Evaluation of Transport Network of Metropolitan City: a Case Study of Navi Mumbai

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December 1, 2021

EVALUATION OF TRANSPORT NETWORK OF METROPOLITAN CITY: A CASE STUDY OF NAVI MUMBAI [1]

Abstract: Rapid urbanization in Indian cities has led to building pressure on urban infrastructure requirements. The higher dependence on private mode has led to traffic congestion in most of the metropolitan cities. The technique of travel demand forecasting is the core part of city transportation planning. The term "TDM"(travel demand modeling) refers to a set of mathematical models that aim to replicate the human travel behavior of a city. The present research is an attempt to develop the travel demand model for Navi Mumbai city, Maharashtra. The four-stage modeling method is adopted here, i.e., trip generation, trip distribution, mode split, and traffic assignments. This work aims to learn about the Urban Transport system of the Navi Mumbai region on a zonal basis and to evaluate the network assignments. After calibration and validation of the base year model, the future scenarios are generated and tested. The scenarios are created for short, medium, and long-term for 2026, 2031, and 2041 respectively, using CUBE software and comparing all the scenarios. Then the effect of public transport improvement strategies on the city's travel demand was studied. The findings from this research can help policymakers and transport planners to evaluate the performance of the Navi Mumbai transport network for the base and future years.

Keywords: *Travel Demand Modelling, Short-Term Strategies, Sustainable Transport, Future Scenarios*

[1] NOTE: PLAGIARISM 6%

1 Background of the Study

India's urban population is growing at the rate of 3% per year, where the whole country's population growth is less than 2% [15]. Based on the 2011 census data, 31% of India's population is living in urban. Considering the trend, these numbers are likely to be 377 million by the next five years. As per the United Nations report, these numbers could grow up to 52% (875 million) by 2050 [30]. With the growing numbers in the total population and its fraction in cities, it is indispensable to work out more efficient urban infrastructures and services [11]. The way a city develops highly depends on the transportation system of the city. Transportation is the main base of the development of cities [1]. It provides mobility for people and goods, shapes an area's economy, and improves the quality of life [16]. However, due to this rapid urbanization and high dependence of city dwellers on private modes of transport, it has led to an increase in transport externalities like environmental pollution, lack of parking spaces, unattractiveness to public transport, etc. It has ultimately resulted in a lack of parking unsustainable transportation system. To design an inclusive and sustainable transport system, it becomes essential to understand and evaluate the transport system.

Based on a comprehensive review of available literature, some research gaps have been identified. The number of comprehensive transportation studies conducted in the metropolis of India is very few. The highly efficient simulation and macro or micro-level modelling software like CUBE usage is not reflecting in the studies, so the current study was conducted on the platform CUBE. Major studies are based on transportation sustainability, but implementing new PT modes or other criteria will not point out the people's behaviour. Separate travel demand studies conducted on the Navi Mumbai area are not recorded; hence, Navi Mumbai was selected as a study area for the present research. With this background, the present study aims (1) To evaluate the performance efficiency of an Urban Transport Network of Navi Mumbai city using parameters like volume- capacity ratios, congested speed, and CO2 emission. (2) To forecast the Business-as-Usual scenarios for the long, medium, and short term planning horizons and (3) To propose the short term public transport mitigation strategies to ensure a sustainable urban transport system for Navi Mumbai city. For modeling the present condition, the base year travel demand model of Navi Mumbai city was developed and calibrated using macroscopic CUBE software for 2021.

The entire paper is structured as follows; the next section discusses the adopted methodology and study area, and the third and fourth section discusses the base year travel demand model and future scenario generation. In comparison, the fifth section talks about the proposed short-term mitigation strategies and is followed by findings and conclusions.

2 Methodology and Study Area

For the present study, the detailed methodology adopted is as shown in figure 1. The methodology includes three stages, i.e., Development of base year travel demand model, Horizon year scenario generation, and development of the short-term strategy to ensure a sustainable transportation system.

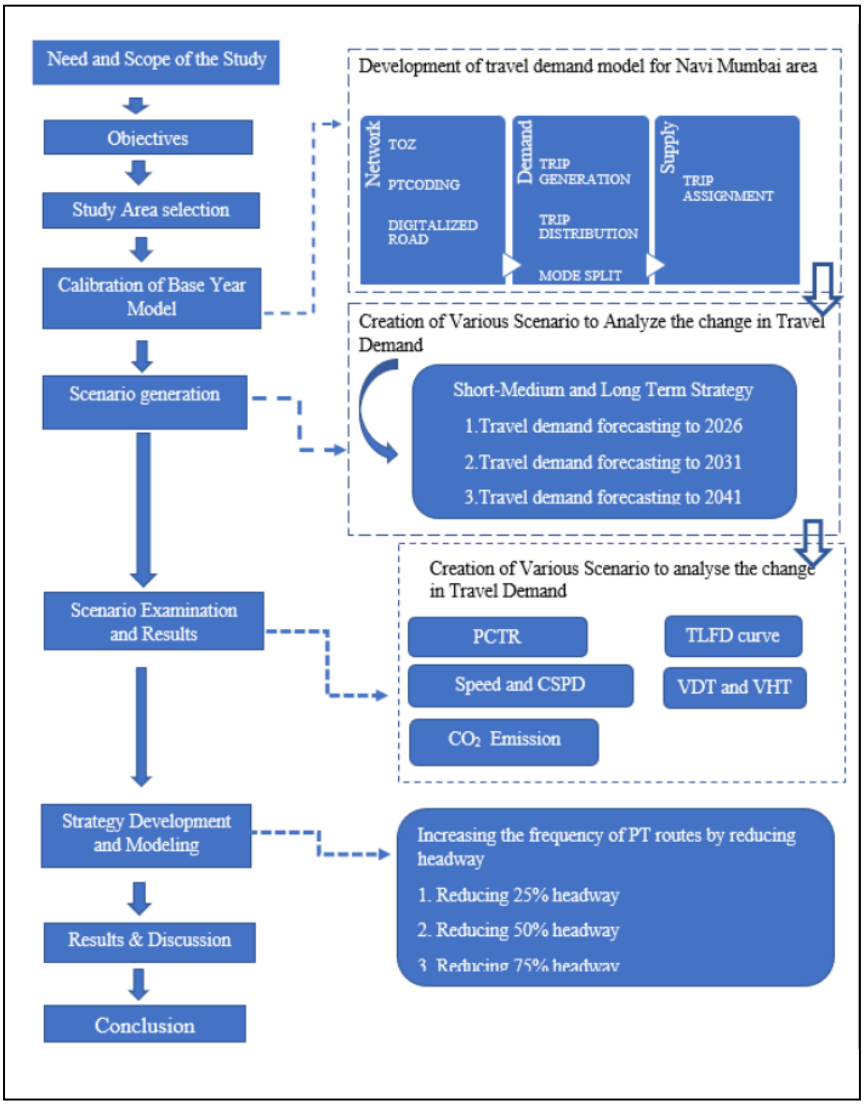


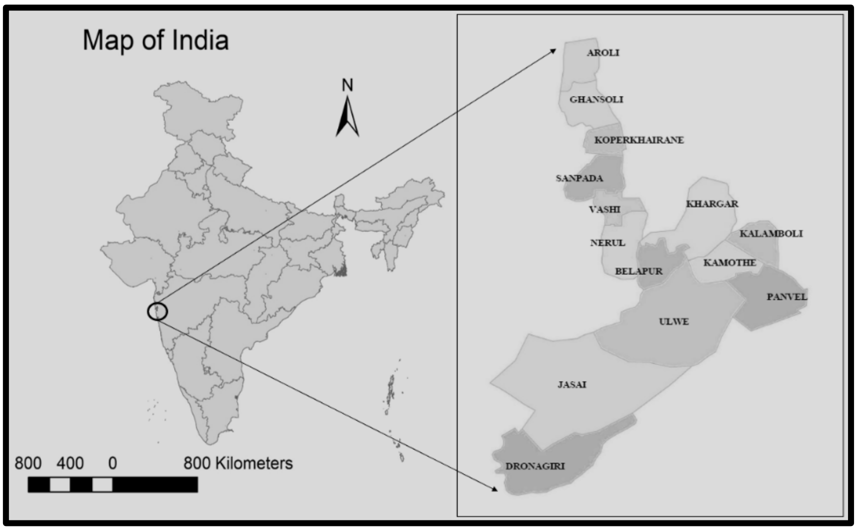
Fig. 1 Detailed Methodology Chart

In the problem identification phase, a brief background of the study and its significance was carried out in the Indian context. The research gaps were identified, and objectives for the present research were defined. Looking to the maximum data availability, Navi Mumbai city was selected for the present study. Data collection was carried out with the help of CIDCO (City and Industrial Development Corporation), which already conducted and recorded the socio-economic profile and NMMC (Navi Mumbai Municipal Corporation) reports for setting a transparent database. Inputs for the development of the model were like Transit Operating Zones (TOZ), digitalized road, coded public transport route network, and calibrated parameters used in each stage of travel demand modeling. After Calibration of the Base Year Model of Navi Mumbai city in CUBE software Scenario Generation in terms of short, medium, and long term planning horizons were carried out using forecasting the population and employment change in horizon periods. Lastly, the strategies to mitigate the issues were proposed.

2.1 Study Area

The city of Navi Mumbai includes part of both the Thane and Raigad districts in Maharashtra. It was created to provide inexpensive accommodation for those who could not afford to live in Mumbai [4],[27]. The total population is 1.2 million according to 2011, with an average number of 120 persons/hectares. The city is having an average household size of 3.83, with 54% males and 46% females. According to the survey conducted, it is observed that 49% of the total population have at least vehicle ownership of one two-wheeler [4], [25], [27]. The present mode share of the city consists of 31 % of trips by two-wheeler, 43% by four-wheelers, 26% by public transport.

Fig 2 Boundaries of Delineated 14 zones of Navi Mumbai Study Area



3 Base year travel demand model of Navi Mumbai city

The detailed four-stage modeling was carried out to analyze and predict the traffic flow in the future. The study area was subdivided into 14 TOZs (Transit Operating Zones). For the analysis of travel pattern, six trip purposes— HBWF (Home-based work-office trip), HBWI (Home-based work industry trip), HBWO (Home-based work-other trip), HBE (Home-based education trip), HBO (Home-based other trips), and NHB (Non-home based trip) was considered. The modeling exercise was carried out for the base year 2021.

The model period for the assignment was taken as a two-hour morning peak. A detailed explanation of the four stages of TDM is explained in a subsequent section.

3.1 Trip Generation

Trip generation estimates the number of trip productions - attractions to each TOZ. Trip productions were estimated based on the trip-making characteristics of each household. The total trip attracted from each TOZ was estimated from employment and student enrolment while using workers, students, population, and employment, the trip produced into each zone was determined. The trip generation equations were derived from the CTS (Comprehensive Transport Study) of the Mumbai metropolitan region. The model estimates are as shown in table1.

Table 1 Production-Attraction model for Navi Mumbai Area

Trip Production					
Purpose	Model	R^2	t	SEE	F
HBWF	0.743 Resident Worker Office category	0.9	38.1	4815	1452
HBWI	0.42 Resident Worker Industry category	0.81	26.66	2857	711
HBWO	0.286 Resident Worker another category	0.85	30.49	3907	929
HBE	0.153 Students	0.81	26.85	3312	721
HBO	0.014 Population	0.69	19.57	1574	383
NHB	0.002 Employment	0.19	6.26	297.8	39
Trip Attraction					
Purpose	Model	R^2	t	SEE	F
HBWF	0.742 Employment	0.94	52.27	4999	2838
HBWI	0.477 Employment	0.9	39.16	2363	1535
HBWO	0.293 Employment	0.88	35.67	3526	1272.8
HBE	0.212 Students	0.71	20.58	4429	423
HBO	0.006 Population +0.019 Employment	0.72	7.56	1371	215.5
NHB	0.002 Total Workers	0.23	7.19	287.7	51.7

R^2, t, SEE, and F: Statistical terms can explain the goodness of fit

Output from the trip generation model is PA- matrix. The share of work and education trips was highest, i.e., 67%, followed by 29%. The home-based other trips contributed 4%, while the non-home-based trips were 1% of total trips.

3.2 Trip Distribution Model

A singly and doubly constraint gravity model was adopted to calibrate trip distribution equations in the present analysis. The gravity model was developed for each of the six purposes. The calibrated values of the alpha and beta of gravity model are as shown in Table 2.

Table 2 α *and* β values were calculated from purpose wise trip length frequency distribution curves

Purpose	Function type	Coincidence ratio	Parameter α	Parameter β
HWF	$fij = tij{-}\beta e{-}tij\beta$	0.9	-	0.028647
HWI	$fij = tij{-}\beta e{-}tij\beta$	0.89	-	0.035312
HWO	$fij = tij{-}\beta e{-}tij\beta$	0.9	-	0.0372246
HBE	$fij = tij\alpha e{-}tij\beta$	0.79	0.001	0.0488166
HBO	$fij = tij\alpha e{-}\beta(lntij)2$	0.73	0.001	0.292015
NHB	$fij = tij\alpha e{-}\beta(lntij)2$	0.76	0.001	0.3445763

(Source – Comprehensive Transportation Study for Mumbai Metropolitan Region-2008)

3.3 Mode Split

For the mode choice analysis, the attributes taken were travel time and travel cost. The utility equations developed by the CTS of the MMR (Mumbai Metropolitan Region) was taken for the present study, which is as follows:

Table 3 Purpose wise Utility equations for different modes of Navi Mumbai Area

	CAR	TW	BUS
HBWF	U (PVT) = 1.7341-0.0103*IVTTCar - 0.0133*PVTCOST	U (PVT) = 1.7341-0.0103*IVTTTW - 0.0133*PVTCOST	$U_{(Bus)}$ = -0.6579-0.0103*IVTTBus-0.0133*IVTCBus-0.0913*BOVDI
HBWI	U (PVT) = 2.3927-0.0138*IVTTCar-0.0150*PVTCOST	U (PVT) = 2.3927-0.0138*IVTTTW-0.0150*PVTCOST	$U_{(Bus)}$ = -0.0716-0.0138*IVTTBus-0.0150*IVTCBus-0.0792*BOVDI
HBWO	U (PVT) = 2.6338-0.0134*IVTTCar-0.0167*PVTCOST	U (PVT) = 2.6338-0.0134*IVTTTW-0.0167*PVTCOST	$U_{(Bus)}$ = -0.8085-0.0134*IVTTBus-0.0167*IVTCBus-0.1071*BOVDI
HBE	U (PVT) = -0.3067-0.0256*IVTTCar-0.0111*PVTCOST	U (PVT) = -0.3067-0.0256*IVTTTW-0.0111*PVTCOST	$U_{(Bus)}$ = 0.9038-0.0256*IVTTBus-0.0111*IVTCBus-0.1960*BOVDI
HBO	U (PVT) = 1.5432-0.0026*IVTTCar-0.0093*PVTCOST	U (PVT) = 1.5432-0.0026*IVTTTW-0.0093*PVTCOST	$U_{(Bus)}$ = 0.0044-0.0026*IVTTBus-0.0093*IVTCBus-0.2039*BOVDI
NHB	U (PVT) = 1.5432-0.0026*IVTTCar-0.0093*PVTCOST	U (PVT) = 1.5432-0.0026*IVTTTW-0.0093*PVTCOST	$U_{(Bus)}$ = 0.0044-0.0026*IVTTBus-0.0093*IVTCBus-0.2039*BOVDI

(Source – Comprehensive Transportation Study for Mumbai Metropolitan Region (2008)

Where UPVT = Utility equation for private vehicles both Car and two-wheeler

UPT = Utility equation for Public Transport

The mode-wise O-D matrix of each zone is analyzed.

- IVTTBus: Vehicle Travel Time by Bus
- IVTTCar: Vehicle Travel Time by Car
- IVTTTW: Vehicle Travel Time by TW
- IVTCbus: Vehicle Travel Cost by Bus
- PVTCOST: Weighted in-vehicle travel cost of Car and TW calculated
- BOVDI: Out of vehicle distance traveled in case of the bus (access + egress)

3.4 Trip Assignment

The selection of pathways or routes between O-D in transportation networks is called a trip assignment, route choice, or traffic assignment. The mode choice analysis predicts which modes will be used by the traveler while trip assignment estimates the total number of travelers on each route. The calibrated values of the BPR function for the Navi Mumbai city is as follows:

$$\mathbf{T_f = T_o \{[1] + \alpha (\frac{v}{c})^{\beta}\}}$$

- T_f = Final link travel time
- T_o = Free flow travel time
- α = Coefficient (0.15)
- V = Assigned traffic Volume
- C = Link Capacity
- β = Exponent (4)

The entire four steps of travel demand modeling were further calibrated and tested with real-world data. The calibrated TDM was run into the macroscopic software CUBE, and the traffic volumes on each road were derived. The operating condition of the roads of Navi Mumbai city in terms of V/C ratios is as shown in table 4.

Table 4 Volume Capacity ratios obtained from CUBE software output

Volume Capacity Ratios	Total Percentage of Major Road (%)
>1	7%
0.75-1	3%
0.5-0.75	5%
0-0.5	85%

From table 4, it is clear that 10% of the major roads had a V/C ratio of more than 0.5 and significant. As the V/C ratios are higher, it will reduce the Level of Service on the road. For the present study, 90% of roads had a V/C value less than 0.5, reflecting the better performance of the road network for the present situation. However, the performance of the transport system became worst in the future. To understand the future situations of the road network, the short, medium, and long-term scenarios were generated which is explained in the next section.

4 Scenario Generation

4.1 Short, Medium, and Long-Term Scenarios

After developing and validating the base year model using CUBE software for Navi Mumbai city, India, the three Business as Usual (BAU) scenarios were created for three horizon periods, i.e., 2026, 2031, and 2041 respectively. For future years, population and employment data were forecasted, and the effect of change in population and employment density on the city's travel demand was modeled. Further, to get a comprehensive view of the future scenarios, the PCTR (Per Capita Trip Rate), VDT (Vehicle Distance Travelled), VHT (Vehicle Hour Travelled), Average speed, CSPD (Congested Speed), TFLD (Trip Length Frequency Distribution), and peak hour CO_2 emission were estimated and compared together. The detailed explanation is as follows:

4.2 Per Capita Trip Rate

The influence of input parameters, i.e., work and education trip on PCTR with different scenarios, are described below Fig 3.

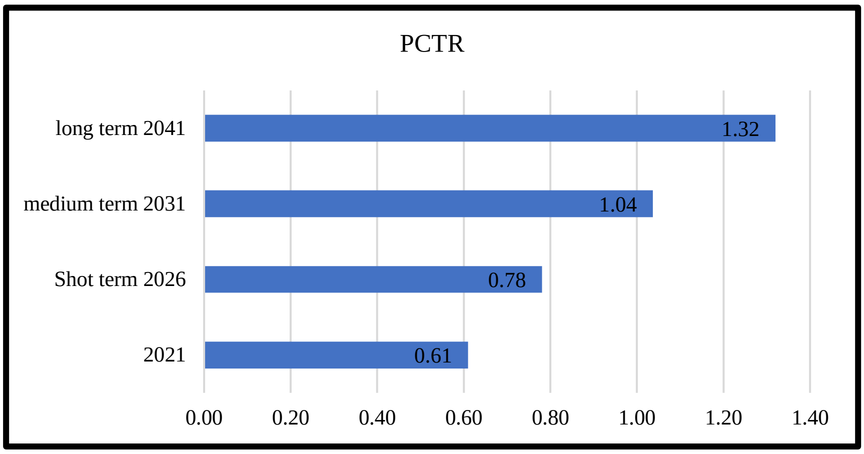


Fig 3 Per Capita Trip Rate for base and horizon years of Navi Mumbai Area

The PCTR for base year value was obtained 0.61. After 20 years, the PCTR was calculated almost double from the base year value. The increasing trend of PCTR values was observed for the horizon years, indicating an increase in the city's travel demand.

4.3 Trip length-frequency distribution curve

The TLFD curve implies the way the travel pattern of the citizen's changes. As the opportunity gets increases, then the need for travel also gets an increase. As Navi Mumbai city has a linear road network, the average trip length does not increase drastically in future years (as shown in figure 4). Even the average trip length of Navi Mumbai was less than some other areas of MMR.

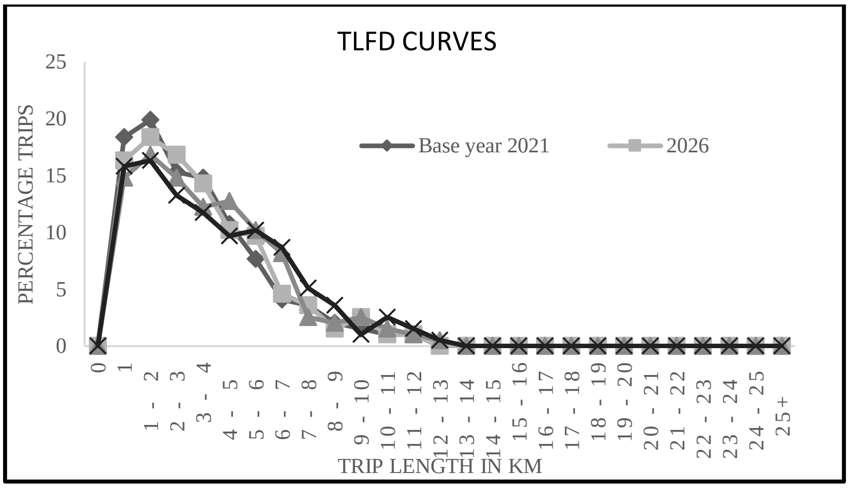


Fig 4 TLFD curve for base and horizon years of Navi Mumbai Area

The 85th percentile trip length increases more for short (7%), medium (21%), and long-term (20%) scenarios compared to the base year indicating higher travel distance in the future years.

4.5 Average speed and Congested Speed (CSPD) on the road network for each scenario

An average and congested speed for the road network was extracted to understand mobility for each scenario, as shown in Fig 5.

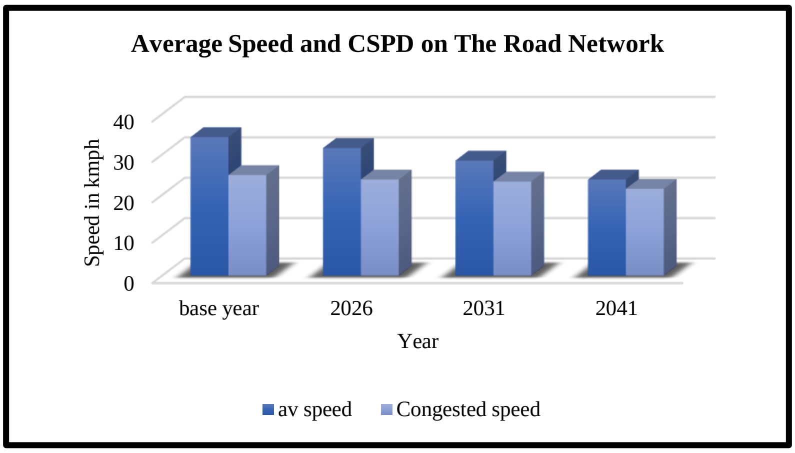


Fig 5 Peak hour Average speed and CSPD on the road network of Navi Mumbai Area

Due to increased link volume in future scenarios, the average speed decreased by 5.5%, 12%, and 20% in short, medium, and long-term scenarios. The congested speed too showcases the decreasing trend. In the long-term scenario, the network's CSPD observed 78% of average speed. It will lead to a more congested situation in the future.

4.6 Change in Vehicle Distance (VDT) and Vehicle Hour Travelled (VHT)

To quantify the increase in travel demand, the change in the VDT and VHT were calculated. Each scenario's results were extracted and compared, which is as shown in Fig 6.

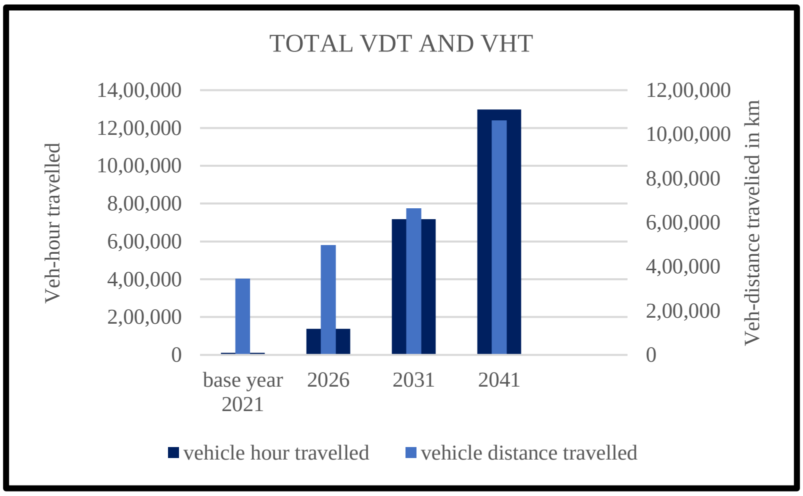


Fig 6 Change in Peak hour total VDT & VHT on the road network of Navi Mumbai Area

Compared to other parameters, the base year observed that VDT was less than VHT, indicating no delay. However, in the case of the long-term 2041, VHT is more than VDT, reflecting delays in the future.

4.7 Increase in CO_2 Emission

To quantify the effect of these scenarios on the environment, the change in CO_2 emission was derived. The carbon emission factors obtained from the policy document for Two-Wheeler and cars were 39.04 gm/km and 170.15 gm/km, respectively. (Source; India GHG Program, 2015). To calculate the CO2 emissions, the emission factors were multiplied with the average VDT values of peak hour for each mode of transport. The total CO_2 emission (in tons) observed is as displayed in the document for Two-Wheeler and cars were 39.04 gm/km and 170.15 gm/km, respectively. 5.

Table 5 Base and horizon years Peak hour CO_2 emission in tons for private modes

Scenarios	CO_2 emission (tons)
Base year 2021	476
2026	943
2031	1403
2041	1937

By calculating the base year, CO_2 emissions drastically increase in future years, so an alternate solution is needed. While comparing between scenarios, from short to medium, the emission of CO_2 increased by 49%. While, from 2031 to 2041, between 10 years, it will increase by almost 38%. The CO2 emissions for all the scenarios are as shown in.

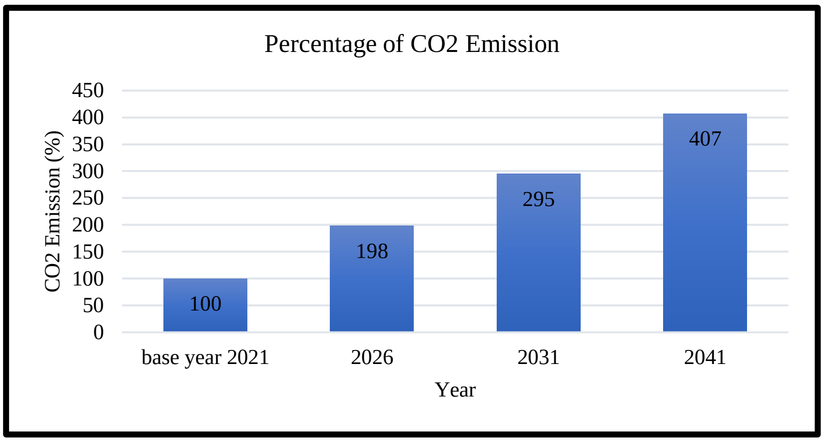


Fig 7 Percentage change in Peak hour CO_2 emission (Taking CO2 emission for the base year as 100%)

Fig 7 reveals that emissions will be four times in 2041 compared to the present situation. The increase in motor vehicles, i.e., ownership and number of trips, are the main reason for increasing emissions. Since the congested speed is significantly less, it led to more emissions of CO2.

5 Short Term Strategy Development

According to the National Association of City Transportation Officials, if the number of passengers per hour per route is more than 100, the headway must be short, generally 10 to 15 minutes[27]. It may be 5 to 10 minutes in peak hours, and the departures per hour must be between 4 to 10. In the case of Navi Mumbai, there was an average of 127 passengers/ route/ hour. This indicates the necessity of revising the departure per hour in every route. The existing frequency distribution of transit services for all the public transport routes is shown in Fig 8.

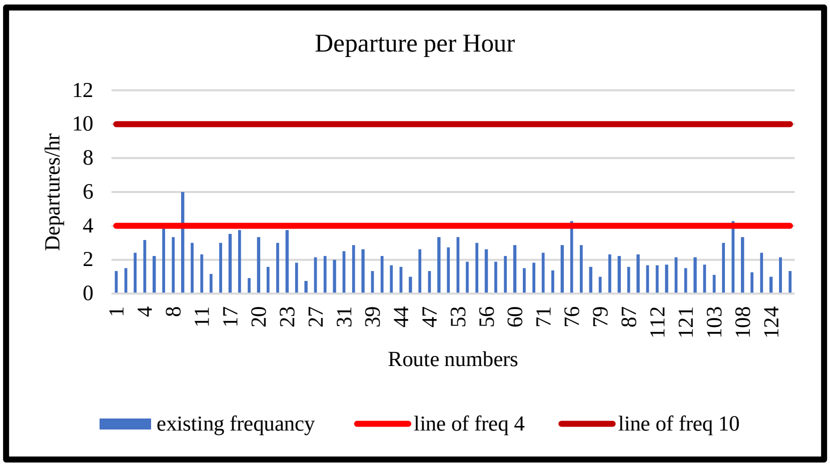


Fig 8 Departure per Hour for all Bus Routes in Navi Mumbai Area

From the base year travel demand model, it was observed that peak hour passenger-km for the base year was maximum in route number 29 and it is showing in figure 9. According to the output from CUBE software, it was assumed that route number 29 having high demand and low supply.

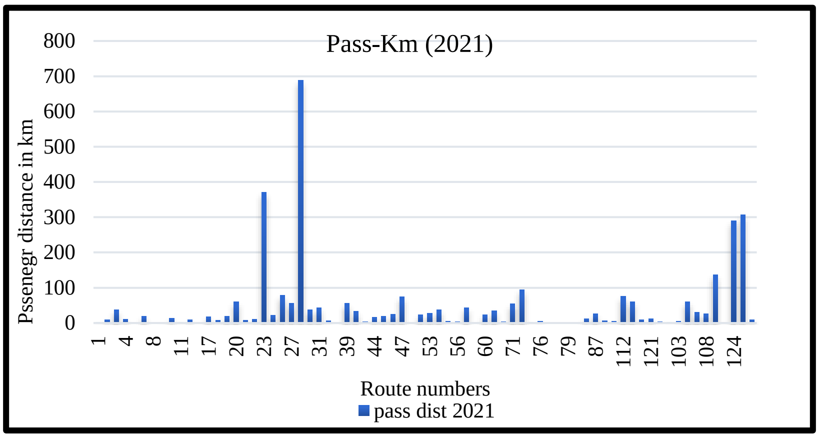


Fig 9 Base year total peak hour passenger km for Bus routes

With this observation, short-term strategies were developed to increase public transportation availability. Here, three strategies, i.e., to increase the frequency of public transport routes, were proposed, which are as follows.

Strategy 1: Reducing 25% headway
Strategy 2: Reducing 50% headway
Strategy 3: Reducing 75% headway

The revised number of departures per hour using three strategies is given in below Fig 9.

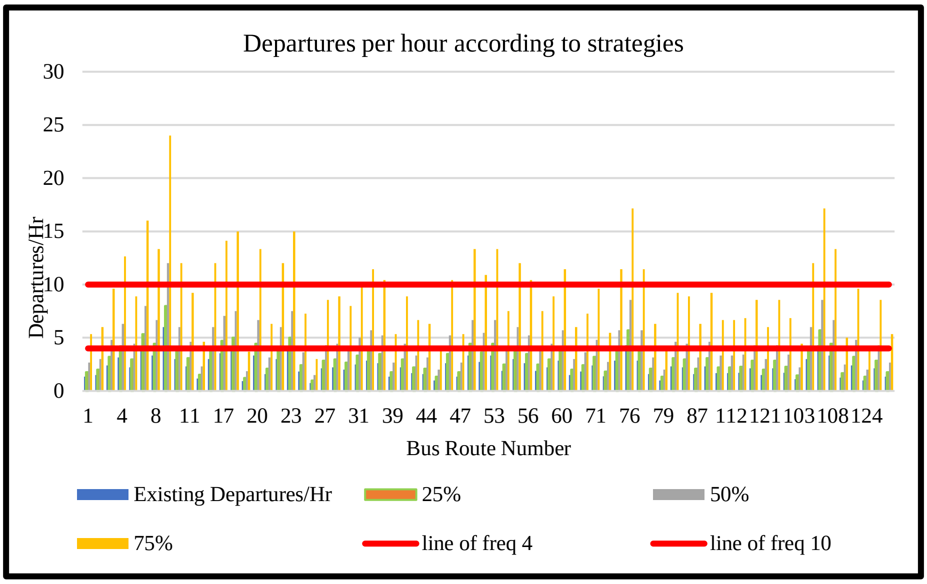


Fig 10 Departures per hour according to different short-term strategies

Fig 10 reveals that reducing 50% of headway for each route will be the most suitable choice. Further, from the base year model of Navi Mumbai city, route number 29 is experiencing high travel demand. To showcase the application of how to reduce headway by 50%, timetable for one hour of that particular route was rescheduled. The departure per hour for particular route number 29 was changed from 2 transit units/ hour to 4 transit units/hour. The revised timetable for a particular route is given below in Table 6, assuming uniform dwell time as 20 seconds.

Table 6 Revised time table of route number 21 for one hour according to new headway

NUMBER	NAME OF BUS STOPS	BUS 1		BUS 2		BUS 3		BUS 4	
		Arrival	Departure	Arrival	Departure	Arrival	Departure	Arrival	Departure
1	CBD SECTOR 03	00:00:00	06:50:00	00:00:00	07:04:00	00:00:00	07:18:00	00:00:00	07:32:00
2	GAVESKAR GROUND SEC 1/2	06:51:30	06:51:45	07:05:30	07:05:45	07:19:30	07:19:45	07:33:30	07:33:45
3	POLICE LINE SECTOR O1	06:53:20	06:53:35	07:07:20	07:07:35	07:21:20	07:21:35	07:35:20	07:35:35
4	CBD HIGHWAY	06:54:40	06:54:55	07:08:40	07:08:55	07:22:40	07:22:55	07:36:40	07:36:55
5	CENTRAL BANK / BELAPUR RLY.STN	06:56:20	06:56:35	07:10:20	07:10:35	07:24:20	07:24:35	07:38:20	07:38:35
6	DIWALE GAON	06:59:00	06:59:15	07:13:00	07:13:15	07:27:00	07:27:15	07:41:00	07:41:15
7	KILLE GAONTHAN/ NMMC HEAD OFFICE	07:01:30	07:01:45	07:15:30	07:15:45	07:29:30	07:29:45	07:43:30	07:43:45
8	BELAPUR HIGHWAY (W)	07:03:10	07:03:25	07:17:10	07:17:25	07:31:10	07:31:25	07:45:10	07:45:25

9	INCOME TAX COLONY HIGHWAY	07:04:40	07:04:55	07:18:40	07:18:55	07:32:40	07:32:55	07:46:40	07:46:55
10	URAN FATA	07:06:00	07:06:15	07:20:00	07:20:15	07:34:00	07:34:15	07:48:00	07:48:15
11	DR ,D.Y PATIL STADIUM	07:07:50	07:08:05	07:21:50	07:22:05	07:35:50	07:36:05	07:49:50	07:50:05
12	NERUL L.P	07:09:00	07:09:15	07:23:00	07:23:15	07:37:00	07:37:15	07:51:00	07:51:15
13	SHIRVANE FATA	07:10:30	07:10:45	07:24:30	07:24:45	07:38:30	07:38:45	07:52:30	07:52:45
14	JUNIAGAR RLY STN. HIGHWAY	07:11:50	07:12:05	07:25:50	07:26:05	07:39:50	07:40:05	07:53:50	07:54:05
15	SANPADA POLICE STN	07:12:40	07:12:55	07:26:40	07:26:55	07:40:40	07:40:55	07:54:40	07:54:55
16	TURBHE NAKA	07:14:00	07:14:15	07:28:00	07:28:15	07:42:00	07:42:15	07:56:00	07:56:15
17	TURBHE NAKA	07:15:20	07:15:35	07:29:20	07:29:35	07:43:20	07:43:35	07:57:20	07:57:35
18	TURBHE DEPOT	07:17:10	07:17:25	07:31:10	07:31:25	07:45:10	07:45:25	07:59:10	07:59:25
19	TURBHE STORES/ TURBHE RLY STN	07:18:30	07:18:45	07:32:30	07:32:45	07:46:30	07:46:45	08:00:30	08:00:45
20	SAVITA CHEMICAL CO.	07:20:00	07:20:15	07:34:00	07:34:15	07:48:00	07:48:15	08:02:00	08:02:15
21	PAWANE GAON	07:21:20	07:21:35	07:35:20	07:35:35	07:49:20	07:49:35	08:03:20	08:03:35
22	KHAIRANE MIDC/RELIANCE SILICON	07:22:50	07:23:05	07:37:50	07:38:05	07:51:50	07:52:05	08:05:50	08:06:05
23	KHAIRANE GAON	07:24:00	07:24:15	07:38:00	07:38:15	07:52:00	07:52:15	08:06:00	08:06:15
24	KOPARKHAIRANE RLY STN	07:25:20	07:25:35	07:39:20	07:39:35	07:53:20	07:53:35	08:07:20	08:07:35
25	DHIRUBHAI AMBANI KNOWLEDGE CITY	07:27:10	07:27:25	07:41:10	07:41:15	07:55:10	07:55:25	08:09:10	08:09:25
26	MAHAPE /LOKMAT	07:28:40	07:28:55	07:42:40	07:42:55	07:56:40	07:56:55	08:10:40	08:10:55
27	MAHAPE NAKA	07:30:00	07:30:15	07:44:00	07:44:15	07:58:00	07:58:15	08:12:00	08:12:15
28	GHANSOLI RLY STN.	07:31:20	07:31:35	07:45:20	07:45:35	07:59:20	07:59:35	08:13:20	08:13:35
29	GHANSOLI RLY STN.	07:33:00	07:33:15	07:47:00	07:47:15	08:01:00	08:01:15	08:15:00	08:15:15
30	STANDARD ALKALI	07:34:10	07:34:15	07:48:10	07:48:25	08:02:10	08:02:25	08:16:10	08:16:25

31	GHANSOLI NAKA	07:35:40	07:35:55	07:49:40	07:49:55	08:03:40	08:03:55	08:17:40	08:17:55
32	TALVALI NAKA	07:36:50	07:37:05	07:50:50	07:51:05	08:04:50	08:05:05	08:18:50	08:19:05
33	RABALE RAY STN.(E) /GOTHIVALI GAON	07:38:20	07:38:25	07:52:20	07:52:35	08:06:20	08:06:35	08:20:20	08:20:35
34	RABALE NAKA	07:39:40	07:39:55	07:53:40	07:53:55	08:07:40	08:07:55	08:21:40	08:21:55
35	RABALE POLICE STATION	07:41:00	07:41:15	07:55:00	07:55:15	08:09:00	08:09:15	08:23:00	08:23:15
36	BHARAT BIJLEE	07:42:00	07:42:15	07:56:00	07:56:15	08:10:00	08:10:15	08:24:00	08:24:15
37	AIROLI RAILWAY STN. (E)	07:43:20	07:43:25	07:57:20	07:57:35	08:11:20	08:11:35	08:25:20	08:25:35
38	AIROLI NAKA	07:44:50	07:45:05	07:58:50	07:59:05	08:12:50	08:13:05	08:26:50	08:27:05
39	RELIABLE PLAZA	07:46:00	07:46:00	08:00:00	08:00:00	08:14:00	08:14:00	08:28:00	08:28:00

6 Findings and Conclusions

The present study attempted to develop the based year model for the Navi Mumbai city using the Macroscopic travel demand modeling software CUBE. The short-, medium- and long-term scenarios were generated to estimate the future travel demand. The performance efficiency of an Urban Transport Network of Navi Mumbai for the base year and planning horizon years considering v/c ratio, CSPD, Average travel speed, TLFD, CO2 emission were evaluated. Based on the present study, the significant findings are as follows:

- The peak hour trips for Navi Mumbai city were found to be 4.5 lacs for HBWF, 37,000 for HBWI, 57,000 for HBWO, 2.39 Lacs for HBO, and 700 NHB for the base year.
- The per-capita trip rate was found to be 0.61.
- The city's average trip length and travel speeds were 3.8 km and 35 KMPH for the base year.
- The calibrated base year model reveals that 90% of the roads had a V/C ratio lesser than 0.5 indicating the excellent performance of the transport network for private modes of transport.
- For the short-, medium- and long-term scenarios, 18%, 21%, and 25% of significant roads had V/C ratios of more than 0.5 in 2026, 2031, and 2046 respectively. Also, with an increase in volume for future scenarios, the average speed decreases to 32, 30, 27 for short-, medium- and long-term scenarios.
- The congested speed observed in long term scenario is 78% of the average speed of the link, and hence the chance of having gridlock on the network is very high. The congestion on the network will create a delay on the vehicles. These conditions will cause more CO2 emissions, and this is unsustainable.
- Total peak hour CO2 emission was 476,943,1403 and 1937 tons for 2021, 2026, 2031, and 2041 respectively. This indicates the need to

have a sustainable urban transport system for the Navi Mumbai cities.

The present study was conducted on Navi Mumbai. However, the methodology proposed in the study can be adopted by any city in India or across the world, and the transport network can be evaluated.

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