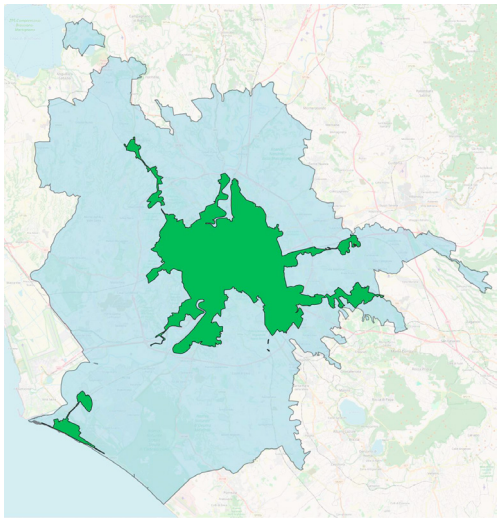


(b) Union of the service areas (2024)

Fig. 2: Visualization of the areas covered by at least one operator (right)



(a) Intersection of the service areas (2021)



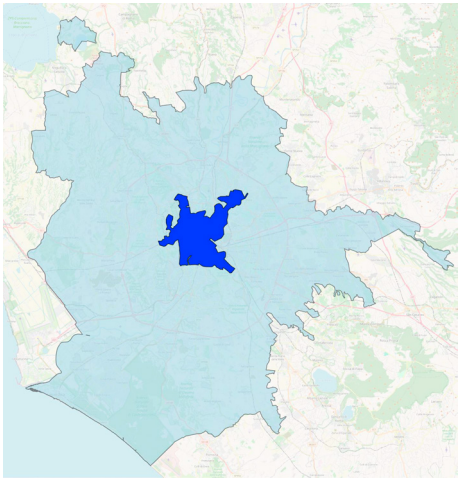
(b) Intersection of the service areas (2024)

Fig. 3: Visualization of the areas covered by all operators

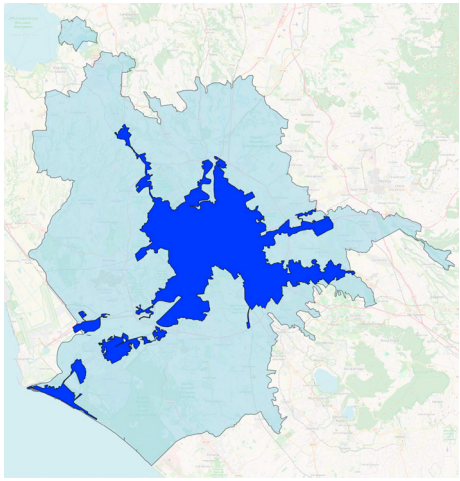
sharing services, with the aim of favouring the adoption of rules that could better reflect and match the local situation (e.g., the possibility of not allowing the e-scooters to circulate in areas of particularly relevant historical value).

In the city of Rome, the experimentation has been started in 2020 with the approval of the Resolution D.G.C. 75 (2020) that has introduced the first tender for issuing sharing services licenses. This local regulation imposed a limit of 16000 on the total number of e-scooters allowed for sharing and sets a lower and upper bound (750 and 1000, respectively) on the number of e-scooters deployable by each company. Furthermore, it provided for the obligation to monitor the status of the fleet, guaranteeing the operativeness of at least 90% of the vehicles of the fleet at any moment.

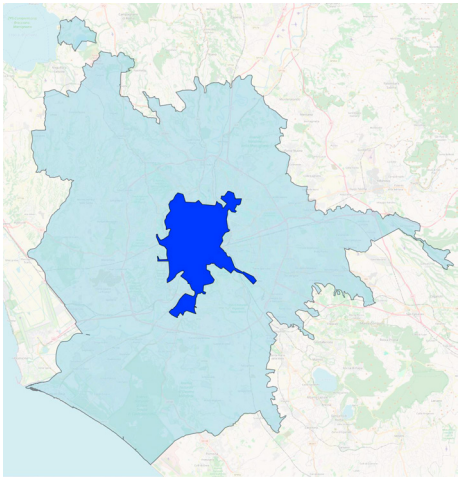
On the basis of the evidence collected during the experimentation, new regulations have been approved in 2023 (D.G.C. 225, 2022). The major novelties have been represented by a reduction in the size of the sharing services accompanied by a great increase in the extent of service coverage: only three companies are now allowed to operate



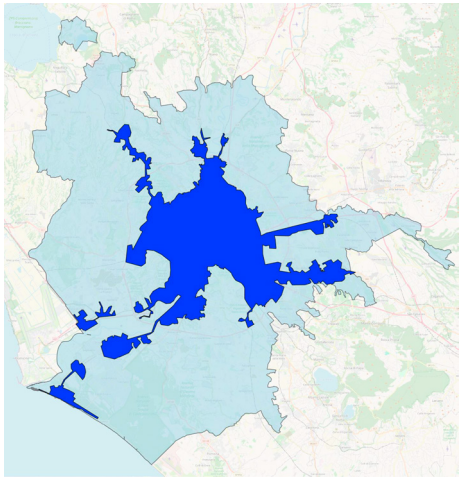
(a) BIRD's service area (2021)



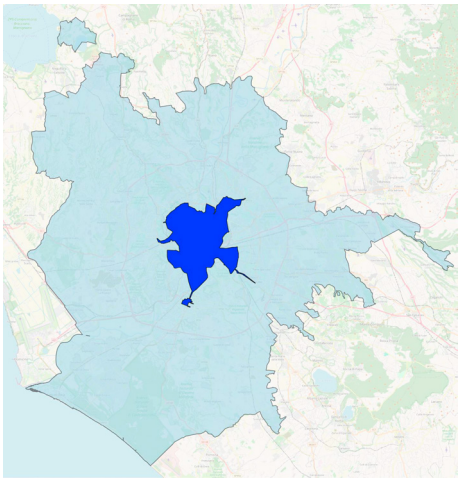
(b) BIRD's service area (2024)



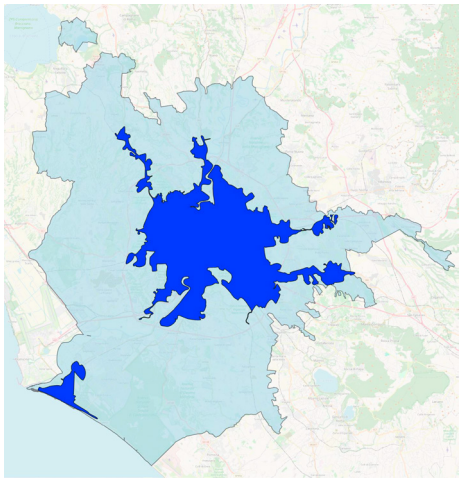
(c) DOTT's service area (2021)



(d) DOTT's service area (2024)



(e) LIME's service area (2021)



(f) LIME's service area (2024)

Fig. 4: Visualization of the service areas of the considered three e-scooter sharing companies (years 2021 and 2024)

and each company may deploy at most 3000 e-scooters. However, each company must now guarantee a coverage of at least 95 km^2.

Furthermore, constraints on the spatial distribution of the e-scooters have been introduced: in the historical center of Rome at most 300 e-scooters may be present; this limit is further restricted to 70 within the very heart of the city, characterized by narrow streets and high density of touristic attractions, whereas it is relaxed to 600 for the central district of the city. In the rest of the service area, extending to outer districts, no hard limits are provided, but each operator must guarantee a presence of at least 12 vehicle per square kilometer.

Talking about constraints on service coverage, an operator cannot anymore define its service area arbitrarily, but must guarantee at least 95 km^2 of coverage and offer a minimum overlap of outer areas of the cities. This is especially aimed at offering a better coverage of peripheral areas, which were previously almost fully neglected.

It is also important to note that, in order to encourage the use of e-scooters for last-mile trips, it has been favoured the coverage of the territory along subway lines and a number of free rides for holders of yearly ticket for public transportation. The guidelines have also tried to more explicitly take into account the question of urban decorum, imposing a minimum distance between groups of deployed e-scooters and anticipating the possibility of introducing reserved parking zones in downtown and tags for the e-scooters for favouring their identification and sanctioning in case of hazardous behaviour (however, this aspect is still under implementation).

4. Conclusions

The GIS-based spatial analysis and evaluation of recommendations that we have conducted have shown a clear positive evolution and expansion of e-scooter sharing services in Rome: the global coverage has been hugely extended, including also non-central districts that were previously excluded, and refined in the sense of providing precise constraints on the spatial distribution of the e-scooter fleet over the territory. Furthermore, the need for promoting urban decorum has been explicitly taken into account providing for the introduction of vehicle tags that should support a more readily identification of e-scooters that violate road rules during riding and parking operations. These modifications reflects a commendable effort and work that have been done by both Roma Capitale and the e-scooter sharing companies, profiting from the experience gained during the experimental phase.

Concerning the definition of the coverage area, we currently note the presence of discontinuities between service areas (in the south-western quadrant or Rome), namely some zones covered with service constitute “islands” that cannot be reached from, e.g., the city center. Studying street maps and road configurations, we make the hypothesis that this is due to the absence of connecting roads that can be safely travelled over by an e-scooter. However, we think that such discontinuities tend to penalize users of these zones and it would be important to eliminate them by setting up suitable reserved lanes that could be employed also by bikes and promote more sustainable mobility.

As in 2021, we must note that there is still a lack of openly available geospatial data: the maps of the service areas are still not made jointly available on an official site of the municipality, thus still not allowing an interested user to easily get a global view on the spatial availability of e-scooter sharing services of all companies. We believe that this would be very important to further promote the use of these sustainable vehicles, which have been clearly identified as a way to reduce car traffic and pollution, and, more in general, to promote shared mobility. Furthermore, we believe that having high-resolution openly accessible maps that integrates the spatial data of private companies with the data of the municipalities about no-parking zones, restricted areas and low-speed zones would favour all e-scooter users, also helping to contain (bad) riding and parking habits that can be also induced by a lack of easily accessible information about the local rules of the road that must be respected.

Besides openly publishing the geospatial data and maps of the service areas, we think that it would be important to also maintain a repository with historical data about the evolution of the areas in size and shape over time. Maintaining such data sets, possibly also including data from other sharing services like bike- and car-sharing, would allow stakeholders and service users to better track the development and changes of the sharing services, promoting more awareness about the evolution of sharing mobility in the city.

As future work, we plan to address the question of optimized service coverage of a city, taking into account the spatial constraints and limits included in the regulations. The adoption of mathematical optimization models and algorithms, similarly to Carrese et al. (2021a,c, 2020), could be particularly suitable for addressing the question of discontinuities in the coverage and for identifying the best connecting corridors, also taking into account road features.

References

BIRD. https://www.bird.co/it/#sali

Carrese, S., D'Andreagiovanni, F., Giacchetti, T., Nardin, A., Zamberlan, L. 2021. A Beautiful Fleet: Optimal Repositioning in E-scooter Sharing Systems for Urban Decorum. Transportation Research Procedia 52, 581-588.

Carrese, S., D'Andreagiovanni, F., Giacchetti, T., Nardin, A., Zamberlan, L. 2021. Seek & Beautify: integrating UAVs in the optimal beautification of e-scooter sharing fleets. 7th International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS), Heraklion, Greece, 1-6. doi: 10.1109/MT-ITS49943.2021.9529312

Carrese S., D'Andreagiovanni F., Giacchetti T., Nardin A., Zamberlan L. An optimization model and genetic-based matheuristic for parking slot rent optimization to carsharing. 2021. Research in Transportation Economics, 85, 100962.

Carrese, S., D'Andreagiovanni, F., Giacchetti, T., Nardin, A., Zamberlan, L. 2020. An optimization model for renting public parking slots to carsharing services. Transportation Research Procedia 45, pp. 499-506.

Colovic, A., Prencipe, L.P., Giuffrida, N., Ottomanelli, M. 2024. A multi-objective model to design shared e-kick scooters parking spaces in large urban areas. Journal of Transport Geography 16, 103823.

D'Andreagiovanni, F., Nardin, A., Carrese, S. 2022. An Analysis of the Service Coverage and Regulation of E-Scooter Sharing in Rome (Italy). Transportation Research Procedia 60, 440-447.

Roma Capitale, 2020. "Deliberazione della Gunta Capitolina n. 75 2020 - Approvazione delle linee guida per l'autorizzazione dei servizi di noleggio (c.d. sharing) di monopattini a propulsione prevalentemente elettrica". Protocollo RC n. 9048/2020.

Roma Capitale, 2022. Deliberazione Giunta Comunale n.225 (in Italian). https://www.comune.roma.it/servizi2/deliberazioniAttiWeb/home

DOTT. https://ridedott.com/it/

Gössling, S. 2020. Integrating e-scooters in urban transportation: Problems, policies, and the prospect of system change. Transportation Research Part D 79, 1-12.

The Guardian. 2023. Rented e-scooters cleared from Paris streets on eve of ban. https://www.theguardian.com/world/2023/aug/31/rented-e-scooters-cleared-from-paris-streets-on-eve-of-ban

Kazemzadeh, K., Haghani, M., Sprei, F. 2023. Electric scooter safety: An integrative review of evidence from transport and medical research domains. Sustainable Cities and Society, 89, 104313.

Ignaccolo, M., Inturri, G., Cocuzza, E., Giuffrida, N., Le Pira, M., Torrisi, V. 2022. Developing micromobility in urban areas: network planning criteria for e-scooters and electric micromobility devices. Transportation Research Procedia 60, 448-455.

Laa, B., Leth, U. 2020. Survey of E-scooter users in Vienna: Who they are and how they ride. Journal of Transport Geography 89, 102874.

Latinopoulos, C., Patrier, A., Sivakumar, A. 2021. Planning for e-scooter use in metropolitan cities: A case study for Paris. Transportation Research D, 100, 103037.

Liazos, A., Iliopoulou, C., Kepaptsoglou, K., Bakogiannis, E. 2022. Geofence planning for electric scooters. Transportation Research Part D: Transport and Environment, 102, 103149.

LIME. https://www.li.me/it-it/

L. 30.12.2018, Repubblica Italiana, Legge 30 dicembre 2018, n. 145, Gazzetta Ufficiale della Repubblica Italiana, 2018. https://www.gazzettaufficiale.it/eli/id/2018/12/31/18G00172/sg

L. 27.12.19, Repubblica Italiana, Legge 27 dicembre 2019, n. 160, Gazzetta Ufficiale della Repubblica Italiana, 2019. https://www.gazzettaufficiale.it/eli/id/2019/12/30/19G00165/sg

Moran, M. 2021. Drawing the map: The creation and regulation of geographic constraints on shared bikes and e-scooters in San Francisco, CA. Journal of Transport and Land Use, 14(1), 197–218

Moran, M., Laa, B., Emberger, G., 2020. Six scooter operators, six maps: Spatial coverage and regulation of micromobility in Vienna, Austria. Case Studies on Transport Policy 8(2), 658–671.

Nardin, A., D'Andreagiovanni, F. 2024. A Quantum-Inspired Ant Colony Optimization Algorithm for Parking Lot Rental to Shared E-Scooter Services. Algorithms 17, 80.

Nikiforiadis, A., Cobian Martín, I., Grau, J.M.S., Ayfantopoulou, G., Basbas, S. 2023. Geofencing and city dashboards for micromobility: Identifying the needs of cities, operators and technology providers. Transportation Research Procedia 69, 663-670.

Orozco-Fontalvo, M., Llerena, L., Cantillo, V. 2023. Dockless electric scooters: A review of a growing micromobility mode. International Journal of Sustainable Transportation, 17, 406-422.

QGIS: A Free and Open Source Geographic Information System. https://qgis.org/en/site/

Sanders, R.L., Branion-Calles, M., Nelson, T.A. 2020. To scoot or not to scoot: Findings from a recent survey about the benefits and barriers of using E-scooters for riders and non-riders. Transportation Research Part A 139, 217-227.

Sobrino, N., Gonzalez, J.N., Vassallo, J.M., de los Angeles Baeza, M. 2023. Regulation of shared electric kick scooters in urban areas: Key drivers from expert stakeholders. Transport Policy, 134, 1-18.

Straub, D., Gajda, A., 2020. E-scooter sharing schemes operational zones in Poland: Dataset on voivodeship capital cities. Data in Brief 33.

Turoń, K., Kubik, A., Chen, F. 2021. When, What and How to Teach about Electric Mobility? An Innovative Teaching Concept for All Stages of Education: Lessons from Poland. Energies 14, 6440.

Turoń, K., Tóth, J. 2023. Innovations in Shared Mobility - Review of Scientific Works. Smart Cities 6, 1545-1559.

Wallgren, P., Rexfelt, O., Nikitas, A. 2023. Comparing the bad media-fuelled reputation of e-scooters with real-life user and non-user perceptions: Evidence from Sweden. Transportation Research Part F 99, 189-203.