

Urban Transformation Through Transit: Socio-Economic Analysis of Pune's Vanaz–Ramwadi Metro

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ABSTRACT

Despite large scale investments in road infrastructure, tactics for land use and transport development, all the urban cities are facing the problem of traffic congestion, accidents, air pollution etc. To cater this demand of growing population and exponential growth of personal use vehicles in cities, Mass Rapid Transport System proves to be very useful. Pune being the national or global headquarter for various companies is witnessing enormous growth, due to which the infrastructure of the city is being stressed as the roads do not have adequate width to cater with the mixed traffic conditions. The aim of this project is to study and evaluate the socio-economic impact of Pune Metro on Vanaz-Ramwadi corridor. The scope of this project includes carrying out survey along the corridor and analyzing the data in view of reduction in air pollution, saving in travel time, decrease in accidents. From the survey it is observed that nearly half of the vehicles will go off the road thus reducing air pollution, noise pollution and traffic congestion considerably, hence impacting the socio-economic status of the commuters along the Vanaz-Ramwadi corridor.

Keyword: *Transportation, MRTS, Pune Metro, Socio-economic, Vanaz-Ramwadi corridor.*

I. INTRODUCTION

Infrastructure is very important for the development of the society and it is considered to be the backbone on which the society is built. Poor transport and communications infrastructure restrain the participation of developing countries in global competition. This can be overcome by improving transport infrastructure, and thereby improving competitiveness. There are many factors that influence in achieving a good transport infrastructure. For example, organized arrangements can have great influence on the quality of transportation in a country.

Transport situation in most Indian cities of all sizes is rapidly getting worse because of the increasing travel demand and inadequate transportation system. Indian cities of all sizes are facing the problem of urban transport. Despite investments in road infrastructure and plans for land use and transport development, all face the problem of congestion, traffic accidents and air pollution and the problems continue to grow. Large cities are facing an exponential growth of two wheelers and cars for personal use, while in medium and small cities public transport are struggling to meet the demand of resident. Many of the people in growing cities are opting for public transport. To cater this demand of growing population in growing cities Mass Rapid Transport System (MRTS) proves to be very useful. The Figure 1 shows the different MRTS options for cities in India. [1]

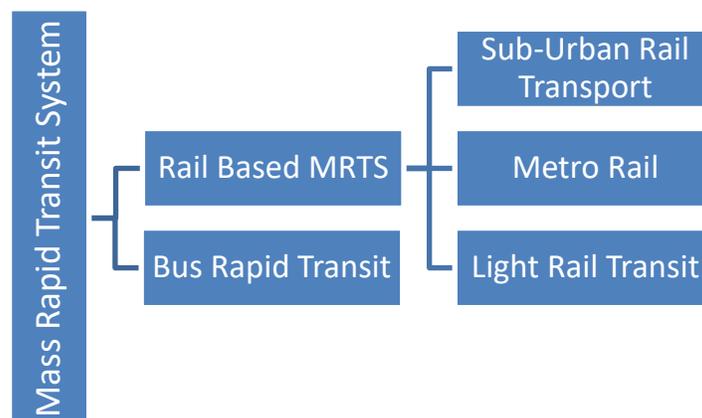


Figure 1.1:- Different modes of MRTS

Metro rail is a cheap mode of transport. It helps in low energy consumption. As metro rails are operated on electricity, they minimize air and sound pollution. It also minimizes the number of accidents and is efficient in terms of space occupancy. Metro rail provides comfort with ultra-modern coaches and modern systems like automatic ticketing, advanced comfort to the passengers thus making their lives less stressful while signaling systems, automatic train protection system and integrated security systems which bring leisure in the journey.

The first rapid transit system in India was started in Kolkata city in the year 1984. Subsequently the Delhi Metro started in 1995 and today it has the largest network in the entire country. Recently the newest metro opened in Hyderabad and Kochi in 2017.

In 2009, the government decided to invest 2000 billion (US\$33.2 billion) on metro rail projects in the upcoming ten years. It is planned that all Indian cities having population more than 2 million will have metro rail system. Currently, rapid transit systems operate in 15 cities and more are under construction or in planning in several cities of India.

Pune has witnessed enormous industrial growth since 2000. The city's travel infrastructure has been stressed due to rapid urbanization in the recent past; due to which the traffic in the city is rising at alarming rates. The roads in the city carries different types of vehicles and are narrow in nature. The narrow roads can carry 8,000 peak hour peak direction traffic (PHPDT). The city area is densely populated which makes it difficult to cater traffic needs by road-based system and additional flyovers. Pune MahanagarParivahanMahamadal Ltd. (PMPML), the public transport provider that operates buses and BRT services in Pune and Pimpri-Chinchwad, has failed to meet the transport needs of the twin cities. This has mainly contributed to enormous growth of vehicles on roads. According to reports published in April 2018, the number of vehicles registered in the city stands at 3.62 million surpassing the population of the city. Such a high density of traffic has put the urban transport system in Pune under severe stress leading to longer travel time, increased air pollution and rise in number of road accidents. In view of this, a strong public transport system has been discussed in Pune since the early 2000s. On 15 August 2008, the preparation of detailed project report (DPR) work was undertaken by the Delhi Metro Rail Corporation and submitted their report to the government. [2]

Pune Metro is a metro rail based rapid transit system under construction to serve the city of Pune and its industrial twin, Pimpri-Chinchwad in the state of Maharashtra. As of March 2018, the system comprises 3 lines with a total length of 54.58 km. The 16.59-km Line 1 (PCMC – Swargate) will be elevated between the headquarters of the Pimpri-Chinchwad Municipal Corporation (PCMC building) in Pimpri to Range Hills, from where it will run underground. Line 2 will run from Vanaz to Ramwadi covering a distance of 14.66 km on an elevated viaduct. Lines 1 and 2 are expected to be operational in 2021. The 23.33-km elevated Line 3 will run from the Rajiv Gandhi InfoTech Park in Hinjawadi via Balewadi to Shivajinagar. All three lines will align at the Civil Court interchange station. [2]

The metro rail in Pune is going to create a socio-economic impact. The Pune metro rail is going to provide multiple

benefits to the residents of Pune such as reduction in traffic congestion and fuel saving, reduction in accidents, travel time of passengers and reduction in air pollution. It is also going to create an impact on economics of the government, passengers, private transporters, general public and unskilled labor. A study and survey of the economic benefits to the government and the passengers, effect on traffic and air pollution has been analyzed and presented.

The aim of this study is to evaluate the socio-economic impact of Pune Metro on Vanaz-Ramwadi corridor. The scope of the paper is restricted to designing the survey form and to collect the vehicular traffic data for analysis purpose. Based on the survey and the data collected from various entities the analysis of reduction in air pollution, saving in travel time, decrease in accidents is presented.

II. LITERATURE REVIEW

Bharath. K. et.al [1] have initially discussed about the importance of ‘Hyderabad Metro Rail Project’ towards improving the traffic and transportation of city. This paper then attempts to make an economic analysis of the HMRP using the framework of “Cost Benefit Analysis” which helps to prove that the project is beneficial on the numeric measure of Cost-Benefit ratio.

Delhi Metro Rail Corporation LTD [2] was entrusted with preparation of ‘Detailed Project Report’ (DPR) for identifying the potential corridors for implementation of metro rail system in Pune. This paper critically reviews and analyses the social and economic impact of Metro rail on Pune city. This analysis and experience from other cities suggest that cities are increasingly seeking large, big solutions to their urban transport problems without considering their importance and their socio-economic impact on particular city.

D.Goel et.al [3] estimated the decline in nitrogen dioxide and carbon monoxide ranges from 3 to 47 percent and 31 to 100 percent respectively, owes to the introduction of metro rail result in Delhi.

J.C.Golias [4] focused on examining the results on mode of choice from the introduction of a new Metro system in the Athens city. The results of this paper shows that the new Metro system has attracted a large number of bus riders (53%) and smaller number of private vehicle users (24%).

K.Chakraborty et.al [5] evaluated and analyzed socio-economic impact of existing metro stations of Bangalore they focused on certain areas like purpose of using metro, frequency of using metro, distance wise metro using by dwellers, means of communication to avail metro, dwellers income and metro, etc. They also present recommendations where they are needed.

K. M. Neware[6], analyzed the effect of Nagpur metro rail on use of transport modes especially private mode such as two wheelers and four wheelers and comparison of fuel consumption and emission saved after introduction of metro rail in Nagpur city.

Murty M N et.al. [7] studied and performed the social cost-benefit analysis of Delhi Metro Phase 1 and Phase 2 projects covering a total distance of 108 km in Delhi. The economic rate of return is 24 percent after accounting for benefits from the reduction of urban air pollution due to the Metro has increased the economic rate of return by 1.4 percent.

According to the report [10], the introduction of this metro rail project, Ahmadabad city resulted in the reduction in number the vehicular traffic which ultimately reduces noise level. This in turn resulted in significant social and economical benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers.

S.Nikfalazar et.al [11] this paper concentrates on evaluating the impacts from the construction of metro by observing and interviewing via a questionnaire which includes demographic questions and questions about using metro and its impact on Tehran city. It also, shows how many people should at least respond the questionnaire.

R.Goel et.al [12] studied the benefits of a low cost and carbon mass rapid transit system for the urban cities in India. The study also shows statics of the revenue generation.

III. METHODOLOGY

The traffic forecast data for determining the number, movement and classification of roadway vehicles at a given location or point of traffic study along the routes of Pune metro is obtained from detailed project report prepared by “Delhi metro rail corporation Ltd.” for Pune municipal corporation [2]. Closed-ended form of questions has been adopted for this study in a well-structured form. The questions required for evaluating a socio-economic impact have been considered while designing the questionnaire [5]. The questionnaire was distributed among the road users such as motorcyclist, car driver, pedestrians and public transport users. In addition to this, Google forms link was used to distribute the questionnaire on social media platforms. For determining the sample size for a finite population, Krejcie and Morgan [11], sampling method was used to calculate required sample size to analyze social and economical impact of Pune Metro on Pune city. The data so obtained from questionnaire and Google forms was interpreted to assess the socio-economic impact of the metro rail on Vanaz-Ramwadi corridor. The limitations faced while carrying out the survey are the sample size, sample error, accuracy of data, non-respondents to survey.

3.1 Data collection

To start a survey finding the number of samples that should be collected is important. In fact, it shows how many people should at least respond the questionnaire. Following formula is used for determination of sample size;[14]

$$n = \frac{z^2 * N * \sigma_p^2}{(N - 1)e^2 + z^2\sigma_p^2}$$

Where, n= Sample size, N= Population of city, Z=Critical value, σ =Standard deviation
e=Acceptable error

$$n = \frac{1.96^2 * 6000000 * 2^2}{(6000000 - 1) * 0.2^2 + (1.96^2 * 2^2)}$$

n = 384.13 ≈ 385

The confidence level used for determination of sample size is 95% with critical value of 1.96. Population of Pune city is around sixty two lakhs while acceptable error is assumed to be 0.2. So the sample size obtained by considering above constants is 384.

3.2 Preparation of Questionnaire

The form of questions adopted for this project is closed question and in well-structured form. The questions required for evaluating socio-economic impact has been considered and grouped appropriately while designing the questionnaire.[5] Structured questionnaire are easy to control and moderately reasonable to investigate. Question-succession ought to go from the general to the more explicit so towards the end so that regardless of whether the respondent chooses not to address such inquiries, impressive data would have just been gotten. In general, all questions should be easily understood and should be very simple. They should be concrete and should conform as much as possible to the respondent’s way of thinking and should not bias the answer. Multiple choice or closed questions have the advantages of easy handling, simple to answer, quick and relatively inexpensive to analyze. To be effective, survey ought to be nearly short and basic i.e., the size of questionnaire should be kept to the minimum. To influence the review work less dull we to have, utilized free online apparatus known as Google structure. This apparatus is extremely simple to utilize. The fundamental trouble at the season of study was to meet the vehicle clients to beat this trouble Google structure assumed imperative job. It encourages us to achieve the vehicle clients effectively and rapidly. The connection of Google structure was shared through WhatsApp and sends.[14]

IV.

V. STUDY AREA

Vanaz-Ramwadi corridor of Pune Metro is taken as study area. The survey was carried along this route. The data is collected from the road users who frequently use this route for various purposes like education, jobs or service, shopping or for any other purposes. The survey is carried out along the route as well as in the areas which are near to the route (500 meter to 1 kilometer). The main proposed metro stations have been approached for data collection where the maximum actual road users were interviewed.

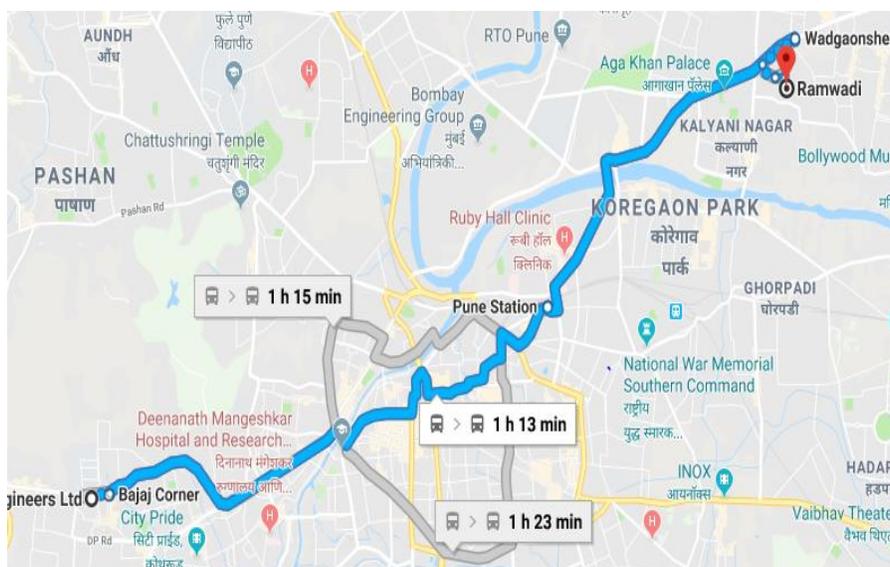


Figure 4.1:- Route map of study area

4.1 Current mode of transport

In this study maximum numbers of two wheelers have been approached followed by car and bus users. According to economic survey, Pune has highest number of two wheelers users which is also evident from the pie chart that 42.9% of the interviewee involved in survey were using two wheeler as their mode of transport while 26.2% were using bus, 17.7% were car users followed 13.2% as auto-rickshaw users.

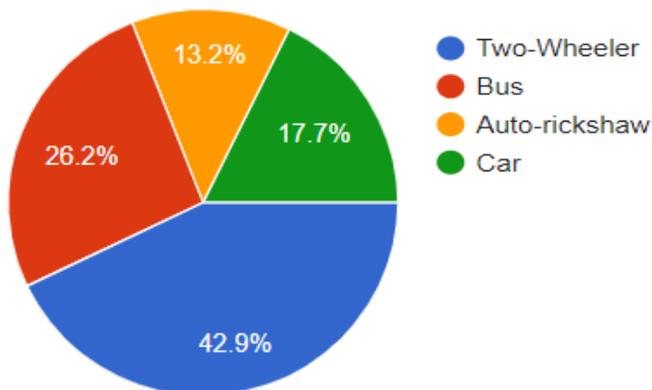


Figure 4.1:- Current mode of transport

4.2 Number of People Willing To Use Metro

During the survey commuters were asked whether they are willing to use metro or not. From the analysis it was found that as much as 69.1% of the people are willing to opt metro while 30.9% of the people are not willing to select metro. While carrying out the survey interviewees were simultaneously asked the reason for saying yes or no.

Some of the common reasons given by 69.1% of people who said yes are as follow:

1. Reduction in journey time.
2. Reduction in traffic congestion.
3. Eco-friendly.
4. Less ground space occupation.

Reasons given by 30.9% of the peoples saying no are as follow:-

1. Availability of required things in nearby places.
2. High ticket cost.
3. Long distance of metro station.

By comparing the pie charts of “current mode of transport” and “people willing to use metro” it is observed that maximum numbers of people who are willing to opt metro are currently using two wheeler and bus as their mode of transport while those who said no for using metro are most of the car users.

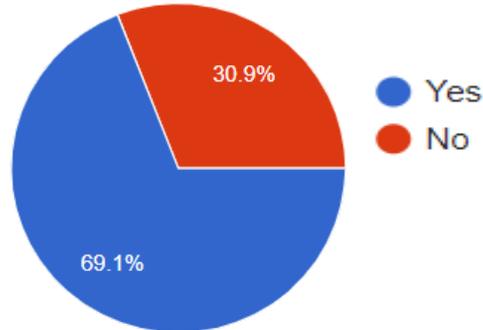


Figure 4.2:- Number of people is willing to use metro

The car users are generally of high economic stature and do not prefer common mode of transport as they believe in having more privacy during their travel. As there will be reduction in number of vehicles on the road, operation and maintenance charges of the commuters will reduce. There could be cost saving to commuters in terms of capital cost and operation and maintenance costs of vehicles if they switch over from road to metro.

4.3 Distance of Metro Station From Commuters Residence

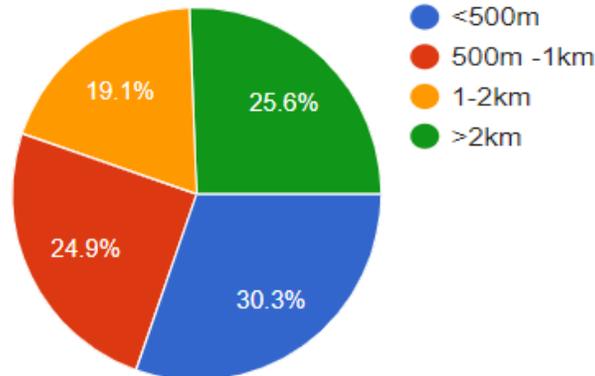


Figure 4.3:- Distance of metro station from commuters residence

The above figure shows the relation between distance and percentage of commuters willing to use metro. From the above pie chart it is observed that 30.3% of the surveyed commuters will travel from less than 500 meter to avail metro, 24.9% of the commuters will travel from less than 1 kilometre, 19.1% will travel from 1-2 kilometres and 25.6% of them will travel from greater than 2 kilometres. From the above chart it can also be observed that 74.3% of the commuters residing within 2 kilometres will make maximum use of metro.

4.4 Means of Commutation Up to Metro Station

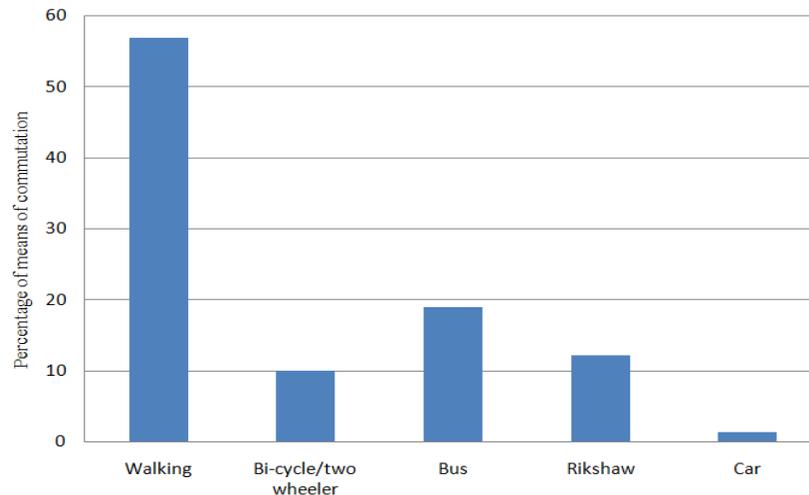


Figure 4.4:- Means of communication up to metro station

From the survey it is observed that about 57% of the commuters who are willing to use metro travel primarily by walking to metro station. Two wheelers including cycles are important mode of transportation accounting 10.1%. It is interesting to note that 19.1% of commuters will use the feeder bus made available till the metro station. Percentage of commuters willing to use rickshaw are 12.3% whereas Percentage of commuters willing to use car add up to very low percent of 1.4.

4.5 Frequency of Using Metro

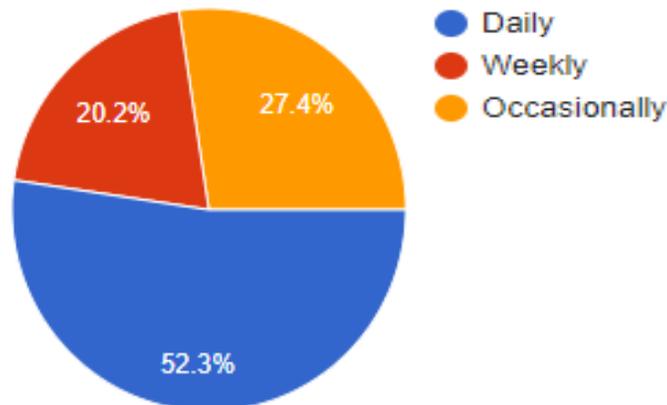


Figure 4.5:- Frequency of using metro

From the above pie chart it is observed that the 52.3% of commuters willing to use metro fall under the category of daily users is maximum, while 27.4% of commuters will be using metro occasionally whereas only 20.2% of people will be using the metro on weekly basis.

4.6 Purpose of Using Metro

From the surveying it has been observed that there are many schools and colleges on the Vanaz-Ramwadi metro route therefore maximum number of commuters on the particular route were students and they prefer to use metro daily as their means of communication. So it is evident that education is the prime purpose of commuters on this particular route. The second most important purpose of using metro is service or job accounting 30.7%. While shopping and other account for 26.7%, being the least.

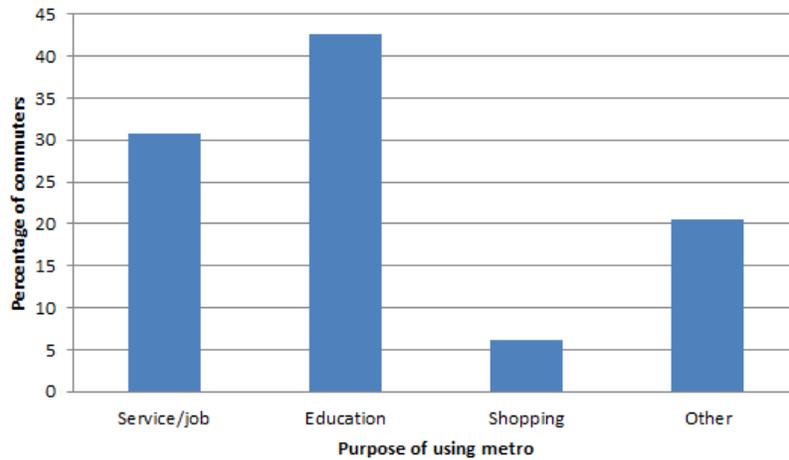


Figure 4.6:- Purpose of using metro

4.7 Commuters Income and Metro

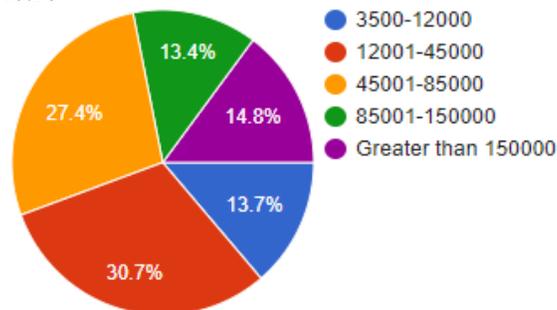


Figure 4.7.1:- Commuters willing to use Metro and their income

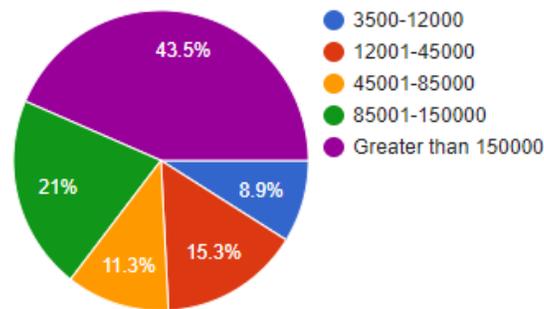


Figure 4.7.2:- Commuters not willing to use Metro and their income

It is observed that 58.1% in general commuters of middle income group (12000 to 85000 per month) are more inclined to use metro. Whereas 64.5% of the total surveyors not willing to use metro are from higher income group (85000 to 150000 per month). From the above two charts is evident that people from middle income group are more keen to use metro as they prefer to travel economically while commuters from higher income group prefer comfort over economy.

4.8 Impact of Metro From Commuters Perspective

During the survey commuters were asked to prioritize the impact of metro on their life. They have given the ratings for the impacts mentioned in the questionnaire on the scale of 1 (highest) to 4 (lowest). Following figure shows the ratings given by the commuters travelling on the route. From the commuters perspective it has been observed that maximum number of commuters thinks that metro will have a major impact on saving in travel time of journey followed by saving in fuel and money. They also think that metro will have moderate impact on reduction in traffic and accidents and least impact on reduction in air pollution.

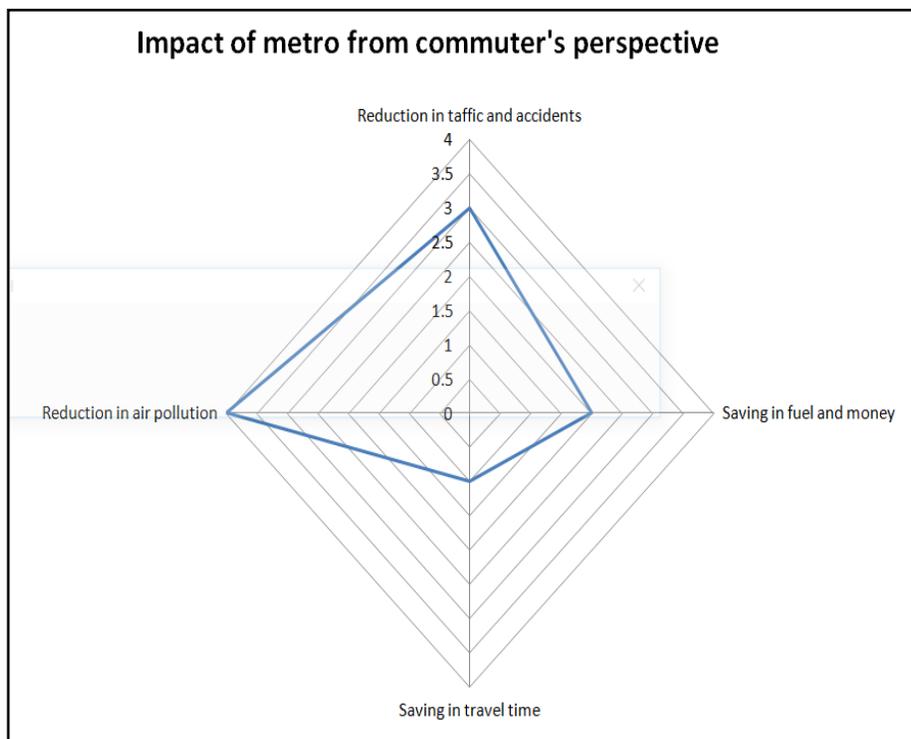


Figure 4.8:- Rating given by metro users

VI. ANALYSIS OF DATA

Analysis is the detailed examination of the data collected to draw some meaningful conclusion. The data has been collected questionnaire and google forms. Google Forms is a tool within Google Drive for creating online survey forms. Google form provide easiest and simplest way of analysing the questions framed in questionnaire. The collected data is inserted in excel sheet and the graphs are plotted according to requirement.

5.1 Reduction In Traffic Accidents And Noise Pollution

From the above graph it is observed that 69.1% of the surveyed people will be making use of metro. Also relating this to the number of vehicles used by them we can interpret that the two-wheelers and cars used by them will go off the road thus directly reducing the accidents and noise pollution. Currently the average noise pollution on the route is 70.28 decibels while it is increasing during the phase of construction. After the completion of construction work it will again reduce subsequently as number of commuters will opt metro.

5.2 Saving In Fuel Consumption

Traffic forecast on Vanaz-Ramwadi corridor:

Year	Traffic volume
2018	189307
2021	212019
2031	290515

(Source:- Pune metro DPR)

Table 5.1:- Fuel consumption

Traffic mode	Diverted traffic	Fuel consumption norm	Average daily run	Fuel savings (in litre's)	Value of fuel saving (in Rupees)

Cars	5777	13	30	13,287	9,04,047.48
Two-wheeler	111716	35	25	79,797	62,48,903.07

Notes: For cars using diesel, price is Rs. 68.04/lit

For two-wheelers using petrol, price is Rs. 78.31/lit

The fuel consumption of two wheelers and four wheelers on Vanaz-Ramwadi corridor before and after implementation of metro is calculated. The cost of fuel saving is calculated by considering the fuel consumption norm and assuming average daily run, the total fuel saved in litre's due to the diverted traffic.

5.3 Reduction In Air Pollution Load Due To Decongestion

According to the Indian Institute of Tropical Meteorology (IITM) data the city's air pollution has increased by 35.7% since 2010.

Table 5.2:- Vehicular inventory of pollution load by vehicles

	PM	NO _x	HC	CO
Two-wheeler	1.22	0.52	33.98	64.39
Car	2.57	33.06	52.89	281.37

Reduction In air pollution due to traffic diverted by metro on Vanaz-Ramwadi corridor

Table 5.3:- Reduction in air pollutants

	Traffic diverted	PM	NO _x	HC	CO
Two wheeler	111716	0.136	0.058	3.796	7.193
Car	5777	0.014	0.191	0.305	1.625

After analyzing all the surveyed data it has been observed that efficiency of metro, time saving, safety and comfortless during the travel attracts the most of the people and automatically forced the citizens of Pune to prefer the use of public transport i.e. metro over the private vehicles. This will result in reduction in number of vehicles.

5.4 Saving In Passenger Time

The saving of travel time of passengers travelling by the metro on Vanaz-Ramwadi corridor instead of by road are calculated by the following formula;

$$T = (D/Sc) - (D/Sd)$$

(Source: report of Delhi metro)

Table 5.4:- Saving in passenger time

Mode	D (km)	Sd (km/hr)	Sc (km/hr)	T (hr)
Car	30	20	17.24	0.24
Two-wheeler	25	22.38	18.75	0.22

The time required for cars and two-wheelers to complete one trip along the Vanaz-Ramwadi corridor in congested and decongested situation is calculated. In decongested situation cars and two-wheelers took 45 minutes and 40 minutes respectively, where in congested situation it was observed to be 52 minutes and 48 minutes respectively. The time saved by shifting to metro rail from other modes was found to be 14.4 minutes and 13.2 minutes for cars and two-wheelers respectively.

VII. CONCLUSION

From the survey it is observed that currently the major source of commutation is two wheeler which accounts to be 42.9% of the total number of vehicles and nearly 69.1% of the current commuters have shown interest in using metro. Nearly 55.2% of commuters residing within one kilometre from the metro rail station will prefer walking rather than using any other means of transport. About 52.3% of the commuters will be using metro daily rather than occasionally for the purpose of education followed by service. Metro is popular to middle income group of commuters as there is subsequent cost saving for them as they prefer economy over comfort and privacy.

The major economic impact of the metro will be resulting from fuel saving due to reduction in number of vehicles used by commuters thus could result in savings of foreign exchange of the government and also there will be cost saving to passenger in terms of capital cost and operation and maintenance cost. Furthermore it is observed that about 50% of the vehicles will go off the road thus reducing air pollution, noise pollution and traffic congestion.

The Pune metro provides multiple benefits such as reduction in air pollution, time saving of passengers, reduction in accidents, reduction in traffic congestion and fuel saving thus impacting the socio-economic status of the commuters on Vanaz-Ramwadi corridor.

REFERENCE

1. Bharath.K., Shishir K Jain, KottamVarun, Ramakrishna N. "Economic Analysis of Hyderabad Metro Rail Project". *International Journal of Technology*, July – December, 2015; Vol. 5: Issue 2, 297-303
2. Detailed Project Report for Pune metro, prepared by Delhi Metro Rail Corporation Ltd., 2009
3. D.Goel and S.Gupta, "The effect of metro rail on air pollution in Delhi.", *Centre for Development Economics*, 2014
4. J.C.Golias, "Analysis of traffic corridor impacts from the introduction of the new Athens Metro System", *Journal of Transport Geography*, June 2002; Vol. 10, Issue 2, 91-97.
5. K.Chakraborty and T.G.Sitharam, "A methodology to evaluate socio-economic impact of metro railway stations of Bangalore: from dwellers perspective report." *IISC Bangalore (March 2013)*
6. K.M. Neware (2018), "Impact of Nagpur metro on other transportation modes in terms of fuel consumption parameters." *IJIES*, 2018, Vol. 3, No.4, 2018
7. M.N.Murty, K.Dhavala, M.Ghosh and R.Singh, "Social Cost-Benefit Analysis of Delhi Metro", *Institute of Economy Growth, Delhi*, 2007, MPRA Paper No. 1658.
8. N.Sharma, A.Singh, R.Dhyani and S.Gaur, "Emission reduction from MRTS projects- A case study of Delhi metro", *Atmospheric Pollution Research*, 2014, Vol. 5, Issue 4, 721-728.
9. P.Chib, "Optimization of Pune Metro Rail", *IJETT*, 2014, Vol.17.297-304
10. Report on Environmental impact assessment study for Ahemdabad metro rail project.
11. S.Nikfalazar, M.Amiri and H.A.Khorshidi, "Social impact assessment on metro development with a case study in Eastern District of Tehran", *International Journal of Society Systems Science*, 2014, Vol.6, Issue 3.
12. G.Tiwari, "Metro systems in India: Case study DMRC, promoting low carbon transport in India." *UNEP*, 2014.
13. W N Deulkar and A F Shaikh, "Pune metro rail project: A review", *IJSCER*, 2015, Vol. 4, No. 1
14. C R Kothari and G. Garg, "RESEARCH METHODOLOGY: Methods and techniques (Third edition)." *NEW AGE INTERNATIONALS PUBLISHERS*, 2016.