

Evaluation of Smart Mass Rapid Transit System – The Cost Benefit Analysis for Elevated Articulated BRT System for Nashik City

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Abstract- Transport is being the life line of the nation. Exponential vehicular growth. Has put a huge burden on fragile infrastructure of city. Nashik city faced several problems due to the i.e. Growing congestion, Rising Energy consumption. Increase Air pollution, coz emission, health effect, declining Road safety. As per to daily pollution Report for Nashik city show “unhealthy condition “because the RSPM PM2.5 particle has exceeded their standard limit. Nashik city really need smart sustainable mass rapid transport system in the use of environmentally friendly fuels and land use pattern. Introduction of CNG Electric for MRTS will resulted in significant reduction of atmosphere condition of Nashik city. The Articulated BRTS (elevated) provide multiple benefit, reduction in air pollution, time saving to passenger, Reduction in accidents. Reduction in traffic congestion fuel savings. There are increments benefits cost to a number of economic agents, government, private transport, passenger, General public. Nashik City is selected as Smart City.

The economic evaluation, of MRTS create a comprehensive frame of the full impact (Benefit of Cost) of particular transport service or improvement, it identification various categories of impact of how to monetize it. It explains economic concepts of evaluation techniques. It provides cost value in a framed designed to help uses easily inform policy analysis and planning situation. The social cost benefit analysis of articulated BRTS is done in this paper tries to measure all the benefits and costs of the project cover a total distance of 32.0 km. in Nashik city. Estimates of social benefit & costs of this project are obtained using the recently estimated shadow prices of investment. After going through cost Benefit analysis estimated B/C ratio is 2.18 which is positive (more than one) mean the project is economically viable. Which help the decision makers to compare different alternatives and mode of transport. This means Elevated, Articulated BRTS project will be prove economical, viable, robust for Nashik city.

Keywords—Sustainable Smart MRTS, Transport congestion, Rapid modernization cost-Benefit Analysis, (CBA), Economic evaluation of MRTS, pollution, NUTP Policy.

I. INTRODUCTION

Nashik city is one of the fastest growing cities. With population of 14.86 million as reported in the census of India Reported is year 2011. Now it's reached App. 18 million. Nashik has potential to become commercial of cultural centre. As per DP report Nashik has 267.68 Sqkm area. The total length of the road network is Nashik is 1901 km., This increase in road length is not at par respect to Exponential growth in number or vehicle on this road of Nashik City. To solve the traffic problem national urban transport policy 2014 formed. The object of the NUPT is to ensure safe, affordable quicks, comfortable, reliable sustainable access for growing number of city residents to job, education, recreate of such other needs with the city. Existing public transportation system is run by MSRTC. But Nashik Municipal Corporation has taken to decision to take over the public transport MSRTC. Nashik City needs smart public transport for Nashik city in with different modes of transport. So, the evaluation for the MRTS is necessary. Is it Economically viable? It will help decision maker that is the project is viable or not. For that purpose, cost benefit analysis is done.

RESEARCH OBJECTIVES

1. To study present transportation system various traffic problem and different mode of transport in Nashik City.
2. To study the existing land use pattern from DP plan.
3. To explore different alternatives for selection of efficient sustainable smart Mass Rapid Transit System. i.e. LRT, Mono Rail, Metro, elevated BRTS & BRTS.
4. Evaluation of Smart Mass Rapid Transit System i.e. CBA analysis, sensitivity analysis etc.

IMPACT OF MODERNIZATION

Demography

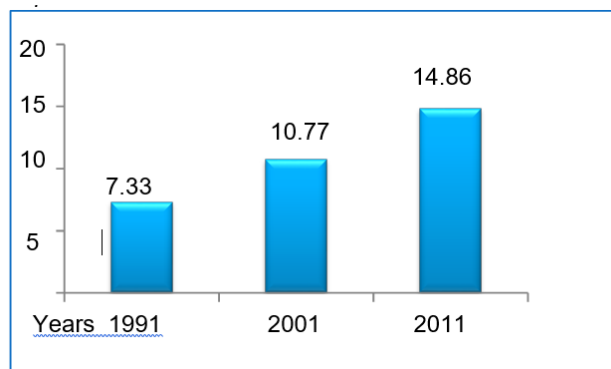


Figure 1 Population trend in NMC area

Cumulative Annual growth rate of population to 3.30 per from 2001 to 2011 population Destiny is 56 person per /H

- Cumulative Annual growth rate of popular to 3.30% From 2001 to 2011 population destiny is 56 person Per / hector

Table 1

Vehicular Growth and Composition

Year	2014-2015	2015-2016	2016-2017	2017-2018
Total Vehicle in lakhs	12.57	13.65	14.63	15.44

There is Haphazard increase in vehicle every year which is near about 8.7% per annum. The population forecasting in 2039 will be approx. 37 million

Table 2

Road Safety and Accidents

Year	No. of accidents				No. of deaths due to accident
	Fatal	Grievous injury	Grievous injury	Non-Injury	
2018-2019	209	287	76	9	217

Air pollution report of Nasik city

Year wise data of air pollution collected from MPCB department, as per that RSPM particle (PM 2.5) in air in 2017-18 (219 µg /m³) crosses above the standard limits (100 µg /m³), due to the traffic emission. Which shows unhealthy condition for sensitive groups of citizens.

Traffic mode of share as per CTP-2017

- Public Transport -6.60%
- Two-Wheeler -19.10%
- Private Vehicle -41.10%
- Non-Motorised transport -33.20%

Data collection from various Dept.

- 1) From previous study: -
 - Comprehensive mobility plan 2008 comprehension transport of traffic plan 2017
 - D. P. Report 2017
 - ITDP study 2013
- 2) Data From various Department: -
 - NMC – PWD, Town planning, Estate Department, Electrical Dept, Smart city cell, Traffic Dept.
 - MPCB Dept, MSRTC, RTO, Traffic Police, Census Dept.

Methodology

Evaluation Analysis of Smart Mass Transit System for Nashik City
 METHODOLOGY OF THE PROJECT

- Sustainable Transportation System for Nashik City
- Literature View
- Data Collection from various Dept.
 (NMC, RTO, MPCB, Traffic Police, Town Planning, MSRTC)
- Data Analysis
 - a) Analysis of Survey /data - O.D. Traffic Count
 - b) Analysis of data from various dept. (Secondary data)
- Mass Rapid Transit (MRT) & Alignment of Corridor
 (MRT, LRT, Elevated Articulated BRTS, Monorail, Metro etc.)
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- Mass Rapid Transit (MRT) & Alignment of Corridor
 (MRT, LRT, EABRTSs, Monorail, Metro etc.)
- Selection of Efficient Mode Transport for Nashik City
 Comparison of different mode of MRT on various features

Economic liability of MRT

Selection Elevated Articulated Bus System as smart & sustainable mode of PT

- Selection of Elevated Articulated BRTS Corridor as per traffic Demand
 As per Traffic Demand 32.00 km Road
- Feasibility Study for Proposed Elevated Articulated Bus System (EABRTS)
 To check the Economic Viability of Project under different parameters
- B/c (CBA) Analysis

Capital cost, Operating and maintenance cost, Total cost, Savings in fuel consumption,
 Reduction in air pollution, Savings in passenger time, Savings due to fewer accidents:
 Savings in vehicular operating costs

Mass Rapid Transport

Mass transport also to be referred as public transport. Urban transportation service which is available to any person who pay prescribed fare such mass transport system is designed to move large number of people at one time.

Selection Criteria

As per traffic demand model, passenger per hour per direction (PPHPD) – the availability of fund, suitable and efficient MRT mode can selection.

Table 3
 MRT Mode Selection Criteria

Sr no	MRT MODE	App.per km costing crore	Capacity PPHPD	POPULATION Millions	TRIP LENGTH Km.
1	Metro Rail	250-300	> 1500	>= 2	> 7-8
2	Mono Rail	150	<= 10000	> = 1	> 5-6
3	Light rail	150	<= 10000	> = 1	> 7-8
4	Elevated BRTS	50	>=4000 & 2000	> = 1	> 5
5	BRTS	15.20	>=4000&2000	> = 1	> 5

Bus rapid transit system will be smart man rapid to Nashik City. For long term solution Elevated BRTS will be beneficial. As per be CTTP 2017, After studying the most demanded corridor following corridor is selected.

- 1) Satpur, Stramik Nagar to Amrut garden trimbak Road, Modak chowk, Sarda Circle to Dwarka to Puna road- Nashik road Railway station = 19.0km
- 2) Mumbai Naka to Ashok Stambh to Gangapur Road – Gangapur Gaon = 13.0 km.
 Total length of elevated articulated BRT system = 32.0km.

Economic analysis for Articulated BRT system - The cost benefits analysis projects.

Project option yield tangible and non-tangible savings due to reduction in number of private vehicles of another vehicle with introduction of Articulated BRT system. There will be savings in travel time for passenger’s reduction in accident, pollution of vehicle operate cost etc. of other benefit to the society in general.

The cost of benefit of streams for the 30 years period of economical prices have been estimated.

i) Project Cost: -

The capital cost estimates for the Nashik articulated BRT show the a fully equipped system with appropriate technology and rolling stock.

Table 4
Economic Cost of BRT Project

Item	Details	Cost in Rs. (Crore)
BRT Corridors	32 Km (Elevated 22) (At grade 10)	1074.54
BRT Stations	70	60
BRT Terminals and Interchanges	35	30
BRT Depots	2	35
Buses	200	160
IT Systems /Control Centre		42
Total for 32 km		1401.54

Total cost:

Capital cost = 1401.54 x 0.9 = 1261

O and M cost= 170.89 x 0.9 = 154.00

Total cost= 1415.00 crore

B) Social benefits of Elevated articulated BRT System following are to the social Benefits: -

1) Savings in fuel consumption

- Savings in fuel consumption due to the diversion of a part of the road traffic to BRTS and reduced congestion to vehicles still operating on the roads.
- Fuel saved due to traffic diverted to the BRTS is estimated given below:

A RITE (1995a) has used the following formula which is also used in a study by the Central Road Research Institute (CRR) and IRC SP-30-2009

$$F_c = A \left(\frac{1}{v_c} - \frac{1}{v_d} \right) + B (v_c^2 - v_d^2)$$

Where,

F= savings in fuel consumption (cc/km) due to decongestion c

v_c = speed of vehicles in a congested situation c

v_d = speed of vehicles in a decongested situation d

A = 1675.52 for cars and 3904.6445 for buses

B = 0.0133 for cars and 0.0207 for buses

Fuel savings

=98690476 litre *Rs. 84 /litre for petrol

= **Rs. 829 Cr**

Fuel savings

=183385 ltr *Rs. 70/litre for diesel

= **Rs. 128.37 Cr.**

Fuel savings for 2 wheelers

= 28.182 Cr

Total savings

= Rs. 829 cr +Rs. 128.37 Lakhs +28.18 Lakhs

= **Rs. 985.55 Cr**

2) Evaluation of air pollution

- Fewer vehicles and the decongestion for the residual traffic on roads due to BRTS could lead to reduced air pollution.
- An estimate of the pollution reduction by a vehicle in this context could be obtained by multiplying the distance saved by the relevant emission coefficient for different pollutants for each category of vehicle.
- The monetary value of these pollution loads is estimated using the estimates of shadow prices of pollutants made in

some recent studies in India.

Table 5
 Standard Value for various Vehicles for estimation of pollution load

	PM	NO_x	HC	CO
<i>Bus</i>	0.05	0.87	2.75	0.66
<i>Car</i>	0.03	0.2	0.25	1.98
<i>2-wheeler</i>	0.075	0.3	0.7	2.2
<i>3-wheeler</i>	0.08	0.02	1.45	0.29

(source- Chatterjee, Dhavala & Murty (2006))

Reduction in pollution load (As per RITES)

Reduction in pollution load	HC	PM	Nox	Co
In MT	320	499	257	134
Shadow prices (In Lakhs)	823	7834	11027	734
Value (In Crores)	2.63	3.9	28.34	27.30

Total Savings = 2.14+2.58+24.5+27.35

Total Savings=- Rs.56.57 crores

3) Savings in passenger time

- The savings of travel time of passengers traveling by the BRTS
- product of the number of passengers traveled daily and the time saved on the average passenger lead in Nasik.
- RITES (1995a) has estimated the daily time saving by the passengers due to decongestion using the following formula:

$$T = \frac{D}{S_c} - \frac{D}{S_d}$$

Where,

T: time saving on average daily run

D: daily run of vehicles (in km)

S_c: average speed in congested situation (without BRT).

S_d: average speed in decongested situation (with BRT)

- Passenger time saving per annum for mass transport is then calculated as the product of daily passengers carried, time saved on average lead on an annual basis.

Table 6
 Standard Values for Average Speed in congested and decongested situations for vehicle (RITES, 1995a)

Mode	D (km)	S_d (km/hr)	S_c (km/hr)	T (hr)
Bus	209	14	10.5	4.98
Car	30	17	13	0.54
Taxi	80	17	13	1.45
3-wheeler	100	17	13	1.81
2-wheeler	25	17	13	0.45

Annual saving in passenger time

Daily passengers	0.95 lakhs
Time saved	0.75 hour/daily
Value of time saved for all type of vehicles	Rs12/hr
Value of daily time saved	Rs.8.55 lakhs/day
Annual savings	Rs.3120 Lakhs

4) Savings due to fewer accidents

- Casualty crashes, in which somebody is injured, disabled or killed, are less frequent but much more costly to society.
- Safety evaluation

Requires monetizing (measuring in INR values) human life and safety.

Applying monetized Values helps make planning decisions that affect safety more consistent.

Table 7

Saving due to fewer accidents (Source - RITES (1995 a) + Kadyali)

Cost	Enhanced Value in lakhs	Reduction in fatalities & Vehicle damages	Compen s-ation in lakhs
Fatal accidents	13.41	217	2909.97
Major accidents	6.10	557	3397.7
Damages to cars	0.49	60	29.40
Damages to 2 wheelers	0.10	500	50
Damages to 3 wheelers	0.12	2	0.24
Total			63.87 Cr

5) Savings in vehicular operating costs due to decongestion effect: -

- Vehicle operating costs refer to costs that vary with vehicle usage, including fuel, tires, maintenance, repairs, and mileage-dependent depreciation costs.
- It is estimated as the product of the residual traffic, time saved on average lead per vehicle annually and the vehicle operating cost per hour.
- According to: RITES (2005b) & IRC-SP-30-2009 Page 21, the value of this component for the year 2018 is Rs. 15 Lakhs.

Savings in VOC due to Decongestion effect = Residual traffic X saved time per vehicle X VOC

Cars = (20.41 X 1.5 hrs) X 114309 = 0.35Cr.

Buses = (2227X 2hr) X 4310 = 1.92Cr.

Bikes = 1/3 of cars = 0.116

Total = 2.88 Cr. X 365 = 1022 crore

6) Savings in Capital and Operating Cost of Diverted vehicles

Reduction in the capital and operating cost of vehicles due to the introduction of the BRTS is given by the product of the diverted traffic stream, the annual run and the VOC/V-km, As per IRC-SP-30-2009.

VOC for cars = 1143096 X 32 X 7.6= 2.78 crore

VOC for buses = 4310 X 32 X1.16= 0.16 crore

VOC for bikes = 1/3 of cars= 0.93

Total= 3.87 crore X 320 days = 1238 crores

The estimated value of this component for the year 2018 is Rs. 1238 crore

7) Evaluation of noise reduction

- There has been increase in the personalized mode of travel in most cities, leading to increase in traffic density resulting in longer travel time, reduced average speed, and increased fuel consumption, higher levels of pollution and discomfort to road users. All these are resulting in considerable environmental damage and health hazards.
- Traffic noise is moderate to large cost in urban areas. In addition to causing ill health effects, noise from roads leads to reductions in property values.

Table 8
Noise Reduction (Rs/km)

Period	Car	Bus
Peak	0.05	0.49
Off Peak	0.13	1.28
Average	0.09	0.89
Enhancing to 2018 from 2015 (88%)	0.17	1.67

Saving in Costs

Buses = 21.75 Cr
 Others = 15.75 Cr.

Total saving due to noise pollution - 36.9 Cr.

The present value of economic cost and benefits are specified in table below for BRTS project option.

Table 9
Present Values of Economic Benefits and Cost

Particular	Amount in Present Value terms (Rs Crore)
<i>Financial Cost of Project</i>	
Capital cost	1401.00
Incremental Maintenance and Fare Collection Cost	170.00
Economical Total cost	1572 x 0.9 = 1415
<i>Total Social Benefits</i>	
Savings in vehicle operating cost due to decongestion	1022.0
Savings in passenger time	31.20
Benefits due to accident reduction	63.87
Vehicular Savings due to emission reduction	56.57
Noise Reduction fewer	36.9
Savings in fuel consumption,	985.55
Savings in capital & operating cost of diverted vehicles	1238.00
<i>Economical Social Benefits</i>	3434.09 x 0.9 = 3091.00

Total economic benefit= 3434.09 crore x 0.9 = 3091 Cr

Total Economic cost of the Project= 1572 crore x 0.9 = 1415 Cr

B/C= 3091/ 1415 = 2.18

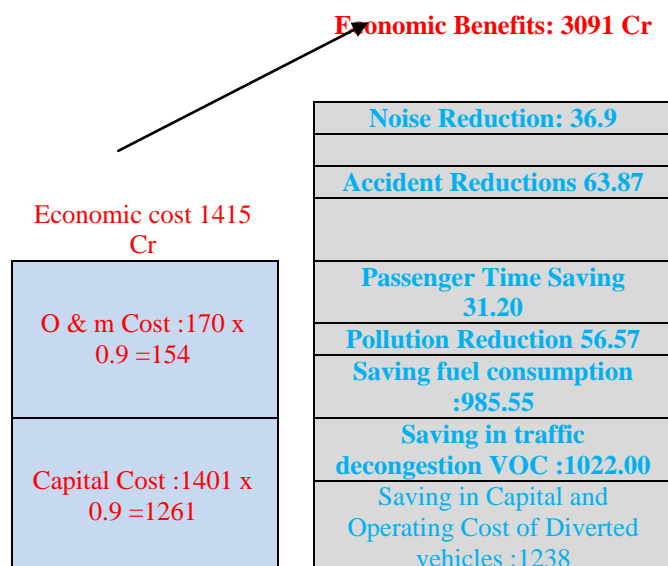


Figure 2 Pictorial view of Cost-Benefits analysis

From Benefits cost Analysis, the proposed Articulated BRTS corridor is found economically viable as benefit cost ratio is 2.18 which is more than 1.

II. CONCLUSIONS

1. There is traffic congestion, high energy or fuel consumption, poor performance of MSRTC bus service, lack of parking space, accident/fatalities which can be taken care by Mass Rapid Transit system for Nashik city i.e. Elevated Articulated BRT System.
2. Among all modes of transport metro, monorail, LRT & BRT for Nashik. Elevated Articulated BRT System is most suitable option.
3. BRT System will be the sustainable public transport but Elevated BRT System will be the best option in long term vision. As in economical cost benefit analysis B/C = 2.18 which is more than 1 so the project is economical viable. In case of B/C is less than 1 still the implementation is important in Social & Environmental aspect for Nashik city.

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