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Feasibility Study of Metro Rail Project in Nagpur City

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ABSTRACT: Metropolitan cities in India are highly witnessing the population growth and consequently the increase in traffic volume in their transport corridors. For smooth running of the transportation system it is necessary to provide them with alternative mode of transportation which is time saving and eco-friendly. The growing demand for public transport in cities has serious effects on urban ecosystems, especially due to the increased atmospheric pollution and changes in land use patterns. An ecologically sustainable urban transport system could be obtained by an appropriate mix of alternative modes of transport resulting in the use of environmental friendly fuels and land use patterns. Transport, because of its pervasive nature, occupies a central position in the fabric of modern urbanized society. In most of the countries, this has been a story of evolutionary change with new transport development replacing the old transport system in response to perceived socio economic needs of the people.
Implementation of such modern transport system of Metro Rail facility to NAGPUR city is the ultimate aim of this project. Metro Route Maps are created as per traffic study and evaluated in accurate manner by using GIS, Global Mapper and find out shortest feasible route. The cost-benefit analysis are done in this research tries to measure all benefits and costs.

I. INTRODUCTION

Nagpur is the largest city of Maharashtra and also the winter capital of the state. With a population of approximately 27 lakhs, Nagpur Metropolitian Area is the 13 largest urban conglomeration in India. In addition to being the seat of annual winter session of Maharashtra state assembly "Vidhan Sabha", Nagpur is also a major commercial and political center of oranges that are cultivated in the region. Nagpur lies precisely at the center of the country with the zero mile marker indicating the geographical center of India. Cotton production not only strengthened the area's traditional hand-loom industry but also led to the establishment of a large textile mill and signaled the development of the city as an important industrial centre. Since that time, Nagpur's industrial complex has diversified considerably. In the 1970s the city expanded to absorb the nearby town of Kamptee, with its factories that produce ferromanganese products, transport and farm equipment, and other metal goods from local mineral deposits (notably coal and manganese). The city, situated at the strategic junction of road, rail, and air routes from Mumbai (Bombay) to Kolkata (Calcutta) and from Chennai (Madras) to Delhi, also developed a flourishing trade sector. More recently, technology-related activities (especially software development) became more important.

1.1 Problem Definition

As the amount of population has increased, there have been a consistent in increasing number of local travelling as the population has increased. Increasing demand in local passengers places great strain on existing transit system especially in crowdie areas.

1.2 Objectives of the Study

a) To identify existing issues related to passengers.
b) To study the solutions for the feasibility of metro rail.
c) To conduct survey which will intimate the need and choices of the local passengers.
d) To suggest suitable solutions on existing as well as future needs by forecasting the predictions based on past and present data and most commonly by analysis of trends.
e) To reduce the burden on the transit service.
f) To propose the new route of Metro rail transport according to demand.

1.3 Methodology used for the Study

The framework of methodology for this study is comprises in following states:
a) Data collection
b) Application of Least Square Method to project future trend of passengers

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c) Application of a powerful multicriteria decision- making tool; Analytic Hierarchy Process (AHP) method to structures a decision problem into a hierarchy with a goal, decision criteria, and alternatives.

II. RESEARCH METHODOLOGY

In recent years, and especially since the early 1990s, the increase in road traffic and in the demand for transport have caused serious congestion, delays, accidents and environmental problems, above all in large cities. Traffic congestion has become a veritable scourge which plagues industrialized countries and developing nations alike. It affects both motorists and users of public transport, and as well as reducing economic efficiency it also has other negative effects on society. The woes of local residents are compounded by unauthorized hawkers in commercial areas. City buses having their own problem of parking and operating. In Nagpur nearly 240 city buses are serving the public, but these buses are passing though some congested areas of Nagpur like MAHAL, ITWARI, COTTON MARKET etc. so generally public of Nagpur face the traffic congestion problem. Because of this timing of buses get disturb. Presently Nagpur having their own 240 private public transport system (city buses). In 2016 Nagpur get 414 city buses to serving the increased population of Nagpur and in 2020 this numbers will be 523 at present there are 171149 private autos which stimulate the traffic congestion problem in city.A lack of parking is not the sole reason for traffic congestion; it is, however, a major contributing factor. Drivers looking for free or low-cost on-street parking may bypass off-street parking simply to save money and contribute to traffic congestion. Off-street parking located too far away from shopping or retail businesses may also cause drivers to circle in search of parking that is more convenient.

2.1 Alignment of Metro Rail

2.2.1 Phases of Metro Rail in Nagpur

Phase – 1: Automotive Square at Kamptee road - via Sitabuildi – Airport – Mihan (19.66km)
Phase – 2: Prajapati Nagar (via Sitabuildi) – Hingna (18.56km)
Proposed Phase – 3: Wadi – Medical square – Mahal – Automative Square (36km)

2.2 Traffic Volume Count (TVC)

To understand traffic characteristics in terms of vehicular, passenger and PCU, 40 traffic count stations were identified. These count stations were so chosen as to cover major inter-zonal traffic movements within the city. These were located on major arterial roads some of which will be eventually used as path of proposed metro alignment. Some locations were fixed as screen line points and some were as outer cordon points. Outer cordon points are for checking external trips which enters and exits the city. Passenger occupancy survey was also simultaneously taken up to estimate passenger flow on roads. Passenger occupancy survey was to visually estimate how many passengers were travelling in a bus, car, auto or scooter. These were done on sample basis (in every 15 minute interval) as counting of passengers in every vehicle (especially bus) was not possible.

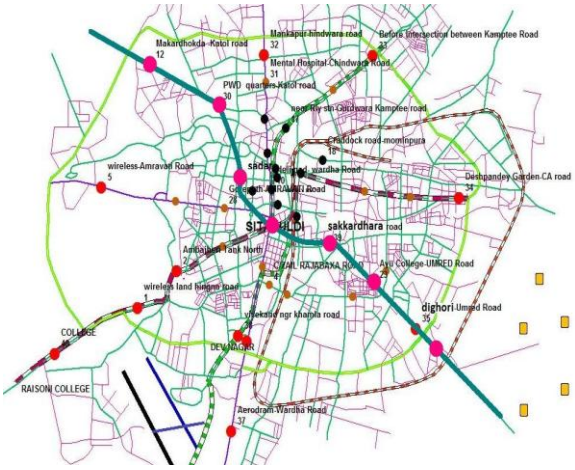

Figure 2.1: TVC points in Nagpur

2.3 Study of Alignment

From above TVC survey we studied the vehicular and passenger traffic of 40 different point of city. This survey can be calculated by manually or by the instrument. From this above table we sort out some points on the basis of maximum vehicular and passenger density. If we join that point we get 3 different phases of Nagpur Metro rail. This phases are passing through the important area of Nagpur with Sitabuildi is the central and interchanging Station. . From this survey we can sort out that area or that route where the vehicular traffic cross the road feasibility limit means 8000PHPDT. Road base system is feasible upto 8000 PHPDT, above this limit mass rapid transit system is to be provided. There are 25 points which are used by maximum number of passenger and vehicles. Traffic densities of that important point are given below.

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2.3 Vehicular and Passenger Traffic on Phases

Phase – I

TVC	Passenger Traffic	Vehicular Traffic
10	139631	30745
08	148996	27540
26	234228	26561
36	157681	33875
37	120926	22663
32	67447	13320
31	84956	17623
16	136751	20534
15	141858	29554

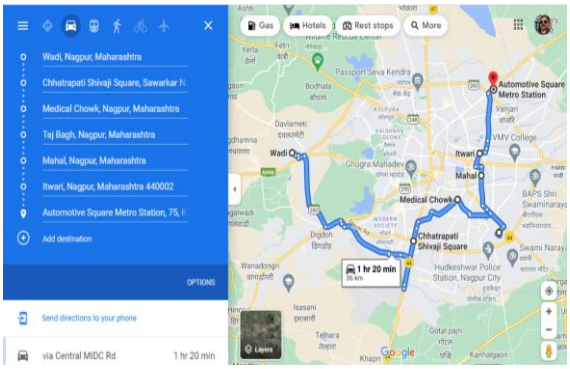
Phase – II

TVC	Passenger Traffic	Vehicular Traffic
34	191285	25008
21	67343	16604
20	107116	21536
03	127135	23971
07	117908	26166
05	61180	19858
24	78767	21606
02	59016	13940

2.4 Proposed Alignment for Phase – III

Considering the utility of Phase – I and Phase – II, another Phase – III is proposed which can make the ease to passengers. The route proposed is:

Wadi
↓
Chhatrapati Square
↓
Medical Square
↓
Tajbaugh
↓
Mahal
↓
Itwari
↓
Automotive Square



2.5 Terminal Study

To check the feasibility of metro rail we have to check the magnitude of passenger at different terminal in the city, on the basis of this data we get the rough idea about how much passenger may use Metro. Bus and Rail Terminal station were surveyed mainly to understand the magnitude of passenger. There are 3 railway stations and 7 bus terminals in Nagpur city. So there are 110945 incoming passenger at different terminal of Nagpur city and 117632 number of passenger use that terminal as outgoing passenger. From this data we can found that which terminal is used mostly by the passenger (incoming + outgoing). However the Nagpur main railway Station, Ajani rail station may be considered as an extended part of Nagpur Rail Station and main bus station is mostly used by commuters. So the provision of Metro station nearer to that terminal is feasible.

Table 2.1: Study of incoming and outgoing passengers

S No.	Category	Incoming	Outgoing
1	Nagpur Main Station	33452	33238
2	Ajni Railway Station	2538	5396
3	Itwari Railway Station	5122	8402
4	Sitabuldi bus stand	7845	10100
5	Ganeshpeth bus stand	32431	33001
6	Ravi Nagar Bus stand	9500	9020
7	Chattrapati Sqaure	3820	7600
8	Gandhibaug Bas Stand	1875	1750
9	Indora	4062	3125
10	More bhavan Bus Stand	10300	6000

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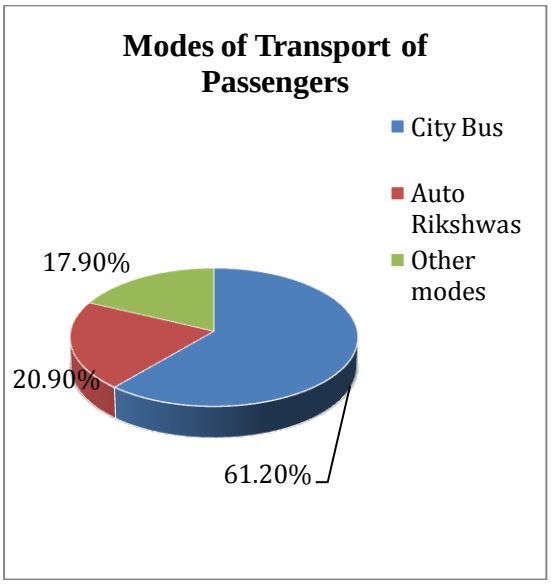
2.6 Terminal Passenger Interview

There are 7 main stops in Nagpur city which is use daily by most of passenger for travel purpose. 120 passengers were interviewed at 7 main bus stands for knowing their travel characteristic. While most of the passenger i.e. 61.2% of passenger use city bus for access and dispersed to. Other than city bus there is large number of passenger i.e. 20.9% of passenger use Auto Rickshaw from various terminal of city. While use of other modes are very low. 17.9% passenger of passenger use other modes. For rail passenger, for access and dispersal, auto rickshaw is used and low use of other modes (except train) indicates, people directly goes to their destination on foot.



Graph 2.1:Modes of Passenger Transport

III. DATA CALCULATION

Forecasting is the process of making predictions based on past and present data and most commonly by analysis of trends.

Quantitative forecasting models are used to forecast future data as a function of past data. They are appropriate to use when past numerical data is available and when it is reasonable to assume that some of the patterns in the data are expected to continue into the future. In our research we used **Least Square Method** to predict the total passenger traffic of each location in 2046.

3.1 Least Square Method (LSM)

The least-squares method is often applied in data fitting. The best fit result is assumed to reduce the sum of squared errors or residuals which are stated to be the differences between the observed or experimental value and corresponding fitted value given in the model. The equation of least square line is given by

$$Y = a + bX.$$

Normal **equation** for 'a':

$$\sum Y = na + b\sum X.$$

Normal **equation** for 'b':

$$\sum XY = a\sum X + b\sum X^2$$

Table 3.1: Calculation of projected passenger traffic in 2046 at Wireless Land – Hingna Road

Yr.	**Value**	**Deviation**		
X	**Y**	**x**	**xy**	**x^2**
2015	93847	1	93847	1
2016	105642	2	211284	4
2017	111829	3	335487	9
2018	113665	4	454660	16
	$\sum Y$ = 424983	**$\sum x$ = 10**	**$\sum xy$ = 1095278**	**$\sum x^2$ = 30**
2019	**?**			
2020	**?**			
|	**?**			
|	**?**			
2046	**?**			

Normal **equation** for 'a':

$$\sum Y = na + b\sum X.$$

$$424983 = 4a + 10b \text{ -------- (1)}$$

Normal **equation** for 'b':

$$\sum XY = a\sum X + b\sum X^2$$

$$1095278 = 10a + 30b \text{ -------- (2)}$$

So we have these two equations

$$424983 = 4a + 10b$$

$$1095278 = 10a + 30b$$

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Multiplying equation (1) by 10 and equation (2) by 4, so we get

4249830 = 40a + 100b

4381112 = 40a + 120b

Subtracting eq. (2) from eq. (1), we get

- 131282 = - 20b, So, b = 6564.1

Putting value of b into eq. (1)

424983 = 4a + 10 x 6564.1

424983 = 4a + 65641

4a = 424983 – 65641

4a = 359342 So, a = 89836

Now to calculate projected volume in 2046, we know that, the equation of least square line is given by

Y = a + bX

Where, X is determined value ie 32

The projected volume in 2046

= 89836 + 6564.1 x 32 = 299887

So the projected passenger traffic at Wireless Land – Hingna Road in 2046 is 299887.

Using above mentioned calculation method, we have calculated the expected passenger traffic for remained places in 2046.

Table 3.2: Projected Passenger Traffic of other locations

Location	Projected Passenger Traffic in 2046
Ambazhari Tank North	162956
Wireless – Amravati Road	240629
Near Rly Stn-Gurudwara Kamptee Road	265038
Indora – kamptee Road	204743
Hingna Road Raisoni College	200623

3.2 Analytic Hierarchy Process (AHP)

The analytic hierarchy method (AHP) developed by Saaty, is a powerful multicriteria decision-making tool that has been used in numerous applications in various fields of economics, politics and engineering. AHP structures a decision problem into a hierarchy with a goal, decision criteria, and alternatives. It has multi-level hierarchical structure of objectives, criteria and alternatives. It is a method for assessing and prioritizing options. The AHP guides practitioner to use a set of pairwise comparisons to derive the pertinent data. These comparisons are weighed and measured for each individual decision criterion. Based on the questionnaire survey, the weightage of decision is calculated. We have seven attributes as:

1. Reduction of the traffic congestion
2. Ease for movement in the city
3. Best mode of transportation
4. Reduction in pollution
5. Able to reach the destination in time
6. Necessity of Metro rail
7. Reduction of the parking congestion

Table 3.3: Weights after calculation by AHP method

Attribute or Criteria	Criteria Weights
Reduction of the traffic congestion	0.52
Ease for movement in the city	0.42
Best mode of transportation	0.26
Reduction in pollution	0.31
Able to reach the destination in time	0.41
Necessity of Metro rail	0.8
Reduction of the parking congestion	0.52

3.3 Cost Estimation

While preparing the capital cost estimates, various items have generally been grouped under three major heads on the basis of (i) route km length of alignment, (ii) number of units of that item, and (iii) item being an independent entity. All items related with alignment, whether elevated or at grade or underground construction, permanent way, traction, signaling & telecommunication, whether in main lines or in maintenance depot, have been estimated at rate per route km basis. The construction cost of each phase is calculated by multiplying the phase distance with per km construction cost. The cost required for each phase is given in table below.

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Table 3.4: Cost Estimation for Phases I – III

Phase	Name of phase	Dist. (Km)	Estimated cost (cr)
I	Automotive sq. at kamptee to Mihan	19.66	4463
II	Wadhamannagar to Hingna	18.56	4213
III	Proposed Route: Wadi – Automative Square	36	9000
	Total	**74.22**	**17676**

IV. RESULTS AND DISCUSSION

4.1 Projected Passenger Traffic

Using LSM method we got the result as follows:

Table 4.1: Projected passenger traffic after 25 years using LSM method

Location	Projected Passenger Traffic in 2046
Wireless Land – Hingna Road	299887
Ambazhari Tank North	162956
Wireless – Amravati Road	240629
Near Rly Stn- Gurudwara Kamptee Road	265038
Indora – Kamptee Road	204743
Hingna Road Raisoni College	200623

From the data we got from authentic sources of last four years (2015 – 2018) we have calculated the projected passenger traffic volume of 2046. From the result it is observed that the increase in passenger traffic sequentially are Wireless Land – Hingna Road, Near Rly Stn-Gurudwara Kamptee Road, Wireless – Amravati Road, Indora – kamptee Road, Hingna Road Raisoni College & Ambazhari Tank North resp. Considering the location of above places we need to concentrate on an effective transit system. In such case Metro rail is the best option.

4.2 Analytic Hierarchy Process (AHP)

As we know, we have collected data of 128 candidates using google form. In that we asked them to rate attributes in comparison with another attributes. After collecting their response we have applied AHP on the data, where we get the result of their preference:

1. Respondents have given 80% weight to necessity of Metro rail.
2. Respondents have given 52% weight to reduction in traffic and parking congestion.
3. Respondents have given 42% weight to ease for movement in the city.
4. Respondents have given 41% weight to reaching destination in time.
5. Respondents have given 31% weight to reduction in pollution.
6. Respondents have given 26% weight to mode of transportation as the best.

From the above result, we can conclude that while decision making the above factors should be considered.

V. CONCLUSION

This research was carried out to study the feasibility of the Nagpur metro rail project. The study involved through the review of numerous literatures and articles which are published in India and abroad which focuses on analysis of various infrastructure projects as well as metro rail projects.

This study involved the unstructured interview method as the construction scope is large. We had taken interviews of passengers associated with regular travelling. On the basis of the responses received we have given relative importance index scale for decision making.

In this study, a systematic comparison was done to analyse the proposal of Phase – III. One forecasting method and prediction model (LSM and AHP) were used to develop prediction model. To implement the models, numerical experiments were conducted to predict the expected traffic after 25 years, located in various places in Nagpur city, of different scales and types.

Our focus was to propose the Phase – III of metro rail. There are lots of solutions, some are short term and some are long term basis, but we need to work on the basis of long term plan and at the same time take care of discomforts or problems. We need the authority that can look after the construction and development of metro project. The authority should make master plans this project which will help us in reducing the traffic congestion. So this mode needs to be promoted in the city among passengers.

REFERENCES

[1]. **Kassiani Tsimplokoukou, Eleni Sfakianaki, George Metaxas**, "*A feasibility study approach for underground railways - A case study: Line 4 of Athens metro*",

Global Journal of Engineering Education, Volume 14, Number 1, 2012.

[2]. **Akshay M. Ramteke, Prof. Vishal Gajghate,** *"Feasibility Study of Metro Rail Project in Nagpur City"*, International Journal of Advance Research In Science And Engineering, IJARSE, Vol. No.4, Issue 04, April 2015.

[3]. **Ashish Wanve , Gaurank Patil , Lavina Karva , Zankhil Patel , Hitesh Mistry , Aditya Kumar Sethi , Kalpesh Kholi,** *"Constructability & Cost Feasibility Analysis of Pune Metro Rail Project Including Planning & Design Specifications"*, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 8, Issue 2, February 2019.

[4]. **Rahul Goel, Geetam Tiwari,** *"Case Study of Metro Rails in Indian Cities"*, UNEP Risø Centre on Energy, Climate and Sustainable Development, Technical University of Denmark, June 2014.

[5]. **Prateek Malhotra, Ajay K. Duggal,** *"Feasibility Study of Metro Rail Project in Chandigarh City"*, International Research Journal of Engineering and Technology (IRJET), Volume: 03 Issue: 07, July-2016.

[6]. **R. Hemavathi, M. Meenakshi,** *"Feasibility Study of Metro Rail Project in Coimbatore City"*, International Journal of Engineering Research And Management (IJERM), Volume-06, Issue-11, November 2019.

[7]. **S. M. Subash, K. Chandrabose, U. Uma Maheshwari, T. Maharajan,** *"Feasibility Study of Metro Transport: Case Study of Madurai"*, International Journal of Civil Engineering and Technology (IJCIET), Volume 4, Issue 4, July-August (2013).

[8]. **Nippon Koei,** *"Joint Feasibility Study for Mumbai-Ahmedabad High Speed Railway Corridor"*, Ministry of Railways, Republic of India(MOR), Volume 1, July 2015.

[9]. **Niju A. S., Anu A., Shiv Shankar Nair,** *"Numerical Analysis of a Framed Structure Subjected to Metro Rail Loads"*, International Research Journal of Engineering and Technology (IRJET) Volume: 06 Issue: 10, Oct 2019.

[10]. **Abhishek Kumar, Rahul Shinde,** *"Pragmatic Study of Government Policies for Metro Rail Project in India"*, International Journal of Scientific Research in Science, Engineering and Technology, IJSRSET, Volume 2, Issue 4, July 2014.

[11]. **Sinto K. A., Ms Saranya S.,** *"Risk Management Analysis on Cochin Metro Rail Project"*, International Research Journal of Engineering and Technology (IRJET), Volume 06, Issue: 05, May 2019.

[12]. **Pallavi S. Deore, R. M. Jadhav,** *"Structural Engineering Aspects of Metro Rail Projects"*, International Research Journal of Engineering and Technology (IRJET), Volume: 06, Issue: 06, June 2019.

[13]. **Bhandekar Praveen P., More Ashok. B.,** *"Time Overrun in Transportation Project - A Case Study of Mumbai Monorail"*, International Research Journal of Engineering and Technology (IRJET), Volume: 04 Issue: 07, July -2017.

[14]. **Sujit Kadam, Atul Autade, Hrishikesh Mane, Akshay Chakke, Abdul Malik Chaudhari, Prof. V. R. Turai,** *"Feasibility Analysis of Pune Metro from Ramwadi to Ranjangaon"*, Journal of Advances and Scholarly Researches in Allied Education Vol. XV, Issue No. 2, (Special Issue) April-2018.

[15]. **Deulkar W. N., Shaikh A. F.,** *"Pune Metro Rail Project: A Review"*, International Journal of Structural and Civil Engineering Research (IJSCER), Vol. 4, No. 1, February 2015.

[16]. **Dr. S. Moses Santhakumar, G. Gokuldas and P. Partheeban**, "Transportation system management for Madurai city using GIS" – Map India Conference (2003).

[17]. **Anurag Ohri and Dr. P. K. Singh**, "GIS Based Secondary Storage and Transportation System", International Journal of Civil Engineering & Technology (IJCIET), Volume 1, Issue 1, 2010, pp. 108 – 130.

[18]. **T Subramani, R Elangovan and P. K. Kumaresan,** "Programming Management for Fixing Priority to Identified Transport Facility Projects using Expert System in Salem City, Tamilnadu", International Journal of Civil Engineering & Technology (IJCIET), Volume 3, Issue 1, 2012, pp. 21 – 32.

[19]. **Dr M. A. Lahori and Mohd Siham**, "Relevance of Ethics in Business-A Study on Public Transport System", International Journal of Management (IJM), Volume 4, Issue 2, 2013, pp. 227 - 235.