EFFECT OF METRO IMPLEMENTATION ON URBAN PLACE FROM PCMC TO PHUGEWADI, PUNE

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Abstract

The rapid expansion of industries and extensive commercial developments in Pune have resulted in a surge in travel demand, putting considerable pressure on the city's transportation infrastructure. Consequently, establishing a highly efficient and effective metro rail network has become a critical necessity for the future. The metro rail system plays a pivotal role in Pune's overall transportation system, presenting a sustainable solution that optimizes space utilization and reduces pollution levels, encompassing noise and air pollution.

This research aims to evaluate the proposed modern transportation framework of the metro rail facility in Pune, with a primary focus on assessing the operational stretch from PCMC to Phugewadi and its impact on vehicular traffic. Moreover, the study aims to analyze the environmental implications associated with commuters' use of the metro system.

By conducting a comprehensive analysis of the PCMC to Phugewadi stretch and its effects on traffic patterns, this study seeks to offer valuable insights into the efficiency and effectiveness of the metro rail network in Pune.

Keywords: ***Metro Rail, mode switch, cost analysis, commuters data.***

1 INTRODUCTION

Pune has experienced significant industrial growth since the 1990s, but rapid urbanization in recent years has put a strain on the city's travel infrastructure. The increasing number of small, medium, and heavy industries has led to alarming traffic congestion in the city. The narrow roads, despite handling various types of vehicles simultaneously, can only manage peak hour peak direction traffic (PHPDT) of up to 8,000 vehicles. As Pune is densely populated, relying solely on roads and flyovers is insufficient to meet the city's transportation needs. The existing public transport provided by Pune Mahanagar Parivahan Mahamandal Ltd. (PMPML) has failed to adequately serve the growing demand, contributing to an unhealthy surge in vehicle numbers. The city now boasts 3.62 million registered vehicles, surpassing its own population, resulting in severe stress on the urban transport system, causing longer travel times, increased air pollution, and a rise in road accidents. In light of these challenges, discussions about implementing a robust public transport system in Pune started in the early 2000s.

A well-established public transport system, whether road-based or rail-based, is space and energy-efficient, leading to a reduction in air and noise pollution. As urban populations expand, the proportion of public transport should be increased. For a city with a population of 1.0 million, the ideal share of public transport should range from 40% to 45%, gradually rising to approximately 75% when the population reaches 5 million.

Pune is renowned for its education, research, and military base, as well as being a significant industrial district in Western Maharashtra and a prominent IT Hub in India, often referred to as the "Queen of Deccan." As of 2021, India has 13 operational rapid transit systems in 18 cities, with a combined length of 810 km and 770 stations. Most metro line projects in India use the standard gauge, with only Kolkata Metro and Delhi Metro employing the Broad gauge. Pune Metro, which opened in March 2022, is the newest addition to India's rapid transit systems.

Pune district enjoys excellent connectivity with the state capital and neighboring headquarters through a network of Express Highways, National Highways, State Highways, and Major District Roads, totaling 13,642 km in length. The district is served by National Highways No. 4, No. 9, and No. 50.

Pune Metro's route alignment comprises three corridors: Corridor-1 from Pimpri Chinchwad (PCMC) to Swargate, Corridor-2 from Vanaz (Kothrud) to Ramvadi, and Corridor-3 from Civil Court to Megapolis Circle (Hinjewadi). The total route length of Pune Metro is 54.58 km with 53 stations. As of December 2023, only certain stretches are operational, including the PCMC to Phugewadi section for Corridor-1 and the Vanaz to Garvare College section for Corridor-2.

2 METHODOLGY

2.1 SITE LOCATION

The metro route being considered covers a distance of 5.6 kilometers; however, it is important to highlight that the metro line is not fully operational, which hinders its ability to reach the expected ridership levels. This limitation significantly affects the overall efficiency and effectiveness of the metro system, as it struggles to meet passenger demand and achieve its projected objectives.

The study area for this project focuses on the metro route running from PCMC to Phugewadi metro station. This particular route currently represents the only operational section of Line 1, encompassing a total distance of 5.6 kilometers and comprising 5

stations along its path: PCMC, Sant Tukaram Nagar, Nashik Phata, Kasarwadi, and Phugewadi. To cater to passengers on this route, a single metro car is provided, resulting in a headway of 30 minutes between trains. However, because the metro is not fully operational from PMC to Swargate, commuters show less inclination to use the metro for the relatively short 5.6-kilometer distance.

It's worth noting that this metro route passes through areas where major industries such as Sandvik and Philips are located. Additionally, the presence of the Pimpri Chinchwad Municipal Corporation in the vicinity serves as an attraction for commuters to utilize this particular metro line for their daily commute.

Gaining a comprehensive understanding of the specific details of the metro route, its current operational status, and its surroundings, which include industrial and administrative hubs, provides valuable context for evaluating the current ridership and potential for future growth. This information plays a crucial role in strategic planning, decision-making, and identifying measures to optimize the metro system's efficiency and convenience for commuters along the 5.6-kilometer stretch.

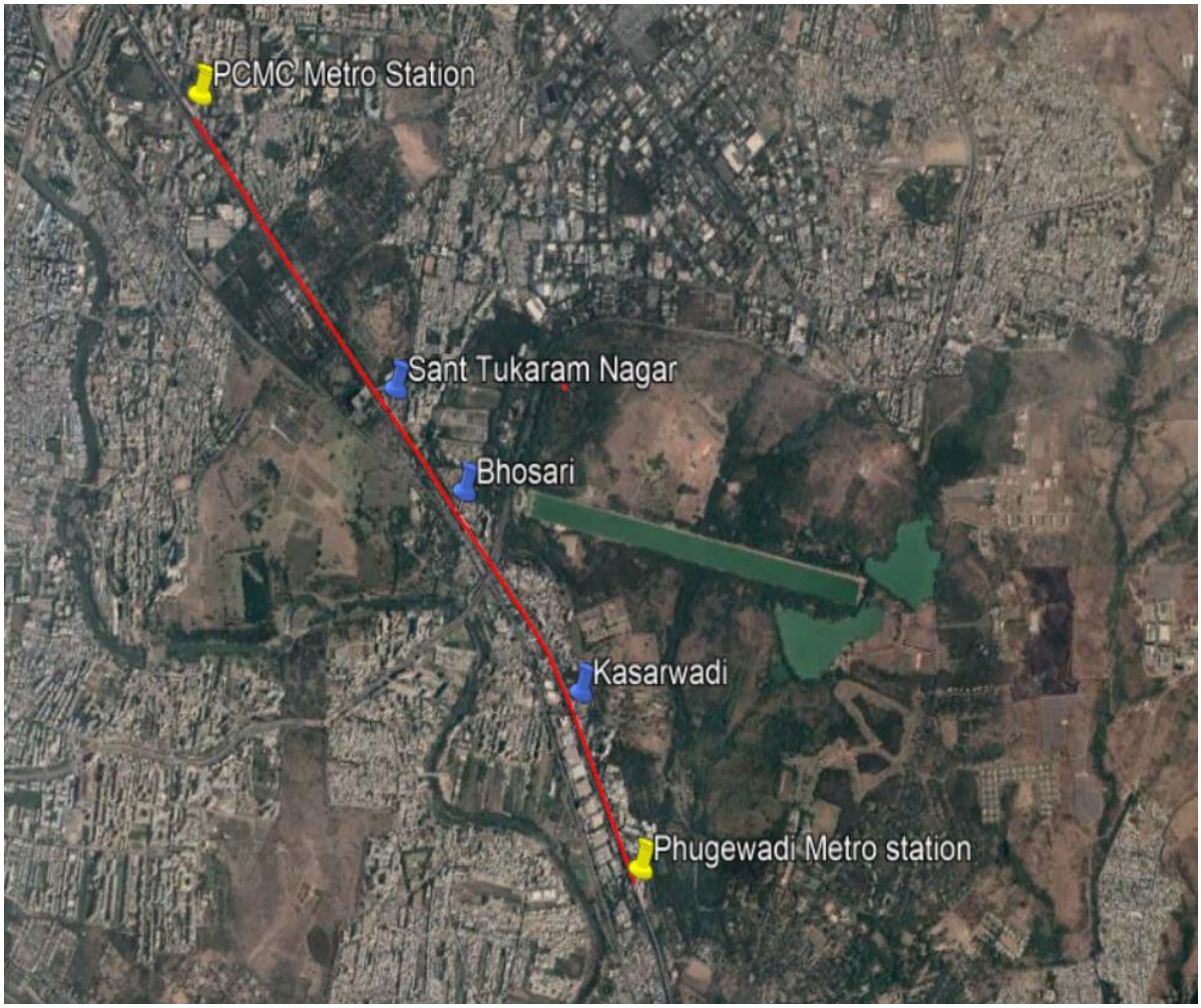


Figure 1 Metro Route

2.2 TRAFFIC DATA

The research method adopted for collecting traffic volume count data is the Indirect Manual counting method using Videography. This technique involves strategically positioning video cameras at selected locations to capture the movement of vehicles passing through a specific area or roadway. The recorded video footage is later reviewed and analyzed to extract relevant information such as vehicle counts, classifications based on size and type, speed, and other parameters.

For this study, a 16-hour turning movement count at an intersection was captured during the morning peak, mid-day peak, and evening peak periods. The vehicle classification was developed based on guidelines provided by IRC (Indian Road Congress). Data was collected in 15-minute intervals. The recorded videos were analyzed visually using a computer system, and a spreadsheet was prepared to categorize different types of vehicles based on their directional movement. Various traffic characteristics, including hourly variation of traffic, peak hour traffic, traffic composition, vehicle modal share, and

directional distribution, were then assessed.

The peak hour volume refers to the highest volume of traffic observed during a specific hour of the day for the intersection, approach, lane, or lane group under consideration. It represents the maximum vehicle volume recorded within the 16-hour volume count period, obtained by summing up the volumes of four 15-minute intervals within the peak hour. In this study, peak hour observations were made during two distinct periods – morning and evening. The morning peak hour was observed between 10:00 am and 11:00 am, while the evening peak hour was between 6:15 pm and 7:15 pm for the junctions on the project route.

2.3 QUESTIONNAIRE SURVEY FOR COMMUTERS

The survey targeted metro users and focused on gathering information related to their previous mode of transportation, cost comparison between their previous mode and the metro, travel time for both options, and the time of travel. The objective was to collect data and compare the mode switch in terms of time, cost, and environmental impact.

To ensure a comprehensive survey, the questionnaire was administered during both peak and off-peak times. Peak hours selected for the survey were from 8:00 AM to 9:30 AM in the morning and from 5:30 PM to 6:30 PM in the evening. Additionally, the off-peak time chosen was from 11:00 AM to 12:00 PM in the morning. The survey was specifically conducted on Monday, Wednesday, Friday, and Sunday. It was noted that on Sundays, most users utilized the metro for recreational purposes, commonly referred to as joyrides. On weekdays, the metro system was predominantly used by working employees and students.

The primary objective of this survey was to collect details about commuters' travel patterns. This included obtaining information on their travel time using the metro, the purpose of their trip, the distance covered, the age of the commuter, the metro fare, the fare of their previous mode of transport, and the travel time excluding the metro.

By collecting this data, the survey aimed to provide insights into the preferences and behavior of metro users, helping to understand the factors influencing their choice of transportation. The survey findings would be valuable for analyzing travel patterns, identifying areas for improvement, and making informed decisions to enhance the efficiency and effectiveness of the metro system in meeting the needs of the commuters.

Questionnaire for Mode of Traffic Switch

Survey carried from_____to_____

Time____

Table 1 Questionnaire for users

No of person interviewed. → Particulars ↓			
How many times do you use metro in a single day?			
Reason for Shifting to metro			
Age			
Purpose of trip (office/school/other)			
Previous mode of transport (Public/ Private)			
If Private, then Car or Bike			
Fare for private vehicle			
If Public, then bus/auto/cab or other			
Fare for public transport			
Distance req. to reach station			
Distance req. from station to destination			
Mode of transport to travel to metro station.			
Time required to travel to the metro station.			
Timing when you use metro			
Travel time by metro			
Travel time (Excluding metro)			

Survey conducted by: -

Sign: -

2.3 MERITS & DEMERITS BASED ON QUESTIONNAIRE SURVEY

Merits:

1. The metro system boasts exceptional energy efficiency, requiring only 1/5th of the energy per passenger kilometer compared to road-based networks.
2. Implementation of the metro system will make a substantial contribution to combat air pollution in the city, promoting cleaner and healthier air for residents.
3. Enjoy a more peaceful urban environment with the metro system's minimal noise pollution, standing in stark contrast to conventional transport modes.
4. Embrace the space-saving benefits of the metro system as it requires minimal land area; underground sections eliminate the need for road lanes, while elevated sections occupy only a narrow 2-meter width.
5. The metro system's capacity is equivalent to accommodating traffic from five lanes of buses or twelve lanes of private motor cars, particularly in light capacity systems.
6. Experience a higher level of comfort, reliability, and safety with metro travel, elevating the overall passenger experience compared to road-based transportation systems.
7. Opt for the metro system and significantly reduce journey times, often ranging between 50% to 75%, depending on the prevailing road conditions.

Demerits:

1. The metro system's drawback lies in the longer time required to reach the station from the origin of travel compared to the more efficient Bus Rapid Transit (BRT) system, potentially affecting certain commuters negatively.
2. For work trips covering distances of approximately 7-9 kilometers on average, a well-established bus service may offer more efficient transportation options than the metro system, especially for these relatively shorter distances.
3. Pune's inadequate pedestrian facilities, such as dirty, uneven, and poorly maintained pavements, pose challenges for seamless walking access to metro stations, making it less suitable for some metro users.
4. The substantial capital cost of implementing the metro system in Pune, estimated at around Rs. 11,500 crores, serves only 2% of the population. In contrast, investing Rs. 1000 crores in 3000 buses could cater to 25% of the population, raising concerns about the metro system's cost-effectiveness and population coverage when compared to the potential benefits of improving the bus system at a fraction of the cost.

2.5 COMMUTERS SWITCHED

The commuter data collected through the questionnaire survey is being used to determine the percentage of commuters who have switched their transportation mode to the Metro. The survey provided valuable insights into the reasons for the mode switch, such as travel time, travel cost, and comfort.

To identify the diverted commuters, the traffic volume count before and after the metro implementation was compared. The questionnaire survey revealed that a significant proportion of commuters using the metro are officegoers, indicating the presence of commercial areas along the metro route. Further research unveiled three major commercial sectors in close proximity to the metro stations on the project route: Philips, Sandvik, and Pimpri Chinchwad Municipal Corporation (PCMC).

The presence of these major centers near the metro stations is expected to lead to a gradual increase in ridership over time, benefiting both the metro system and the commuters. Additionally, the completion of Line-1 (PCMC-Swargate) is anticipated to further boost ridership due to the increased length of the metro network. Currently, only a 5.5km stretch is operational, which has not yet reached the expected ridership levels.

In summary, the questionnaire survey has provided valuable insights into the mode switch behavior of commuters, and the presence of major commercial sectors near the metro stations suggests a positive impact on ridership as the network expands and gains popularity among officegoers and other commuters.

4 RESULTS & DISCUSSION

4.1 TRAFFIC VOLUME COUNT

The collected data encompasses various essential parameters, including PCU values (Passenger Car Units) and overall peak hour information. Additionally, a comprehensive comparison of traffic volume counts is conducted between the period before metro implementation and after its implementation. This analysis aims to identify the commuters who have switched to different transport modes, providing crucial insights into the mode switch behavior.

Through careful examination and analysis of all the data gathered from the questionnaire survey, the feasibility of the metro system can be thoroughly assessed. This evaluation considers several key factors, such as the impact on traffic patterns, the preferences of commuters, and the overall effectiveness of the metro system in fulfilling the

transportation needs of the population.

By considering a wide range of variables and factors, this assessment provides a comprehensive understanding of how the metro system has influenced commuting behavior and traffic flow in the area. It enables policymakers and authorities to make informed decisions regarding future improvements, expansions, and optimizations to further enhance the metro system's efficiency and effectiveness in serving the needs of the commuters and the community as a whole.For Junction 1 (Nashik Phata)

Table 2 Vehicle count for Nashik Phata Junction

Vehicle Composition	Before implementation	After Implementation	% variation
4 Wheelers	5808	5532	4.752
2 Wheelers	6155	5862	4.760
3 Wheelers	1185	1128	4.810
Minibus	40	38	5.000
Large Bus	350	350	0.000
LCV	1048	1048	0.000
Regular Truck	151	151	0.000
Multi-axle Truck	0	0	0.000
Bicycles	0	0	0.000

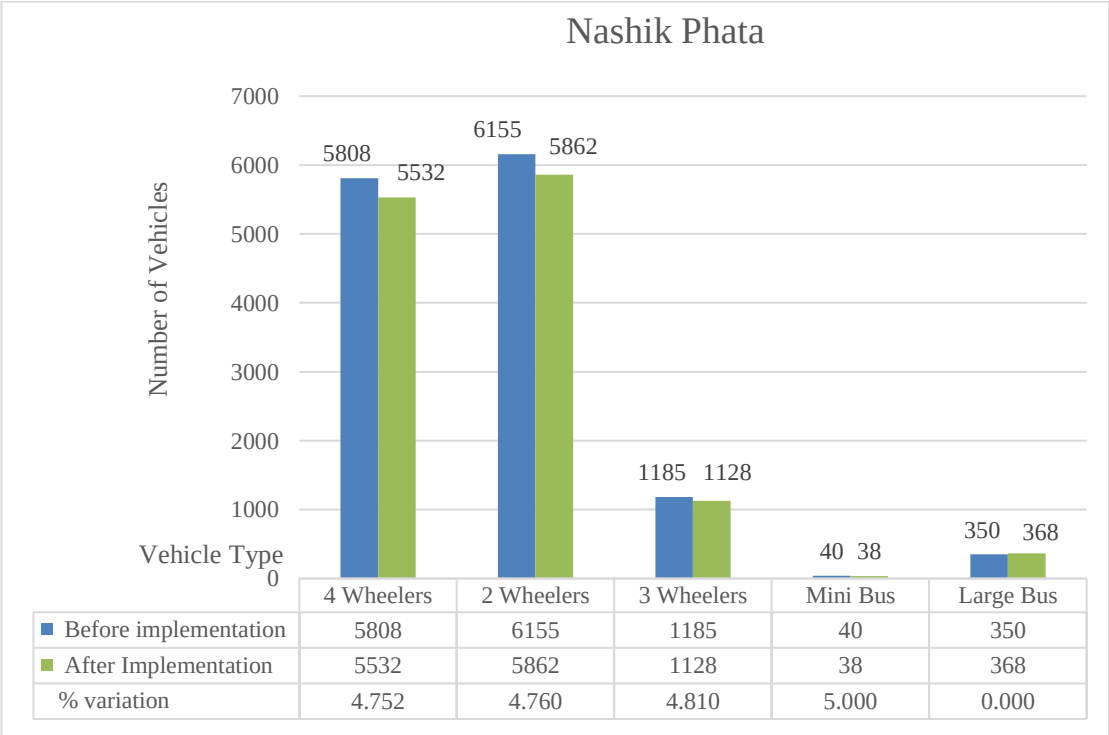


Figure 2 Traffic volume count variation of before & after metro implementation for Nashik Phata

The vehicle count survey conducted before and after the implementation of the metro stretch reveals a noticeable decrease in volume count, ranging from 4.6% to 5%. The accompanying graph visually illustrates this trend. Notably, the count of minibuses has shown a significant reduction of 5%, indicating a shift of passengers who previously relied on company transport to the metro as their preferred mode of transportation. This shift is likely attributed to the time and cost savings offered by the metro system. Additionally, there has been a decrease of 4.760% and 4.752% in the count of two-wheelers and four-wheelers, respectively, suggesting that commuters who used these vehicles have opted for the metro due to factors like safety, cost-effectiveness, and time efficiency.

It is essential to acknowledge that the observed variation in volume count is not substantial. This is primarily because Line 1 of the metro stretch is not yet fully operational, with only stations like PCMC, Sant Tukaram Nagar, Bhosari, Kasarwadi, and Phugewadi currently operational. As a result, the full potential of the metro system has not been realized, and commuters may not have fully switched to the metro for longer distances. However, based on the findings from the Questionnaire Survey discussed in section 4.3 of the report, it is predicted that once the section is entirely operational, commuters will prefer the metro for larger distances.

It is important to note that vehicles traveling interstate are likely to continue opting for personal transport or public transport like buses, leading to no significant variation in their count even after the construction of the metro. Commercial vehicles, including large buses, light commercial vehicles (LCVs), and regular trucks, also do not show a decrease in their count. These vehicles are designed for transporting goods and a large number of passengers, making the metro impractical and unsuitable for their use. However, there could be a potential switch in public transport usage once Line 1 is fully operational and covers a more extensive route network.

For Junction 2 (PCMC Chauk)

Table 3 Vehicle Count for PCMC Chowk

Vehicle Composition	Before implementation	After Implementation	% variation
4 Wheelers	7671	7285	5.032
2 Wheelers	10163	9629	5.254
3 Wheelers	3944	3821	3.119
Minibus	743	706	4.980
Large Bus	404	404	0.000
LCV	225	225	0.000
Regular Truck	30	30	0.000
Multi-axle Truck	20	20	0.000
Bicycles	24	24	0.000

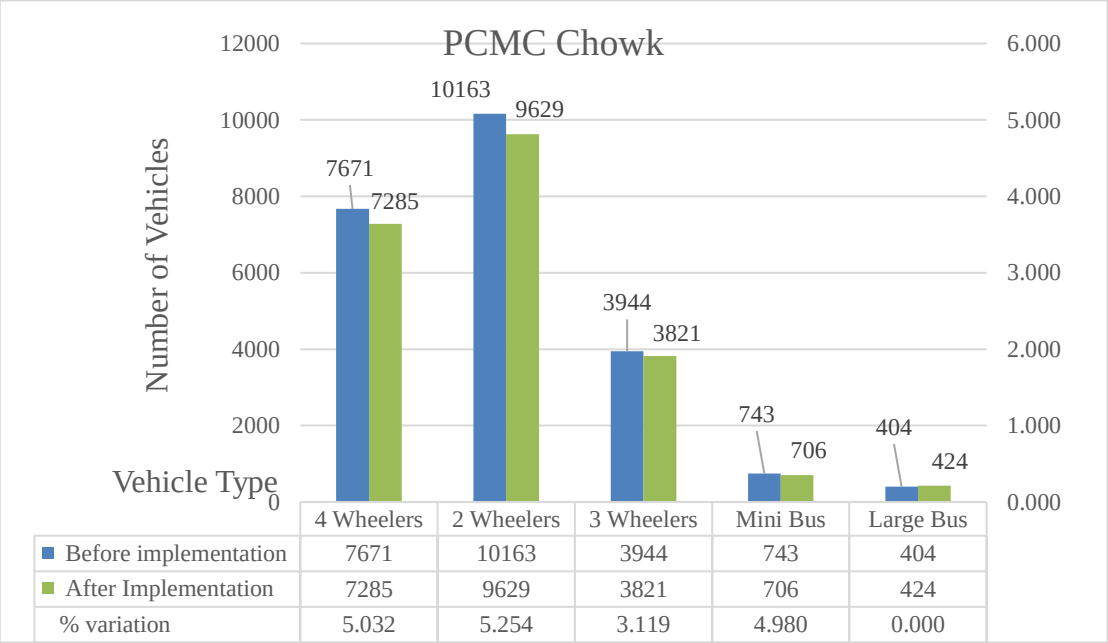


Figure 3 Traffic volume count of before & after metro implementation for PCMC Chowk

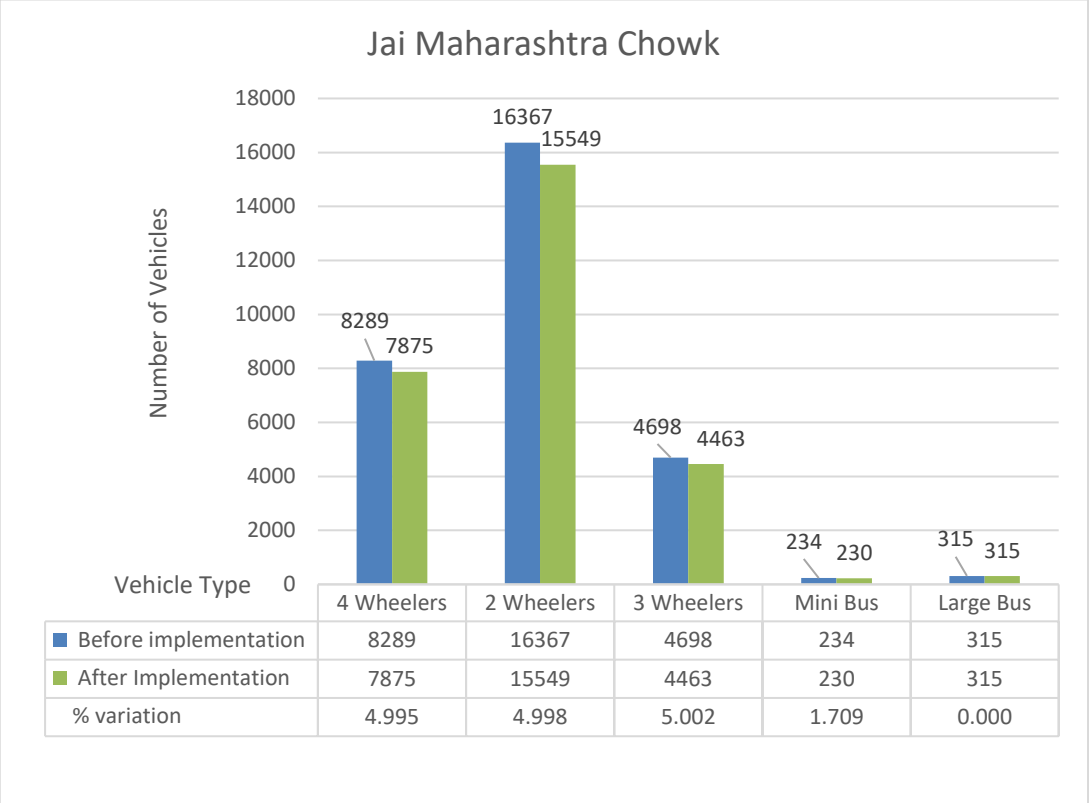
The section towards PCMC Metro station has shown greater variation compared to the previous section of Nashik Phata Metro Station. The graph presented above clearly illustrates that there has been a significant shift among 2-wheeler users, with a percentage of 5.254. This can be attributed to the proximity of industrial areas near the metro stations, providing convenient transportation options for commuters. Similarly, there has been a noticeable variation of 5.032% among 4-wheelers. Other commuters who previously relied on public transport have also shown a preference for the metro system. A detailed analysis and discussion of these findings can be found in the Questionnaire Survey

section of this report.

For Junction 3 (Jai Maharashtra Chowk)

Table 4 Vehicle count for Jai Maharashtra Chowk

Vehicle Composition	Before implementation	After Implementation	% variation
4 Wheelers	8289	7875	4.995
2 Wheelers	16367	15549	4.998
3 Wheelers	4698	4463	5.002
Minibus	234	230	1.709
Large Bus	315	315	0.000
LCV	934	934	0.000
Regular Truck	109	109	0.000
Multi-axle Truck	9	9	0.000
Bicycles	26	26	0.000



The variation among 3-wheelers is notably higher at 5%, which can be attributed to the presence of residential areas near that junction. Commuters in the vicinity may have switched to the metro system to travel towards PCMC Stand or Nashik Phata. On the other hand, the variation among 2-wheelers and 4-wheelers is nearly equal, with percentages of 4.995% and 4.998% respectively. This indicates that once the metro line

is completed and offers enhanced connectivity, there will likely be a significant shift from private modes of transportation to the metro system.

The overall variation in volume counts ranges from 1.709% to 5.002%. Although the variation may not be substantial at present, it is evident that with thorough connectivity provided by the complete metro line, the variation is expected to increase. This suggests that as the metro system becomes more accessible and connected, there will be a greater likelihood of commuters opting for the metro as their preferred mode of transportation.

3.2 COST ANALYSIS

The study involves a cost analysis to examine the feasibility of the metro system. The analysis considers the economic aspects for both the commuters and the metro itself.By gathering information from switched commuters, the study aims to understand the overall savings in travel expenses for passengers. The average cost of travel is compared using data obtained from the questionnaire survey, allowing for an assessment of the cost-effectiveness for commuters. The analysis specifically compares the fares of the metro system with those of various road-based transportation options, such as cars, bikes, buses, and autorickshaws.The primary goal of this cost analysis is to provide insights into the cost factor associated with using the metro system for daily commuting. As travel cost is a crucial consideration for commuters, evaluating the financial implications of utilizing the metro system is essential.Through the questionnaire survey, the researcher collected data on the cost of fares for both round trips and single trips via the metro system. These trips were compared with the cost of using road-based transport options, focusing on the most commonly used metro routes by commuters, particularly those traveling from PCMC, Sant Tukaram Nagar, and Phugewadi metro stations. These stations are significant due to the presence of major companies like Philips, Sandvik, and the Pimpri-Chinchwad Municipal Corporation.By conducting a detailed analysis comparing the fares of metro transport with those of road-based transport options, the study aims to assess the cost-effectiveness of the metro system. This analysis is crucial in understanding the financial implications for commuters and evaluating the attractiveness of the metro as a viable mode of transportation. The results of the cost-benefit analysis will provide valuable information for decision-makers and stakeholders involved in urban

transportation planning and infrastructure development.

Table 5 Cost comparison between metro & road-based transport

Route	Metro (Rs.)	Private (Rs.)		Public (Rs.)	
		car	bike	Bus	auto
PCMC to Phugewadi	20	70	35	25	40
PCMC to Sant Tukaram Nagar	10	25	15	10	20
Sant Tukaram Nagar to Phugewadi	20	50	20	20	35

The comparative cost analysis of fares for both round trips and single trips provided valuable insights into the cost differences between the metro system and various road-based transport options such as cars, bikes, buses, and autorickshaws. Specifically, the analysis focused on the PCMC to Phugewadi stretch, where the metro fare was found to be Rs. 20. In comparison, private car fare was Rs. 70, private bus fare was Rs. 35, public bus fare was Rs. 25, and 3-wheeler fare was Rs. 40. These figures were obtained from a comprehensive questionnaire survey conducted among commuters.

The results of the analysis revealed that the metro fare was lower than bus fares by less than Rs. 5 and significantly lower than car fares by Rs. 50. Additionally, the metro fare was lower than bike fares by Rs. 15 and 3-wheeler fares by Rs. 20. These findings highlight the cost advantages of using the metro system compared to road-based transport options.

The selected routes for this analysis primarily focused on trips originating from PCMC, Sant Tukaram Nagar, and Phugewadi metro stations, strategically located in close proximity to major companies such as Philips, Sandvik, and the Pimpri-Chinchwad Municipal Corporation. The cost comparison data provides commuters with valuable information to make informed decisions regarding the affordability and overall travel expenses associated with using the metro system as their preferred mode of transportation.

By understanding the financial benefits or drawbacks of utilizing the metro system, commuters can assess the cost-effectiveness and attractiveness of the metro as a

sustainable mode of transportation for their daily commute. This data aids in determining whether the metro system aligns with their affordability and overall travel expenses, offering a viable and cost-efficient alternative for daily commuting needs.

A comparative analysis of fares for both round trips and single trips was conducted to assess the cost differences between the metro system and various road-based transport options, including cars, bikes, buses, and autorickshaws. Specifically, a cost analysis was performed for the PCMC to Phugewadi stretch, where the metro fare was found to be Rs. 20, while private car fare was Rs. 70, private bus fare was Rs. 35, public bus fare was Rs. 25, and 3-wheeler fare was Rs. 40. These figures were obtained from a comprehensive questionnaire survey conducted among commuters.

The results of the analysis revealed that the metro fare, compared to bus fares, was lower by less than Rs. 5, and significantly lower by Rs. 50 when compared to car fares. In addition, the metro fare was lower by Rs. 15 compared to bike fares, and Rs. 20 compared to 3-wheeler fares. These findings provide valuable insights into the cost advantages of using the metro system as opposed to road-based transport options. Commuters can use this information to make informed decisions regarding the affordability and overall travel expenses associated with using the metro system as their preferred mode of transportation.

Comparison of fare between metro & road-based transport is showcased. The cost analysis of metro fare is Rs. 5 less than bus, Rs. 50 less than car, Rs. 15 less than bike & Rs. 20 less than 3-wheeler.

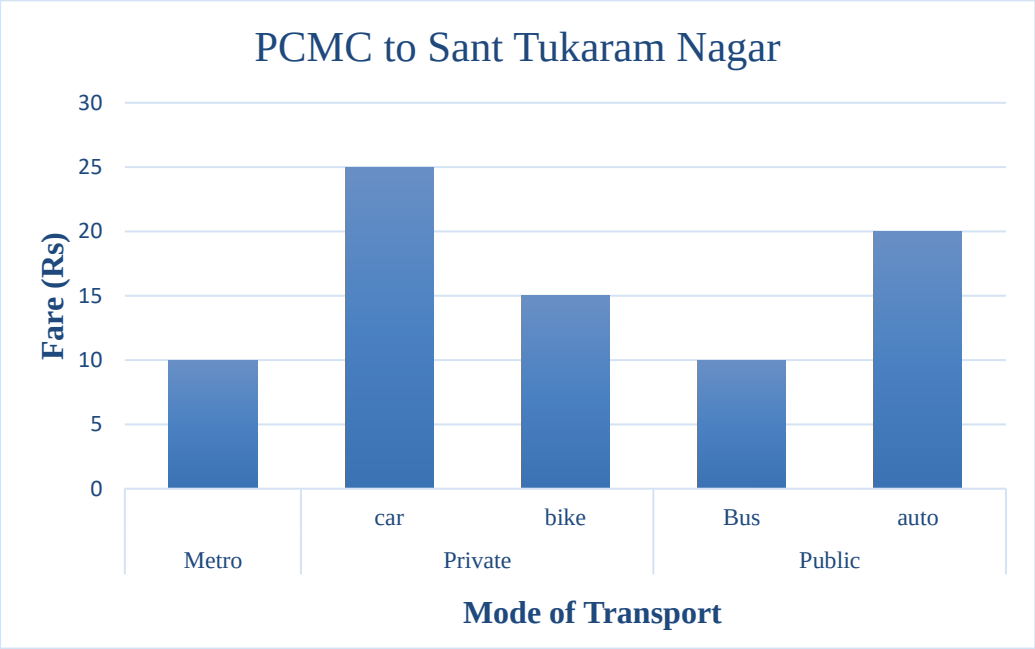


Figure 4 Cost analysis for route PCMC to Sant Tukaram Nagar

Comparison of fare between metro & road-based transport is showcased. The metro fare is same as bus, Rs. 30 less than car, Rs. 5 less for bike & Rs. 15 less than 3-wheeler. Comparison of fare between metro & road-based transport is showcased. The cost

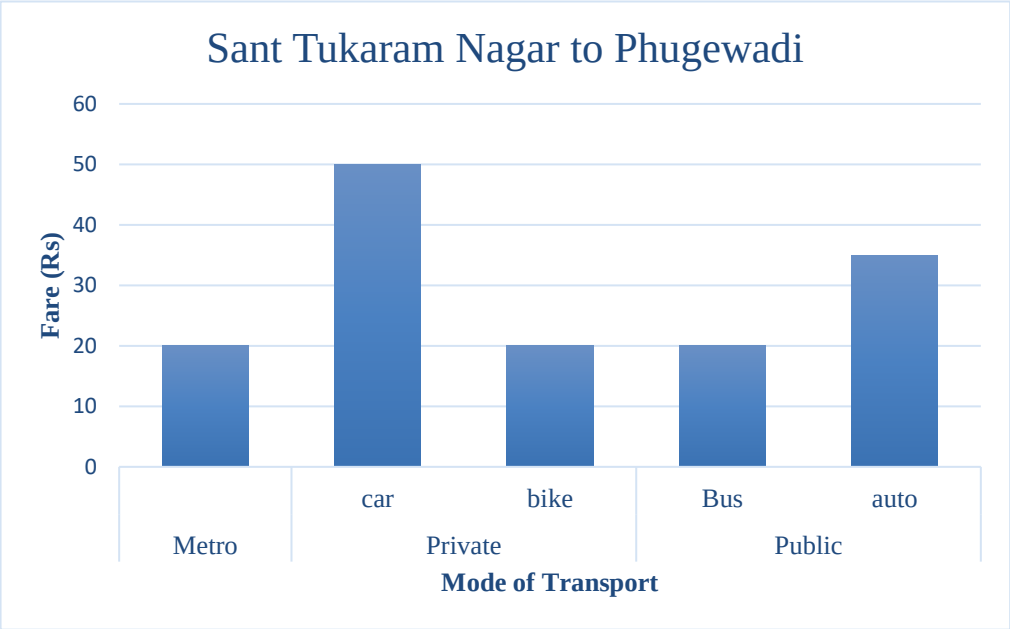


Figure 5 Cost analysis for route Sant Tukaram Nagar to Phugewadi

analysis of metro fare is same for bus, Rs. 30 less than car, same for bike & Rs. 15 less than a 3-wheeler.

3.3 COMMUTER'S QUESTIONNAIRE SURVEY

The data collected from the questionnaire survey provides crucial inputs that are essential for accurately assessing and understanding the impact of the metro implementation on the selected route, specifically the stretch from PCMC to Phugewadi.

Analyzing the purpose of the trip helps determine the primary reasons for travel, such as commuting to work, educational purposes, or leisure activities. This information aids in evaluating the potential benefits and convenience offered by the metro system for different types of trips. For example, if a significant portion of respondents use the metro for their daily work commute, it indicates that the metro system is serving a vital role in meeting the transportation needs of the working population.

The input on fare for transportation provides insights into the cost implications of using the metro compared to other modes of transport. This information is critical for assessing the affordability and attractiveness of the metro system in terms of fare pricing and its competitiveness with existing transportation options. If the metro system offers lower fares or comparable fares to other modes of transport, it becomes an appealing choice for cost-conscious commuters.

The travel time input is crucial for assessing the efficiency and time savings associated with using the metro. By comparing the travel time of the previous mode of transport with the projected travel time on the metro route, researchers can estimate the potential reduction in travel time and the overall impact on commuters' schedules. Shorter travel times with the metro system may incentivize more people to choose it over other modes of transport.

Lastly, understanding the respondents' previous mode of transport provides a baseline for comparison. It helps evaluate the shift in mode choice resulting from the metro implementation and assess the extent to which the new system is successful in attracting passengers from alternative modes of transport. If a substantial number of respondents switch from their previous mode of transport to the metro, it indicates that the metro system is effectively appealing to commuters and fulfilling their transportation needs.

However, it is noted that the data collected from 220 commuters may be relatively low, primarily due to the incomplete route of Line-1 of the metro (PCMC to Swargate) and the relatively short distance between PCMC and Phugewadi, which may make road-based transport more preferable for some daily commuters. Nonetheless, the data still provides valuable insights into the impact of the metro system on commuters' travel patterns and preferences within the available route. As the metro system expands and more sections become operational, the data collection and analysis can be further enriched to provide a comprehensive understanding of the metro's impact on transportation in the area.

3.4 Mode of Transport

The purpose of collecting data on the mode of transport was to examine the transition of commuters from specific modes of transportation such as buses, cars, bikes, and two-wheelers. By studying the switch in modes of transport, valuable insights can be gained regarding the effectiveness of the metro system in attracting and accommodating commuters.

Understanding the switch in modes of transport is essential to evaluate the extent to which the metro has been successful in providing a viable and convenient alternative to traditional modes of transportation. This information will contribute to assessing the overall impact and effectiveness of the metro system in meeting the needs and preferences of the daily commuters, as well as promoting sustainable and efficient transportation options for the city.

Table 6 Mode of transport used by commuters before switching to metro.

Previous mode of transport	
Public	Private
120	100

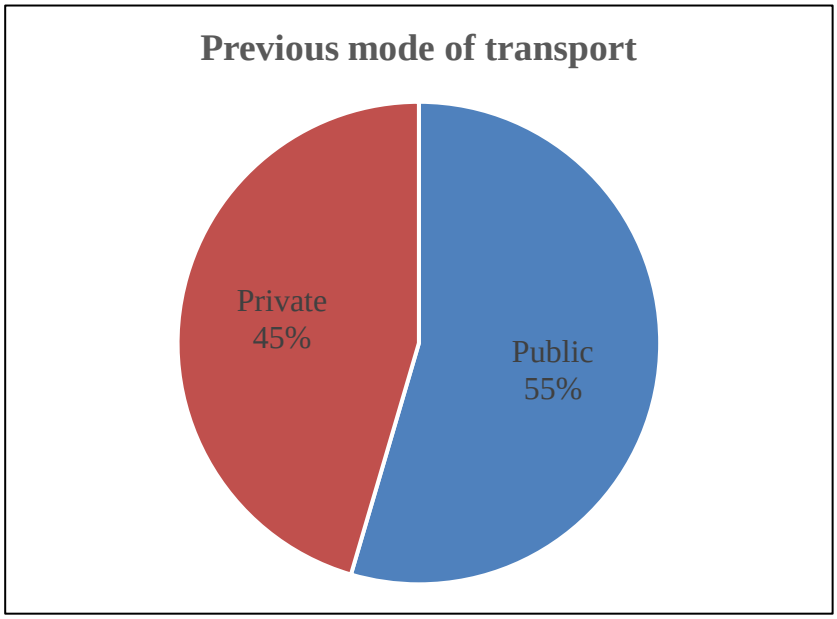


Figure 6 Previous mode of transport

The above figure illustrates the percentage distribution of public & private modes of transportation. This data reveals the proportion of commuters either utilizing public or private means of transport in their daily travel.

To gain a comprehensive understanding of both the private and public transport sectors, detailed information is provided in the following table and figure. These visual representations aim to provide a comprehensive analysis and explanation of each sector's characteristics and features. (Total 220 commuters)

Table 7 Previous mode of transport for each sector

Public		Private	
Bus	Autorickshaw	Bike	Car
100	20	70	30

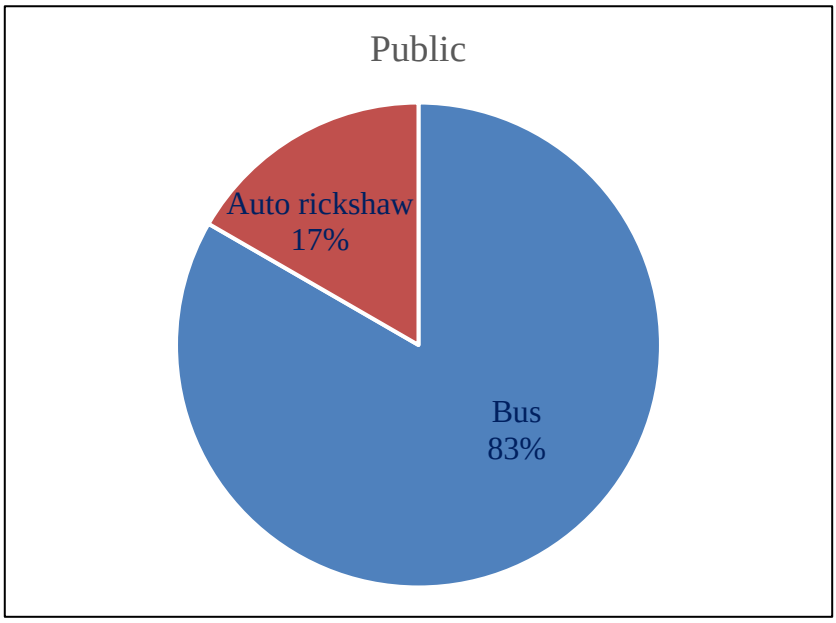


Figure 7 Mode of transport switch from public

Commuters switched to metro from public transport are maximum in percentage for bus mode rather than 3-wheeler. This is because the commuters travelling by bus before switch was higher than auto-rickshaw.

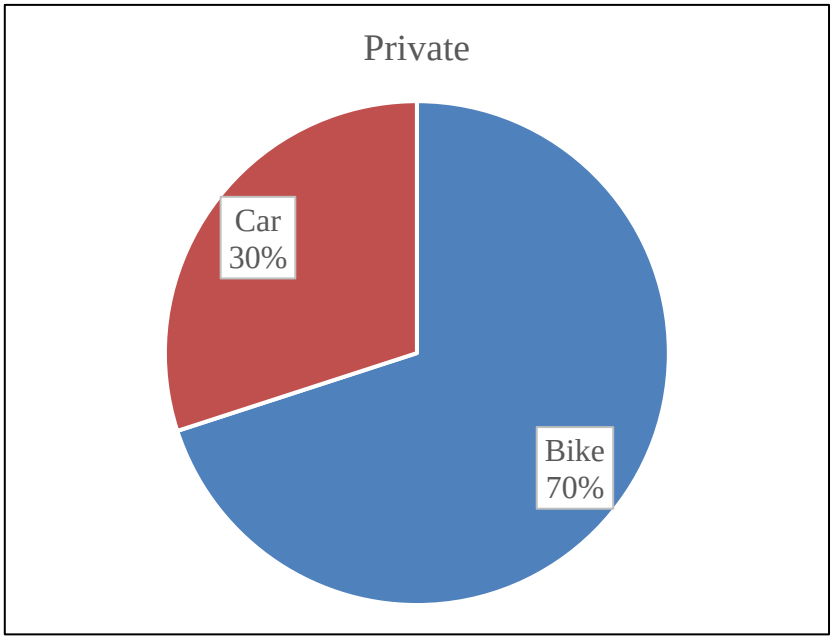


Figure 8 Mode of transport switch from private

Commuters switched from private transport are maximum in percentage for bike mode as compared car transport. As per the traffic volume count, the maximum percentage of bike commuters are switched. This effect is seen in the questionnaire survey.

2.3.1 Age of commuter

Within this sub-chapter, a detailed analysis is conducted to distinguish commuters based

on their age groups. By categorizing commuters into specific age ranges, valuable insights can be gained regarding the demographic composition of metro users and their daily commuting patterns.

Through a comprehensive examination of the data, including survey responses and demographic information, we can gain a deeper understanding of the age groups that show a higher propensity for utilizing the metro system. This analysis provides valuable insights into the effectiveness of the metro in meeting the transportation needs of different age demographics, highlighting areas of success and potential areas for improvement.

By aligning the metro services with the needs and preferences of different age groups, transportation authorities can foster increased ridership, customer satisfaction, and overall success of the metro system.

Table 8 Commuters previous mode of transport

Age Group	Mode of Transport			
	Bus	Auto	Car	Bike
18-30	40	0	3	45
30-60	50	15	22	25
60-90	10	5	5	0

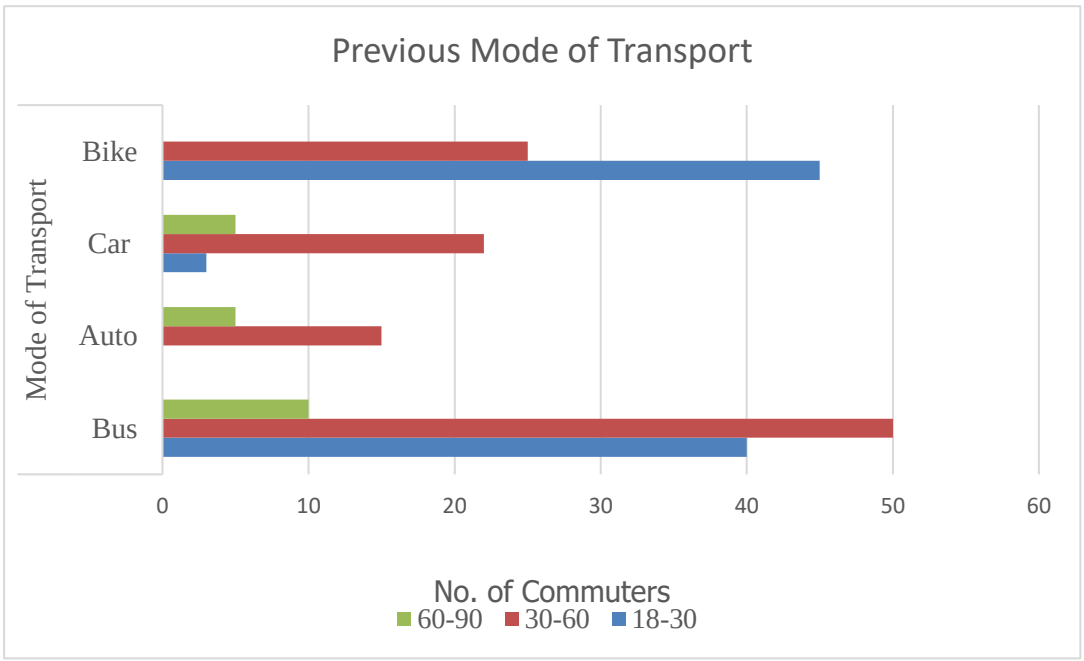


Figure 9 Previous mode of Transport in terms of age groups of commuters

Previous mode of transport of commuters as per table 12 & figure 15 states that in age

group (18-30) commuters switched from bus are 40, auto 0, car is 3 & for bike is 45. For the age group (30-60) commuters switched from bus are 50, auto is 15, car is 22 & for bike is 25. For the age group (60-90) commuters switched from bus are 10, auto is 5, car is 5 & for bike is 0.

2.3.2 Purpose of Trip

During the survey, the commuters were asked about the specific purpose of their trips. By analyzing the collected data, we were able to discern the number of individuals who opted for the metro for their office commutes, school journeys, and other purposes. The results revealed that a significant majority of commuters predominantly rely on the metro for their office-related trips, indicating its popularity and convenience as a mode of transportation for work-related travel. Conversely, the number of commuters utilizing the metro for school or other purposes was comparatively lower. This finding underscores the metro's prominence as a preferred means of transportation for the daily office commutes of a substantial portion of the surveyed commuters.

A comprehensive dataset was gathered, comprising the responses of a total of 220 commuters. Among these respondents, 170 individuals reported utilizing the metro primarily for their daily office commutes, while 40 commuters stated that they used the metro for school trips. Additionally, 10 respondents indicated that they utilized the metro for various other purposes.

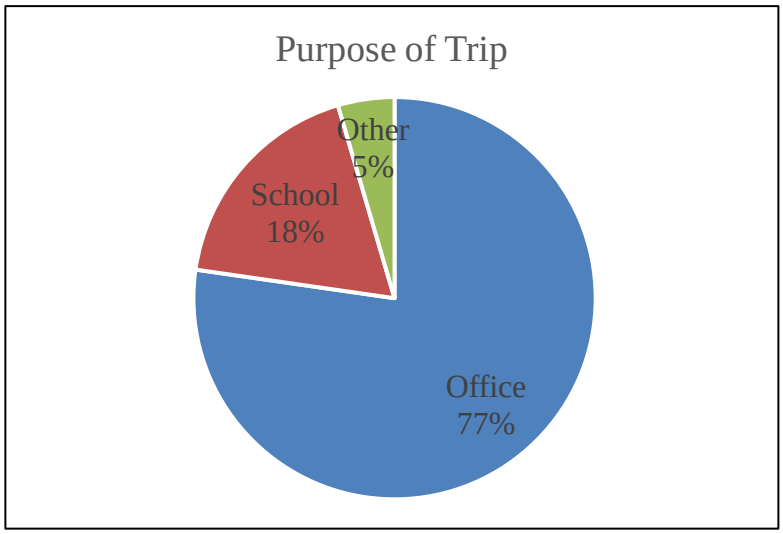


Figure 10 Commuters Purpose of trip

Purpose of journey of the commuters are showcased above. Office commuters travelling by metro are 170 which is 77% of total data. School commuters travelling by metro are 40 which is 18% of total data. Other commuters travelling by metro are 10 which is 5% of total data. Notably, there has been a significant increase in the number of office

commuters, which can be attributed to the presence of prominent industrial companies, such as Sandvik and Philips, located in close proximity to the Phugewadi and Sant-Tukaram Nagar metro stations, respectively. These companies serve as major employment centers, attracting a considerable number of commuters who find the metro system to be a convenient and efficient mode of transportation for their daily commutes to work. Furthermore, the presence of the Pimpri Chinchwad Municipal Corporation near the PCMC metro station further contributes to the influx of office commuters opting for the metro as their preferred mode of transport.

2.3.3 Travel time analysis

During the questionnaire survey, one of the key inquiries posed to the respondents pertained to the travel time they experienced while using the metro as well as their previous mode of transportation. This aspect holds paramount importance for daily commuters who rely on efficient and time-saving travel options. The findings revealed that the implementation of the metro system has resulted in a notable reduction in travel time from 30 minutes to a mere 15 minutes. This indicates a significant 50% decrease in the overall travel duration when compared to road-based transport alternatives. Such a substantial reduction in travel time serves as a compelling incentive for commuters to consider switching to the metro system in the near future, especially upon the completion of Line-1.

It is important to note that both ridership and headway are expected to improve significantly once Line-1 becomes fully operational. As part of the future plans, the metro department intends to introduce five metro cars initially for this route. This strategic approach will allow them to gauge and assess the ridership patterns and demands more effectively. Based on the ridership figures and feedback, additional metro cars will be provided to cater to the growing demand. This progressive approach will ensure that the metro system aligns with the evolving needs of commuters and provides efficient and convenient transportation services.

Table 9 Travel time for commuters required.

Route	Travel Time by Metro (mins)	Travel Time Excluding Metro (mins)
PCMC to Phugewadi	15	30
Sant Tukaram Nagar to Phugewadi	10	25

PCMC to Sant-Tukaram Nagar	5	10

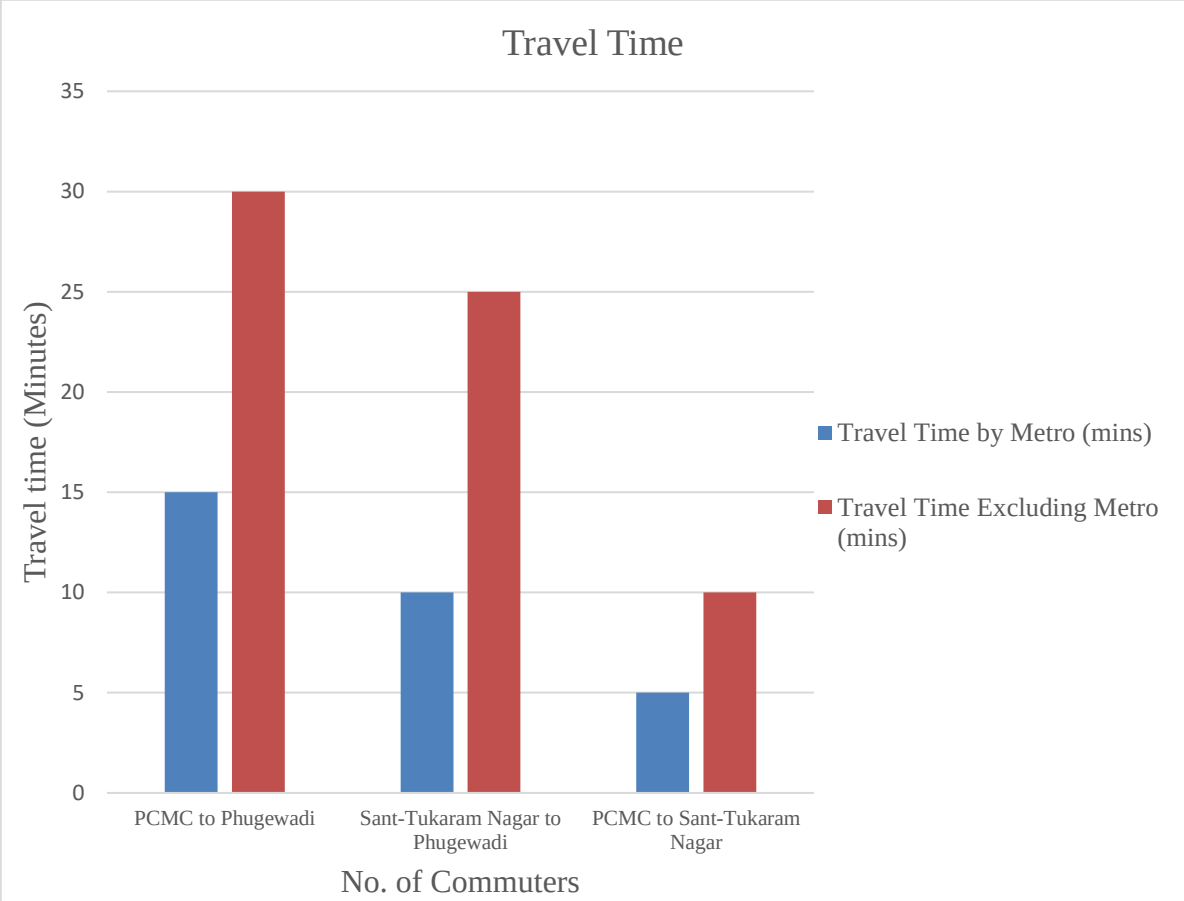


Figure 11 Travel time required for commuters according to routes

Travel time by metro for stretch PCMC to Phugewadi is 15 mins as compared to travel time excluding metro is 30 mins. Travel time by metro for stretch Sant Tukaram Nagar to Phugewadi is 10 mins as compared to travel time excluding metro is 25 mins. Travel time by metro for stretch PCMC to Sant Tukaram Nagar is 5 mins as compared to travel time excluding metro is 10 mins. Travel time by metro is less for all stretch of the metro.

3 CONCLUSIONS

1. The metro system's ridership is not meeting the expected projections outlined in the Pune Metro DPR (Detailed Project Report) primarily due to the non-operational status of Line-1 (PCMC to Swargate).

2. The results from the travel time analysis indicate a significant reduction in travel time

by 50% compared to road-based transport, offering commuters a more efficient and time-saving option for the stretch from PCMC to Phugewadi.

3. The cost analysis shows that the current fare reduction for the metro compared to bus fare is only Rs. 5/- for a single trip, accounting for a 20% reduction. However, it is important to note that the metro fare is expected to decrease once Line-1 becomes fully operational.

4. Among the surveyed commuters, approximately 55% of public transport users have switched to the metro, while 45% of private transport users have also opted for the metro as their mode of transportation. Within the public transport category, buses account for 83% of the switch, while 3-wheelers represent 17%. In the private transport category, cars account for 30%, and 2-wheelers make up the remaining 70%.

5. The majority of commuters fall within the age group of 30-60, largely attributed to office commuters. Conversely, the age group of 60-80 represents a smaller percentage according to the survey findings. A higher percentage of bus commuters have made the switch within the age group of 18-30, while for the age group of 30-60, the percentage of bus commuters who switched to the metro is also comparatively higher.

6. Office commuters predominantly utilize the metro system for the surveyed stretch because of the industrial sector present near the metro stations. The number of school commuters is lower because the metro's purpose may not align with their needs. Out of the 220 surveyed commuters, 77% are office commuters, 18% are school commuters, and the remaining percentage represents other types of commuters.

7. The traffic count reveals that an average of 5.004% of two-wheeler commuters and 4.926% of four-wheeler commuters have made the switch to the metro. On the other hand, the number of buses shows little variation, with approximately 0% change. It is important to note that while the number of individual commuters using buses may decrease, the count of public buses will not reduce until the construction of the complete metro section is finished.

8. To enhance ridership, awareness campaigns should be conducted at nearby schools and junctions within the study area. These campaigns aim to inform daily commuters about the advantages of using the metro and introduce new schemes available to them.

9. Increasing the amenities at the metro stations will encourage commuters to choose the metro as their preferred mode of transportation. The provision of dedicated parking spaces ensures that commuters have a convenient and secure location to park their

vehicles while they use the metro. This eliminates the hassle of finding parking elsewhere and provides a seamless transition between driving to the metro station and using public transportation.

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