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A comprehensive examination of public transport user satisfaction in Indian megacities

RUPAS KUMAR MEESALA[a*,b], M V RAJU[b]

a. Department of Civil Engineering, Rajiv Gandhi University of Knowledge Technologies, Ongole Campus, Andhra Pradesh, India.
b. Department of Civil Engineering, Vignan's Foundation for Science, Technology, and Research (Deemed to be University), Vadlamudi, Guntur, Andhra Pradesh, India.

ABSTRACT: In recent times, traffic congestion has emerged as a persistent problem, critically affecting travel time, fuel consumption, and commuter stress, while also contributing to poor air quality and a reduced quality of life. This global problem is especially acute in Indian megacities, which have dense populations, massive vehicular fleet, and limited road space. Although public transport is considered a promising solution to traffic congestion and related emissions, the effectiveness and adoption of road public transport depend on the characteristics of the service. This study examines commuter satisfaction with public transport services in three Indian megacities (Bengaluru, Chennai, and Hyderabad), highlighting key factors influencing user perceptions. An online survey with 2,274 respondents, divided by location, gender and age group, was conducted from January to April 2023, assessing 12 service attributes. The present study shows varied perception levels of service attributes in the three selected cities. Principal component analysis (PCA) was performed to reduce the dimensionality of the large dataset and confirm the robustness of the data, with high internal consistency across demographic variables using XLSTAT. Key factors identified in the study include ease of maintenance, accessibility, and affordability, with each city having its own strengths and weaknesses. The insights and findings of the current study provide valuable guidance for targeted improvements in public transportation systems to enhance commuter satisfaction and address the widespread problem of vehicular pollution and traffic congestion in Indian megacities.

KEYWORDS: Public transport; user satisfaction; factor analysis; serviceability; public perception levels

1. INTRODUCTION

Traffic congestion is a critical and pervasive issue contributing to significant travel time delays, increased fuel consumption, rise in air pollution levels, and increased accidents. Recent studies have reported that traffic congestion has a direct impact on the psychological condition of commuters inducing stress, nervousness and aggravation (Alalool et al., 2016; Bitkina et al., 2019). To address this aggravating problem, many research attempts have been made across the globe, recommending the policy measures such as improvement of public transport, development and expansion of road infrastructure, implementation of congestion pricing, and promotion of car-pooling programmes. Nevertheless, it continues to remain a challenge to majority of the urban centres across the world, particularly to Indian megacities. The urbanisation is witnessed at a rapid rate in India due to various factors which stimulate the rise in population levels and vehicular fleet. The current contemporary studies reported that Indian megacities such as Bengaluru, Chennai and Hyderabad have experienced a massive increase in population density, compact settlements with limited road space complimented with massive vehicular growth rate. For instance, Bengaluru witnessed a high vehicle ownership with over 10.4 million registered vehicles, further straining the existing road infrastructure and contributing to traffic congestion (KSTD, 2022). In light of these circumstances, the expansion of existing roads and development of infrastructure supporting non-motorized transport modes could be infeasible in practice. In addition to traffic congestion, massive vehicular fleet in urban centres is observed to be a significant contributor in worsening the air quality (Gertler, 2005). Vehicular movement is found to enhance human exposure to respirable particulate matter by about 50% due to continuous emitting of tiny particulate matter due to tire wear, brake wear and road surface wear (Bereitschaft, 2015). Particulate matter refers to the mix of tiny solid and liquid particles in the air, denoted by $PM_{2.5}$ & PM_{10} indicating the particles of size below 2.5 m and 10 m respectively (Timmers & Achten, 2016).

The mass concentration and exposure to airborne particulates is largely dependent on various characteristics of the traffic environment such as traffic volume, type of the vehicle, age and behaviour of the driver (Onat & Stakeeva, 2013). In recent times, many research attempts were made to quantify the particulate exposure levels by commuting through different transport modes. While few studies demonstrated a higher particulate exposure level while commuting through buses compared to cars (Maji et al., 2020; Knibbs & de Dear, 2010; McNabola et al., 2008; Adams et al., 2002), other affirmed higher exposure levels by commuting through cars when compared with buses (Raj & Karthikeyan, 2020; Kingham et al., 2013; De Nazelle et al., 2013). Few experimental studies showcased only minor differences in $PM_{2.5}$ concentrations while commuting between cars and diesel buses (Kaur et al., 2005; Boogard et al., 2009; Zuurbier et al., 2010). The inconsistency of these previous studies attempted on particulate matter exposure under different commuting modes necessitates the need for more comprehensive comparative analyses and standardized research methodologies.

2. LITERATURE REVIEW AND SCOPE OF THE ARTICLE

As rail-based mass rapid transit systems have become widely recognized as a solution to many traffic and environmental pollution issues, metro rail construction projects are being

* Corresponding author: mrk@rguktong.ac.in

extensively carried out in Indian megacities such as Bengaluru, Chennai, and Hyderabad (Sharma et al., 2013). Nevertheless, public transport bus services remain preferred choice due to factors like broader coverage, lower costs, greater operational flexibility and adaptability. Public transportation facilitates mass transit of public by reducing the number of private vehicles on the road, making it a viable solution for alleviating traffic congestion and improving air quality in urban centres. In addition, it supports the people of all income groups stimulating the reliability and accessibility of the road network. Public transportation also plays an important role in connecting the people, and provides affordable travel options. Further, it creates accessibility to public utilities, maintains social equity, safety and reduced urban sprawl. Access to public transportation hubs often encourages walking and cycling, promoting physical activity and healthier lifestyles. Furthermore, public transportation typically produces fewer exhaust and non-exhaust emissions per passenger mile compared to private vehicles, contributing to cleaner air and a reduction in the environmental impact of transportation. However, it is observed that public transportation systems in Indian megacities are either inadequate or inefficient, leading more people to rely on personal vehicles. Public transportation in India faces several challenges, including overcrowding, lack of frequency, inadequate infrastructure, lack of maintenance, comfort and safety concerns (Badami, 2005; INAE, 2019; Shah et al., 2023). Despite these challenges, the governments and the responsible authorities adopted various measures to improve public transportation such as are investing in modernizing their bus fleets, heightening the number of buses, introducing intelligent transportation systems, and expanding road networks. In addition, Initiatives such as clean air programme and smart cities mission were launched to improve the air quality levels in Indian urban centres. Further, governments have continued to maintain the travel fares affordable for the general public and have offered concessions to various groups such as students, senior citizens, and women. Nevertheless, the existing public transport services are not widely used due to inadequacies in the service quality. Despite the critical importance of service attributes in the usage and adoption of public transportation, limited efforts have been made to assess user satisfaction based on data directly collected from the public in Indian megacities (Sinha et al., 2019; Chaudhary, 2020; Rajathi & Kumar, 2021; Jaiswal et al., 2023). Moreover, these studies often relied on small sample sizes and did not encompass all age groups and categories of the public. Additionally, none of these studies covered Indian megacities such as Hyderabad, Bengaluru, and Chennai, which face significant challenges such as large vehicular fleets, high population density, traffic congestion, and vehicular emissions. The present study aims to comprehensively assess public perception by gathering extensive data from different categories of public in the southern Indian megacities of Hyderabad, Chennai, and Bengaluru.

3. METHODOLOGY

Commuters Satisfaction on public transportation services is dependent on the numerous factors such as gender, age, economic, social and cultural characteristics of the people. With an objective to evaluate the public perception levels, an online survey has been conducted on the urban dwellers and regular commuters belonging to different classes in the cities of Bengaluru, Chennai and Hyderabad from 1st January 2023 to 30th April 2023. As shown in Table 1, the survey sample of daily commuters includes 2274 respondents, with almost equal proportion of male (51.19%) and female (48.81%) commuters. The percentage of the sample size from Chennai, Hyderabad and Bengaluru in the current study was observed to be 28.28%, 44.37% and 27.35% respectively. The majority of respondents (72%) are between the ages of 20 and 45, while those under 20 years old constitute 19.44% and those over 45 years old make up 18.56%. It was observed that the number of commuters over the age of 45 is lower compared to younger age groups, specifically those aged 20-45 and under age 20. In addition, a significant number of these commuters over the age of 45 are uneducated women, many of whom expressed their reluctance to participate in the study. Nevertheless, the study recorded responses from all age groups that exceeded the adequate sample size. The study concentrates on the evaluation of user satisfaction levels using twelve (12) service attributes viz. (1) Parking facilities for 2-wheelers and Bicycles in the near Public Bus Stop, (2) Frequency of public transport services, (3) Maintenance of time schedule, (4) Cleanliness in Public transport Buses, (5) Coverage of the city area, (6) Safety, (7) Noise pollution, (8) Inconvenience due to overcrowding, (9) Travelling time as per the schedule, (10) Comfort, and (11) Behaviour of the Staff (12) Cost of travel. Users of the public transport were asked to indicate their level of satisfaction on the attributes of public transportation services in Bengaluru, Chennai and Hyderabad. To interpret and analyse the data, a five point Likert scale was used (1-Very dissatisfied to 5-Satisfied) to rate the degree to which the public agree or disagree with the given statements (Sullivan & Artino Jr, 2013). Table 2 presents public satisfaction scores for various service attributes of public transport in Bengaluru, Chennai, and Hyderabad. Each attribute is evaluated by mean satisfaction scores (μ) and their standard deviations (σ). It is evident that the mean scores of Bengaluru, Chennai and Hyderabad ranged from 2.69 to 4.14 indicating that respondents had a varied perception levels that are notable on all the dimensions of the service attributes.

Demographic Variable	Category	Sample Size	Percentage
Gender	Male	1164	51.19
	Female	1110	48.81
City	Bengaluru	622	27.35
	Chennai	643	28.28
	Hyderabad	1009	44.37
Age of respondent	Below 20	442	19.44
	20-30	719	31.62
	30-45	691	30.38
	Above 45	422	18.56

Table 1. Demographic Characteristics of the participants

The analysis of public transport satisfaction in Bengaluru, Chennai, and Hyderabad clearly reveals distinct strengths and weaknesses. The data presented in the study revealed that Hyderabad excels in frequency (3.84), cleanliness (3.78), and managing overcrowding (3.73), making it efficient for commuters. Bengaluru leads in safety (4.07), network connection (3.82), and staff behaviour (3.68), highlighting its secure and well-connected services. Chennai scores highest in affordability (4.14), travelling time (3.51) and maintenance of time schedule (3.42), offering cost-effective and timely options. Despite these strengths, the data collected reveal that each city has specific areas for improvement. Chennai lags in comfort (2.96), staff behaviour (2.95), parking facilities (2.95), cleanliness (2.92), noise pollution (2.81), and managing overcrowding (2.69), Bengaluru in comfort (2.92), travelling time (2.81), and maintaining time schedules (2.81) and Hyderabad in Network connection (2.86) and maintaining time schedules (2.84). The correlation analysis of the questionnaire categories across Bengaluru, Chennai, and Hyderabad reveals several significant relationships. A strong

positive correlation exists between noise pollution and frequency (0.990), indicating that higher service frequency is often associated with increased noise levels. Similarly, cleanliness is positively correlated with frequency (0.875), suggesting that cleaner services are perceived in areas with more frequent transit. On the other hand, affordability shows strong negative correlations with both cleanliness (-0.986) and overcrowding (-1.000), implying that as services become more affordable, they may experience declines in cleanliness and increases in overcrowding. Additionally, there is a positive correlation between safety and staff behavior (0.959), indicating that better staff behavior is associated with higher safety perceptions.

The Study also focused to examine the satisfaction levels of the public from different age groups and gender as presented in Table 3. While majority of the respondents below 20 age group considered in the current study are students, few less proportion in this category are workers and job holders who expressed highest satisfaction levels Safety & Overcrowding, and highest dissatisfaction levels on Parking availability near transit stops & travelling time. While the public within the age group 20-30 are dissatisfied with parking availability near transit stops, travelling time and noise pollution, the age group 30-45 are dissatisfied with cleanliness of the vehicles in addition to the above service attributes. The category of respondents above 45 is satisfied with only maintenance of time schedule, travelling time, and cost of travel. While the male commuters expressed their dissatisfaction on time schedule, travelling time and parking availability, female commuters exhibited their dissatisfaction on noise pollution, and parking availability near transit stops. The correlation analysis of the questionnaire categories across different age groups and genders reveals several significant relationships. Younger age groups, particularly those "Below 20" and "20-30," exhibit a strong positive correlation (0.928), indicating that their perceptions of transit services are closely aligned. Similarly, the "20-30" and "30-45" age groups have a strong positive correlation (0.895), suggesting consistency in their responses. In contrast, there is a moderate negative correlation (-0.514) between the "Above 45" age group and male respondents, indicating differing perceptions between these groups. The correlation between male and female respondents is slightly negative (-0.094), pointing to a weak inverse relationship in their views on transit services. These findings suggest that while younger individuals share similar views, older age groups and gender differences play a role in how transit services are perceived.

4. RESULTS & DISCUSSION

The extensive datasets collected, characterized by numerous dimensions and features per observation, accentuates the necessity for dimensionality reduction. Principal Component Analysis (PCA) is a "multivariate statistical technique that converts a set of correlated variables into uncorrelated variables, known as principal components, based on the correlation patterns of the original variables" (Ghosh & Chatto-

S.No	Questionnaire/Category	Bengaluru		Chennai		Hyderabad	
		μ	σ	μ	σ	μ	σ
1	Frequency	3.25	0.84	3.09	0.91	3.84	0.79
2	Maintenance of time schedule	2.81	0.81	3.42	0.93	2.84	0.88
3	Cleanliness	3.49	0.86	2.92	0.90	3.78	0.90
4	Network connection	3.82	0.69	3.27	0.71	2.86	0.85
5	Safety	4.07	0.89	3.06	0.76	3.80	0.84
6	Noise pollution	3.06	0.87	2.81	0.85	3.54	0.90
7	Overcrowding	3.22	0.74	2.69	0.78	3.73	0.83
8	Travelling time	2.80	0.85	3.51	0.85	3.28	0.88
9	Comfort	2.92	0.69	2.96	0.86	3.52	0.94
10	Behaviour of the Staff	3.68	0.71	2.95	0.75	3.30	0.73
11	Affordability	3.76	0.84	4.14	0.84	3.40	0.98
12	Parking availability near transit stops	3.46	0.90	2.95	0.84	3.43	0.98

Table 2. Public perception levels in various Indian megacities

S.No	Questionnaire/Category	Below 20	20-30	30-45	Above 45	Male	Female
1	Frequency	3.25	3.41	3.26	2.88	3.10	3.23
2	Maintenance of time schedule	3.29	3.33	3.21	3.13	2.99	3.02
3	Cleanliness	3.15	3.06	2.94	2.83	3.16	3.28
4	Network connection	3.24	3.35	3.15	2.95	3.38	3.30
5	Safety	3.48	3.51	3.26	2.93	3.84	3.22
6	Noise pollution	3.02	2.95	2.81	2.79	3.42	2.95
7	Overcrowding	3.46	3.58	3.54	2.85	3.28	3.02
8	Travelling time	2.94	2.93	2.99	3.35	2.83	3.37
9	Comfort	3.07	3.08	3.11	2.74	3.60	3.28
10	Behaviour of the Staff	3.39	3.36	3.49	2.84	3.54	3.01
11	Cost of travel	3.30	3.10	3.14	3.03	3.65	3.01
12	Parking availability near transit stops	2.81	2.75	2.73	2.93	2.98	2.96

Table 3. Mean public satisfaction scores of service attributes based on gender & age

padhyay, 2012). This technique is widely used in data analysis and machine learning for purposes such as dimensionality reduction, feature extraction, and data visualization. Essentially, PCA reduces the dimensionality of a dataset by transforming it into principal components, which are new variables created as linear combinations or mixtures of the initial variables. To determine the appropriateness of applying PCA, the Kaiser-Meyer-Olkin (KMO) test is commonly used to assess the reliability of the data.

To accurately represent public perception levels in Hyderabad, Chennai, and Bengaluru, the sample size was determined using the Krejcie and Morgan table (KMT), a well-known measure among behavioral and social science researchers. According to this table, a sample size of 384 is adequate for a population of 1,000,000 or more at a 95% confidence interval (Memon et al., 2020; Wright, 2009). The collected data is categorized by gender, city, and age groups, as shown in Table 4. High Kaiser-Meyer-Olkin (KMO) values indicate the suitability of Principal Component Analysis (PCA), which is considered appropriate if the KMO value is above 0.5 (Shrestha & Kazama, 2007). In this study, all data sets recorded KMO values above 0.687, validating the use of PCA for data extraction. The analysis of demographic variables using the KMO measure reveals varying degrees of common variance. Gender-wise, both males (KMO = 0.828) and females (KMO = 0.816) show a Meritorious level of common variance. City-wise, Bengaluru (KMO = 0.850) and Hyderabad (KMO = 0.865) also exhibit Meritorious levels, while Chennai (KMO = 0.780) is classified as Middling. Age-wise, groups under 20 (KMO = 0.901) and 20-30 (KMO = 0.910) are rated Marvelous, the 30-45 group (KMO = 0.807) is Meritorious, and those over 45 (KMO = 0.687) are Mediocre. This indicates high common variance in younger age groups and specific cities, underscoring the robustness of the collected data for evaluating public perception. In order to assess the underlying factor structure of the data, the factor analysis is carried out using principal component analysis and varimax rotation. Items that had a factor loading of less than 0.50 were eliminated, and items that cross-loaded were also left out.

Demographic Variable	Category	KMO Value	Degree of common variance
Gender	Male	0.828	Meritorious
	Female	0.816	Meritorious
City	Bengaluru	0.850	Meritorious
	Chennai	0.780	Middling
	Hyderabad	0.865	Meritorious
Age Groups	Below 20	0.901	Marvelous
	20-30	0.910	Marvelous
	30-45	0.807	Meritorious
	Above 45	0.687	Mediocre

Table 4. Adequacy of data sets for factor analysis

The present study employs powerful and intuitive statistical tool, 'XLSTAT' for multivariate analysis, as it is observed to be user-friendly, quick, cost effective, and flexible besides providing an extensive documentation and support by seamlessly integrating with Microsoft Excel. XLSTAT is statistical software that can be employed to perform multivariate analysis of complex datasets (Vidal et al., 2000). Cronbach's alpha test is conducted to measure the internal consistency reliability of the constructs for factor analysis. Its value ranges from 0 to 1, with value closer to 1 indicating greater stability and consistency. The values of Cronbach's alpha extracted from the data collected are presented in Table 5. The reliability of survey responses across various demographic categories, assessed using Cronbach's Alpha scores, indicates high internal consistency overall. The analysis showcased that both male (0.881) and female (0.863) respondents exhibit very reliable responses. Among cities, Chennai (0.832) and Hyderabad (0.830) are rated as very reliable, while Bengaluru (0.737) is reliable. Age-wise, respondents below 20 (0.916) and those aged 20-30 (0.865) show very reliable responses, followed by the 30-45 group (0.817). The above 45 age group, though reliable, has the lowest score (0.742). The data showcased highlights particularly high reliability among younger respondents and in specific cities.

As presented in Table 6, the factor analysis of public transport attributes for Bengaluru City recognizes three key factors. Serviceability (F1) is the most significant factor, explaining 42.37% of the variance, encompasses cleanliness, comfort, safety, maintenance, travel time, noise pollution, and staff behaviour, indicating that the importance of overall service quality and maintenance of transport service are paramount to users. Accessibility (F2), explaining 18.87% of the variance, emphasizes the importance of cost, frequency, and network connectivity in making the service accessible and affordable. Overcrowding (F3), though explaining a smaller variance (8.64%), remains a distinct and notable concern for users, highlighting the issue of passenger volume and space availability. These insights suggest that improving service quality and accessibility should be prioritized, while also addressing overcrowding to enhance overall public satisfaction with transport services.

Demographic Variable	Category	Cronbach's Alpha Score	Level of Reliability
Gender	Male	0.881	Very Reliable
	Female	0.863	Very Reliable
City	Bengaluru	0.737	Reliable
	Chennai	0.832	Very Reliable
	Hyderabad	0.830	Very Reliable
Age Groups	Below 20	0.916	Very Reliable
	20-30	0.865	Very Reliable
	30-45	0.817	Very Reliable
	Above 45	0.742	Reliable

Table 5. Reliability analysis of the data

Variables	Factor loadings		
	F1	F2	F3
Serviceability			
Cleanliness	0.743		
Comfort	0.725		
Safety	0.705		
Maintenance of time schedule	0.631		
Travelling time	0.616		
Noise pollution	0.612		
Behaviour of the Staff	0.592		
Accessibility			
Cost of travel		0.760	
Frequency		0.729	
Network connection		0.677	
Overcrowding			
Overcrowding			0.587
Variance	42.37	18.87	8.64

Table 6. Factor loadings of variables for Bengaluru City

The factor analysis of Chennai's public transport service attributes identifies three key factors as shown in Table 7. Serviceability (44.5% variance) encompasses cost, safety, maintenance, frequency, staff behaviour, cleanliness, travel time, and network connection, emphasizing the importance of overall service quality. Comfort (26.66% variance) includes comfort, overcrowding, and noise pollution, highlighting the need for a comfortable and less crowded travel environment. Facilities at bus stop, explaining a smaller variance (9.07%), concentrates on the amenities and comfort at bus stops. These insights suggest that enhancing service quality, ensuring passenger comfort, and improving bus stop facilities are crucial for increasing public satisfaction. The factor analysis of public transport attributes at Hyderabad identifies four main factors, each contributing uniquely to public satisfaction as indicated in Table 8. The first factor, Serviceability explains 34.00% of the variance, encompassing crucial elements such as the maintenance of time schedules, frequency, cleanliness of vehicles, safety, and network connection. These aspects highlight the critical need for reliable, clean, well connected, and safe transport services, reflecting the foundational qualities that passengers prioritize. The second factor, comfort accounts for 26.97% of the variance and includes variables like staff behaviour, cost of travel, comfort, noise pollution, and travelling time. This factor emphasizes the importance of a pleasant and affordable travel experience, where comfortable commuting and courteous staff play significant roles. Overcrowding, explaining 9.32% of the variance, stands out as another distinct factor, focusing solely on the issue of passenger volume and the need to manage crowded conditions effectively. This highlights a significant area of concern for passengers who value space and comfort during their commute. Lastly, facilities at bus stop contribute 7.77% to the variance, underscoring the importance of amenities and comfort at transit stops. Adequate facilities at bus stops enhance the overall travel experience, making waiting times more comfortable and convenient. These insights suggest that to enhance public satisfaction, transport authorities should prioritize improving overall service quality, ensuring a comfortable and affordable travel experience, managing overcrowding effectively, and upgrading bus stop facilities. Addressing these areas comprehensively can lead to a more efficient, pleasant, and user-friendly public transport system.

Variables	Factor loadings		
	F1	F2	F3
Serviceability			
Cost of travel	0.704		
Safety	0.690		
Maintenance of time schedule	0.668		
Frequency	0.616		
Behaviour of the Staff	0.597		
Cleanliness	0.596		
Travelling time	0.556		
Network connection	0.524		
Comfort			
Comfort		0.695	
Overcrowding		0.559	
Noise pollution		0.507	
Facilities at Bus stop			
Facilities and comfort at Bus stop			0.667
Variability	44.50	26.66	9.07

Table 7. Factor loadings of variables for Chennai City

Variables	Factor loadings			
	F1	F2	F3	F4
Serviceability				
Maintenance of time schedule	0.741			
Frequency	0.725			
Cleanliness	0.701			
Safety	0.697			
Network connection	0.591			
Comfort				
Behaviour of the Staff		0.679		
Cost of travel		0.624		
Comfort		0.653		
Noise pollution		0.581		
Travelling time		0.570		
Overcrowding				
Overcrowding			0.730	
Facilities at Bus stop				
Facilities and comfort at Bus stop				0.592
Variability	34.00	26.97	9.32	7.77

Table 8. Factor loadings of variables for Hyderabad City

5. SUMMARY AND CONCLUSIONS

Traffic congestion is a major issue worldwide, leading to delays, increased fuel consumption, pollution, and accidents. It also affects the physical and mental health of the commuters causing hypertension, increased stress levels and frustration. Rapid urbanization in India has led to high population density and vehicle growth, straining road infrastructure beyond the capacity. The massive vehicular fleet also contributes significantly to air pollution, increasing exposure to harmful particulate matter. Despite numerous studies suggesting improvements in public transport, road infrastructure, congestion pricing, and car-pooling, the problem persists, especially in Indian megacities. Public transport, despite being a solution for congestion and air pollution, faces challenges in India due to deficiencies in service attributes such as overcrowding, infrequent services, and poor infrastructure. However, limited research attempts have been made to assess user satisfaction on public transportation based on data directly collected from the public in Indian megacities.

The study concentrates on the comprehensive evaluation of user satisfaction levels in the southern Indian megacities of Hyderabad, Chennai, and Bengaluru using twelve (12) service attributes. Principal component analysis (PCA) was performed to reduce the dimensionality of the large dataset and confirm the robustness of the data, with high internal consistency across demographic variables. 'XLSTAT', a powerful and intuitive statistical tool, was employed to perform multivariate analysis of complex datasets collected. The analysis of public satisfaction with public transport services in these megacities reveals notable differences across various attributes. The study evaluating user satisfaction exhibited varied perceptions across service attributes such as safety, comfort, and cleanliness in the selected megacities. Analysis by gender and age revealed higher satisfaction among the 20-30 age group, with males feeling safer than females. Hyderabad scores highest in frequency, cleanliness, and comfort, indicating a well-received public transport system. Bengaluru leads in safety, network connection, and staff behaviour, suggesting a secure and efficient service. Chennai excels in affordability and travelling time, making it a cost-effective and timely option. However, public dissatisfaction remains due to service inadequacies. In Bengaluru, the low-

est score of 2.80 for travelling time indicates that users are dissatisfied with the duration of their commutes, suggesting a need to optimize routes, increase vehicle frequency, or implement dedicated transit lanes. Chennai's most significant issue, with a score of 2.69, is overcrowding, highlighting the need to manage passenger loads better, possibly by increasing the number of vehicles during peak hours or enhancing the capacity of existing services. In Hyderabad, the category with the lowest satisfaction, scoring 2.86, is network connection, indicating that connectivity is the primary inadequacy in public transportation.

The study recommends for the measures to improve the efficiency and speed of travel at Bengaluru, possibly by optimizing routes, increasing the frequency of vehicles, or implementing dedicated transit lanes to reduce travel times. In addition, the study necessitates enhancement of existing vehicles capacity and improving the frequency of service to meet the passenger load at Chennai. Further, the study accentuates improvements in network connections and upgrading the existing infrastructure to support better connectivity at Hyderabad. By focusing on these key issues, improving travel times in Bengaluru, alleviating overcrowding in Chennai, and enhancing network connectivity in Hyderabad, transit authorities can significantly enhance user satisfaction. The targeted approach made in the study will improve the quality of public transportation and heighten the ridership. These insights exhibited in the study highlight specific strengths and areas for improvement, providing guidance for the decision makers in enhancing public transport services.

REFERENCES

Adams, H. S., Nieuwenhuijsen, M. J., Colvile, R. N., Older, M. J., & Kendall, M. (2002). Assessment of road users' elemental carbon personal exposure levels, London, UK. *Atmospheric Environment*, *36*, 5335-5342.

Alalool, A., Alhashaikeh, B., Ibrahim, H., Majdalawi, R., & Ainawi, R. (2016). Traffic congestion and long driving hours: Impact on stress, emotional and physical health among drivers in Sharjah. *Health Care: Current Reviews*, *4*.

Badami, M. (2005). The urban transport challenge in India: Considerations, implications and strategies. *International Development Planning Review*, *27*(2), 169-194.

Bereitschaft, A. (2015). Pedestrian exposure to near-roadway $PM_{2.5}$ in mixed-use urban corridors: A case study of Omaha, Nebraska. *Sustainable Cities and Society*, *15*, 64-74.

Bitkina, O. V., Kim, J., Park, J., Park, J., & Kim, H. K. (2019). Identifying traffic context using driving stress: A longitudinal preliminary case study. *Sensors*, *19*(9), 2152.

Boogaard, H., Borgman, F., Kamminga, J., & Hoek, G. (2009). Exposure to ultrafine and fine particles and noise during cycling and driving in 11 Dutch cities. *Atmospheric Environment*, *43*(27), 4234-4242.

Chaudhary, M. L. (2020). Commuters' Perceptions on Service Quality of Bus Rapid Transit Systems: Evidence from the Cities of Ahmedabad, Surat and Rajkot in India. *European Transport*, *79*.

De Nazelle, A., Seto, E., Donaire-Gonzalez, D., Mendez, M., Matamala, J., Nieuwenhuijsen, M. J., & Jerrett, M. (2013). Improving estimates of air pollution exposure through ubiquitous sensing technologies. *Environmental pollution*, *176*, 92-99.

Gertler, A. W. (2005). Diesel vs. gasoline emissions: Does PM from diesel or gasoline vehicles dominate in the US?. *Atmospheric Environment*, *39*(13), 2349-2355.

Ghosh, D., & Chattopadhyay, P. (2012). Application of principal component analysis (PCA) as a sensory assessment tool for fermented food products. *Journal of food science and technology*, *49*, 328-334.

INAE, (2019). Urban transportation-challenges & way forward. *INAE forum on Civil Infrastructure-Traffic & Transportation*. Retrieved from https://www.inae.in/storage/2020/01/Urban-Transportation.pdf

Jaiswal, A., Jain, G., & Goswami, S. (2023). Assessment of Satisfaction Level for Existing Public Transport Systems using Machine Learning: A Case of Bhopal (India). *European Transport*, *93*.

Kaur, S., Nieuwenhuijsen, M., & Colvile, R. (2005). Personal exposure of street canyon intersection users to PM2. 5, ultrafine particle counts and carbon monoxide in Central London, UK. *Atmospheric Environment*, *39*(20), 3629-3641.

Kingham, S., Longley, I., Salmond, J., Pattinson, W., & Shrestha, K. (2013). Variations in exposure to traffic pollution while travelling by different modes in a low density, less congested city. *Environmental Pollution*, *181*, 211-218.

Knibbs, L. D., & de Dear, R. J. (2010). Exposure to ultrafine particles and PM2. 5 in four Sydney transport modes. *Atmospheric Environment*, *44*(26), 3224-3227.

KSTD, (2022). Karnataka State Transport Department Annual Report 2011-12. *Commissioner for Transport and Road Safety, Bengaluru*, pp. 34. Retrieved from https://transport.karnataka.gov.in/storage/pdf-files/annual%20report%202022-202-397.pdf

Maji, K. J., Namdeo, A., Hoban, D., Bell, M., Goodman, P., Nagendra, S. M. S., Barnes, J., Vito, L. D., Hayes, E., Longhurst, J., Kumar, R., Sharma, N., Kuppili, S. K., & Alshetty, D. (2021). Analysis of various transport modes to evaluate personal exposure to $PM_{2.5}$ pollution in Delhi. *Atmospheric Pollution Research*, *12*(2), 417-431.

McNabola, A., Broderick, B. M., & Gill, L. W. (2008). Relative exposure to fine particulate matter and VOCs between transport microenvironments in Dublin: Personal exposure and uptake. *Atmospheric Environment*, *42*(26), 6496-6512.

Memon, M. A., Ting, H., Cheah, J. H., Thurasamy, R., Chuah, F., & Cham, T. H. (2020). Sample size for survey research: Review and recommendations. *Journal of Applied Structural Equation Modeling*, *4*(2), 1-20.

Onat, B., & Stakeeva, B. (2013). Personal exposure of commuters in public transport to $PM_{2.5}$ and fine particle counts. *Atmospheric Pollution Research*, *4*, 329-335.

Raj, M. G., & Karthikeyan, S. (2020). Effect of modes of transportation on commuters' exposure to fine particulate matter (PM2.5) and nitrogen dioxide (NO2) in Chennai, India. *Environmental Engineering Research*, *25*(6), 898-907.

Rajathi, A., Kumar, R.V. (2021). A Study on Customer Satisfaction on Government Buses with Special Reference From Trichy To Chennai. *International Journal of Research in Engineering and Science*, *9*(12), 74-79.

Shah, S., Rajiv, R. M., & Lokre, A. (2023). Moving toward gender-equitable transportation in post-COVID-19 urban South Asia. *Transportation research record*, *2677*(4), 865-879.

Sharma, N., Dhyani, R., & Gangopadhyay, S. (2013). Critical issues related to metro rail projects in India. *Journal of Infrastructure Development*, *5*(1), 67-86.

Shrestha, S., & Kazama, F. (2007). Assessment of surface water quality using multivariate statistical techniques: A case study of the Fuji river basin, Japan. *Environmental Modelling & Software*, *22*(4), 464-475.

Sinha, S., Swamy, H. S., & Modi, K. (2020). User perceptions of public transport service quality. *Transportation Research Procedia*, *48*, 3310-3323.

Sullivan, G. M., & Artino, A.R. Jr. (2013). Analyzing and interpreting data from likert-type scales. *Journal of Graduate Medical Education*, *5*(4), 541-2.

Timmers, V. R. J. H., & Achten, P. A. J. (2016). Non-exhaust PM emissions from electric vehicles. *Atmospheric environment*, *134*, 10-17.

Vidal, N. P., Manful, C. F., Pham, T. H., Stewart, P., Keough, D., & Thomas, R. (2020). The use of XLSTAT in conducting principal component analysis (PCA) when evaluating the relationships between sensory and quality attributes in grilled foods. *MethodsX*, *7*, 100835.

Wright, C. (2009). A guide to Sampling and statistical reliability. *Research Sandwell*. Retrieved from https://www.sandwelltrends.info/wp-content/uploads/sites/5/2018/07/A-guide-to-sampling-and-statistical-reliability.pdf

Zuurbier, M., Hoek, G., Oldenwening, M., Lenters, V., Meliefste, K., Van Den Hazel, P., & Brunekreef, B. (2010). Commuters' exposure to particulate matter air pollution is affected by mode of transport, fuel type, and route. *Environmental health perspectives*, *118*(6), 783-789.