Ridership Analysis of the Public Bicycle Sharing System in Ahmedabad

Tothad Sattarsad Shagufta[1], Dimpu Byalal Chindappa[1], Seelam Srikanth[1*]

[1] School of Civil Engineering, REVA University, Rukmini Knowledge Park, Kattigenahalli, Yelahanka, Bengaluru 560064, Karnataka, India
[*] Corresponding author, e-mail: srikanths.reddy@reva.edu.in

Abstract

This study examines the Public Bicycle Sharing System (PBSS) in Ahmedabad, the patterns of ridership, user behavior, and spatial distribution in various density zones based on the data provided by MYBYK. In 2023, 577,228 rides were registered, and high ridership areas were concentered around educational and recreational locations, which recorded 350,000 rides in 132 stations. In the high-density zones, the analysis indicates that most of the preference is for the short-distance ride, 55 percent of the total number of trips are made by zero-displacement rides, which is a good indicator that the trend is shifting towards leisure cycling. The monthly ridership trends show some significant variations, with the highest number of 68,529 rides in March, indicating that significant operation policies should be implemented when demand is very high. The dominance of short-term subscriptions (87.3%) indicates the users' preference for flexibility, whereas the number of rides longer than 5 km (424,893 trips) shows a growing tendency towards longer trips. Furthermore, a multinomial logistic regression model was used to identify factors affecting the use of PBSS, with emphasis on the relationships between the type of subscription, length of trip, time of use, and weather conditions. The model findings indicate that short-term users tend to have shorter rides, and the length of the trip is highly influenced by climatic conditions. The results can be useful to policymakers and urban planners to optimize the PBSS operations and improve sustainable mobility in Ahmedabad and other urban settings.

Keywords

PBSS, MLR model, ridership analysis, urban mobility, mobility patterns

1 Introduction

The need to have sustainable urban transportation has led to a great interest in Public Bicycle Sharing Systems (PBSS), especially in the fast-urbanizing areas. Cities are struggling with issues like traffic jams, air pollution, and the need to adopt healthier lifestyles, thus PBSS has become a possible and environmentally friendly alternative to motorized transportation (Patel et al., 2020). These systems offer affordable and easily accessible bikes to use on short routes, hence ensuring environmental sustainability and less reliance on fossil fuels. The beneficial effects of bicycle-sharing programs on urban mobility have been noted in many studies, and the programs have been shown to increase accessibility, reduce environmental footprints, and create a cycling culture (Fishman et al., 2013; Shaheen et al., 2010). The density of stations, the combination with the public transport, and the demographics of the users are the aspects that influence the success of PBSS to a large extent (Efthymiou et al., 2020). Bike-sharing can facilitate work-related and leisure travel, decrease urban congestion, enhance air quality, and decrease the cost of transport infrastructure by providing flexible and point-to-point mobility (de Chardon, 2021; Kou et al., 2020).

Bike-sharing schemes were first introduced in Europe but have spread all over the world because of their efficiency in supporting sustainable mobility. By 2020, more than 2,000 systems were in operation around the globe, and in India, both large and medium-sized cities have been very fast in adopting them. There are now more than 48 cities in India with public bike-sharing systems, which control in total more than 21,000 bicycles (Machavarapu and Ram, 2022). These systems come in different designs, such as docked and dockless, traditional and electric bicycles, and are becoming more and more digitally-based in terms of booking, payment, and real-time tracking. India has over 27 cities under the Smart Cities Mission, which have implemented PBSS to enhance sustainable and last-mile connectivity (Machavarapu et al., 2024). Large-scale systems are used in

cities such as Delhi, Bengaluru, and Ahmedabad, although Ahmedabad, while not as large, is showing great local adoption. MYBYK has been instrumental in developing the PBSS ecosystem in Ahmedabad since its introduction in 2014. Started with four stations, it has grown to more than 253 stations and 10,000 bicycles. This increase indicates the increased acceptance of cycling as well as a behavior change towards last-mile connectivity and recreational travel. MYBYK has a strategic network of stations, which include educational institutions, residential and recreational areas, and this offers access to a wide range of users. Besides the decrease in congestion and emissions, PBSS encourages healthy living and physical movement. Nevertheless, the spatial and temporal dynamics of ridership are still a significant area of research gap because the effective policy and operational planning are based on the knowledge of user behavior and usage patterns.

Even though bike-sharing has been fully established in the Western world, its implementation in developing countries such as India is still in the development phase. PBSS initiatives have been established in about 27 Indian cities to deal with congestion and environmental degradation. However, they cannot be successful due to the lack of cycling infrastructure, parking spaces, and security issues (Dhingra and Kodukula, 2010; Patel and Patel, 2020). Poor road design, traffic volume, and driver awareness are some of the factors that lead to perceived cycling risks. The problem of theft and vandalism also discourages users, and the cultural view of cycling as a low-income activity also supports the barriers to usage (Sharmeen et al., 2020). In addition, the poor connectivity with the public transportation and lack of financial support jeopardize the sustainability of such systems. It has been emphasized that researchers should be able to comprehend user preferences and behavior to enhance performance and avoid failures of programs (Machavarapu and Ram, 2022; Patel and Patel, 2020). It is not possible that by merely imitating Western models, India will succeed in its endeavors because of the unique urban features, such as mixed land use, high population density, and different governance systems. Therefore, it is necessary to have localized strategies that consider socio-economic and infrastructural factors (Machavarapu et al., 2023).

Since there is a dearth of research on the use of bike-sharing in developing nations, this paper analyzes the PBSS of Ahmedabad as a model of small and medium-sized cities in India. It aims to produce insights on how to optimize similar systems across the country by examining the data on operations and user behavior. This paper examines the ridership trends, the length of trips, and the distance covered

to determine the effectiveness of the PBSS in ensuring sustainable transport. It also uses the Multinomial Logistic Regression (MLR) model to identify the effect of subscription type, length of trip, time of day, and weather on the behavior of ridership. To perform the spatial analysis, PBSS stations were classified into high, medium, and low ridership areas according to the volumes of trips in 2023 and mapped with the help of Geographic Information System (GIS) tools. Such zoning methodology allowed making comparative assessments of user behavior and accessibility based on the level of demand. The results will be useful in the study of sustainable mobility and offer practical suggestions to policy makers and planners who wish to make bike-sharing systems in India more efficient and inclusive.

2 Study area and data

The research was carried out in Ahmedabad, the largest city in Gujarat, India, which is characterized by a high rate of urbanization and the problems associated with traffic congestion and air pollution. Ahmedabad has a hot, semi-arid climate and has seasonal variations. Summers (March-June) are very hot, and the temperatures may reach up to 40 ºC and the monsoon season (June-September) is very wet and humid, especially in July. Winters (October-February) are warm and pleasant with daytime temperatures of between 20 ºC and 30 ºC and night temperatures of about 10 ºC. The humidity is low except during the monsoon, and the quality of air is usually poor during winter because of the automobile and industrial emissions. To address these environmental and mobility issues, the city adopted the MYBYK public bicycle sharing system, which has a network of 253 stations spread throughout Ahmedabad as indicated in Fig. 1.
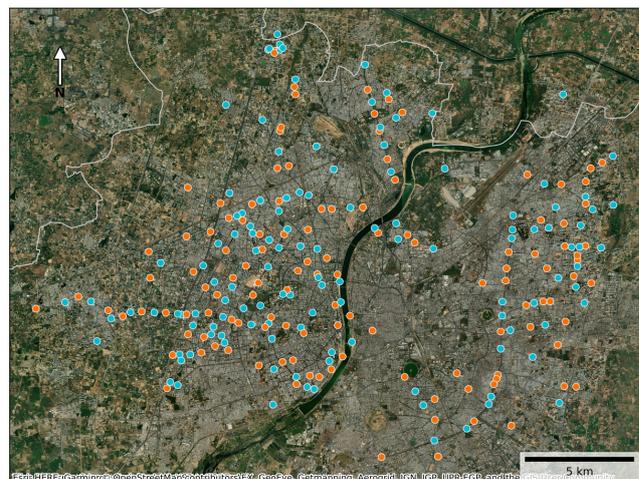

Fig. 1 MYBYK PBSS stations. Source: Esri (online); HERE (online); Garmin (online); OpenStreetMap contributors (online); mapped by the authors using Python.

The system will improve sustainable mobility and decrease the use of motorized transportation. In this analysis, the operational data of MYBYK from 2023 is used, and it includes 577,228 operational trips. The data contains the number of trips, their duration, and distance, which provide useful information on the behavior of ridership and the performance of the system. The GIS methods were used to map out spatial areas and examine the distribution and accessibility of PBSS stations, which allowed to understand the usage patterns in the city in-depth.

3 Data analysis and discussion

The subscription type analysis in the PBSS of Ahmedabad shows useful information on the preferences of the users as presented in Table 1. The system is dominated by short-term subscriptions, including hourly and daily access, which constitute 87.3% of all rides. This high preference means that most users use PBSS to make short-distance journeys and last-mile connectivity. The weekly subscriptions are only 1.33 percent of the total rides, which indicates that there is little engagement in the middle term, and long-term subscriptions of three-month, six-month, and annual plans are only 4.93 percent. This lack of interest in long-term plans highlights the flexibility of users and the short-term nature of the system as a mobility solution. Overall, these results indicate that PBSS is an effective system of sustainable urban mobility in Ahmedabad, as it can serve users who want to have quick and convenient access to bicycles.

A further examination of zero-displacement rides in which the start and end of the trip are in the same station shows that they have a large proportion of PBSS usage as provided in Table 2. These made-up 55 percent of the total number of rides in 2023, amounting to 317,473 trips. Forty percent of

Table 1 Ridership analysis by subscription type

Subscription type	Number of rides	Percentage of total
Short-term (hour + daily)	504,185	87.30%
Weekly	7,676	1.33%
Monthly	32,260	5.59%
Long-term (3 Months + 4 Months + 6 Months + Yearly)	28,468	4.93%

Table 2 Zero displacement rides

Duration	Number of rides	Percentage of total
Less than 15 min	52,656	17%
15 to 30 min	31,670	10%
30 to 60 min	104,816	33%
More than 60 min	128,422	40%

them took more than 60 minutes, which means that a significant number of users were on long leisure rides and not commuting. About 33 percent of rides took between 30 and 60 minutes, 17 percent took less than 15 minutes, and 10 percent took between 15 and 30 minutes. These trends indicate that there is a high tendency towards recreational cycling, especially among the younger users who visit the popular locations like the Sabarmati Riverfront and university campuses. Overall, the statistics indicate the dual role of the PBSS that allows short-range travel and encourages recreational cycling and active mobility.

The PBSS ridership distribution in Ahmedabad has specific temporal patterns of usage, as indicated by the hourly distribution of PBSS ridership, as indicated in Fig. 2. The use of bicycles starts to grow rapidly at about 5 a.m. and peaks at 6 a.m. with about 66,415 rides and then starts to decrease gradually until the middle of the morning. The morning hours of 6 a.m. to 9 a.m. contribute to almost 30 percent of the total number of rides in a day, which shows that people are highly dependent on PBSS to get to their workplaces and institutions. The number of people using it significantly decreases during the midday (12 p.m. – 4 p.m.), which constitutes only 6.7 percent of the total usage, probably because of the high temperatures in the daytime. A secondary peak is created between 4 p.m. and 8 p.m., which is associated with post-work travel and recreational cycling, with an average of about 30,000 rides per hour. The activity at night is insignificant, and few riders are registered during the period between midnight and 5 a.m. In general, these time patterns suggest that climatic conditions are the decisive factor in determining the behavior of users, and the most favorable conditions to ride are in the morning and evening when it is cooler.

Monthly ridership trends analysis of Ahmedabad PBSS, as illustrated in Fig. 3, reveals that there is a significant seasonal variation during the year. In 2023, 576,261 rides were registered, the highest number was in March (68,529 rides), and then in April (64,737 rides). These are the months of moderate climatic conditions, which are conducive to cycling. The ridership was constant until early summer when there were 56,364 rides in June and then dropped drastically in the monsoon months of July and August (37,885 and 32,154 rides, respectively). The rain and high humidity at this time probably do not encourage outdoor cycling activities. With the weather settling down after the monsoon, the ridership slowly picked up, with 44,981 rides in November. These results demonstrate that there is a strong relationship between climatic changes and the intensity of ridership, which supports the significance
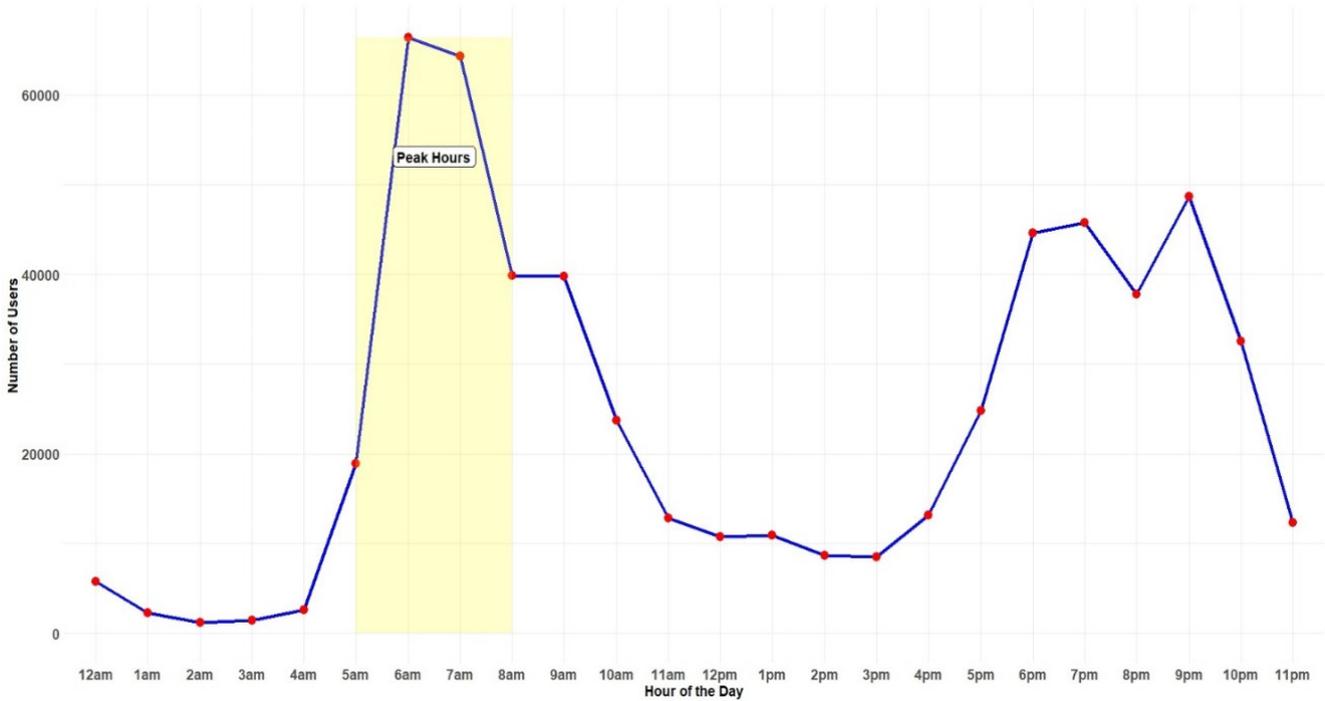
Fig. 2 User distribution of PBSS in Ahmedabad by hour

Fig. 3 Monthly ridership trend of PBSS in Ahmedabad

of weather-resistant infrastructure and operational plans to enhance the reliability of PBSS throughout the year.

The percentage of rides that returned the bicycle to a PBSS station was high at 85.8%, as indicated in Fig. 4, meaning that the majority of users use the system to make short trips or last-mile connectivity. This trend indicates that riders usually finish their trips by riding to the closest places and dropping the bicycle at the closest docking stations, which supports the idea that the PBSS is convenient in offering urban access. Conversely, 14.2% of rides were

classified as "Take Home" in which users kept bicycles over extended periods. This group is smaller, but it represents those users who like to have bicycles for long-term travel or recreational use. The difference between these two actions highlights the flexibility of the PBSS to support both utilitarian and recreational cycling.

The ride distance analysis as shown in Fig. 5 shows that the PBSS is used well in different travel distances. It is worth noting that rides longer than 5 km made 424,893 trips, which is about 72.7 percent of the total usage. Rides of moderate
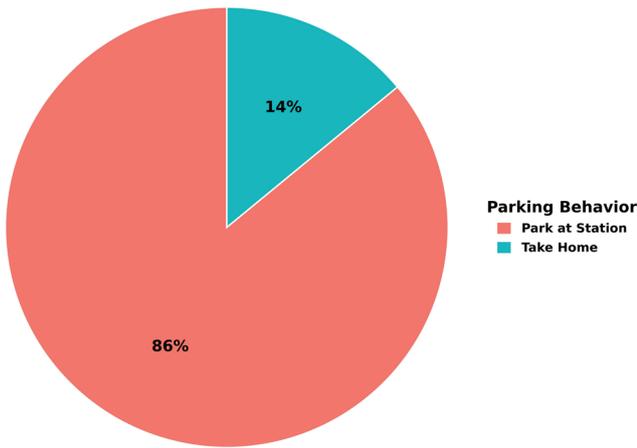
Fig. 4 Parking behavior

distance (2-5 km) were 22.5%, and 1–2 km rides were 3.5%. Conversely, short journeys less than 2 km in total amounted to 20,680 rides (approximately 3.6%). These results emphasize the fact that even though PBSS allows last-mile mobility, a significant portion of users make longer trips, which means that they trust the reliability and coverage of the system. The introduction of special cycling paths, safe parking areas, and shaded resting spots would also promote the use of bicycles and increase user satisfaction. Overall, the findings indicate that the PBSS in Ahmedabad is effective in addressing various mobility requirements, both commuting and recreational cycling over long distances.

The spatial distribution of PBSS usage in Ahmedabad was examined by dividing the city into three different density areas, each with different user characteristics and travel patterns, as illustrated in Fig. 6. The high ridership area is mostly located in the areas of educational and recreational centers, especially around the university and the Sabarmati Riverfront. The people in this region usually make short and recreational journeys, which are supported by the closeness of docking stations. The zone has the most adoption of the PBSS, which is mainly due to the younger riders who enjoy cycling as a recreational activity and also as a means of commuting over short distances. The medium ridership area is a large area on the eastern side of the city and includes the older residential areas and business districts. The level of usage is moderate, and there is an equal proportion of commuters and recreational cyclists. This zone is a transition zone between high and low ridership zones, which is an indicator of a balance between accessibility, station density, and user demand. The low ridership area is primarily in the northern areas of Ahmedabad, where the use of PBSS is relatively low. Travel in this region is mostly work related, but generally the participation is limited due to lack of infrastructure, poor station coverage, and poor connectivity. Lack of necessary cycling facilities limits the potential development of the system and reduces the user participation in such peripheral regions. Taken together, the zonal analysis shows that there are spatial differences in the use of PBSS, and that investment in specific infrastructure should be made, and stations should be better placed to provide easy access and promote ridership in all parts of the city.
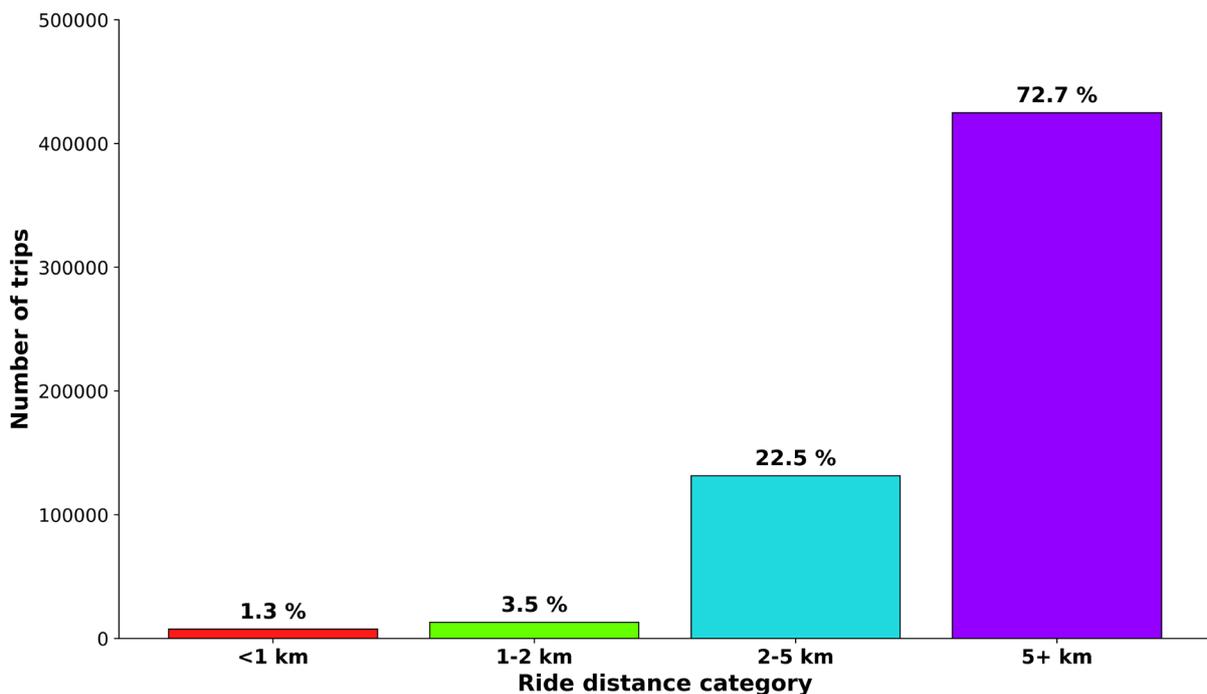

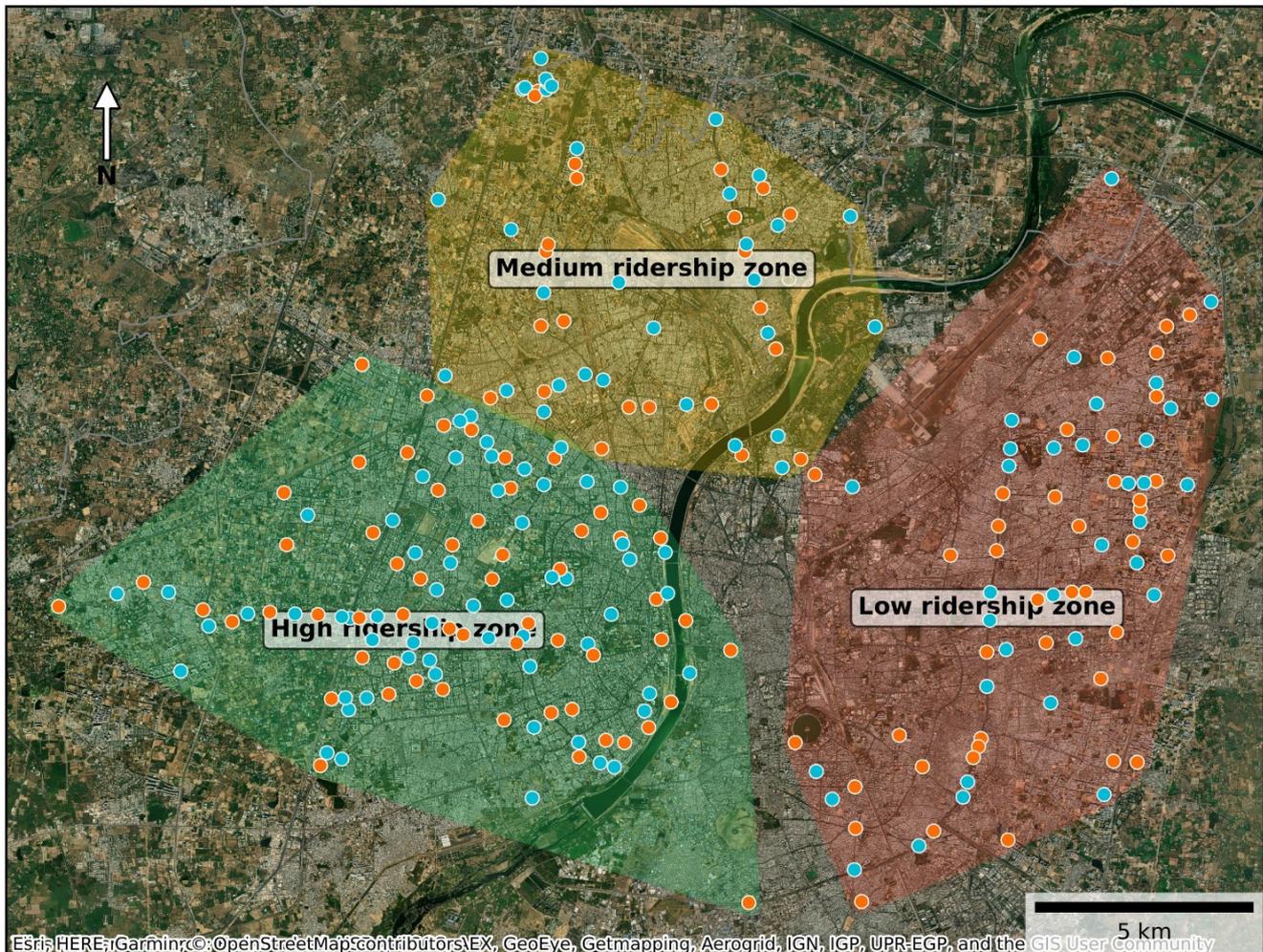
Fig. 5 Trip length of PBSS users

Fig. 6 Density zones of the PBSS in Ahmedabad. Source: Esri (online); HERE (online); Garmin (online); OpenStreetMap conributors (online); mapped by the authors using Python

4 Multiple logistic regression (MLR) model

The literature on the analysis of bike-sharing systems presents a large variety of modeling approaches, such as discrete choice models (Narayan et al., 2023), machine learning frameworks (Schnieder, 2023), spatial interaction models (Ma et al., 2018), data mining methods (Bordagaray et al., 2016), and time-series analyses. All these methodologies offer unique information about user behavior and system dynamics, which will help to make shared mobility systems more effective in planning, optimization, and management. Discrete choice models are concerned with the decision-making process of individuals and have been widely applied to model the decisions of users regarding when and where to use bike-sharing services, usually including socio-demographic variables and environmental effects. Machine learning models use big data to forecast demand trends and optimize the performance of the system with predictive analytics. Spatial interaction models analyze the movement of riders between stations and how it is influenced by geographical variables, which can be useful in understanding how stations are placed and how they can be rebalanced. Data mining has been used to reveal the latent patterns in ride data, which allows the determination of specific user segments and their behavior. The time series analysis, which is commonly used to record seasonality and time variations in the use of bikes, can be used to forecast future trends and assist in making operational changes during peak demand times. This study used a MLR model to determine the most important variables that affect the ride duration in the PBSS of Ahmedabad due to the constraints of the available data. The model was developed to investigate the relationships between ride duration and various independent variables, which allows a subtle insight into how the system performance is influenced by subscription type, user behavior, time trends, and infrastructure utilization.

The MLR model divided ride duration into four categories, namely, less than 15 min, 15–30 min, 30–60 min, and more than 60 min (reference category). The independent

variables were subscription type (Short-Term, Weekly, Monthly, and Long-Term as reference), user distribution by time of day (Morning, Afternoon, Evening, and Night as reference), monthly ridership by season (Winter as reference, with Summer and Monsoon as other categories), parking behavior (Take Home vs. PBSS Station as reference), trip length (<1 km, 1–2 km, 2–5 km, and >5 km as reference), and station usage (Low, Medium, and High as reference). This model allowed assessing the effect of time, space, and behavior on the probability of various ride times.

The findings of the MLR analysis provided in Table 3 show that there are a number of important relationships. The negative relation between shorter ride times (less than 15 min and 15–30 min) and short-term, weekly, and monthly subscriptions implies that the users of these plans take short trips. The time-of-day variable indicates that shorter ride times are positively related with morning, afternoon, and evening use, indicating a high concentration of demand during commuting and leisure periods. The seasonal analysis shows that the summer and monsoon seasons are related to shorter rides, which can be explained by the fact that high temperatures and rainfall do not encourage long rides. Regarding parking, the users who choose to bring bicycles home will have longer ride times than those who bring bikes back to docking stations. The length of the trip is a decisive factor: rides shorter than 2 km are highly correlated with shorter time, which confirms the usefulness of the PBSS in the context of fast and short-range mobility. Moreover, the stations that are characterized by the intensity of use are associated with shorter ride time, which means that the users of the busy stations make frequent and short trips that are supported by the availability of the stations.

The model showed good statistical results, where McFadden $R^2 = 0.758$ and Nagelkerke $R^2 = 0.785$, which means that the selected predictors explained a significant part of the variance in ride duration. Model validation confirmed its robustness, achieving a total classification accuracy of 82%. The confusion matrix revealed that the true-positive rates were especially high with the extreme duration categories (<15 min and >60 min) in which the ride behavior is more pronounced. Although there was slight overlap in moderate-duration categories (15–30 min and 30–60 min), accuracy was above 75 percent, which indicates consistent model discrimination. The high explanatory power (Nagelkerke $R^2 = 0.785$) also indicates that the model is appropriate in the analysis of behavior in the context of urban mobility. These results highlight the dual purpose of the PBSS to facilitate short-term commuting and longer recreational rides, and it is necessary to focus on specific operational strategies, including redistribution of the peak hours, weather-sensitive planning, and flexible subscription design to improve the performance of the system and user satisfaction.

5 Policy implications and recommendations

The results of this research are important in improving the PBSS in Ahmedabad and can be used to guide other

Table 3 Coefficients of MLR model for ride durations (outcome reference category: >60 min rides; reference levels of predictors - subscription: long-term; period: night; season: winter; parking: station; trip length: >5 km; station usage: high)

Predictor	< 15 min β (95% CI)	15–30 min β (95% CI)	30–60 min β (95% CI)
Intercept	−0.42 [−0.60, −0.25]**	−0.67 [−0.85, −0.49]**	−1.03 [−1.25, −0.82]**
Subscription: short-term	−0.62 [−0.72, −0.53]**	−0.44 [−0.55, −0.33]**	−0.32 [−0.43, −0.21]**
Subscription: weekly	−0.41 [−0.50, −0.32]**	−0.31 [−0.41, −0.22]**	−0.20 [−0.30, −0.10]*
Subscription: monthly	−0.33 [−0.42, −0.24]**	−0.22 [−0.32, −0.13]*	−0.13 [−0.23, −0.04]*
Time of day: morning	0.63 [0.50, 0.76]**	0.91 [0.80, 1.02]**	1.23 [1.10, 1.37]**
Time of day: afternoon	0.42 [0.31, 0.54]**	0.61 [0.50, 0.72]**	0.80 [0.68, 0.92]**
Time of day: evening	0.52 [0.40, 0.64]**	0.72 [0.60, 0.84]**	0.91 [0.79, 1.03]**
Season: summer	−0.33 [−0.45, −0.21]**	−0.42 [−0.53, −0.31]**	−0.64 [−0.75, −0.53]**
Season: monsoon	−0.61 [−0.72, −0.50]**	−0.44 [−0.55, −0.33]**	−0.82 [−0.93, −0.71]**
Parking: take home	1.62 [1.50, 1.74]**	0.22 [0.00, 0.45]	0.31 [0.08, 0.55]*
Trip length: <1 km	1.52 [1.40, 1.64]**	1.22 [1.13, 1.32]**	0.91 [0.80, 1.02]**
Trip length: 1–2 km	1.24 [1.15, 1.34]**	0.93 [0.82, 1.04]**	0.62 [0.50, 0.74]**
Trip length: 2–5 km	0.84 [0.74, 0.94]**	0.63 [0.52, 0.74]**	0.52 [0.40, 0.64]**
Station usage: low	0.61 [0.50, 0.72]**	0.41 [0.30, 0.53]**	0.25 [0.12, 0.38]**
Station usage: medium	0.21 [0.09, 0.33]**	0.31 [0.18, 0.44]**	0.11 [−0.02, 0.25]

Levels of significance: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$. (no asterisk means that the effect was not statistically significant at the 95% confidence level)

systems in the Indian cities. In comparison to international systems like Citi Bike and Velib, success factors as strong infrastructure, smooth integration with the public transport, and dynamic fleet management are important (Fishman et al., 2013; Shaheen et al., 2010). Nevertheless, Ahmedabad has its own problems, such as seasonal changes in ridership, which are not the same as in more moderate areas. The high ridership areas of Ahmedabad that revolve around educational and recreational centers prove the significance of strategic location of stations and infrastructure. Cities with more stable climates have systems that are likely to be used throughout the year (de Chardon, 2021). The seasonal peaks and troughs of Ahmedabad highlight the necessity of local interventions that can maximize the performance of the system and enhance the engagement of the users on a year-round basis. The network of bike stations, especially in low density areas, should be expanded to make them more accessible and cover a larger area of the city. The stations are to be located in strategic locations close to transit centers and busy locations to increase the number of riders, just like other successful examples such as Citi Bike and Velib (Patel and Patel, 2020). The infrastructure should also be enhanced by establishing special cycling paths and bike parking areas to make the process safer and more convenient, especially in areas with a high ridership potential (Kou et al., 2020). The other significant problem facing the PBSS in Ahmedabad is the inability to integrate with other forms of transport. The connection of bike stations with metro and bus stations would enhance the last mile connectivity, making cycling an option to motorized transportation. The development of a smooth urban mobility system that facilitates efficient movement between various modes of transport is dependent on multi-modal solutions (Narayanan et al., 2023). The research found that 87.3 percent of the ridership is comprised of short term subscriptions, which means that bike-sharing plans need to be more flexible. The introduction of discounted long term passes, and off-peak usage rates would help to promote more frequent use, especially among commuters and students. The provision of corporate partnerships and subsidized memberships may help to attract regular users and further incorporate the system into the institutional transport solutions (Machavarapu et al., 2023). The analysis also reveals that the highest ridership is recorded between 6–9 a.m. and 4-8 p.m. meaning that bicycles have to be rebalanced dynamically during these periods. Bike shortages in high-demand zones can be detected and addressed with the help of real-time data analytics, which has been proven to be successful in Hangzhou (Ma et al., 2018). This would reduce waiting time and enhance user satisfaction especially

during peak hours. The seasonal variations in Ahmedabad, especially the heat and monsoon rains, have a great impact on the ridership. To address these issues, the introduction of e-bikes, weatherproof stations, and shaded docks may help to make the user experience more comfortable and usable in the case of extreme weather. Renting ponchos or other weather-adaptive clothing would motivate the use of the product throughout the rainy season, minimizing weather-related downtime and ensuring service continuity (Kou et al., 2020). Moreover, the cultural attitudes towards cycling in India particularly among the higher-income population should be addressed with the help of the public awareness campaigns. By emphasizing the environmental and health benefits of cycling, as well as its affordability, it is possible to change the attitudes of the society and decrease the stigma of bike-sharing (Sharmeen et al., 2020). The campaigns must focus on promoting cycling as a sustainable, efficient and enjoyable mode of transportation, and extend its popularity to a wide range of socio-economic groups. Although the results are limited to Ahmedabad, they can be extended to other cities in India, including Bengaluru, Chennai, and Hyderabad, where the issue of urban mobility is also relevant (Machavarapu and Ram, 2022). Nevertheless, local conditions like weather conditions, infrastructure preparedness, and socio-cultural acceptance must be considered when transferring these results to other cities. As an example, the climate in Bengaluru is milder and the population density is greater, which might lead to other ridership trends than in Ahmedabad and thus needs specific interventions.

6 Conclusions

This study provides comprehensive insights into the operational dynamics and user behavior of the Public Bicycle Sharing System PBSS in Ahmedabad. The major findings are summarized below:

- Annual ridership totaled 576,261 trips, with the highest activity in March (68,529 rides) and the lowest in October (28,580 rides). These results emphasize the strong influence of climatic conditions on cycling behavior, suggesting that targeted promotional initiatives and infrastructure enhancements during off-peak months can help maintain consistent ridership.
- Ridership peaks during morning and evening hours, indicating that users predominantly rely on PBSS for leisure activities and last-mile connectivity when temperatures are more comfortable.
- Approximately 55% of all rides were classified as zero-displacement, reflecting a preference for short, localized leisure trips, many lasting more than an hour.

- The majority of users preferred short-term access plans, highlighting a demand for flexibility and spontaneous bicycle usage rather than long-term commitments.
- High-ridership zones were concentrated around educational and recreational centers, confirming PBSS's effectiveness in providing both connectivity and recreational mobility opportunities.
- Over 424,893 rides (73.5%) exceeded 5 km, signifying strong user interest in longer cycling trips and underscoring PBSS's role in promoting sustainable urban transport. Infrastructure upgrades such as expanded cycling lanes and improved parking facilities are essential to support this demand.
- The MLR model revealed that subscription type, seasonal weather, and trip length significantly affect ride duration, with short-term users more likely to take shorter trips.

Overall, the study highlights the need for targeted interventions to enhance service accessibility, strengthen user engagement, and expand infrastructure. By addressing these areas, Ahmedabad's PBSS can maximize its contribution to sustainable urban mobility, ensuring that the system remains inclusive, efficient, and adaptable to diverse user needs.

Study limitations
There are a few limitations to this study. To begin with, the analysis is limited to one year (2023) and one city (Ahmedabad), which restricts its generalizability and does not allow evaluating long-term trends. The dataset does not include socio-demographic variables and trip-purpose information, which limits the analysis of the differences in usage by age, gender, or income. There can be potential self-selection bias because only active users will be represented, and non-users will not be represented, as they might be affected by other factors like safety concerns, cost, or lack of awareness. The ridership zone classification, which is determined by the tertiles of station usage, offers a convenient way of categorization, but it can obscure the micro-level differences in the local travel behavior. MLR model only captures statistical associations but not causality. Data constraints did not allow the inclusion of unobserved variables like weekday/weekend patterns, real-time weather conditions or temporal events. Also, small data errors, including GPS errors, rides that have not been undocked, or missing trip data can have a slight impact on the results. Lastly, the results might not be directly relevant to cities that have other climatic, infrastructural, or socio-cultural settings. Future studies must consider multi-year and multi-city data, incorporate more contextual data, and comparative studies of users and non-users to strengthen the model and make it more policy relevant.

Acknowledgement

References
Bordagaray, M., dell'Olio, L., Fonzone, A., Ibeas, Á. (2016) "Capturing the conditions that introduce systematic variation in bike-sharing travel behavior using data mining techniques", Transportation Research Part C: Emerging Technologies, 71, pp. 231–248.
https://doi.org/10.1016/j.trc.2016.07.009

de Chardon, C. M. (2021) "Bicycle sharing", In: International Encyclopedia of Transportation, Elsevier, pp. 19–30. ISBN 978-0-08-102672-4
https://doi.org/10.1016/b978-0-08-102671-7.10608-6

Dhingra, C., Kodukula, S. (2010) "Public Bicycle Schemes: Applying the Concept in Developing Cities – Examples from India", (pdf) Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklunk (BMZ), Bonn, Germany, Sustainable Urban Transport Technical Document # 3. Available at: https://bicycleinfrastructuremanuals.com/manuals4/India-Public-Bicycle-Schemes.pdf (Accessed: 20 October 2024)

Efthymiou, D., Chaniotakis, E., Antoniou, C. (2020) "Chapter 10 - Factors affecting the adoption of vehicle sharing systems", In: Demand for Emerging Transportation Systems, Elsevier, pp. 189–209, ISBN 978-0-12-815018-4
https://doi.org/10.1016/b978-0-12-815018-4.00010-3

Esri (online) "World Imagery" [map] Available at: https://www.arcgis.com/ [Accessed: 01 November 2025]

Fishman, E., Washington, S., Haworth, N. (2013) "Bike Share: A Synthesis of the Literature", Transport Reviews, 33(2), pp. 148–165.
https://doi.org/10.1080/01441647.2013.775612

Garmin (online) "Garmin", Available at: https://www.garmin.com/en-US/ [Accessed: 01 November 2025]

Here (online) "Here" [map] Available at: https://www.here.com/ [Accessed: 01 November 2025]

Kou, Z., Wang, X., Chiu, S. F., Cai, H. (2020) "Quantifying greenhouse gas emissions reduction from bike share systems: a model considering real-world trips and transportation mode choice patterns", Resources Conservation and Recycling, 153, 104534.
https://doi.org/10.1016/j.resconrec.2019.104534

Machavarapu, P. K., Ram, S. (2022) "Review on public bike share schemes in large developing cities: A case study of Delhi, India", Case Studies on Transport Policy, 10(4), pp. 2075–2091.
https://doi.org/10.1016/j.cstp.2022.09.009

Machavarapu, P. K., Ram, S., Kant, P. (2023) "Factors influencing bike share intentions of users in Indian cities: a structural equation modelling approach", Urban Planning and Transport Research, 11(1), 2276405.
https://doi.org/10.1080/21650020.2023.2276405

Machavarapu, P. K., Ram, S., Kant, P. (2024) "Exploring the factors affecting bike sharing usage in developing countries: a case study on Chandigarh, India", Urban Planning and Transport Research, 12(1), 2310544.
https://doi.org/10.1080/21650020.2024.2310544

Ma, X., Ji, Y., Jin, Y., Wang, J., He, M. (2018) "Modeling the Factors Influencing the Activity Spaces of Bikeshare around Metro Stations: A Spatial Regression Model", Sustainability, 10(11), 3949.
https://doi.org/10.3390/su10113949

Narayanan, S., Makarov, N., Magkos, E., Grau, J. M. S., Aifadopoulou, G., Antoniou, C. (2023) "Can Bike-Sharing Reduce Car Use in Alexandroupolis? An Exploration through the Comparison of Discrete Choice and Machine Learning Models", Smart Cities, 6(3), pp. 1239–1253.
https://doi.org/10.3390/smartcities6030060

OpenStreetMap contributors (online) "OpenStreetMap" [map] Available at: https://www.openstreetmap.org/ [Accessed: 01 November 2025]

Patel, S. J., Patel, C. R. (2020) "A stakeholders perspective on improving barriers in implementation of public bicycle sharing system (PBSS)", Transportation Research Part A: Policy and Practice, 138, pp. 353–366.
https://doi.org/10.1016/j.tra.2020.06.007

Patel, S. J., Patel, C. R., Joshi, G. J. (2020) "Planning of Public Bicycle (Bike) Sharing System (PBSS): A case study of Surat City", Transportation Research Procedia, 48, pp. 2251–2261.
https://doi.org/10.1016/j.trpro.2020.08.283

Schnieder, M. (2023) "Ebike Sharing vs. Bike Sharing: Demand Prediction Using Deep Neural Networks and Random Forests", Sustainability, 15(18), 13898.
https://doi.org/10.3390/su151813898

Shaheen, S. A., Guzman, S., Zhang, H. (2010) "Bikesharing in Europe, the Americas, and Asia: Past, Present, and Future", Transportation Research Record: Journal of the Transportation Research Board, 2143(1), pp. 159–167.
https://doi.org/10.3141/2143-20

Sharmeen, F., Ghosh, B., Mateo-Babiano, I. (2020) "Policy, users and discourses: Examples from bikeshare programs in (Kolkata) India and (Manila) Philippines", Journal of Transport Geography, 90, 102898.
https://doi.org/10.1016/j.jtrangeo.2020.102898