Spatiotemporal Analysis of e-scooter Demand in Lexington, Kentucky

Eleni Nalmpantidou[1], Dimitrios Sarafidis[1], Andreas Nikiforiadis[2(✉)], Nikiforos Stamatiadis[3], Grigorios Fountas[1], and Socrates Basbas[1]

[1] School of Rural and Surveying Engineering, Faculty of Engineering, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

[2] School of Civil Engineering, Democritus University of Thrace, 67100 Xanthi, Greece
anikifor@civil.duth.gr

[3] Department of Civil Engineering, University of Kentucky, Lexington, KY, USA

Abstract. In the city of Lexington, Kentucky shared e-scooters made their appearance in the summer of 2019. This paper aims to examine which factors and how they affect the e-scooter demand based on data related to Lexington, KY. The data were obtained from two e-scooter sharing companies, Bird and Spin, and covered the entire year of 2022. Using this data, the characteristics influencing demand were analyzed, and behaviors and patterns were identified. Specifically, the analysis was conducted both in terms of the general and temporal characteristics of the recorded trips through graphs, and spatially through the creation of appropriate maps. The findings showed that e-scooter usage is greater in the city center and is affected by months, weather, days, and hours. In addition, by depicting points and areas of interest and comparing them with areas with increased demand, the main reason of a trip undertaken with an e-scooter, can be determined. The University of Kentucky community, although constituting 14% of the population, appears to represent a much larger percentage of e-scooter users, thus significantly influencing the demand profile.

Keywords: e-scooters · micromobility · demand analysis · spatial analysis

1 Introduction

In recent years, the use of shared electric scooters (e-scooters) has increased significantly, establishing them as a flexible and sustainable mode of transportation in urban centers [1]. Their introduction in the United States in 2017 marked a turning point in urban mobility, offering an efficient solution for short-distance travel [1]. The widespread adoption of e-scooters has been facilitated by the convenience of app-based rentals and the flexibility of parking options, which have contributed to their rapid expansion in the global micromobility market [2, 3]. As a result, shared e-scooters now play a crucial role in urban transport networks, effectively bridging the gap between residential areas, public transportation hubs, and other key destinations [2, 3].

The growing popularity of e-scooters is primarily driven by their practicality and environmental benefits. By providing an alternative to private vehicles, they help reduce

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2026
O. Gervasi et al. (Eds.): ICCSA 2025 Workshops, LNCS 15899, pp. 35–47, 2026.
https://doi.org/10.1007/978-3-031-97663-6_3

traffic congestion and mitigate urban air pollution [1]. However, despite these advantages, integrating e-scooters into existing transportation systems presents several challenges. A comprehensive understanding of demand patterns and the factors influencing them is essential for the effective management and regulation of shared e-scooter services [1, 4].

Analyzing e-scooter demand is of critical importance for both micromobility service providers and policymakers [5]. For operators, demand data can be leveraged to optimize fleet distribution and ensure the availability of e-scooters in high-demand areas during peak hours [3]. Effective fleet management can improve service efficiency while minimizing operational costs. At the same time, policymakers can utilize demand analysis to develop appropriate regulatory frameworks and urban infrastructure, such as dedicated lanes and parking zones, to enhance safety, accessibility, and sustainability [6]. Ensuring a well-regulated e-scooter ecosystem requires data-driven decision-making processes that consider both user behavior and broader urban mobility trends.

A rigorous analysis of e-scooter demand necessitates the application of advanced statistical and spatial methodologies[7]. Statistical models help identify usage trends, assess the relationship between demand and key environmental variables, and evaluate the impact of external factors such as weather conditions [3, 7]. Meanwhile, spatial analysis techniques, including Geographic Information Systems (GIS) and spatial regression models, provide insights into the geographic distribution of e-scooter use and help identify high- and low-demand areas [8]. These analytical approaches contribute to a more comprehensive understanding of micromobility demand and inform evidence-based policy and business strategies.

The present study aims to investigate the key determinants of shared e-scooter demand, with a particular focus on spatial and temporal distribution patterns [1]. By examining factors such as weather conditions, temporal characteristics and points of interest, this research seeks to enhance understanding of e-scooter usage trends and provide insights for optimizing their integration into urban transport networks [7, 8]. The findings of this study are expected to support the development of policies and operational strategies that promote the efficient and sustainable use of shared e-scooters in contemporary urban environments.

2 Methodology

2.1 Data Collection

Lexington is the second-largest city in the state of Kentucky and the 57th largest city in the United States, with a population of approximately 320,000 (2022). The city is the seat of Fayette County and hosts significant business and educational activities. Electric scooters were introduced to the city in the summer of 2019, offering an alternative mode of transportation. As of 2022 (the year referenced in this paper), two electric scooter rental companies, Bird and Spin, were operating in the city. Bird was selected to provide electric scooter rental services within the University of Kentucky campus. The adoption of these new modes of transportation was expected to be particularly positive in a city like Lexington, where the only public transportation option is the city bus, with routes running from 5 a.m. to 9 p.m. (except for four routes that operate until midnight).

The data used for this study were obtained from the aforementioned companies. The files included information about the characteristics of each route (distance, duration), as well as the period in which the route was taken (month, day, start time, and end time). Additionally, they contained spatial information, such as the geographic longitude and latitude of the starting and ending points. By combining distance and duration data, the average speed for each route was calculated. It was necessary to check the quality of the recordings, as some entries contained incomplete or incorrect information or had anomalous values regarding speed, duration, or distance. Routes with a distance of zero, a duration under one minute or over 60 min, and speeds outside the range of 10–25 km per hour were removed (see Table 1).

Table 1. Data filtering process.

Data Filtering Process	Number of Records
Initial Data	178.287
Route Length = 0 km	3.154
Duration < 1min	1.654
Duration > 60 min	6.384
Speed < 10 km/hr	52.032
Speed > 25 km/hr	229
Final Data	114.834

2.2 Data Analysis

The data were analyzed using two methods: statistical analysis and spatial analysis. For statistical analysis, bar charts were used to examine the general and temporal characteristics of the routes, identifying patterns and factors influencing demand. These charts depict the duration, distance, speed, and month, as well as the relationship between the month, mean temperature, and mean rainfall (in millimeters). Additionally, differences in trip characteristics between weekdays and weekends were examined.

For spatial analysis, starting and ending points were visualized and analyzed using two methods. The first method was deterministic spatial interpolation using IDW (Inverse Distance Weighting). This technique allowed for estimating the number of trips in areas with no recorded data, providing a more complete picture. Additionally, a graduated color scheme was applied, categorizing the number of trips and representing them with varying shades. Finally, to better understand areas of high demand, points of interest (POIs) were extracted from Open Street Map and mapped, including stadiums, theaters, universities, dining areas, retail stores, and parks.

3 Results

3.1 Statistical Analysis

In this subsection, selected charts produced during the analysis are presented. These charts highlight the most interesting results and the most significant findings.

Based on Fig. 1, approximately 77% of trips are between 0–2 km in length. Electric scooters are primarily used for the first and last segments of a journey ("first-mile and last-mile"). They often serve as a connection to public transportation, such as bus stops, or parking areas, allowing users to complete the rest of their trip by bus or private vehicles.

On weekdays, the highest percentage of trips last between 0–5 min, whereas on weekends, the majority of trips last between 5–10 min (see Fig. 2). The average duration and distance were calculated separately for weekdays and weekends. On weekdays, trips have an average duration of 6.6 min and an average distance of 1.6 km, while on weekends, the average duration is 10 min, and the average distance is two kilometers. This suggests that trips on weekends tend to be longer, possibly because people use electric scooters for recreational purposes, whereas on weekdays, trips are more purposeful and often linked to inflexible commitments.

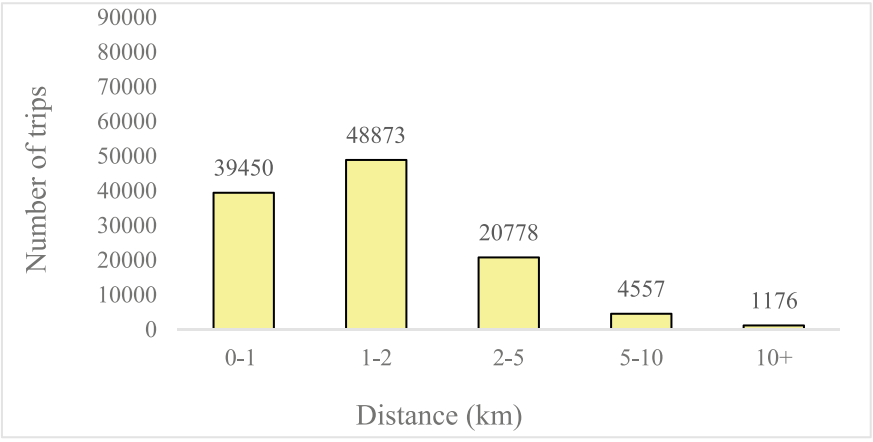

Fig. 1. Relationship between number of trips undertaken and distance measured in kilometers.

The number of trips cannot be described as directly proportional to temperature, but it is certainly influenced by it. In Fig. 3 is observed that from January to April, the number of trips and temperature increased together, showing a proportional relationship. However, from May to July, while the temperature continues to rise, the number of trips decreases. June and July record the highest temperatures and the fewest trips. From July to September, the temperature decreases while the number of trips increases. Finally, from September to December, both temperature and the number of trips decline.

Different weather conditions over these two months seem to impact electric scooter usage in an analogous way. However, when examining the average trip duration (in

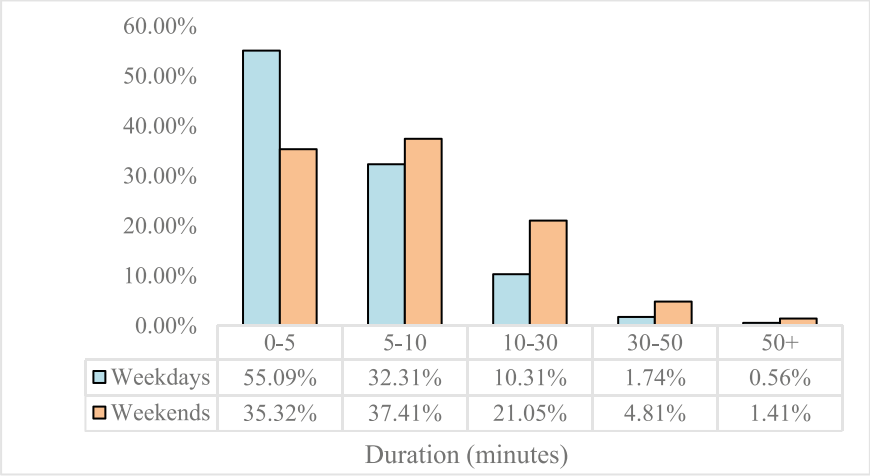

Fig. 2. Correlation between number of trips undertaken and duration measured in minutes.

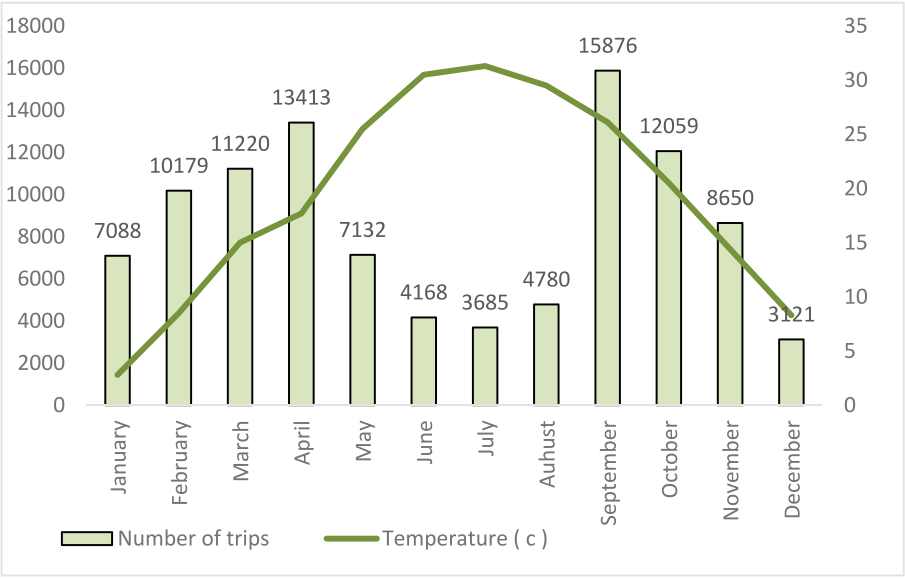

Fig. 3. Correlation among number of trips undertaken, mean temperature and month.

minutes) and the average distance traveled, it was observed that trips in July are significantly longer (see Fig. 3). Therefore, while the weather may not have influenced the total number of trips, it appears to have affected their characteristics (Table 2).

From Fig. 4 is becoming understood that on weekdays, higher percentages of trips occur during the morning and midday hours, between 09:00 and 16:00, whereas on weekends, peak usage is recorded between 17:00 and 00:00. Notably, between 16:00

Table 2. Comparison between July-December.

Comparing July – December					
	Number of trips undertaken	Mean temperature (c)	Mean rainfall (mm)	Mean duration (minutes)	Mean distance (km.)
July	3685	31.3	5.3	14	3.2
December	3121	8.3	2.8	5.8	1.5

and 17:00, usage rates equalize. From that time until 04:00, higher usage is recorded on weekends, while from 05:00 to 16:00, usage is higher on weekdays. This suggests that on weekdays, electric scooter activity is more intense in the morning, likely due to work, university lectures, or other obligations. After 17:00, most people return home to rest. On weekends, morning demand is lower because people can start their day later, as they are not restricted by strict work schedules or university timetables. Finally, the increased demand in the afternoon and evening hours compared to weekdays is attributed to recreational outings, which are more frequent on Saturdays and Sundays.

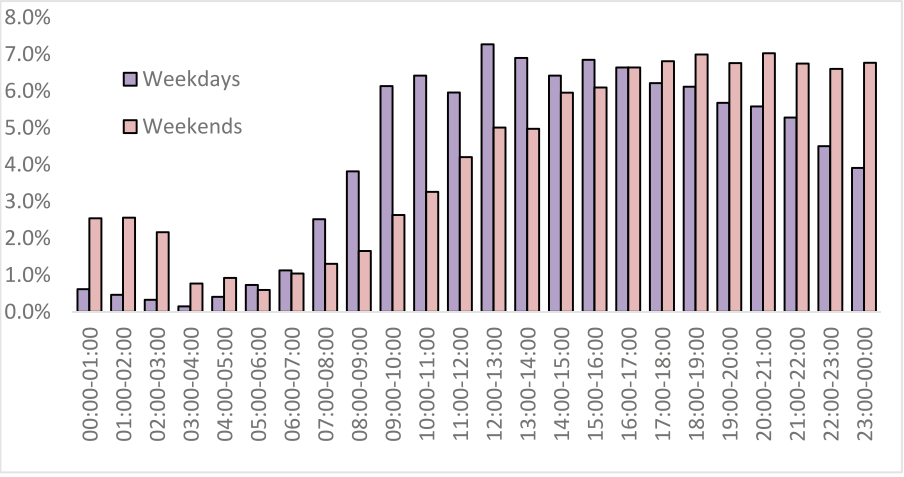

Fig. 4. Correlation among percentages of trips undertaken days and time.

3.2 Spatial Analysis

With regards to the spatial distribution of the demand, Figs. 5 and 6 depict the concentration of trip points on weekdays and weekends.

No significant differences are observed between the two maps, with the highest concentration in both cases found in the city center. On weekdays, the area with the highest demand is the University of Kentucky campus, as well as its northern side, where cafés, entertainment venues (bars), and restaurants are located. This suggests that most routes have either the campus as their destination, possibly due to lectures, or nearby dining establishments. On weekends, the routes concentrated within the university primarily relate to the Central Library. At the same time, increased activity is observed around the Central Bank Center (Opera House, Rupp Arena), where concerts, sporting events, and various other activities take place. Additionally, significant movement is recorded east of the center, in an area with theaters, cinemas, restaurants, and bars.

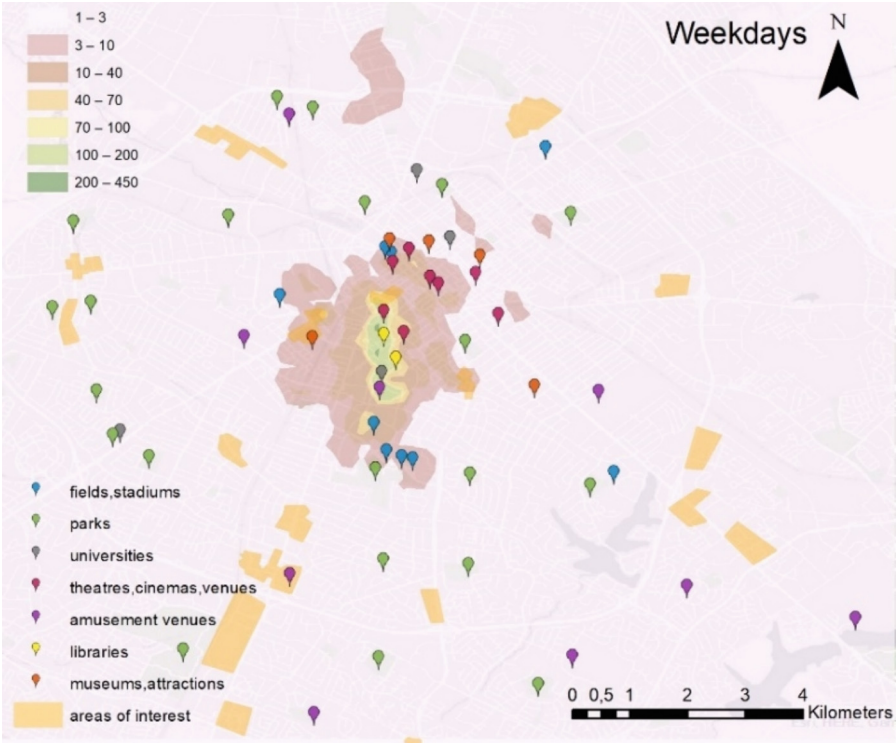

Fig. 5. Map displaying the concentration of drop-off points (destinations) and points of interest on weekdays.

With regards to the spatial distribution of the demand within the day, Figs. 7 and 8 are being presented. In the early morning hours, the highest demand is observed in the university dormitories and nearby areas of interest surrounding the campus. During this

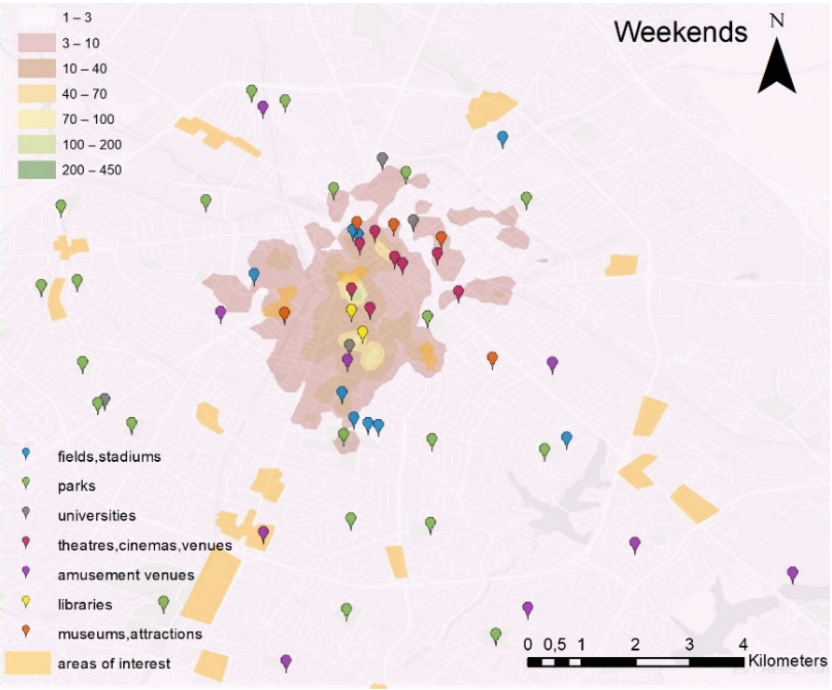

Fig. 6. Map displaying the concentration of drop-off points (destinations) and points of interest on weekends.

time, some students return from their night out and choose nearby dining spots, while others leave their dorms either to attend classes, engage in other activities or visit a store for breakfast or coffee.

In the evening, the concentration within the campus decreases compared to earlier hours, while the Historic South District—where many students and university staff reside—and the North Side District show increased activity. Additionally, during these hours, routes are more dispersed, with certain high-density points emerging farther from the city center.

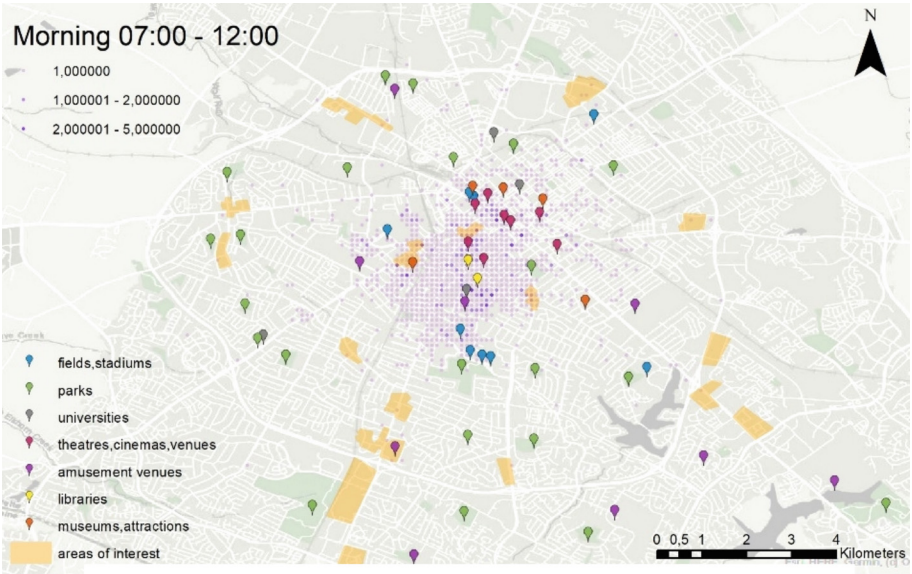

Fig. 7. Map displaying the distribution of drop-off points (destinations) and points of interest in the morning.

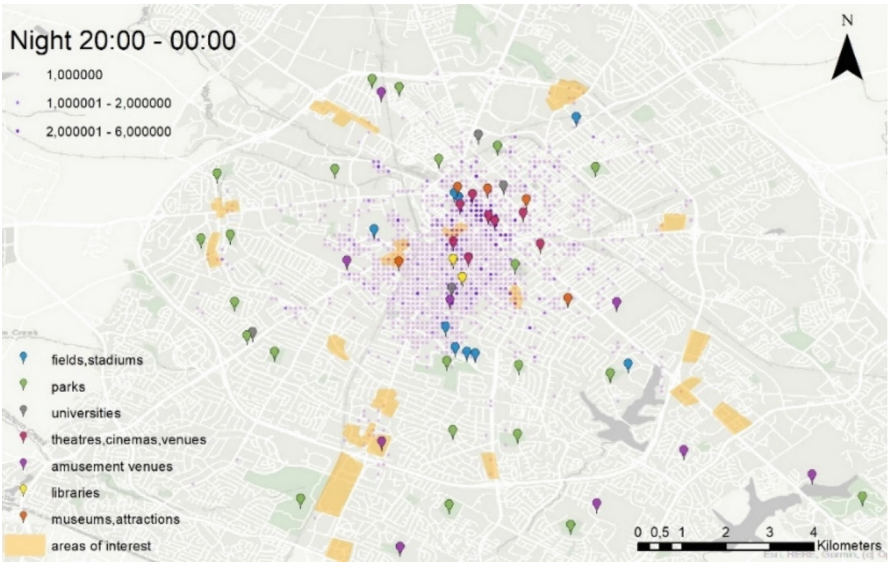

Fig. 8. Map displaying the distribution of drop-off points (destinations) and points of interest in the night.

Finally, the spatial distribution of the demand between a typical summer and a typical winter month is being explored (Figs. 9 and 10). The first map, which represents

February, shows a strong concentration of routes around the University and its surroundings, indicating heightened student activity during the academic semester. In contrast, the July map shows a clear shift in routes from the University to the Historic South District, where many students and staff reside. This shift is likely due to reduced university activity during the summer period, with students remaining in the city moving mainly towards residential areas and recreational spaces.

Additionally, there is noticeable increased activity around the Central Bank Center and Rupp Arena, as the stadium hosts numerous concerts and performances, attracting many visitors from both the city and beyond.

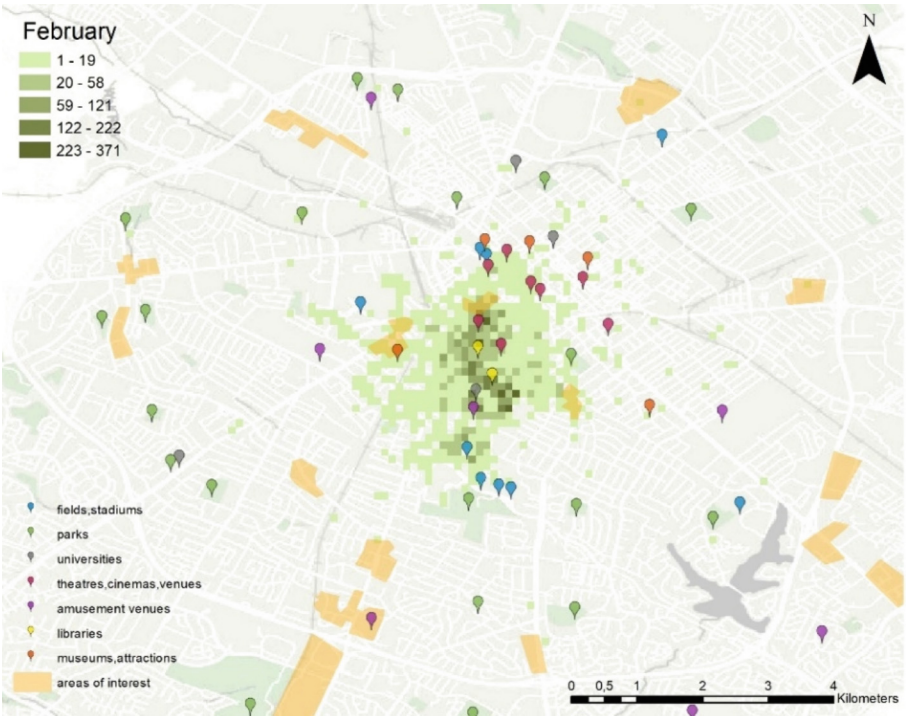

Fig. 9. Map displaying the distribution of drop-off points (destinations) and points of interest in February.

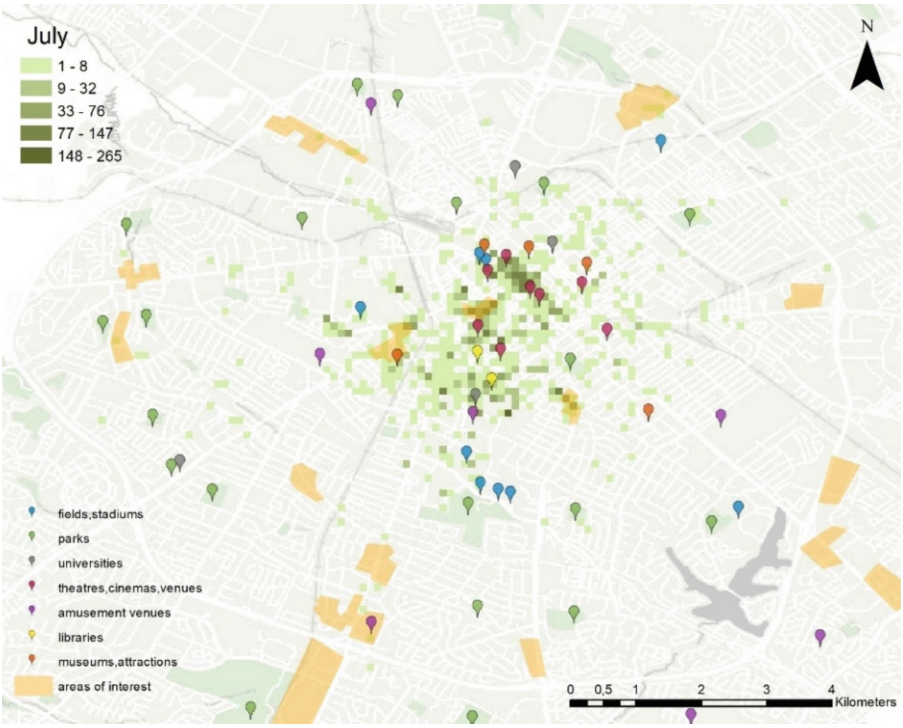

Fig. 10. Map displaying the distribution of drop-off points (destinations) and points of interest in July.

4 Conclusions

Trips at a speed of 10–15 km per hour account for 51% of the total, while those at a speed of 15–20 km per hour make up 40%. Overall, trips within the 10–20 km/h speed range represent 91% of all recorded trips.

Regarding distance, 77% of trips fall within the 0–2-km range, while in terms of duration, 84% of trips last between 0–10 min. These findings indicate that electric scooters are primarily used for short trips or to cover the "first-mile, last-mile" segment of a longer journey. Additionally, weekday trips tend to be shorter, whereas weekend trips have longer durations, suggesting a shift in usage patterns depending on the day of the week.

For the temporal characteristics, months, days, and hours were analyzed. September recorded the highest percentage of trips, while July had the lowest. To better understand the influence of months on demand, the average temperature and precipitation per month were examined. Regarding temperature, extreme conditions—whether excessively hot or cold—tended to reduce scooter usage, while milder temperatures encouraged it. However, the relationship between precipitation and demand was less clear. Some months with high rainfall recorded more trips than others with lower rainfall levels, and vice

versa. Since rainfall is reported as a monthly average and can vary significantly over 30 days, it is reasonable that no clear trend emerges.

Regarding daily usage patterns, weekdays showed a higher number of trips compared to weekends, indicating greater commuting needs related to work, university lectures, and other obligations. In terms of hourly trends, the highest percentage of weekday trips occurred between 12:00 and 13:00, while on weekends, peak usage was recorded between 20:00 and 21:00. Comparing hourly demand across weekdays and weekends, trips were more frequent on weekdays from 05:00 to 17:00, whereas from 17:00 to 05:00, weekends exhibited higher demand.

From the demand maps depicting starting and ending points, the highest concentrations were observed in areas of interest in downtown Lexington, particularly within the University of Kentucky campus. However, starting and ending points did not show significant differences, as many of them overlapped. Most conclusions were drawn from demand visualization (by day, hour, and month) overlaid on a map with points of interest.

On weekdays, the highest number of trips was concentrated within the university campus and nearby areas of interest. Scooter usage appears to be driven primarily by commuting to lectures and short recreational activities (such as meals or coffee breaks) between classes. On weekends, hotspots shifted to areas with theaters, cinemas, bars, and restaurants, emphasizing the increased demand for leisure activities.

In terms of time-of-day patterns, mornings and midday hours showed a higher concentration of trips within the university campus and surrounding points of interest on weekdays. In the evening, at night, and even in the early morning hours, demand was significantly higher at weekends, particularly in entertainment districts.

Finally, it is worth noting that the university community (students, faculty, and staff), although comprising only 14% of the city's population, appears to represent a significantly higher proportion of electric scooter users. This highlights the considerable influence of the University of Kentucky on the overall demand profile for electric scooters in Lexington.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

References

1. Zhu, R., Zhang, X., Kondor, D., Santi, P., Ratti, C.: Understanding spatiotemporal heterogeneity of bike-sharing and scooter sharing mobility. Comput. Environ. Urban Syst. **81**, 101483 (2020)
2. Tuli, F.M., Mitra, S., Crews, M.B.: Factors influencing the usage of shared E-scooters in Chicago. Transp. Res. Part A: Policy Pract. **154**, 164–185 (2021)
3. Nikiforiadis, A., Paschalidis, E., Stamatiadis, N., Paloka, N., Tsekoura, E., Basbas, S.: E scooters and other mode trip chaining: preferences and attitudes of university students. Transp. Res. Part A: Policy Pract. **170**, 103636 (2023)
4. Shah, N.R., Guo, J., Han, L.D., Cherry, C.R.: Why do people take e-scooter trips? Insights on temporal and spatial usage patterns of detailed trip data. Transp. Res. Part A **173**, 103705 (2023)
5. McKenzi, G.: Spatiotemporal comparative analysis of scooter-share and bike-share usage patterns in Washington, D.C. J. Transp. Geogr. **78**, 19–28 (2019)

6. Hosseinzadeh, A., Algomaiah, M., Kluger, R., Li, Z.: Spatial analysis of shared e-scooter trips. J. Transp. Geogr. **92**, 103016 (2021)
7. Nikiforiadis, A., Paschalidis, E., Stamatiadis, N., Raptopoulou, A., Kostareli, A., Basbas, S.: Analysis of attitudes and engagement of shared e-scooter users. Transp. Res. Part D: Transp. Environ. **94**, 102790 (2021)
8. Caspi, O., Smart, M.J., Noland, R.B.: Spatial associations of dockless shared e-scooter usage. Transp. Res. Part D: Transp. Environ. **86**, 102396 (2020)