Spatial assessment of Public Transport Network for Strategic Transportation Plan of Vadodara, Gujarat

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Partial Fulfilment for
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By
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CERTIFICATE

Spatial assessment of Public Transport Network for Strategic Transportation Plan of Vadodara, Gujarat

The contents presented in this Thesis represent my original work and it Has not been submitted for the award of any other Degree or Diploma Anywhere else.

VAGHELA JAYRAJ JAYESHKUMAR

This Thesis is submitted in partial fulfilment of the requirements for the Degree of Master of Urban and Regional Planning
At the Department of Architecture
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The present work has been carried out under our supervision and Guidance and it meets the standard for awarding the above stated degree.

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ABSTRACT

Urbanization is an integral part of economic development. In India especially, rapid economic growth and urbanization have led to formation of slums, deterioration in environment, congestion etc. A sustainable strategy is thus required to maintain the economic growth and alleviate the problems arising due to the growth. Transit oriented development which is an integrated approach to land use and transport planning is one such strategy. Transit oriented development (TOD) is defined as a high density, mixed use type of development close to transit services. Indian cities traditionally have high density and mixed use type of development. In such a context, TOD might already be a reality in some form.

Thus the current research investigates the concept of transit oriented development in an Indian context especially for Vadodra,Gujarat .Since TOD requires co-operation between consumers, planners, administrators, designers etc. A framework has been used to develop a TOD score for the study area of Vadodara (VMC Area) using which it has been determined that greater portions of the city is already close to being well connected. Especially, the inner walled city with high density, mixed use type of development ranks very high on the TOD score. The outer corridors on the other hand have a more or less suburban type of development and hence rank very low on the TOD score. These regions have great potential in terms of re-development.

This thesis is dedicated to my parents, family and friends for patiently waiting for me to socialize with them. To all who believe in themselves and have followed their will to find the way.

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It is an impeccable fact that every vision needs a spirit of dedication and hard work but more than that it needs proper guidance. Therefore, first and foremost I would like to thank my department for letting me carry out this Study. I am extremely grateful to Head of the Department Dr. Bhawana Vasudeva, for providing me this platform to conduct the study.

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I am extremely grateful to my Family for their love, prayers and sacrifices for educating and preparing me for my future. I would like to thank all my friends and colleagues to help me whenever I needed them throughout the study. Finally, my thanks go to all the people who have supported me to complete the research work directly or indirectly.

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Abbreviations

TOD:	Transit Orient Development
BRTS:	Bus Rapid System
IPT:	Intermediate public transport
TSI:	Transportation Services Index
GOI:	Government of India
JNNURM:	Jawaharlal Nehru National Urban Renewal Mission
KM:	Kilometer
M:	Meter
VMC:	Vadodara Municipal Corporation
VUDA:	Vadodara Urban Development Authority
GDP:	Gross Domestic Product
Sq.m:	Square meters
Sq.km:	Square Kilometers

CHAPTER 1

1.Introduction

In India urbanisation is taking place at a rapid speed. During the past few decades there had been enormous growth in urban areas due to concentrated activities in and around these centres and consequently enormous demand for transportation facilities exist. Growing cities require movement of people. Such large scale movements, if carried by personalized means of transport create congestion on roads, excessive energy consumption, environmental pollution and parking problems. Efficient and affordable public transport is the urgent need for the cities of India today.

The rapid growth of India's urban population, as in other developing countries, has generated an enormous need for efficient public transport services to carry high volumes of passengers through dense congested urban areas. Since large cities are far more dependent on public transport than small cities, the need for public transport services has increased faster than overall population growth. Moreover, the lack of effective planning and land-use controls has resulted in rampant sprawled development extending rapidly in all directions, far beyond old city boundaries into the distant countryside.

The urban transport scenario in India is falling short in serving the demand safely and efficiently, which needs especial attention from government bodies as well as researchers. The rise in vehicle population has hit our cities hard. Most city authorities today are running about to keep traffic flowing. Though intermediate public transport (IPT) has a potential to play its role, but it rather than being useful can become a nuisance. Expected average journey speed on major corridors in future for various cities categories are tremendously decreasing's, increasing numbers of two

wheelers has become an eye catching issue for India due to insufficient public transport facilities.

Due to many such traffic problems like congestion, accidents, parking problems, this research deals with the above mentioned all problems and discusses various solutions for these problems more specifically for Vadodara city.

1.1 What is Transit Oriented Development (TOD)?

Mixed-use communities within an average 2,000-foot walking distance of a transit stop and a core commercial area. TODs mix residential, retail, office, open space, and public uses in a walkable environment, making it convenient for residents and employees to travel by transit, bicycle, foot or car. In addition, the transportation hub should be located in the heart of the neighborhood, within a 400 meter, or 10 minute walk from residents.

TOD comprises a mix of commercial, residential, and institutional developments built to support a transportation hub and to encourage non-motor vehicle mobility options, such as biking and walking, within the Transit-Oriented Development: Lessons from Indian Experiences 2 community.

A TOD area could encompass a radius of as little as 0.5 miles or as much as 1 mile from a transit station (Cervero 2002).

- Rapid economic growth and Urbanization have led to problem congestion, traffic jams, load on infrastructure, pollution etc. Along with these, rapidly growing population has very large effect on the housing in the city. Increasing population led to problems of Slums, haphazard development etc.
- Transit Oriented Development (TOD) which concentrates development near and around transit systems to promote transit ridership in one such sustainable development strategy.

- Transit Oriented Development is essentially any development, macro or micro that is focused around a transit node, and facilitates complete ease Of access to the transit facility thereby inducing people to prefer to walk and use public transportation over personal modes of transport. It provides convenient and affordable accessibility to the greatest number of people for the lowest total costs. It creates a truly efficient and equitable community.

Over time TOD has acquired the meaning of planned development around any type of transit and not necessarily a train station. TOD is not just any development near transit. It is a development that:

- Increases "location efficiency" so people can walk, cycle and use public transport.
- Boost's public transport ridership and reduces use of private vehicles.
- Provides a rich mix of housing, jobs. Shopping and recreational choices.
- Provides value for the public and private sectors, and for both new and existing residents.
- Affords an accessible and safe living environment for children, adults, and those of advanced age and limited mobility
- Creates a sense of community and place

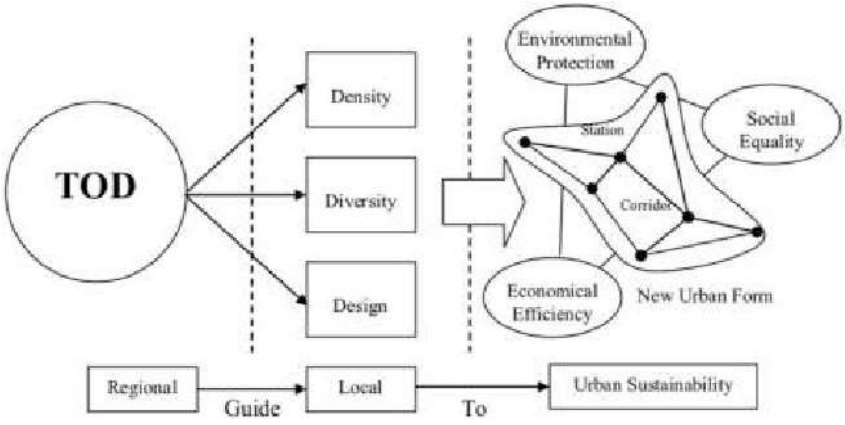


Figure 1 Transit Orient Development

1.1.1 What are the Principals of TOD?

- **WALK**

Walking is the most natural, affordable, healthy and clean of travel for short distances, and a necessary component of the vast

Figure 2 Walk

Majority of transit trips. As such, walking is a fundamental budding block of sustainable transport. Walking is, can be, the most enjoyable and productive way of getting around, provided that paths and streets are populated and desired services and resources conveniently located.

Walking also requires physical effort, and it is highly sensitive to environmental conditions. The key factors to making walking appealing form the basis for the three performance objectives under this principle: **safety, activity and comfort**

- **CYCLE**

Cycling is an elegant, emission-free, healthy, and affordable transport option that is highly efficient and consumes little space and few resources. It combines the convenience of door-to- door travel, the route and schedule flexibility of walking, and the range and speed of many local transit services.

Figure 3 Cycle

Bicycles and other means of people-powered transport, such as pedicabs. Activate streets and greatly increase the area coverage of transit stations. Cyclists, however. Are among the most vulnerable road users, and their bicycles are also vulnerable to theft and Vandalism. The key factors encouraging cycling is **the provision of safe street and secure cycle parking and storage**.

- **CONNECT**

Figure 4 Connect

Short and direct pedestrian and cycling routes require a highly connected network of paths and streets small, permeable Bocks. This is primarily important for walking and for transit station accessibility, which can be easily discouraged by detours. A tight network Of paths and streets offering multiple routes to many destinations can also make walking and cycling trip varied and enjoyable. Frequent street corners and narrower right of ways, with slow vehicular speed and many pedestrians, encourage street activity and local commerce. An urban fabric that is more permeable to pedestrians and cyclists than to cars also prioritizes non-motorized and transit modes.

- **TRANSIT**

Figure 5 Transit

Transit connects and integrates distant parts cf the city for pedestrians. Access and proximity to High-capacity public transit service, defined as bus rapid transit (BRT) or rail transit is a prerequisite for TOD Standard recognition. High-capacity public transit plays a critical role. as it allows for highly efficient and equitable urban mobility and supports dense and compact development patterns. Transit also comes in various forms to support the entire spectrum of urban transport needs, including low- and high-capacity vehicles, taxis and motorized rickshaws, bi-articulated buses and trains.

- **DENSIFY**

Figure 6 Densify

To absorb urban growth in compact and dense forms, urban areas must grow vertically (Densification) instead of horizontally (sprawl). In turn, high urban densities oriented towards transit support a transit service of high-quality, frequency

and connectivity, and help to generate resources for investment in system improvements and expansions.

Transit-oriented density results in well-populated streets, ensuring that station areas are lively, active, and vibrant and places where people want to live. Density delivers the customer base that supports a wide range Of services and amenities and makes commerce thrive.

The only limits to densification should result from requirements for access to daylight and circulation of fresh air, access to parks and open space, preservation of natural systems, and protection of historic and cultural resources, the performance objective under this principle emphasizes residential and non-residential density to support high-quality transit and local services.

- **COMPACT**

Figure 7 Compact

The basic organizational principle of dense urban development is compact development. In a compact city, or a compact district, the various activities and uses are conveniently located close together, minimizing the time and energy required to reach them and maximizing tie potential for interaction. With shorter distances, compact cities require less extensive and costly infrastructure (though higher standards of planning and design are required), and they preserve rural land from development by prioritizing the densification and redevelopment of previously developed land.

The principle Compact can be applied to a neighborhood scale, resulting in spatial integration by good walking and cycling connectivity and orientation toward transit stations. At the scale of a city, being compact means being integrated spatially by public Transit systems. The two performance Objectives for this principle focus on the proximity Of a development to

existing urban activity, and short travel time to the major trip generators, in the central and regional destinations.

- **MODAL SHIFT**

When cities are shaped by the above principles, personal motor vehicles become largely Unnecessary in day-to-day life. Walking, Cycling and the use of hell-capacity transit are easy and convenient and can be supplemented by a variety of intermediary transit modes and rented vehicles that are much less space-intensive.

Figure 8 Modal Shift

Scarce and valuable urban space resources can be reclaimed from unnecessary roads and parking and can be reallocated to more socially and economically uses.

1.1.2 Components of TOD

The TOD components are the 3 Ds below:

- Density (For adequate population density for transit ridership)
- Diversity (Mixed Use, Mixed Income that use transit)
- Design (Safe, Comfortable, Active (24X7) Environment created by walkability and access to transit.

The 3 Ds define the density, mix of uses and connectivity required within walking distance of transit stations to encourage transit use and a 24 hour environment the transit stations.

Figure 9 Density, Diversity and Design

1.1.3 Structure of TOD

- **Station Level TOD:** Station Accessibility plans and Development Control regulations Indiranagar, Bangalore;
- **Area Level TOD:** Safe Access interventions and better connectivity to transit, MIDC Marole, Mumbai;
- **City Level TOD:** Parking Norms in India's most transit rich city, Mumbai;

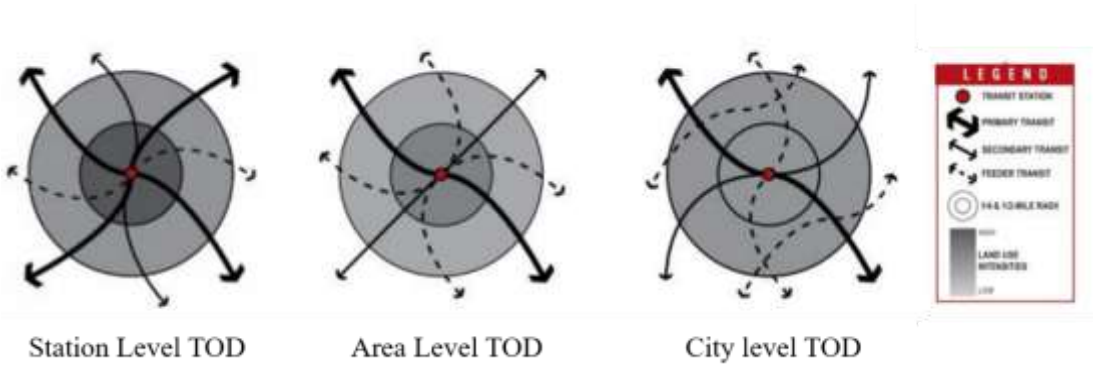


Figure 10 Station, Area and City Level TOD

1.1.4 What are the main elements of TOD?

- Walk able sign with pedestrian as the highest priority
- Train stations as prominent feature of town centre
- Public square fronting train station
- A regional node containing a mixture of uses in close proximity (office, residential, retail, civic)
- High density, walk able district within 10minute walk circle surrounding train-station
- Collector support transit systems including streetcar, light and buses, etc.
- Designed to include the easy use of bicycles and scooters as daily support transport
- Large ride-in bicycle parking areas within stations

- Bike share rental system and bikeway network into stations
- Reduced and parking inside 10. minute walk circle around town Centre / train station
- Specialized retail at stations serving and locals including cafes, grocery, dry cleaners

1.2 Literature Review

The literature review is done in two parts before finalizing aim and objectives and after. Depending upon the TOD oriented Cities which can be implemented in Vadodara city.

- **Khandelwal Palak (2010): Transit Oriented Development**
- The proposed transit oriented strategies in India do address new high density development around the transit stations, Investing In critical transportation infrastructure and better traffic and transportation management and parking management. Pedestrian safety and convenience are also addressed.
- The strategies do not address immediate and short term solutions for generating transit ridership and moving people away from private vehicles towards the use of public transportation.
- Therefore, the proposed strategies may not reduce congestion on an immediate and short term basis. The issue of increasing transit ridership on an ongoing basis is also not addressed.

- **Ar. Deepshikha Jain, Ekta Singh, Rashmi Ashtt (April 2013)** :

  A Systematic Literature on Application of Transit Oriented Development
- TOD does not only relate to mass transit, but it is a strategy to decongest nodal, major points, arteries of the city by making people

walk, use public transport, in order to make city environmentally sustainable.

- TOD as a policy is envisaged to have a significant positive impact in mitigating issues at urban scale but there are variety of attributes and indicators that impact the applicability of (SLR) that targets the consolidated knowledge on Transit Oriented Development, analyze the parameters for the successful TOD's.
- TOD can have a heap of social, natural and financial advantages for individuals and groups, from lessened expenses of living, better access to employments, and financial development, to more beneficial ways of life and, through diminished car utilize that defines the rationale of TOD in India.

Sara shafiei and Nagendra h.n (2014): **Transit oriented development: a strategy for an effective urban growth**

- The result is that both methods have advantages and dis-advantages. For instance, the use of Bus and BRT is suitable for smaller population size lower population density areas and less costly for implementation and operation. But successful implementation of TOD based on the bus is more difficult for longer cities than an implementation of TOD based on rail. Also, the cost of implementing rail transport during the implementation the project cost is high, but fora longtime, this will be beneficial for the city.

1.3 Problem Statement

The rapid growth in automobiles has resulted in congestion, and air pollution. In order to solve these problems the city has already invested in a bus transit system. The city has also become a Centre of opportunities, with more and more people from regional areas moving into the city looking

for jobs. These people often lack the skill to get a good steady job and cannot afford to live within the inner city, instead choosing to live around the periphery of the city (as the cost of living in the inner city is usually very high) where the transit services are poor. Since transit is the main mode of travel for the urban poor, their mobility and accessibility is limited. Thus there is a need for inclusive planning to improve the socio-economic status of all citizens.

Transit investment can help to increase the access to opportunities, and in conjunction with good land use planning and policies can achieve sustainable urban development. Around the world, integrating land use and transport planning has been recognized as the way to achieve sustainable development. If transit has to be the driver in urban development, transit ridership needs to increase. Many factors such as zoning policies, land use distribution, transport policies etc. play a role in increasing ridership. The current study will assess the sufficiency of transit investment and other factors influencing transit ridership for achieving sustainable urban development in Vadodara.

1.4 Aim of the Study

To Create Mobility plan of Vadodara with Accessible, safe and integrated transport network.

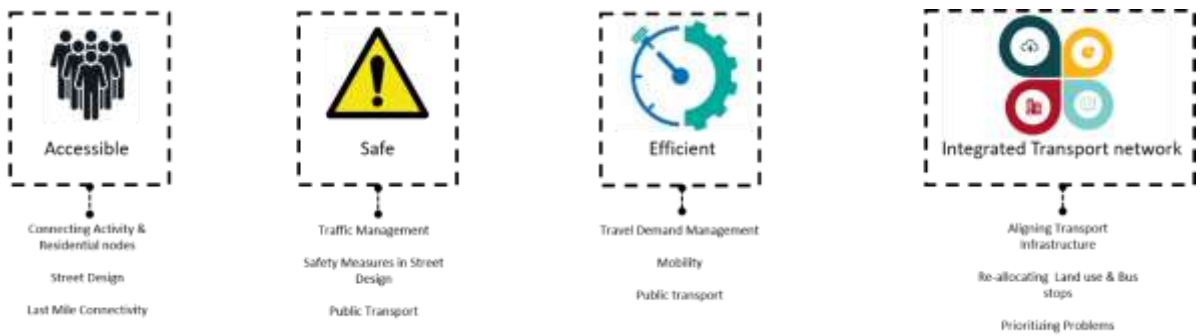


Figure 11 Aim of the Study

1.5 Research Objectives of the Study

This research would mainly focus on fact that how the poor Public transport mode impacts the Vadodara City, How the Traffic congestion, carbon emission and TOD are interlinked. The objectives of the study will be as following:

1. To determine whether the current urban form and transport development on and around the bus transit routes in Vadodara can be characterized as a TOD type of development
2. To investigate the changes that need to be made to make the current development a TOD or a more successful TOD.
3.

1.6 Research Questions of the Study

In order to achieve the above objectives, the research questions to be answered are:

1. Whether the Mass transportation can resolve the problem of Vadodara City's Network and Congestion problems in present condition and in Future?
2. Whether the TOD can make the Development self-sufficient?
3. By discouraging personalized transport can we improve Mass Transportation?
4. Which criteria from the evaluation framework can be selected for improvement in the current case?

1.7 Scope of the study

The scope of the study is focused on the parameters that have caused private Motorization hike in Vadodara city.

- In context on the present study, the analysis is done for the situation emerged in the city along the VMC boundaries and influence zones

provided in Development plan of 2041.

- VMC Boundary which is part of Vadodara City is delineated for the present study.

1.8 Limitations of the study

The study limits itself to VMC boundaries within the city only. Analysis of the entire city is done and solution will be provided as statutory because it depends on public awareness. Detailed analysis of Vadodara city is done for specific parameters which are related to research objectives.

1.9 Research Methodology

The methodology adopted during the study started with identification of Traffic and Congestion issues for Vadodara city. From the various issues identified, Constant decline in Public transport usage in Vadodara city that motivated to take up this particular topic.

The name of the topic was finalized which reflected a holistic approach towards the study. The next step was stating down the exact problem that was faced by the city due to traffic congestion and difficulties faced by poor while trip generation. Public Transport assessment is a very broad aspect, so specific question related to the problem were scrutinized and a focus was created for the research topic. Based on the previous process research questions, aim and objective were finalized.

The aim and objectives helped the research not getting diverted into other aspects of Traffic management and focused study was maintained. The step followed study of literature. Literature review included books, journal papers, articles, reports, etc. which were categorized according to research objectives and the understanding of TOD as in how it is implemented and what are the issues that are faced by Vadodara city in order to achieve Resilience. Findings from literature review were written in the form of summary. The next step is data collection.

A detailed methodology is created in collecting the data and analysing it. Data is also further divided into various categories which helped in collection of precise and relevant data focusing to the research objectives. Analysis is carried out based on the data collected. Final step includes deriving conclusions and recommendation for the study. The overall methodology is presented in the below Figure.

Research Methodology

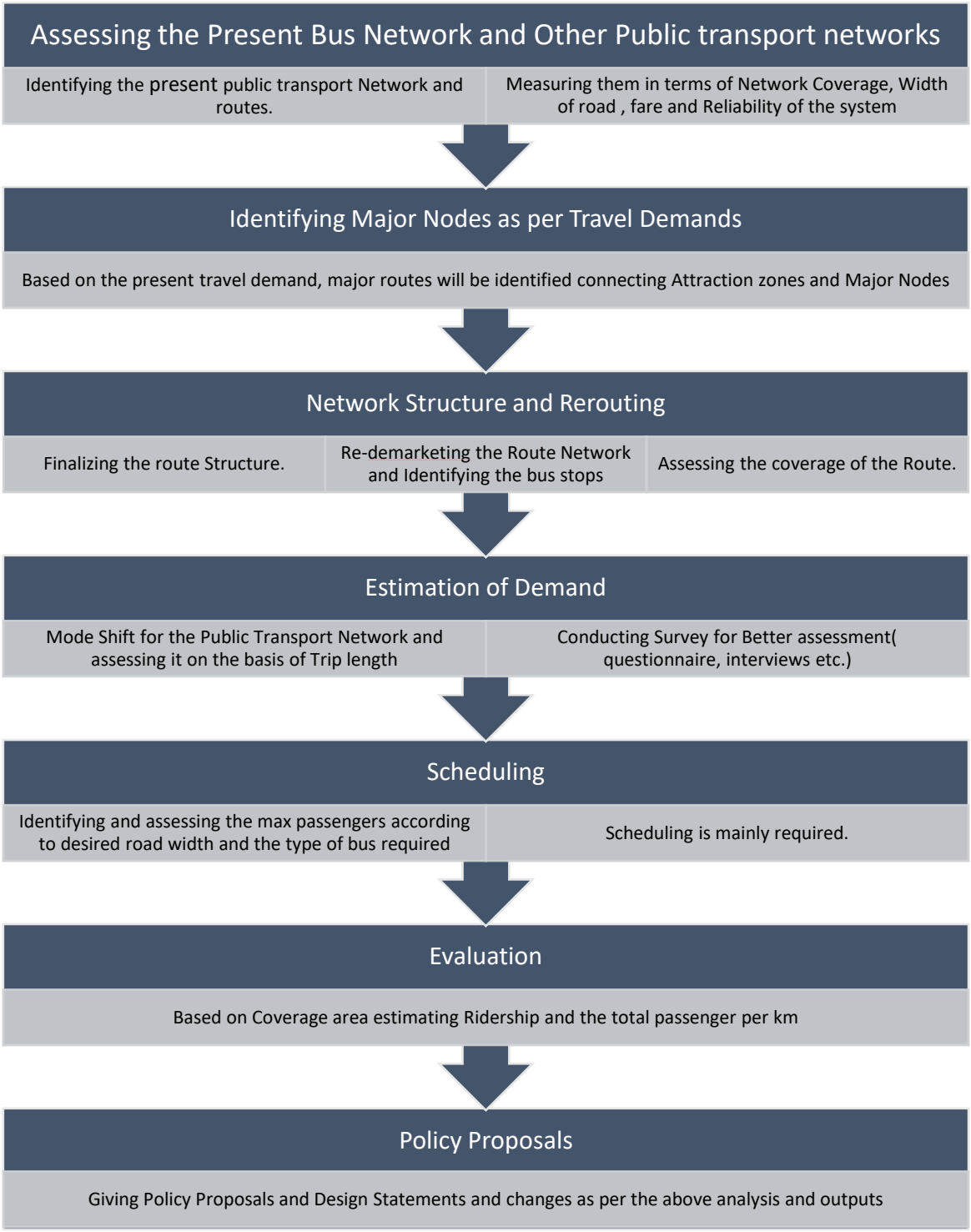


Figure 12 Research Methodology

CHAPTER 2

2 Study Area

In this study the years which are considered to be base years are from 2012-2019 and on the basis of this calculations inventory forecasts are made for 2021, 2031 and 2041.

2.1 General Overview

The study area comprises of Vadodara city and VMC area jurisdiction. In Vadodara city the study area for analysis is limited to area along the VMC Boundary of the city and the Traffic junction spots. Flooding situation has occurred when the river has crossed its H.F.L.

2.2 Vadodara City Profile

Vadodara is located in the Middle East side of Gujarat state, India. It is the third largest city of Gujarat also known as the cultural city. The geographical location is 22°18'N 73°19’E. Total area of city within the municipal limits is about 159.95 sq.kms. The city has population of

16, 66,495 people and is divided into 4 zones, 28 election wards and 12 administrative wards. The 15th largest city in India with the area of 260.33km2.

Vadodara metropolitan region is located at 120km distance from Ahmadabad and 140km from state capital Gandhi agar. Vadodara is well connected to Delhi and Mumbai by railway and state bus service with high frequency. The other railway line connects Dabhoi, Chandod, Karjan,

Dahod, Padra, Sankheda and Kathana. The city is also connected to all major cities by air. The city also known as a "gateway to the golden corridor" as it has major road and rail arteries joining Delhi, Ahmadabad and Mumbai. Delhi-Mumbai Industrial Corridor also passes through Vadodara.

Vadodara District Map

Figure 13 Location map of Vadodara city

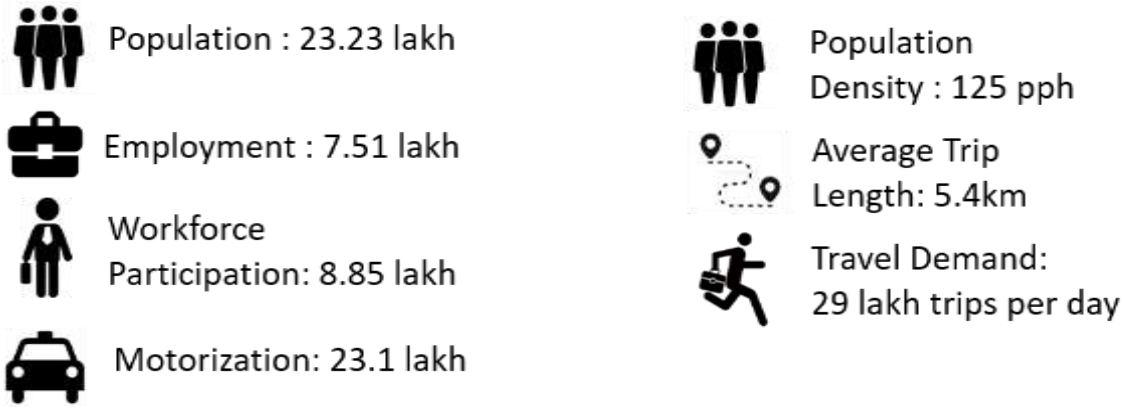


Figure 14 Statistics of Vadodara City

2.3 Climate

Vadodara features a tropical savanna climate under Koppen's climate classification. There are three main seasons: Summer, Monsoon and winter. The climate is dry. The weather is hot through the months of March to July — the average maximum summer is 36 °C, and the average

minimum is 23 °C. From November to February, the average maximum temperature is 30 °C, the average minimum is 15 °C, and the climate is extremely dry. Cold northerly winds are responsible for a mild chill in January. The southwest monsoon brings a humid climate from mid-June to mid-September. The highest temperature recorded is 47 °C and the lowest is 15 °C

2.4 TOD profile of Vadodara City

The geographic area within the jurisdiction of Vadodara Municipal Corporation (VMC) is the Study area. The city was known as Baroda in past and located in central Gujarat between Ahmedabad and Surat. Vadodara is the third largest city in the state of Gujarat.

The average household income of Vadodara is about Rs.6920. The average house hold size is about 4.6. About 80% of household own at least l two-wheeler and 63% own at least 1 cycle. Only about 14% of the households own cars. Average expenditure on transport per household is about Rs. 900 per month, which is 13% of average household income. The percentage of male population to the total population is about 52%, which indicate 923 female per 1000 male (City Development Plan Vadodara, 2006). Also, the existing land use pattern of Vadodara is as follows:

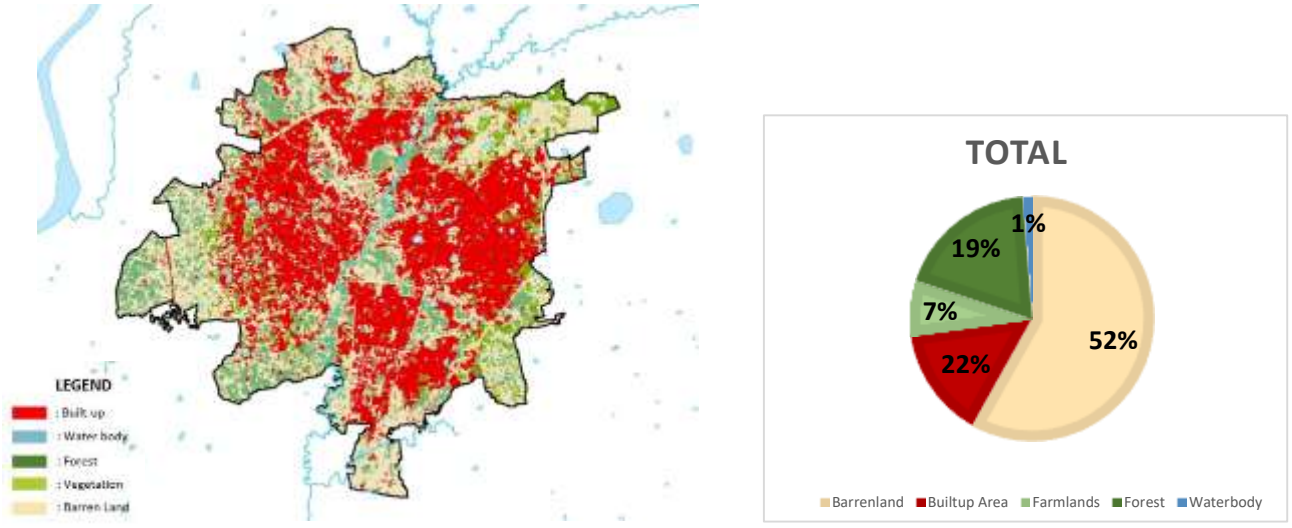


Figure 15 Land use Map of 2021 of Vadodara

The total road length in VMC Area is about 1000 km (composite of arterial, sub-arterial, collector and other roads). Approximately about 11.5 Sq.km of area is under roads, which is about 11% of the total area. More than 80% of the roads are surfaced mostly black topped while 9% roads are subsurface i.e. earthen roads. The city also has a very well-developed road network with eight flyovers, four under passes and two ring roads of 40 meter and 36 meter each .The city is well connected with the major urban centres by Expressway No.1, National Highway (NH8) and State highways.

It also has major road links with Waghodia in the east, Dabhoi in the southeast and Jambusar in the southwest.

2.5 Regional Connectivity of Vadodara City

Road Network:

Vadodara ring radial road network pattern encompasses the entire city and covers 2.7% of the city's land use. Road density is 7 km road per sq. km and for every one km of primary road there are 3 local or other roads joining, resulting in a very well-distributed and dense road network.

Traffic Generating Activity:

The city centre primarily consists of a mix of uses with major administrative buildings, recreational places, medical centres, religious places, and transit nodes, such as bus stops and shared autostands. Some of the active areas in the central parts of the city that include Mandvi, Nyay Mandir, Raopura and railway station area(s) are connected by major arterial roads including Alkapuri Road, Race Course, Nizampura Road, Subhanpura Road, Palace Road, R.C Dutt Road.

The important National Highway No.8 passes through the city. Further major roads leading to the other major cities are Savli Road, Godhra Road,

Vaghodia Road, Ajwa Road, Dabhoi Road, on eastern side and Jambuser Road, Gotri road on the western side.

Broad gauge railway line passing through the city is also an important regional link. A narrow gauge railway line towards Dabhoi and Jambusar also provide a good network. Looking to the city structure and major arties linking the city with the region gives a sound network.

Still it is to be strengthening for future requirements. Location of Railway Station and Bus Stand in the same area creates heavy conjunction but at the same time both gives sound link off the city with the region, state and other parts of the country.

In VUDA area the Urban part i.e. The V.M.C. area and nearby Urban villages are connected with the major roads but fails to provide micro level sect oral roads. A comprehensive circulation plan for the entire urban area is a prime need. Proper parking provisions proper designing of inter sections, segregation of heterogeneous traffic and its implications needs a special attention

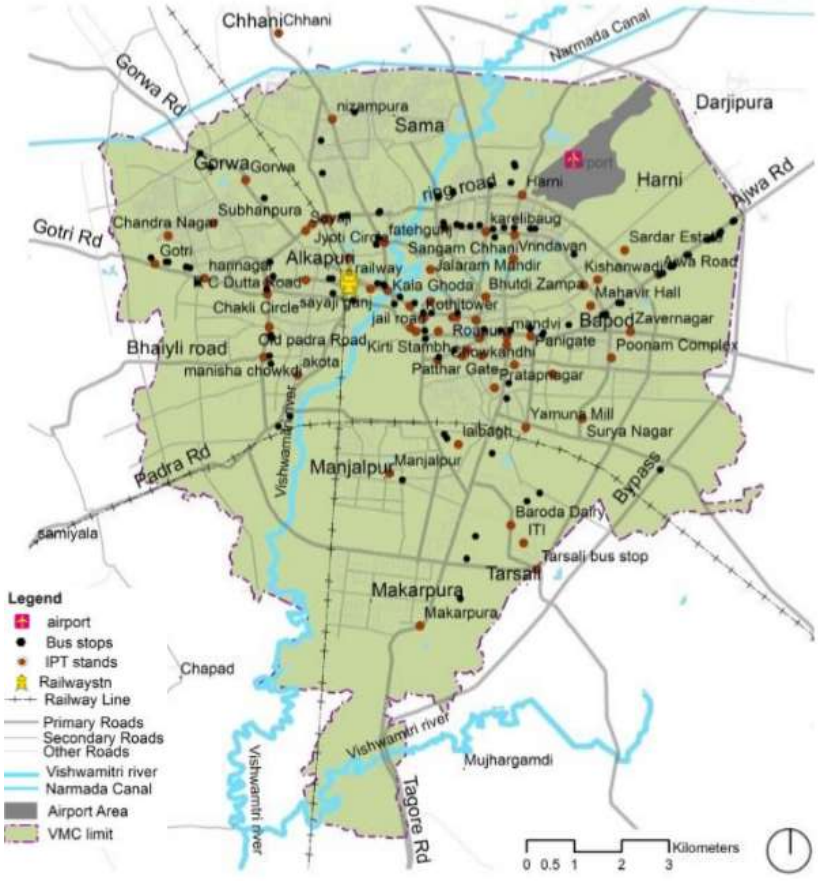


Figure 16 Regional Connectivity of Vadodara City

National Express Highway no. 1

The Ahmedabad Vadodara Expressway or Mahatma Gandhi Expressway or National Expressway 1 is an expressway connecting the cities of Ahmedabad and Vadodara in the state of Gujarat, India. Its width is 3.5 m. It was declared as National Expressway 1 in 1986. It has tow exit loops at Nadiad and Anand.

National Highway no. 48

National Highway 48 (NH 48) is a National Highway of India that starts at Delhi and terminates at Chennai traversing through seven states of India. Its width is 23.5 m. In Vadodara it passes through Dumad, Golden chowkdi, Air force Station, Ajwa chowkdi, L & T knowledge city, Waghodia chowkdi, Kapurai chowkdi, Tarsali chowkdi and Jambuva.

Passengers:

There are approximately 5170 passengers traveling by express bus, 16500 passengers traveling by local bus and 4160 passengers traveling by the city bus schedules.

Buses Owned by State Transport Corporation:

There are approximately 68 buses which are running on the city schedule and around 473 buses running on the rural schedule, which makes around a total of 541 buses of the corporation in the Vadodara Division. The division owned approximately 185 buses on the city schedule around 7 years back.

CHAPTER 3

3 TOD and its Network of Vadodara

For this study, the VMC area is taken into the study and its connectivity of roads, its hierarchy and condition.

3.1 Existing Road Network and Public Transportation Characteristics:

Though public bus transport is not domination in passenger mode choice in Vadodara City, still it has its own significance in sharing the travel needs. The bus transport is indirectly allowing to grow the intermediate public transport in a drastic way. The public bus system is operating in more than 1000 routes, not a single route has the desired frequency to meet the requirement of travel demand.

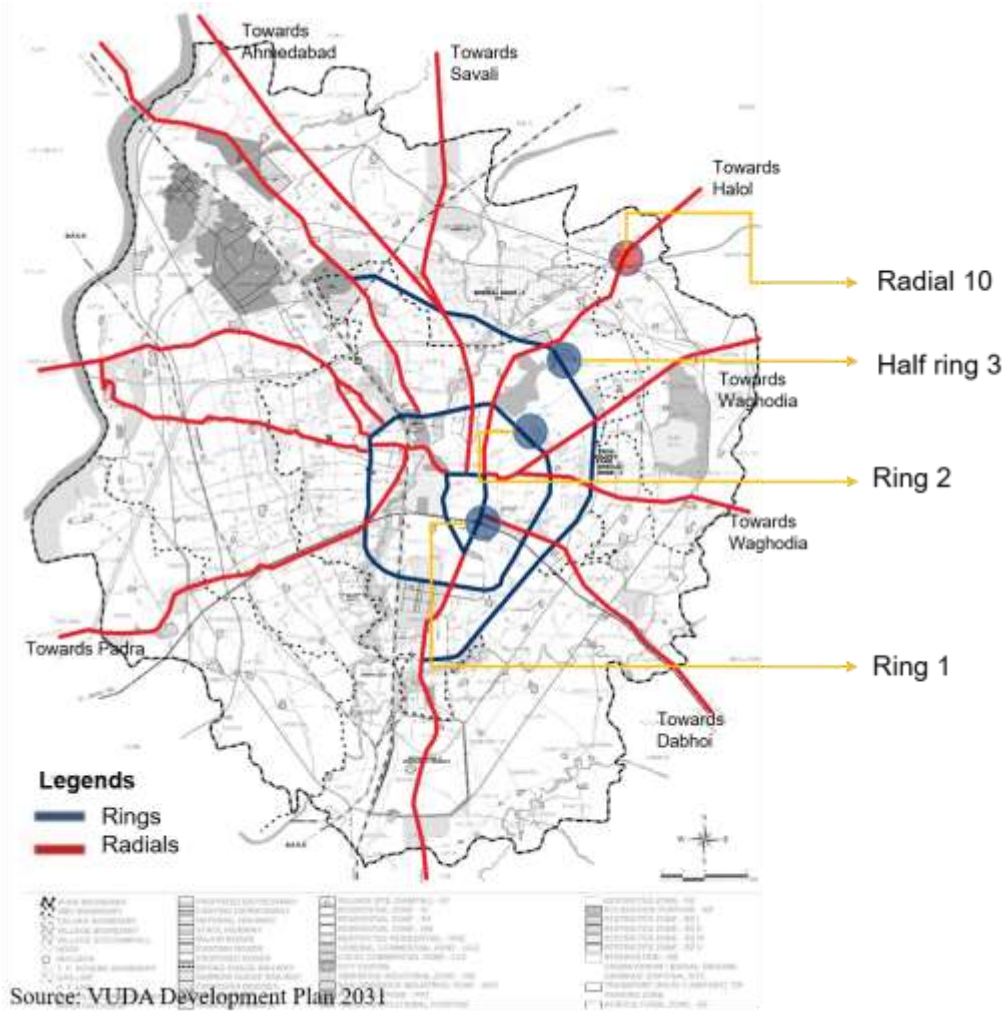


Figure 17 Road Network of Vadodara City

- ***Ring 1: Connecting City centre to the surrounding settlements and Arterials enabling quick movement.***
- ***Ring 2: Connecting City centre and other areas in Municipal limits through Radials***
- ***Half Ring 3: Connecting Vadodara City to Settlements nearby and farther from Vadodara and provide***
    - ***Regional Connectivity and allows through traffic movement.***
- ***Ring 10: Connecting Rings, settlements outside and inside of the city.***

IPT system is competing with public transport system in the above routes. Public bus transport services with a total fleet of 162, the total daily kilometre age has more than 40,000 km. On an average each bus is running 175 Km per day.

City operations in Vadodara are being provided by GSRTC from 3 depots.

They are Makarpura, Panigate, and Race Course depots. Makarpura depot is operating its 39 bus fleet in 186 routes Race Course depot is operating its 64 bus fleet with a combined city and routes where for city operations, it has 33 schedules in 400 routes and Panigate depot has 59 schedules with overburden routes of 450.

Transportation & Connectivity to other parts of the state:

Passengers:

There are approximately 5170 passengers traveling by express bus, 16500 passengers traveling by local bus and 4160 passengers traveling by the city bus schedules. The ratio of the passengers to that of the no. of buses is more in no. and that is why the increasing no. of passengers are creating load on the State Transportation Dept.

Buses Owned by State Transport Corporation:

There are approximately 68 buses which are running on the city schedule and around 473 buses running on the rural schedule, which makes around a total of 541 buses of the corporation in the Vadodara Division. The division owned approximately 185 buses on the city schedule around 7 years back.

3.2 Road Hierarchy in Vadodara City

The Roads of the City are divided into Four categories Arterial ,Sub-arterial, collector and Local.

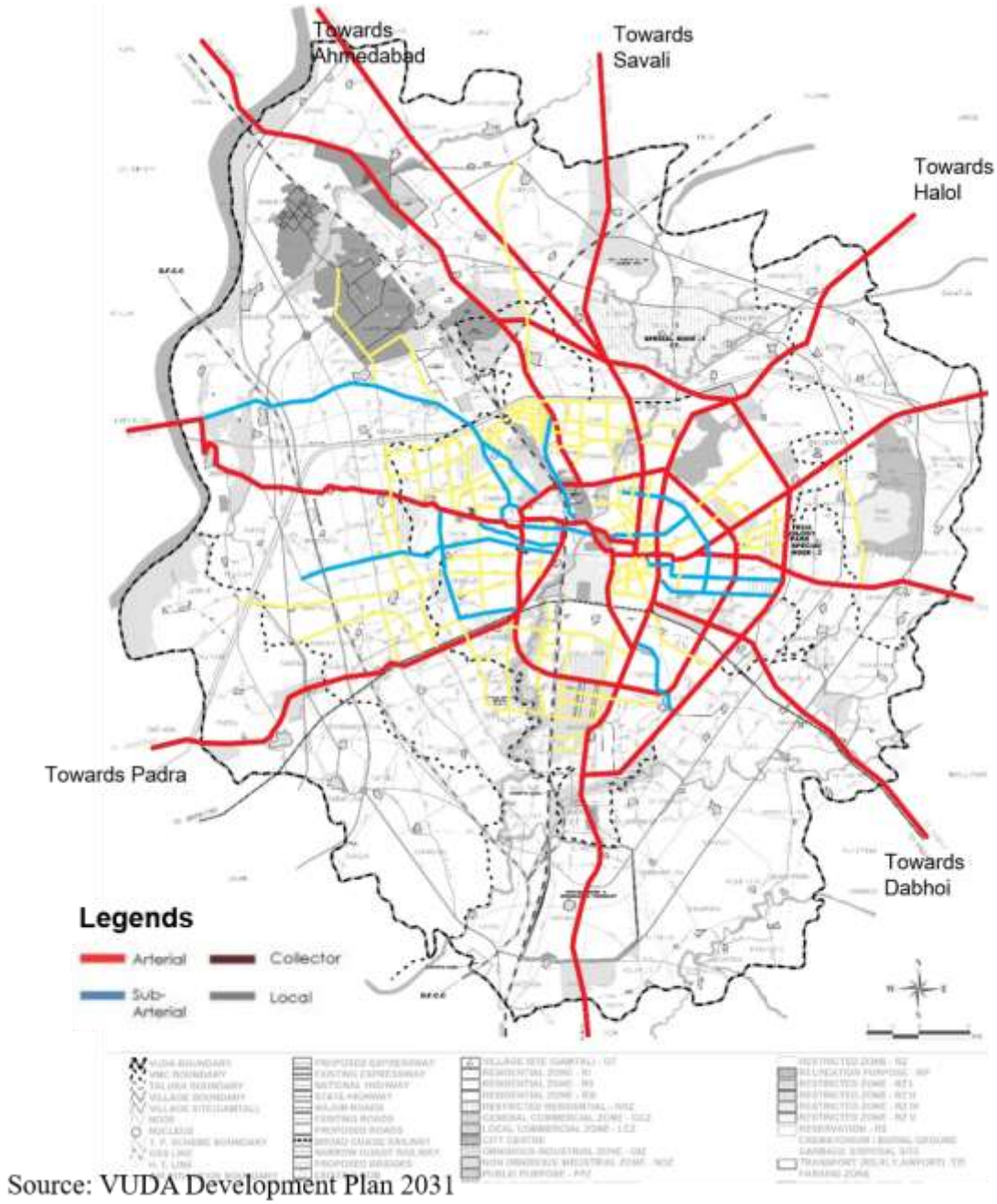


Figure 19 Road Hierarchy of Vadodara City

East-West Roads

- Vinoba Bhave road, connecting Tilak Marg, Salatwada, Nagarwada, Bhutdi zampa upto Champaner gate, north of the walled city;
- R. C. Dutt road, Tilak Marg, Raopura road connecting Jubilee baug, Nyay mandir, Mandvi. Panigate & further east to vaghodia road and Ajwa road;
- Indira avenue diversion from Tilak Road at the Vshwamitri river bridge, Jawaharlal Nehru Marg, Dandia Bazar upto Nyay mandir;
- Rajmahal Road from Laxmi vilas palace to Nyay mandir.
- Vishwarnitri Road between Padra Road in the western side of the river; &
- Jawaharlal Nehru Road and east to Dabhoi road via Lalbaug;

Western Roads

- V. S. Marg - R.C. Dutt Road
- Jetalpur Road
- Gotri Road
- Padra Road

Ring Road

- Ring road along Padra road in the west, Vikram Sarabhai Marg, Subhash Bridge, University Road, Harni Road, Waghodia Road to Tarsal] and via Makarpura GIDC to Padra Road Junction.

North-South Roads

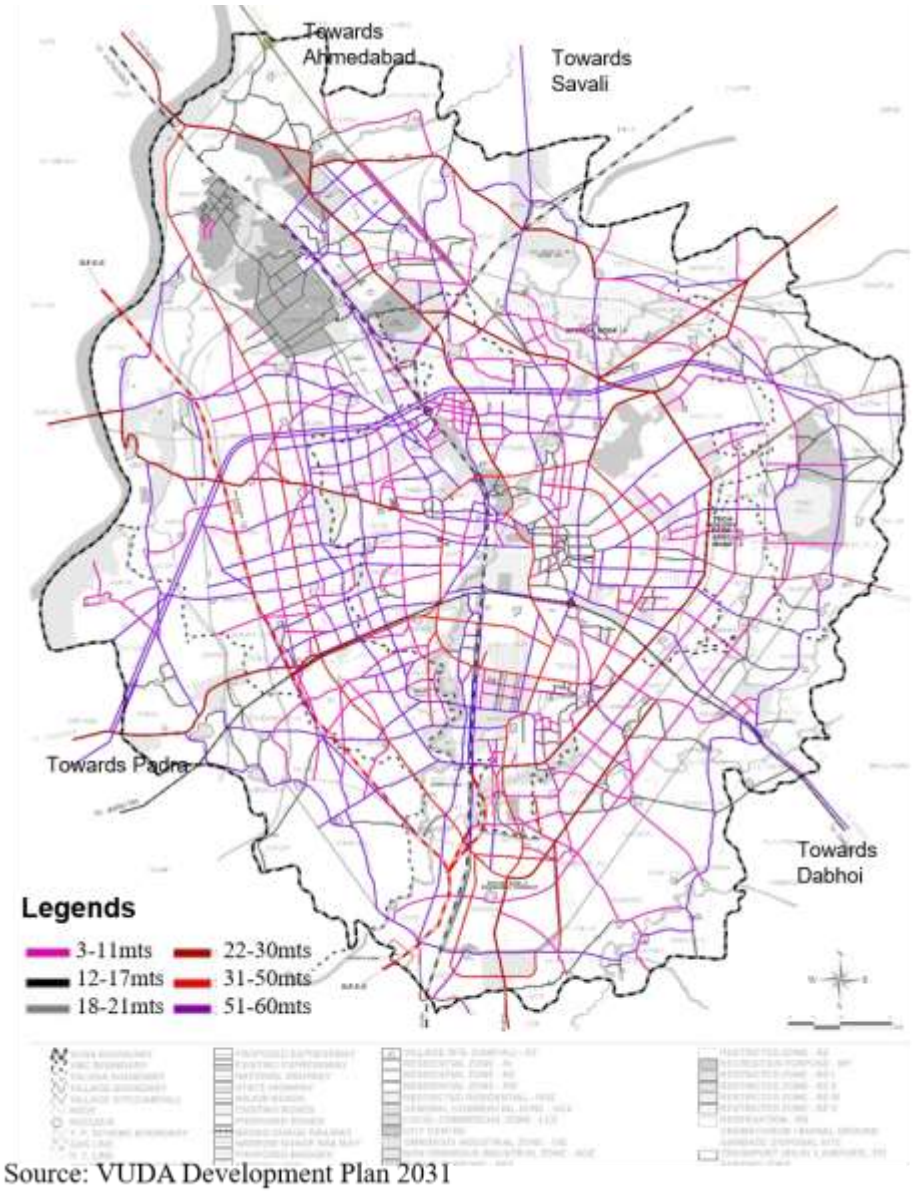
- Fatehgunj road in the west side of Sayaji Baug. - Long Road connecting Baucharaji road, Prof. Manek Rao road, R. V. Desai Road upto Pratapnagar. - Link connecting Godhra Road State Highway with Harni Airport and southwards to Bank road; & - Gendigate road, Pratapnagar Road upto the railway crossing.

3.3 Road Width and Condition of Existing Road Network:

On an average, Vadodara city has Ring-radial form of Road network which is divided into Four categories Arterial, Sub-arterial, collector and Local.

In Arterial it is 15m to 52m Roads, in sub-arterial it is 12m to 30 m roads and in collector it is 9m to 21m roads.

It is observed that mandvi are and fategunj area have roads < 18m width



Source: VUDA Development Plan 2031

Figure 20 Road Width of Vadodara City Roads

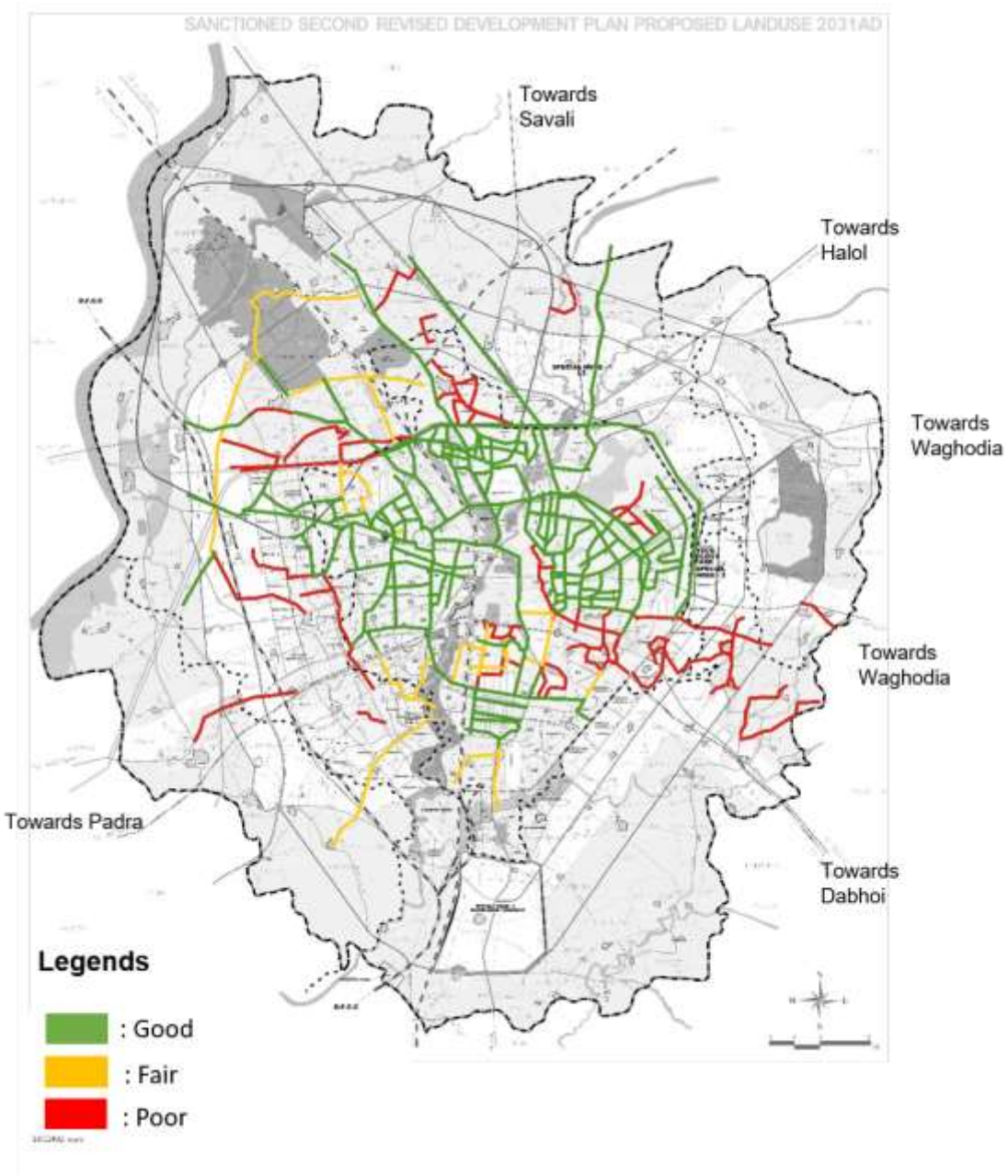


Figure 21 Condition of Roads in Vadodara

The Roads of the City are divided into Four categories Good, Bad and poor on basis of reference picture i.e. figure 22

Apart from Roads near Makarpura GIDC, Ranoli GIDC and Gujarat Refinery, maximum roads are in good condition.

Some Roads in Navapura and Fategunj(City centre) are in Bad condition.

Figure 22 Conditions of Roads of Vadodara

	Road Hierarchy (length in km)				**Total**	
Condition of Road	Arterial	Sub-Arterial	Collector	local	length	Length%
Good	124	51	209	642	1025	60%
Fair	16	8	93	471	588	34%
poor	0	1	13	89	103	6%
Grand Total	140	60	314	1202	1716	100%

Table 1 Road Hierarchy and Road Condition

Typical Cross sections of Existing Roads:

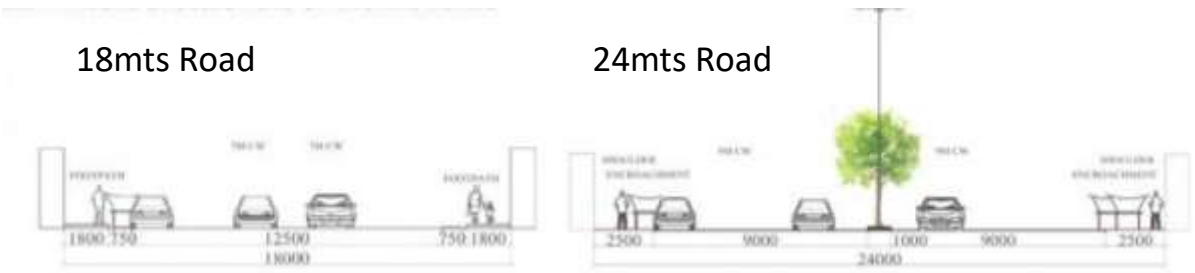


Figure 23 Typical Cross-section of 18m and 24m roads of Vadodara City

3.4 Identification of major spines, landuse along the spines and major nodes of Vadodara

Vadodara is well connected with its road networks, radial ring roads and spines from north to south and east to west. National Highway 48 (NH 48) in Vadodara passes through Dumad, Golden chowkdi, Air force Station, Ajwa chowkdi, L & T knowledge city, Waghodia chowkdi, Kapurai chowkdi, Tarsali chowkdi and Jambuva.

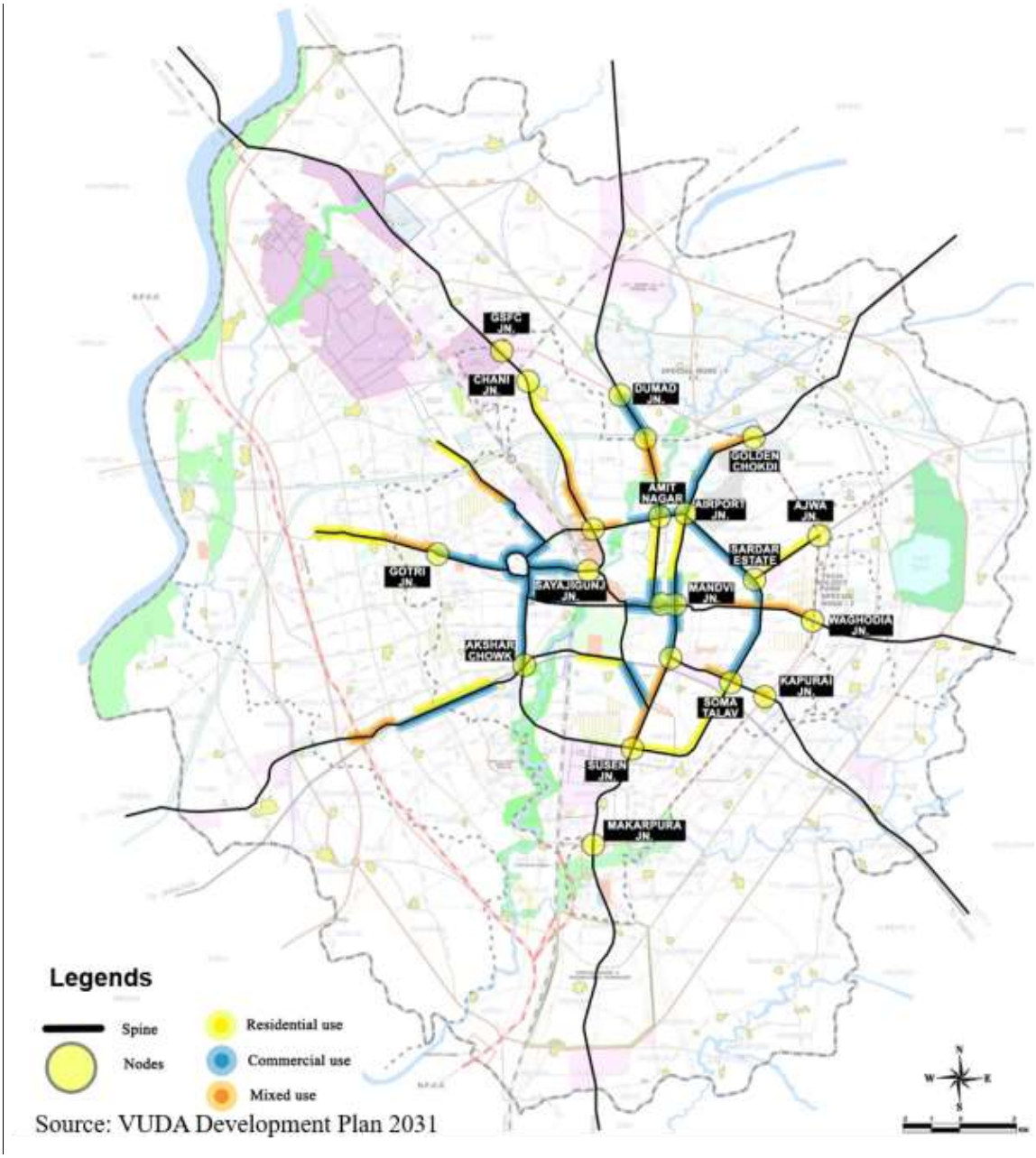
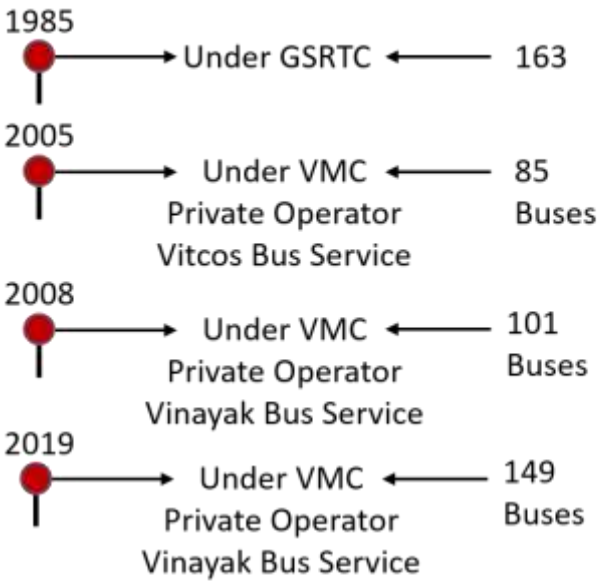


Figure 24 Major junction , Land-use and Nodes along the spines of Vadodara Road Network

Major landuse along the spines are observed to be commercial and mixed-use. Major nodes in the city started with core city area i.e. Mandvi expanding gradually till Makarpura in south and GSFC in the north. These nodes caters to major activities of the city be it commercial, industrial or residential. Traffic junctions, Paratransit and public transport stops and routes are all associated with these nodes in the city.

- **26% Road needs improvement**
- **55% roads are encroached**
- **23 major missing linkages in the network**
- **2 options for East-West Connectivity**

3.5 Existing Bus Network of Vadodara City



Operational Characteristics:

Contract Net Cost	Fare Structure Rs 5 For 1 km
Service Period 17 Hours	Fleet Utilization 90%
No of Routes 60	Bus Stops 281

% Road Network Covered:

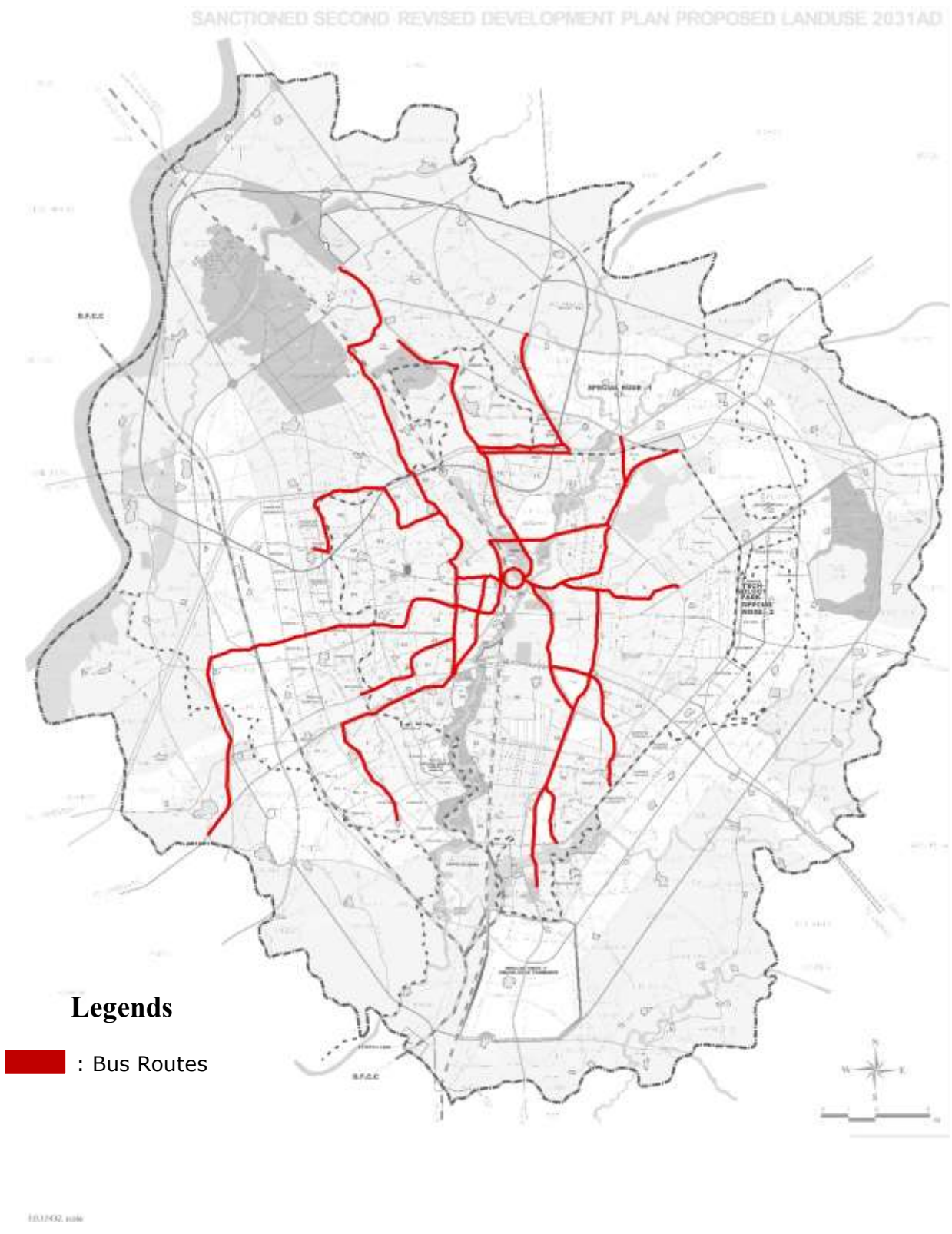


Figure 26 Existing Bus network of Vadodara City

CHAPTER 4

4 Vehicular Analysis of Vadodara

Vadodara city has mixed vehicular traffic which includes slow and fast vehicles, cycles and other type of vehicles on the same roads. This reduces the effective capacity of the roads.

4.1 Vehicular Growth in Vadodara

As per the RTO record Within the VMC limit in 2010 total vehicle was 1,100,037. In 2011, 2012, 2013, 2014 and 2015 vehicle incising by 1301156, 1409526, 1538259 and 1673882 with respected year. So in 2021 total vehicle will be incising 2,493,282 by the average growth rate of 8.5%.In graph it shows the gradual increase between 2012-2015 and after 2016 it is sudden increase in registered vehicles. Vehicles, Walking, bus and IPT in total is just 22% of the total share

The mode share of NMT has reduced from 35% to 30% in past 7 years.

With increase in the income, the mode share of non motorized modes reduces and proportion of 4 Wheeler increases.

Vehicular ownership of the city is increasing along with high mode share of auto as no reliable PT is available for commuters. Cycle contributes to only 19% of the total vehicle ownership and 6.2% to the mode share.

Mainly the cycle trips generated are for education and work purpose.

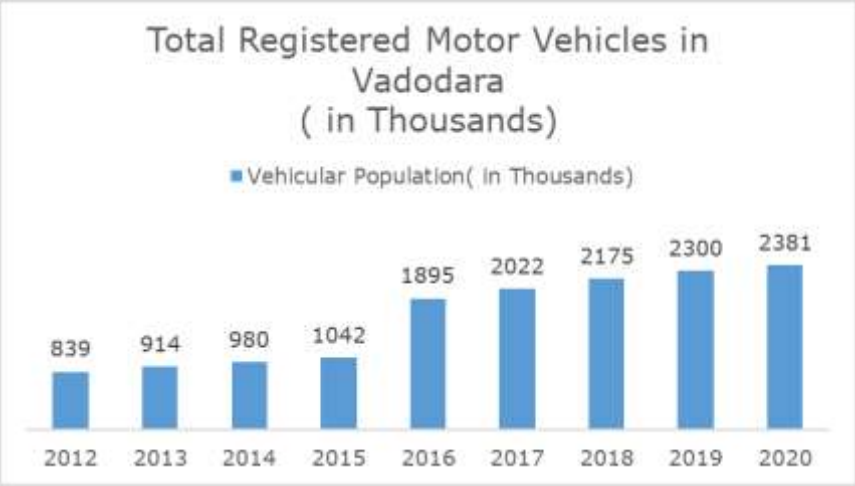


Figure 27 Total Registered Vehicles in Vadodara

Modal Share	Per Share
2w	61
4w	13
cycle	4
walking	10
bus	6
IPT	6

Table 2 Total Modal Share

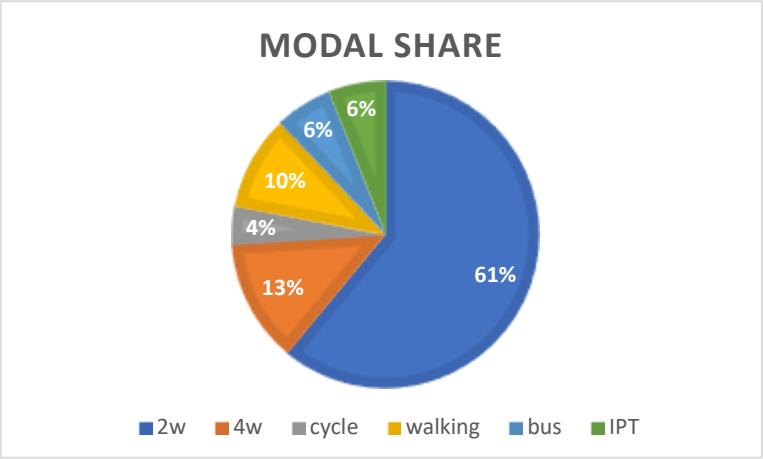


Figure 28 Total Modal Share

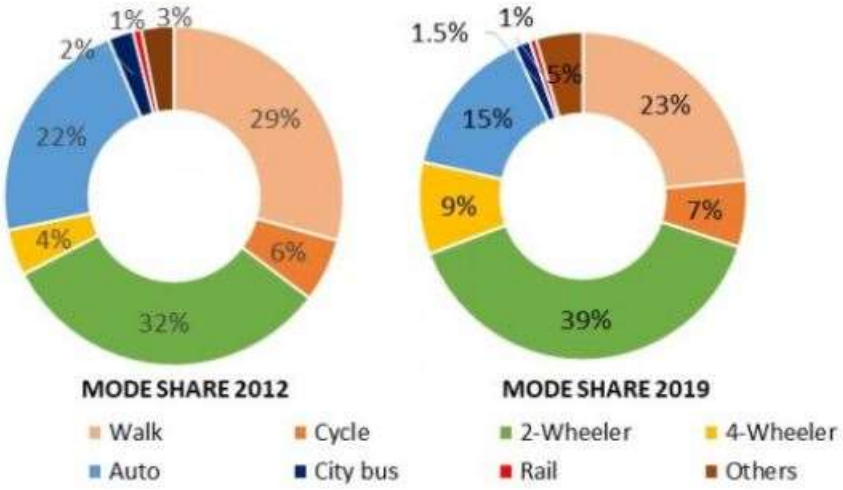


Figure 29 Mode share of 2012 and 2019

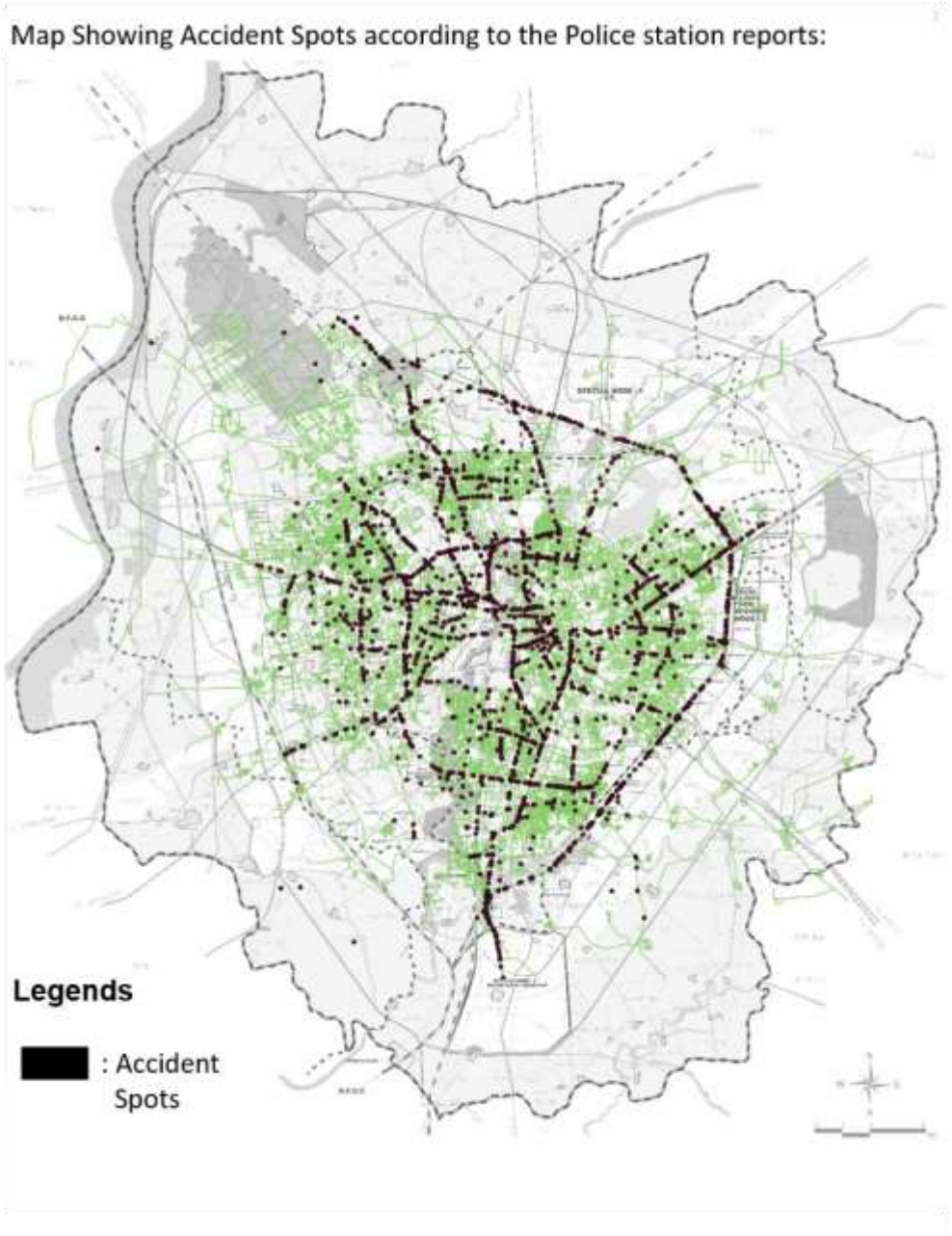


Figure 30 Map showing the Traffic Accident spots in Vadodara

Traffic Accidents:

With the pace of vehicular growth and new fast speed vehicles traffic accidents have also increased. The other part of it is defective layouts of roads, mix traffic, inadequate pedestrian way and poor intersection's design. In 2016 and 2018 there were total of 130 accidents with in VMC limits out of which 63 were fatal and 67 serious. There is also absence of designated cycle tracks in city areas. Total 21% of total accidents happen on national Highway.

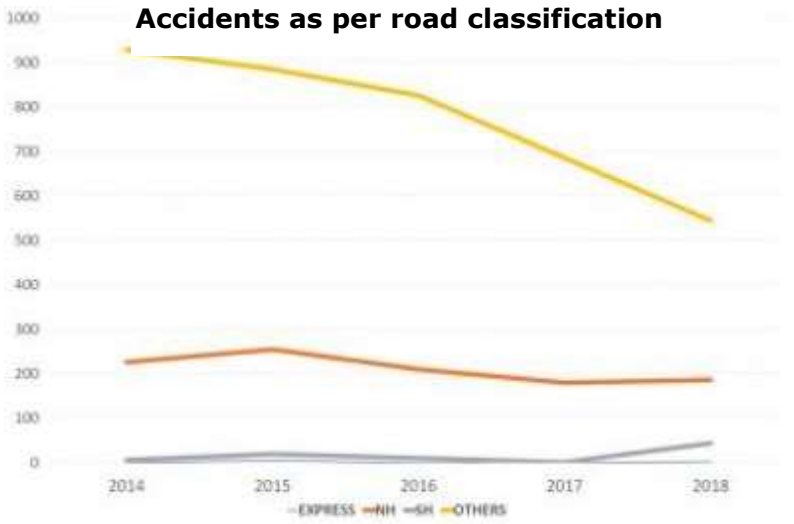


Figure 31 Accidents as per Road classification

Negligible accidents happen on the expressway. There is a slight increase in the accidents from 2017 to 2018,on the stale highways. After multiple measures, by the Corporation to control speeds, the accidents on the highway have decreased. Accidents are still happening due to absence of proper infrastructure.

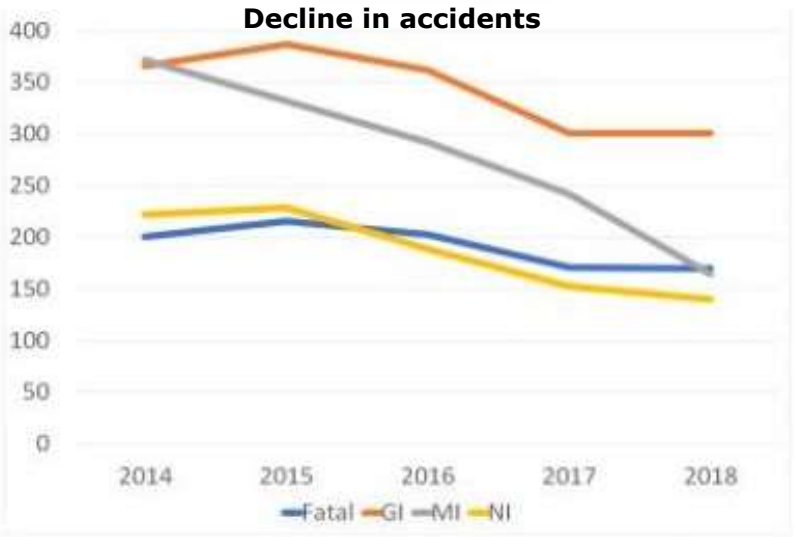


Figure 32 Decline of accidents

There has been a 30 % decrease in the total number of accidents from 2014 to 2018.Despite the decrease in the accidents, city continues to be poor than Ahmedabad and Surat in terms of road safety.

4.2 IPT Growth in Vadodara

With increase in income the mode share of non-motorised vehicles have reduced and proportion of 4 wheelers is increased The NMT has reduced from 35%-30% in last 9 years. The Intermediate Public Transport System, comprising the Auto-rickshaw, Taxi and Tempo's are the backbone of the present IPT system of Vadodara city. Together they account for a share of 7.25 percent of the passenger travel demand In the city. With all their limitation and drawbacks they are keeping the city mobile and active.

The popularity of auto rickshaws in Vadodara is gained through their flexible, short distance and localized characteristics as well as their ability to penetrate the congested parts and offer access to them from the commercial and residential parts of the city.

Year:	2W:	CARS	BUSES	IPT	AUTO	TAXIS
2012	644069	101794	1816	37480	31519	5961
2013	698852	113557	3847	40379	33665	6714
2014	749457	122766	3945	43171	35840	7331
2015	803969	133979	5950	79842	66160	13682
2016	1427034	244197	5452	83816	69425	14391
2017	1519103	267028	5737	87446	72490	14956
2018	1616917	292211	6070	91676	76227	15449
2019	1720593	317745	6386	97171	81131	16040
2020	1807623	341891	6742	102592	85838	16754
2021	1860161	361839	6827	103130	86140	16990

Table 3 IPT growth in Vadodara

There has been a gradual increase in the number of IPT vehicles each year and among IPT vehicles, Taxies are growing at an annual growth rate of 25.28% whereas Autos are growing at a rate of 4.76. It clearly shows that there is a shift in demand from Auto to Taxies.

Growth of IPT Vehicles in Vadodara is also shown in above table.

4.3 Identification of Para-transit routes and its missing Linkages

The public transport system operates 1077 routes with a total length of over 9000km.Passengers are served with 162 bus schedules for intra-city bus transport. Intercity bus services are also serving intra-city passengers.

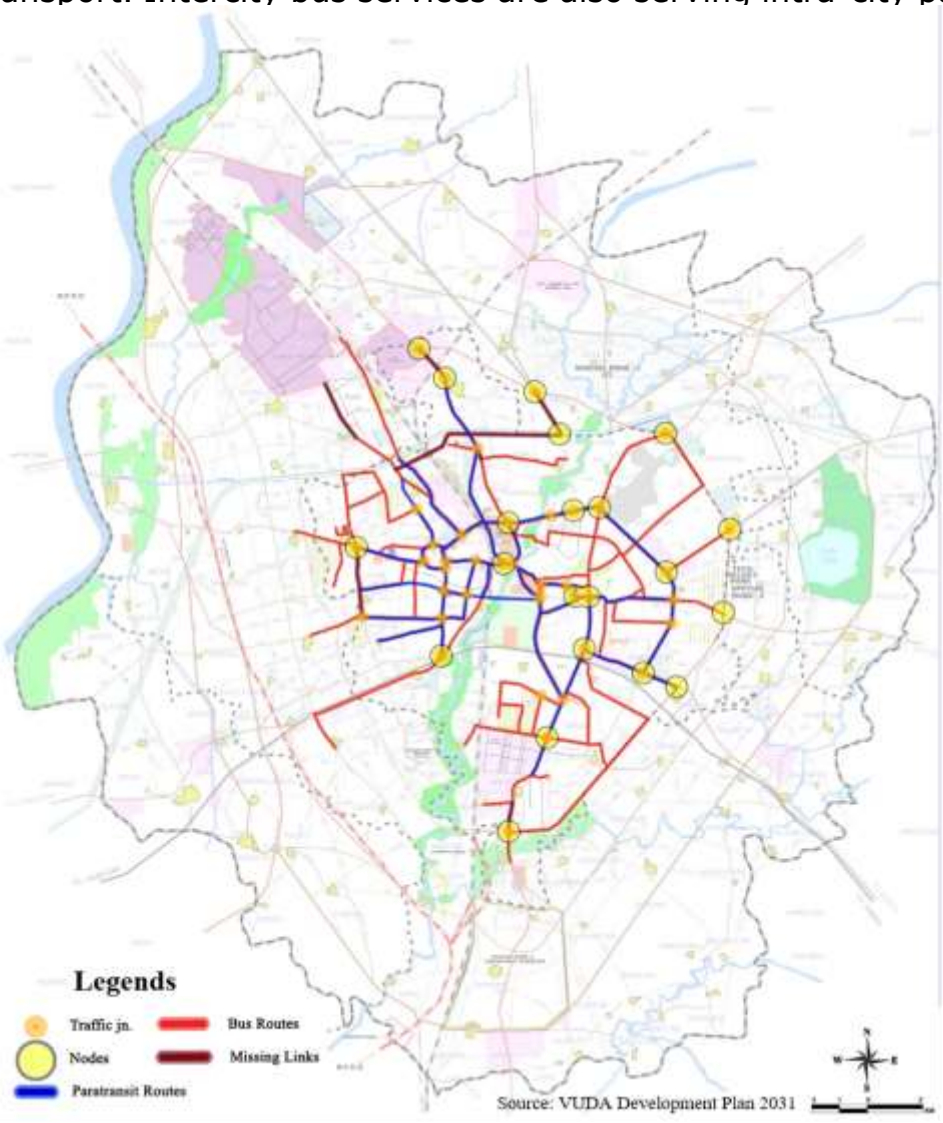


Figure 33 Map showing para-transit routes and its Missing linkages

Sr. No.	Major Corridors	Sr. No.	Major Corridors
1	Railway Station to Gorva	16	Nyaya Mandir to Maneja
2	Railway Station to Anand nagar	17	Nyaya Mandir to Anand nagar
3	Railway Station to Vishwamithri	18	Nyaya Mandir to Pratap nagar
4	Railway Station to Pratap nagar	19	Nyaya Mandir to Makarpura
5	Railway Station to Panchavati	20	Nyaya Mandir to Vishwamithri
6	Railway Station to Wadi	21	Nyaya Mandir to Tarsali
7	Railway Station to Gothri	22	Nyaya Mandir to Harni
8	Railway Station to Gayatri nagar	23	Nyaya Mandir to Lalbaug
9	Railway Station to Channi	24	Mandvi to Channi
10	Railway Station to Padra	25	Sayajibaug to Vishwamithri
11	Railway Station to Makarpura	26	Nagarwada to Channi
12	Railway Station to Panigate	27	Pratapnagar to Makarpura
13	Railway Station to Karelibaug	28	Panigate to Railway station
14	Nyaya Mandir to Baroda dairy	29	Raopura to Vishwamithri
15	Nyaya Mandir to Hariom nagar		

Table 4 Bus routes of Vadodara City

4.4 Parking Scenario in Vadodara

Existing Scenarios	Area in Sq.m	ECS
On-Street Parking	**56190**	**3746**
Off-Street Parking	**15954**	**3746**

Table 5 Existing parking scenarios

In Vadodara city it is observed to have a haphazard parking approach in every area as mentioned in above table on-street parking is designed in area of 56190 sq.m and off-street parking is observed to be in 15954 sq.m Off street parking charges are considered free and onstreet parking charges varies from 20-60rs per hour.

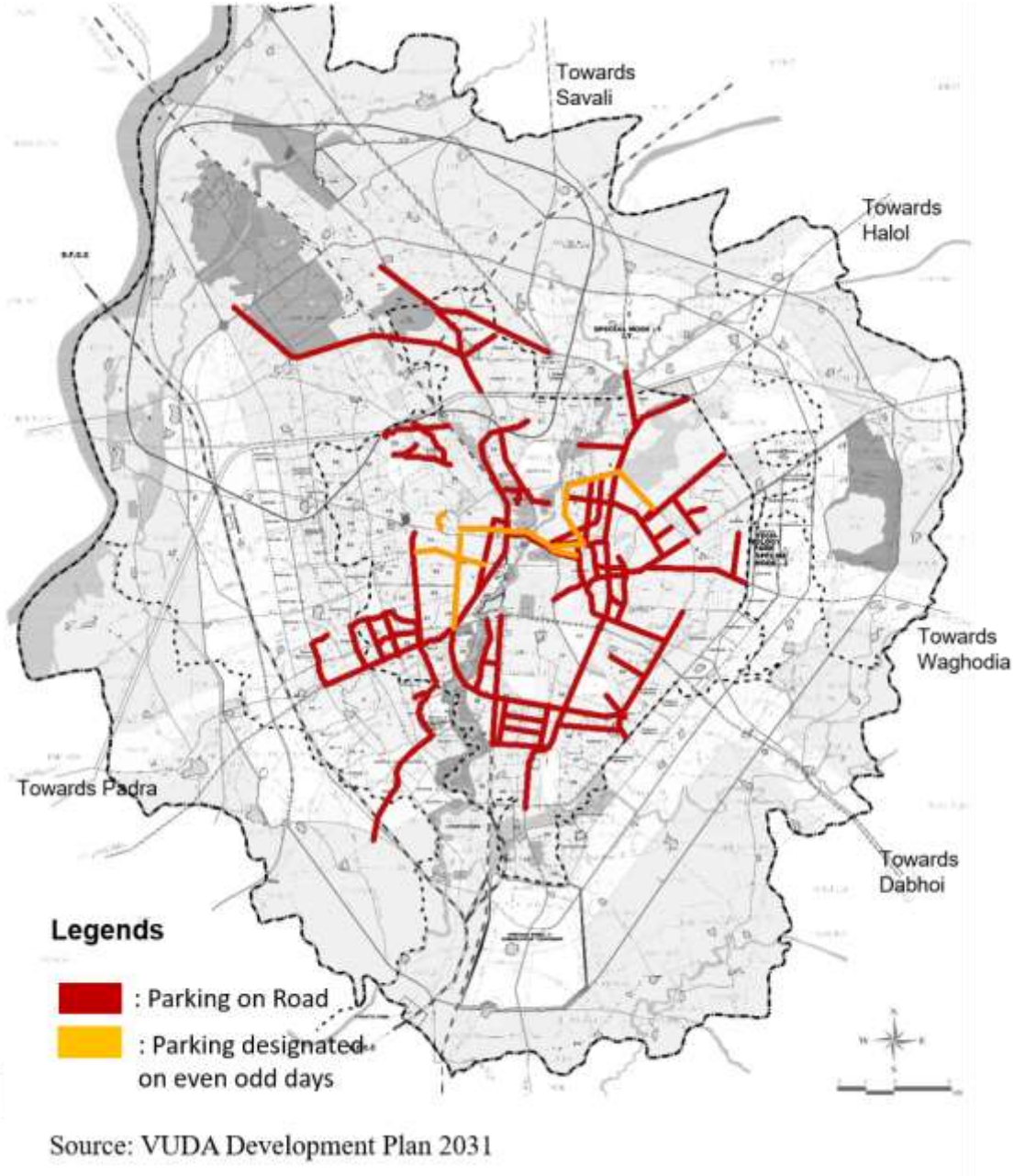


Figure 34 Parking scenarios of Vadodara

The parking designated on odd even days parking charges varies from one authority to another depending on of parking demand. Airport manages to provide short term parking along with incremental charges on hourly basis. While railway station and other private locations have charges considering long-term parking demand. Since there are off-street parking prices and On-street parking is free, vehicles are getting parked on footpaths and causing congestion on major functional roads.

Parking Charges	
Railway Station	
Cars	60rs for 4 hrs l 90rs for 4-8hrs l 140rs for 1 night
Autos	10rs for 2 hrs l 15rs for 2-6hrs l 20rs for 12hrs
Taxi	20rs for 3 hrs l 30rs for 4-6hrs l 35-40rs for 1 night
Minibus & Tempo	40-100rs l 15-30rs per hr
Multiplex and Malls	
Cars	30rs per hr
2-wheelers	15rs per hr
Towing Charges	
Cars	500-700 rs
2-wheelers	300-500 rs

Table 6 Parking charges in Vadodara

2-W have increased 1.6 times from year 2011to 2018 and are projected to increase more than double by year 2040. Total 5 off-street pay & park locations provided by VMC, Railway, GSRTC and Private. 18 On-street free parking locations. Few of the inner city streets are provided with on-street parking, free of charge, on odd-even date alternate lane parking. Legal and Illegal parking areas are marked and parking are done accordingly. Illegal parking are towed and fine are imposed. There is a team of total 302 brigadier, 40 home guards and 70 Civil defence to manage traffic.

The Ownership of Private Vehicles is higher and consistently growing in Vadodara and lack of dedicated parking space has led to haphazard parking scenario in the city. Due to high growth in Private Vehicle Ownership city is lacked with Parking Spaces due to not following of GDCR parking rules, lack of law and enforcement related to parking causing issues like congestion, speed delays, Accidents, environmental degradation. With Consistent hike in growth rate of Private Vehicles, more parking spaces will be required in future which is an Infrastructural cost, affecting Vadodara's economy and is a never ending demand.

According to a Research paper survey 2016, it is observed that Vadodara people are willing to pay Congestion and parking charges if implemented to reduce congestion, and are also willing to change mode (which could be PT). Prioritising Public Transport along with NMT with well-planned network will resolve the Parking issues by 2040. Since, On-street parking is totally free while Off-street parking is highly paid, private vehicle owners find it easy to park on streets & footpaths causing congestion, speed delays, bottlenecks and problem.

4.5 Footpath Condition and Encroachment assessment of Vadodara City

Footpath is present only on 162km length of road network Out of which 80% are encroached by parking, vendors and roadside activities. Level of Service of footpath is 4 which also poor and degraded, As per Mould India Policy Footpath should be designed with minimum width of 1.8mts to 2.5m. As per observation 95% of Footpath were below the standard

Discontinuation of footpath and Enchroachment on Road near fategunj Bride Underpass

Figure 35 Footpath picture showing existing scenario

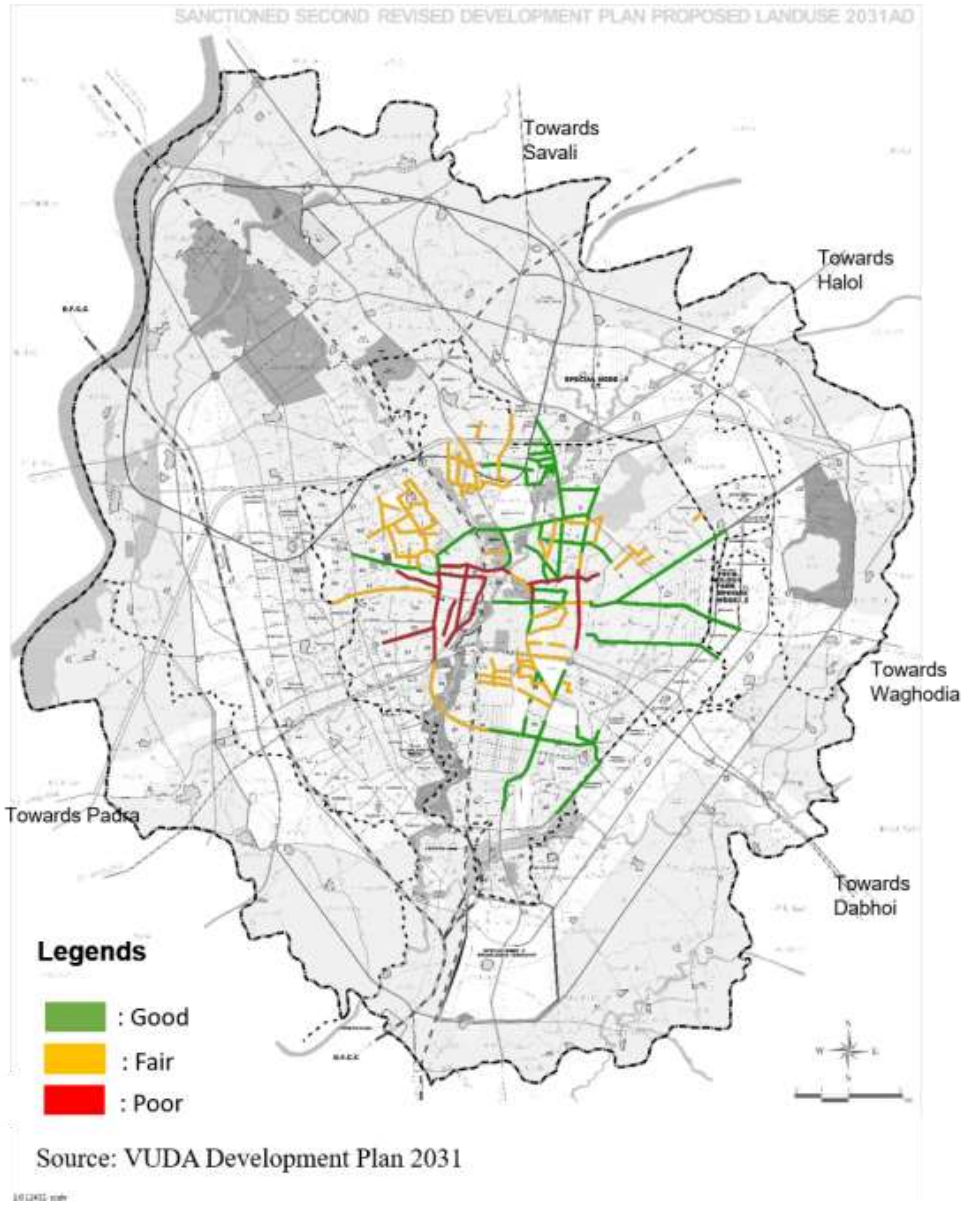


Figure 36 Conditions of Footpaths in Vadodara City

Footpath Width	Length in Km	Encroached in Km	% of Encroachment
> 1.8m	55	47.8	86.9
<1.8m	106	78.76	74.3
No foot Path	295	271	91.5
Total	456	397.5	87.17

Table 7 Footpath width, length and percentage of encroachment on it

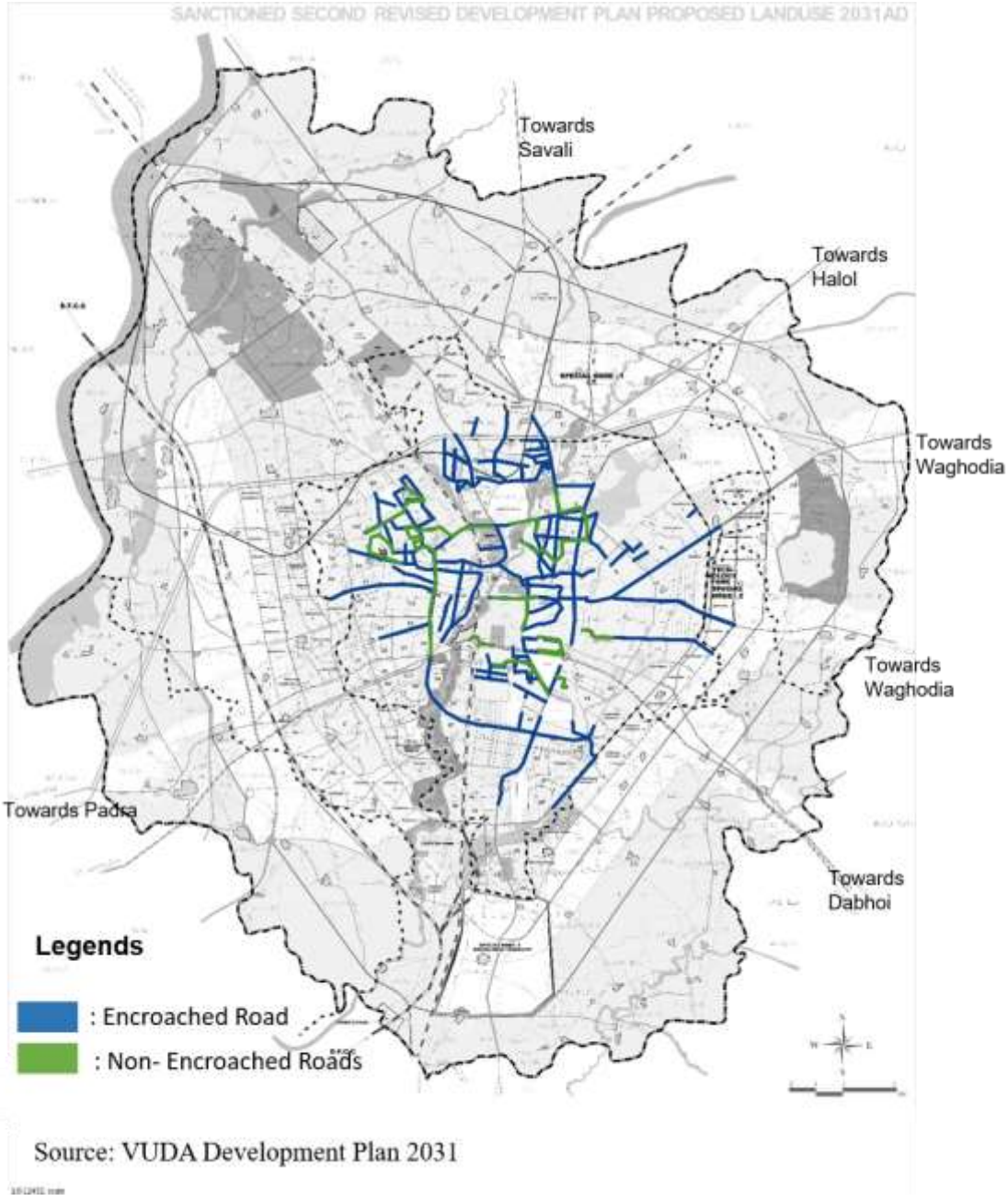


Figure 37 Encroachment on Footpaths

4.6 Gap Analysis and Statutory Recommendations

Node Development	• Node Development in Vadodara is highly required because of the haphazard movement of traffic flow, parking situation, No safety it leads to Congestion.
Improve Road network and connectivity	• Last Mile connectivity is not reached through IPT modes which is a must for any city with urban poor living in the vicinity.
Street space development	• Hawkers, shops and many other poor business owners encroach the streets and it leads to less parking space and Traffic congestion.
Mitigating network discontinuity(bottlenecks)	• City has dead ends rather than that bottle necks should be incorporated where ever there is need.
Promoting mixed land use along the influence spine	• Promoting this can leas to saleable FSI which is economic generation for other parking facilities and street development infrastructure.

Figure 38 Gap Analysis Found while Research Study

CHAPTER 5

5 Proposals and Statutory Recommendations

This chapter includes the policies and mitigation measures which can be taken to prevent Parking and Transportation situations in the city. There are several policies and strategies through which private mode of transport can be decreased. Below are some policies and strategies to strengthen the Public transport network and its usage.

5.1 Devising parking Policy and Management System: PUSH and PULL Approach

For Short Term

- The parking layout must be prepaid with a passing drawing.
- Parking standards should be based on efficiency-based. For new development, parking requirement should be decided by the owner rather than the authority.
- Installation of Parking meters as well as digital parking displays showing the availability of parking. To monitor the parking and traffic situation in the city, On-street, parking pricing will introduce on the roads where heavy congestion, and has potential travel demand corridors.
- Given priority to short term parker and Parking on roads should be charged. Provision of parking meters is desirable. Parking lots and on-street lots are (with meters) to display total and real-time available parking spaces.
- Revenue should be used to improve enforcement, security, maintenance and mobility management program that encourage the use of alternative modes and public transport.
- Space for parking lots should be reserve in the master plan.

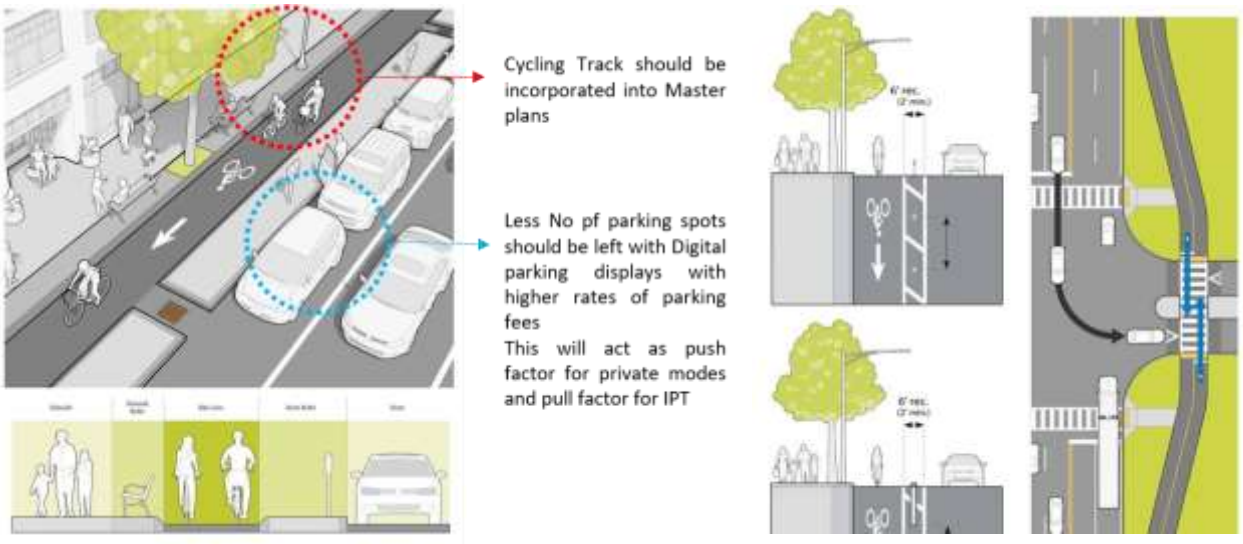


Figure 39 Services that should be provided next to roads

For Long Term

- A traffic cell should be introduced with Director (traffic) and traffic enforcement officers under the director should be appointed by VMC
- Revenue will be used to develop new parking lots as per demand in the city.
- Multistory parking will/should be introduced.
- Cross subsidies are given to a citizen.

Mode Share	Parking Rates	Parking Toeing Penalty
Car	80rs per hr 150rs for 4hrs	1500rs
2 wheeler	40rs per hr 100rs for 3hrs	1200rs

Table 8 Mode Share Parking rates and its toeing panelty rates

Figure 40 Services that should be provided next to roads

5.2 Transit Oriented Development Approach implementation:

Influence Zone :

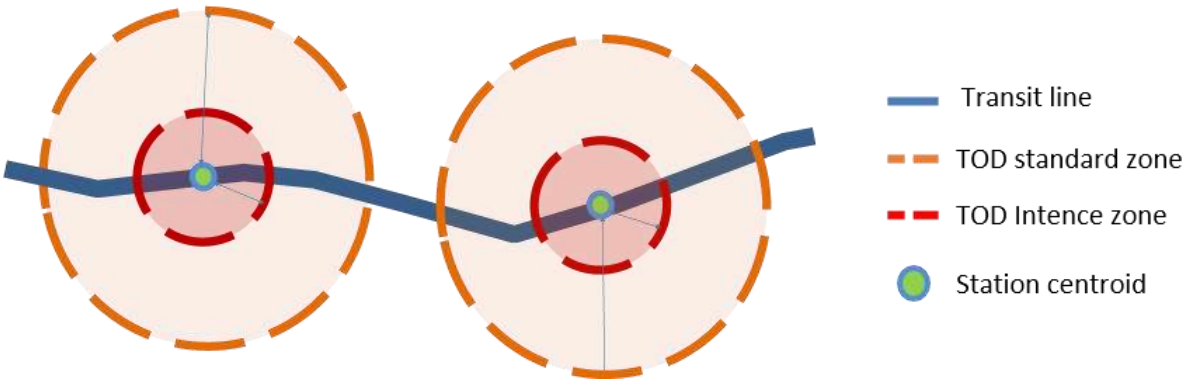


Figure 41 Influence Zone Demarcation

The area in the immediate vicinity of the transit nodes, i.e. within a walking distance, having high density compact development with mixed land use to support all basic needs of the residents is called the influence zone of a transit station/ corridor.

High Density Compact Development :

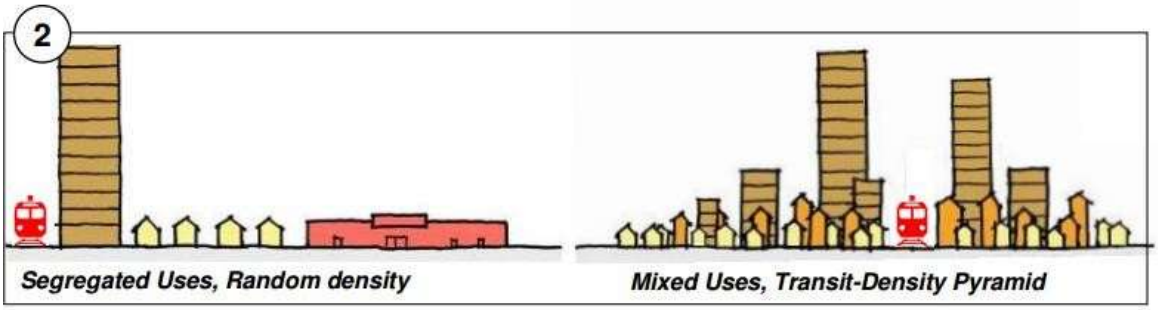


Figure 42 High Influence Compact Development

TOD promotes densification in the influence area by providing higher FAR/FSI and higher population & job density as compared to the area around the influence areas. To ensure sustainable development, the minimum FAR should be 300 - 500%. This will promote higher walkability of transit station, thereby increasing the ridership of the public transport and resulting in increased fare revenue, pollution and congestion reduction.

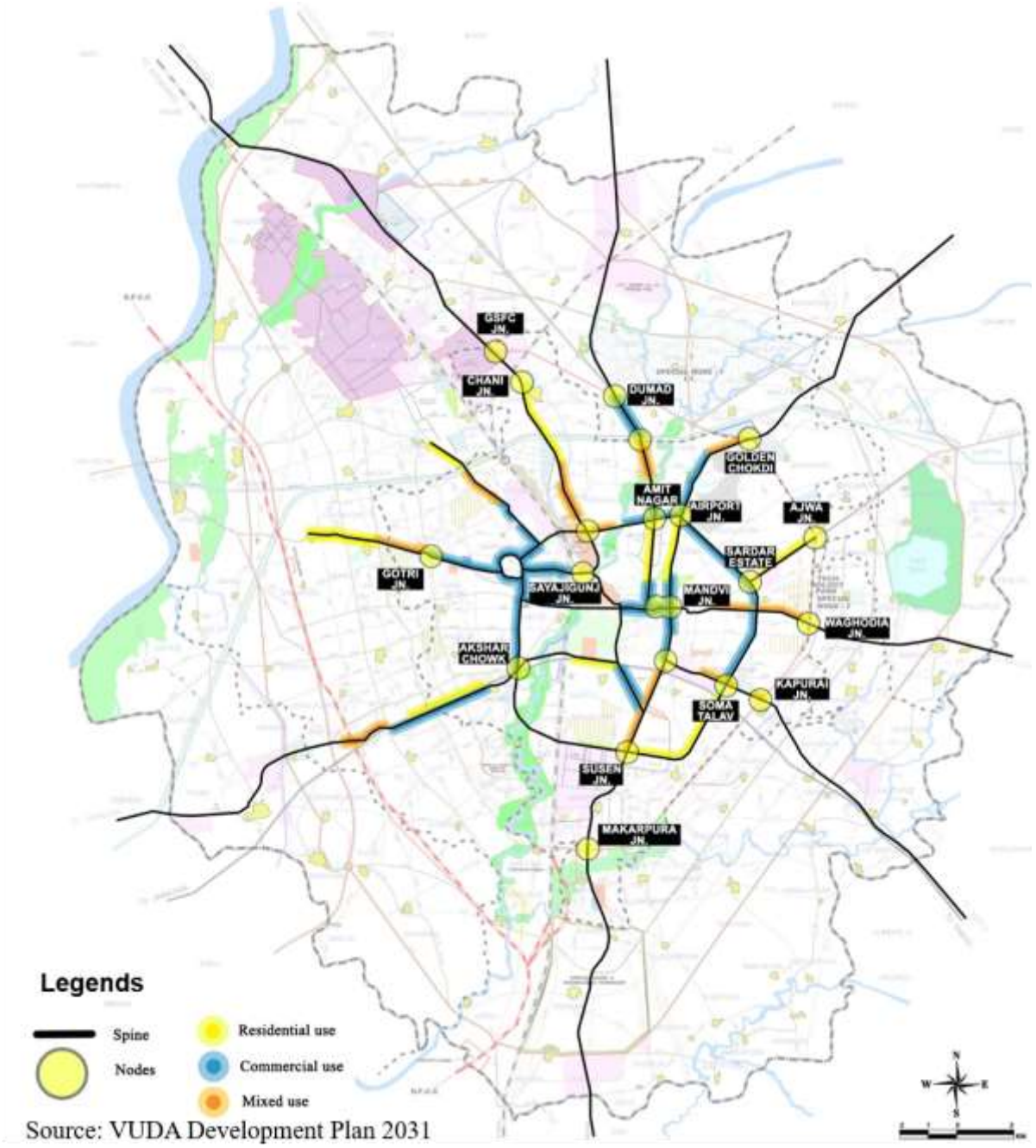


Figure 43 Map showing Land use along the major spine

Policies for high density development:

1. It is imperative to restrict developments such as low-density housing, low-rise development, warehouses, petrol pumps/CNG stations, cremation ground etc. as in the influence area for these categories of development promote personalized vehicle usage.
2. This restriction is to reduce personalized vehicle usage in the influence zone. And in turn reducing unnecessary carbon emissions.

3. Gradient over proximity in the provision of FSI in the influence zone is in place for revenue generation for the authorities. In turn provision of infrastructure towards streetscape and Transit convenience facilities from the generated revenue.
4. The FSI provision promotes outer radius plot holders to increase or promote development and generating economic opportunities.

The FSI distribution over proximity to transit node:

Particulars	100 mtr.	200 mtr.	300 mtr.	400 mtr	500 mtr.	600 mtr	700 mtr.	800 mtr.
Free F.S.I	3	3	3	2.5	2	1.5	1	1
Reduction in chargeable F.S.I	0	0	0	20%	25%	30%	35%	40%
Chargeable F.S.I	3	3	3	0.5	1	1.5	2	2
Land use	Commercial	Mixed use	Mixed use	Mixed use	Residential	Residential + Recreational	Mixed use	Mixed use

- **The major spine FSI distribution**
- The FSI distribution will be 3 units for plots in the 500m range from the road centerline.
- The land use will be same as existing with exemptions in certain areas of growth potential accordingly.

5.3 Proposed City Bus Network and its need for Strengthening:

Figure 44 Demand Comparison between 2019 and 2040

- Low Mode share of city bus In Vadodara shows high dependency on private vehicles.
- As the dependency on private vehicles increases, so does CO2 emission, parking demand and congestion on streets.
- As per the Proposed Network Transit share will be achieved to 14%

- **As per calculation 2000 PPHPD will be catered With the Proposed Bus Network in City Bus.**(PPHPD: Passenger per hour in peak direction)
- In present scenario Passenger flow is less than 2000 so it can be catered easily in Future Road widening and may be BRTS ha to be imposed.

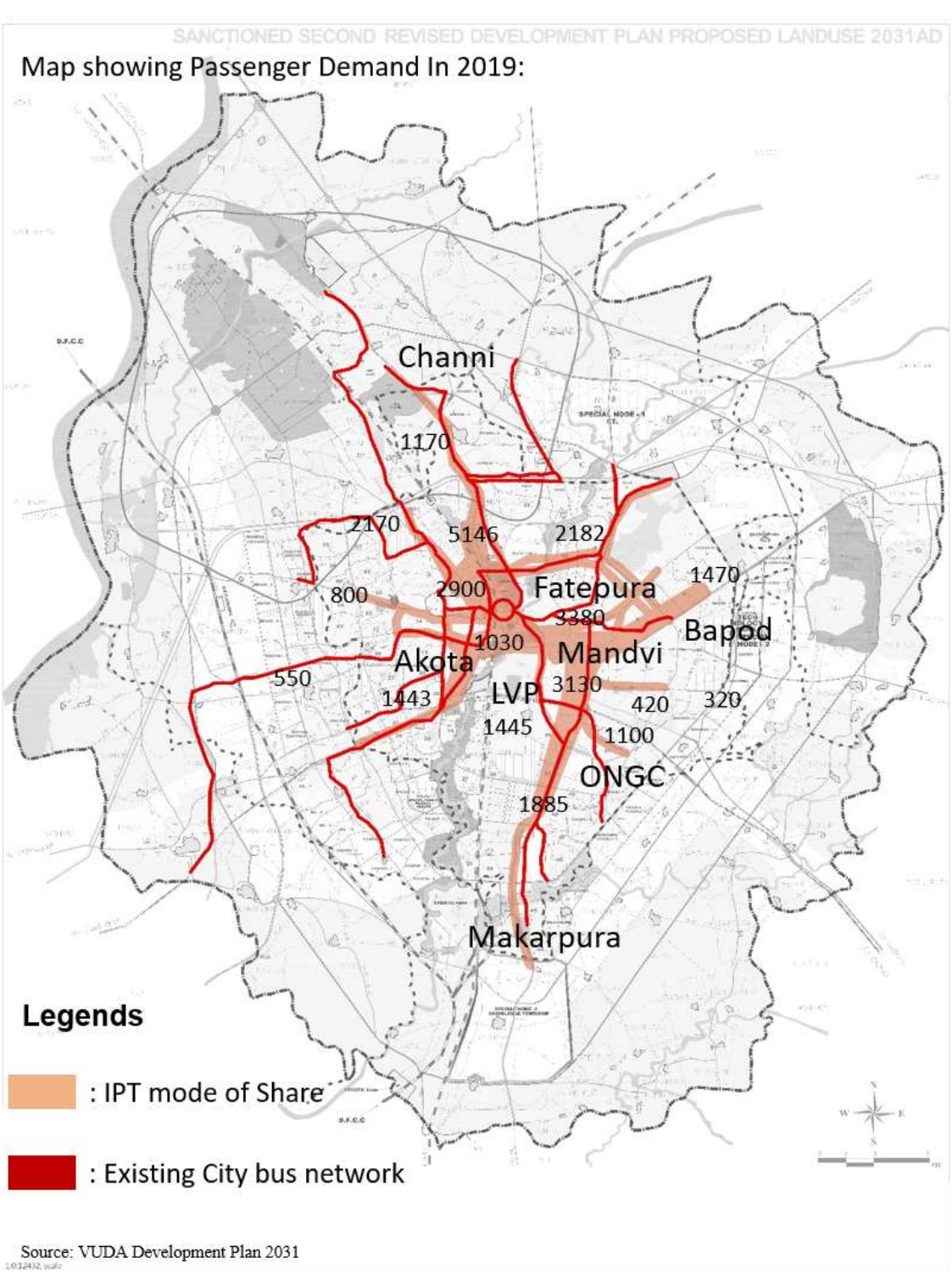


Figure 45 Map showing Intensity of passenger flow

- In present scenario Passenger flow was maximum in Mandvi and Fatepura area and minimum in Bapod.

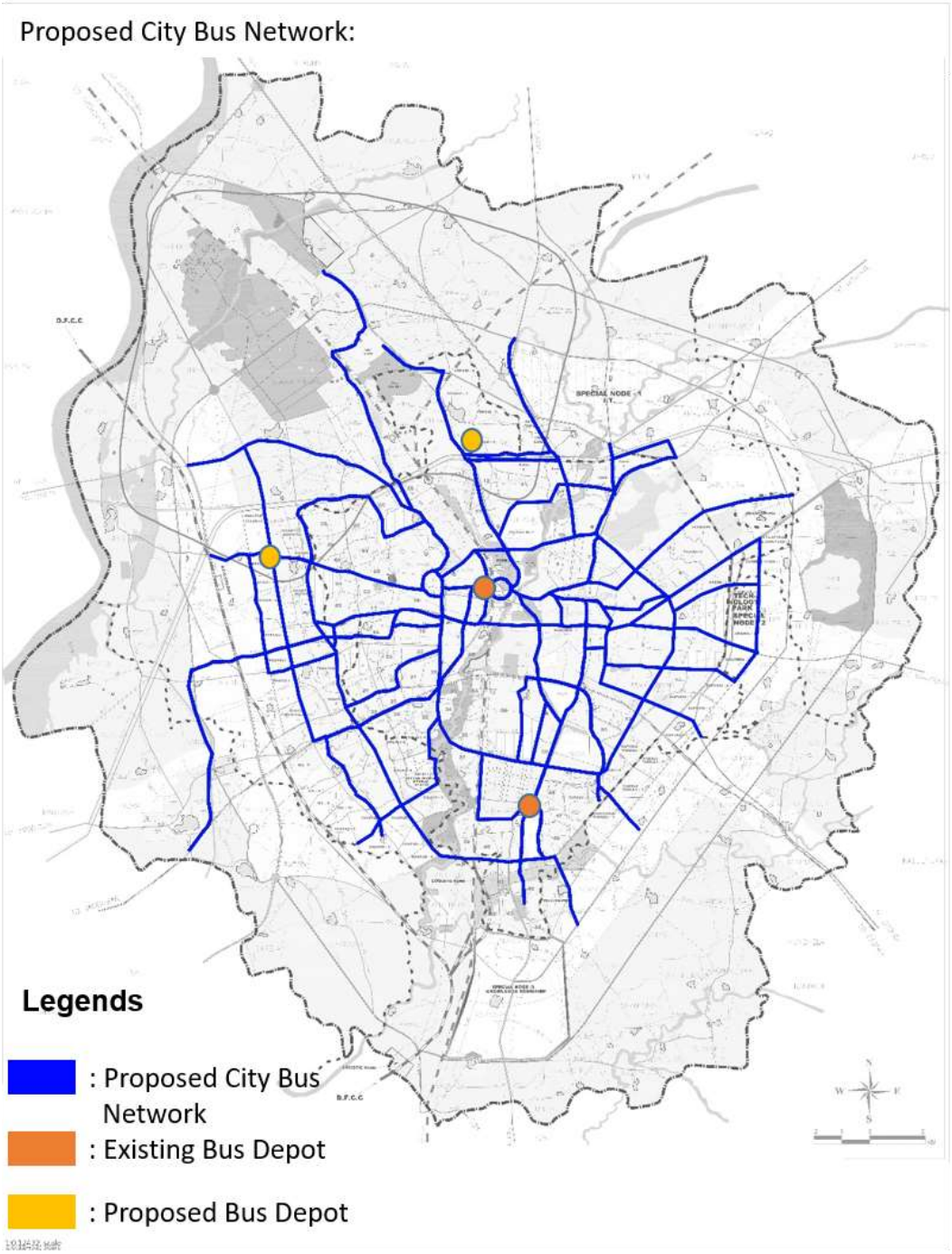
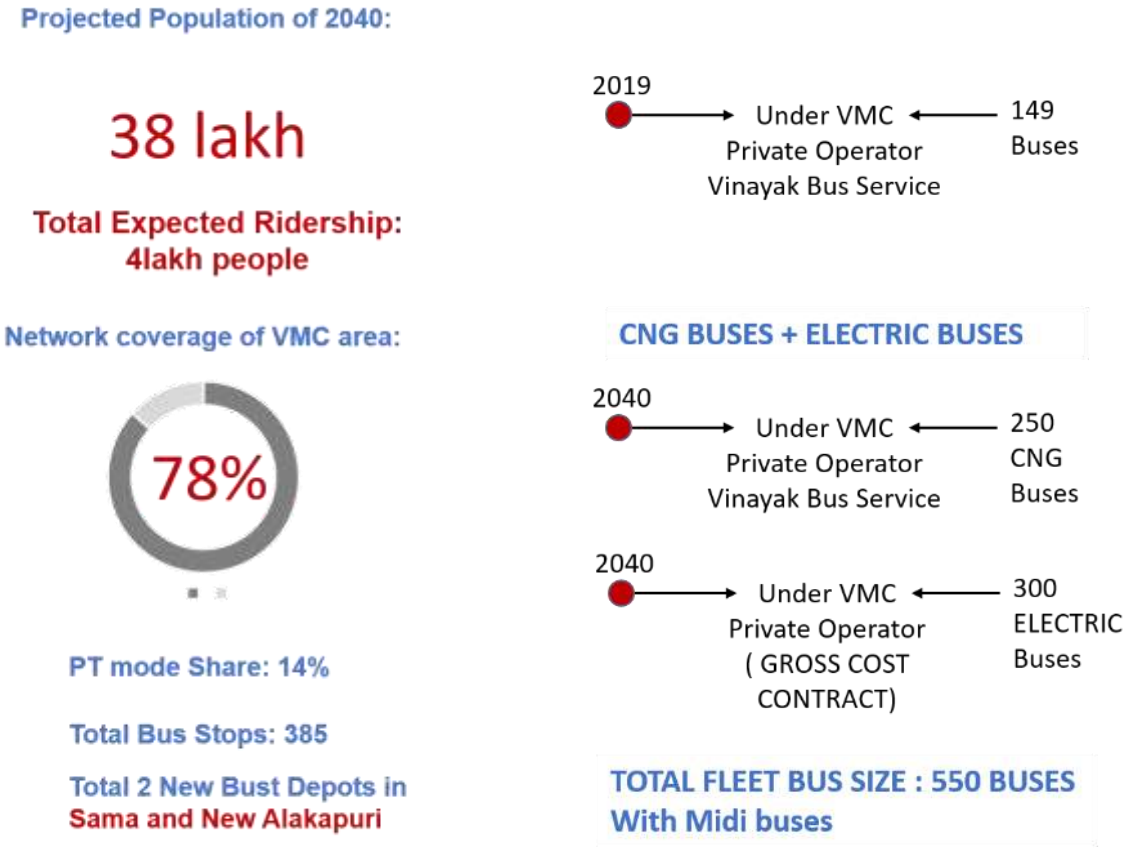


Figure 46 Proposed City bus network and Depot stations

Proposed Routes: 34

Network Length: 189.7km

Headway: 6-8minutes



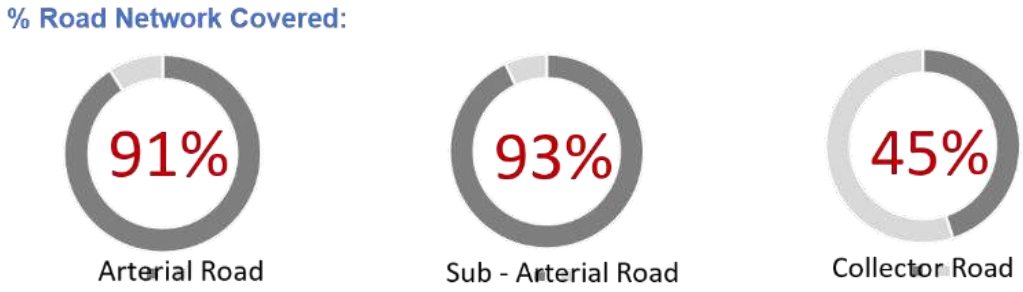


Figure 47 Percentage of Road covered by Proposed Bus Network

5.4 Up gradation Recommendations for Existing Footpaths:

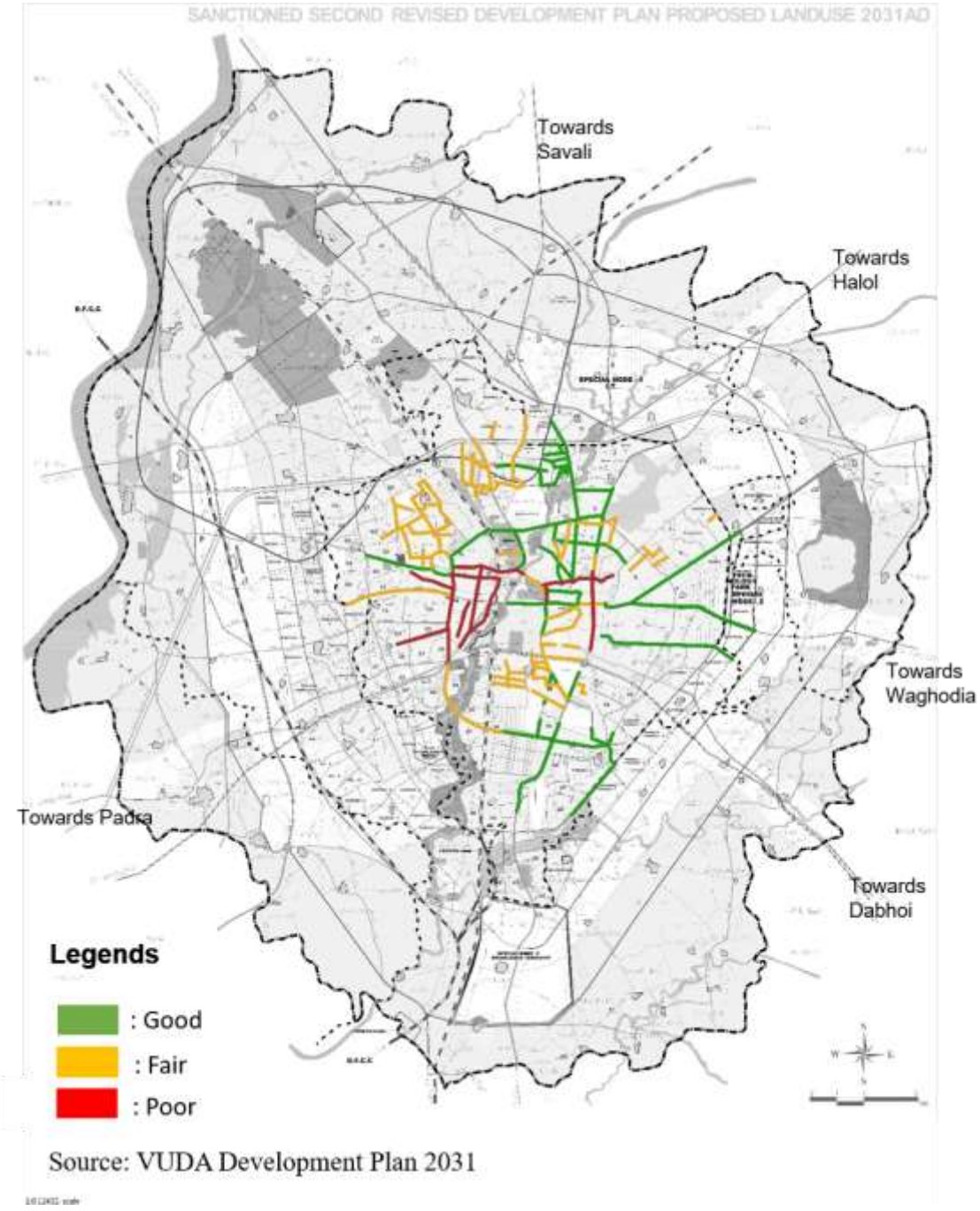


Figure 48 Map showing Footpath Condition of Vadodara City

Existing Footpath up gradation:

50% of the footpaths need up gradation to 1.8mts in VMC limits → 16% of the footpaths need up gradation to 2mts in VMC limits → Total of 106km of footpaths needs up gradation

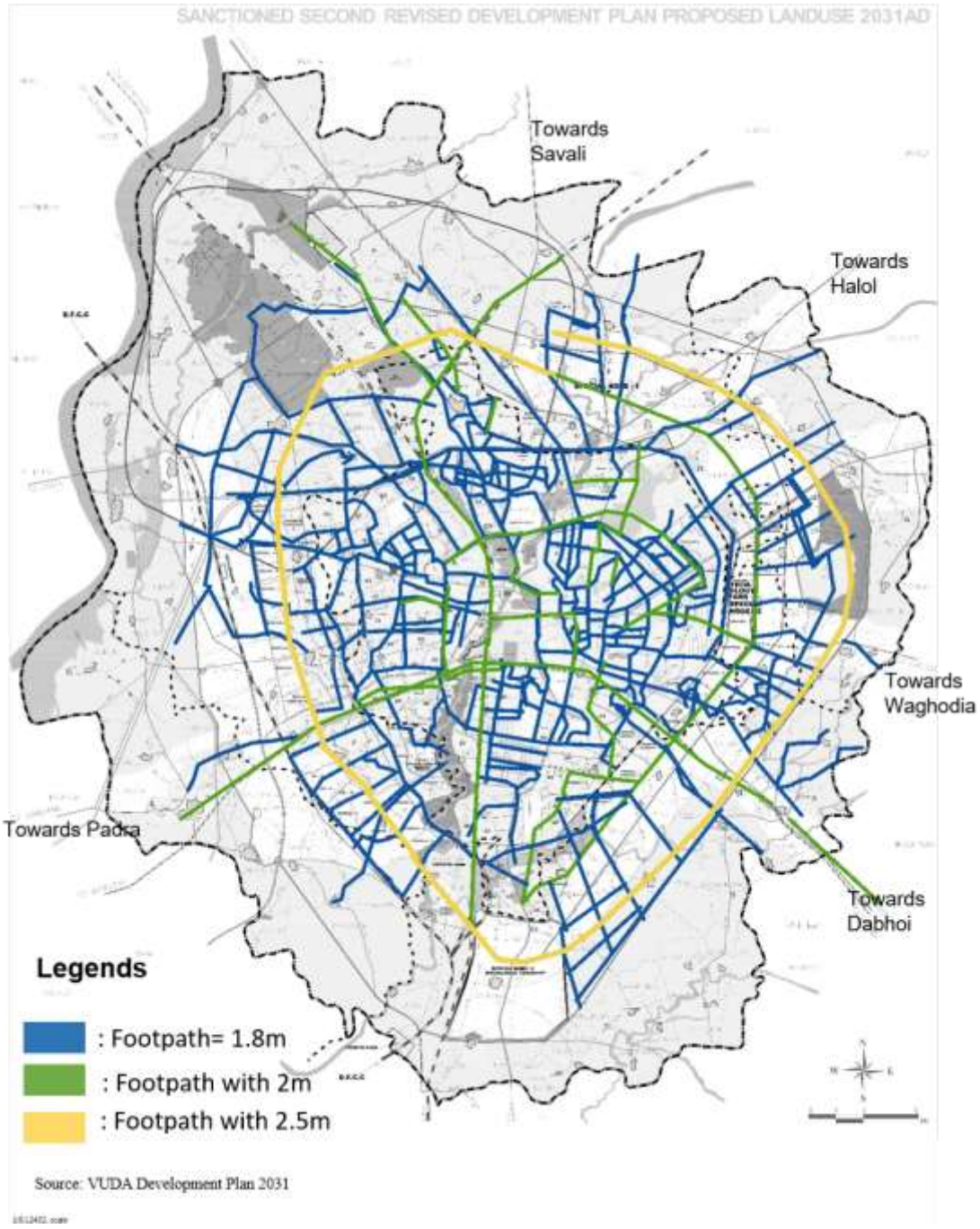


Figure 49 Map showing Proposed Footpath Coverage Network

Provision of New Network of Footpath:

New roads will be designed with continuous footpath with streetscape as shown in above proposal

148km=1.8mts

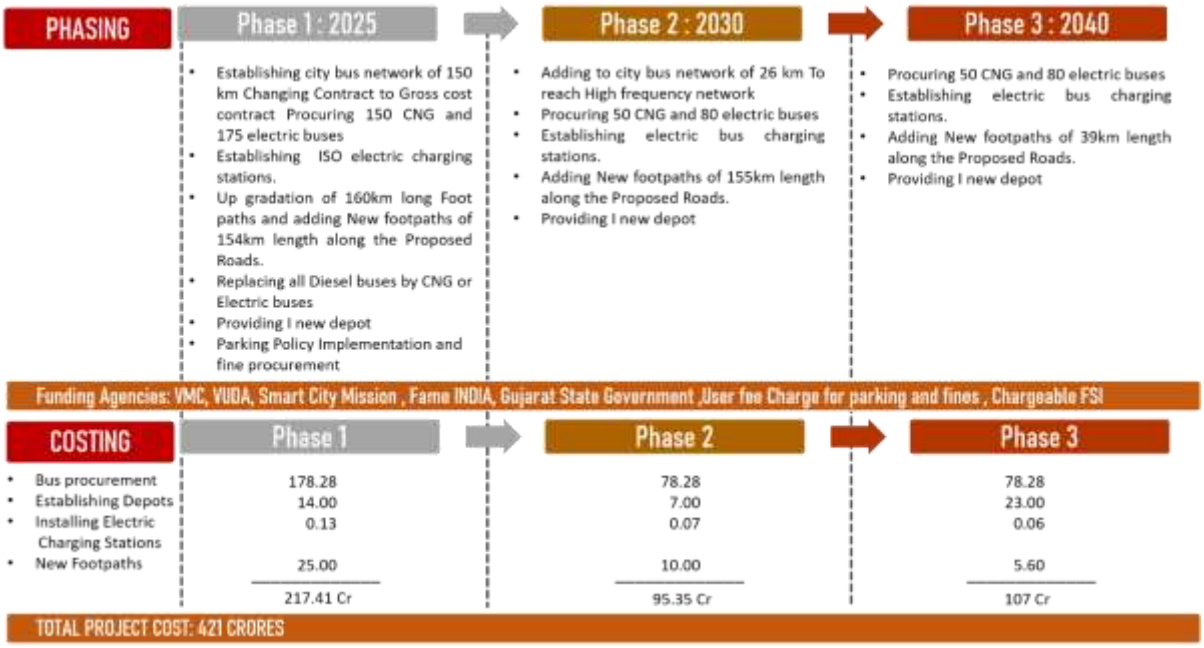
55km= 2.5mts

Total of 224km of footpaths Network is Proposed on existing roads and 203km on proposed Roads

Phase	Footpath in Km
Immediate	Up gradation of 160kms of existing footpath
Phase 1 2021-2025	154kms
Phase 2 2026-2030	155kms
Phase 3 2031-2040	39km

Table 9 Phasing of Proposed and up gradation of Footpath Network coverage

5.6 Phasing of the Projects



RECCOMENDATIONS

Public transport is facing low rider-ship issue because of overlapping routes, poor infra- structure (less fleets, poor bus-stops).

Low mode share of PT (1%) results into high congestion, high carbon emission etc.

Road Network Lacks of East-West connectivity Parking causing reduction in effective CW and it is observed that there is Less river and canal crossings(average distance 2.5km) and 52% roads are encroached.

Poor Public Transport because the headways are too large i.e. 30 mintues and Competitive fares and Routes overlaps are found between IPT and Bus transport networks.

Mode Share It is observed that there is increase in Motorization, poor PT mode shares which is 1.5% and IPT share i.e. 15% and 52% Congestion is also observed. Currently the predominant mode in Vadodara is 2 wheelers it has increased from 32 % (2012) to 39% (2019). Private vehicle ownership has Increased nearly doubled which leads to more mobility and Congestion

NMT Mode share: 30%

PT Mode share: 15%

Private Mode share: 23%

CONCLUSION

This study calculated how the connectivity power of Vadodara bus stations can be increased and to shift people to mode bus transit mode by incorporating the service hours, frequency, speed, vehicle capacity, provision of routes with less headways, by erasing overlapping routes and number of accessible stations.

- **Compact Development** Encourage high density, mixed-use development with a high level of services in places where people stay and work within walkable and biking distances.
- **Transit Supportive Uses** Provide and intense mix of complementary activities like residential, commercial, institutional such that they allow safe use of public spaces and access to transit throughout the day.
- **Complete Streets** Provide safe access to people (walking or biking) that allows informal sector as well as vehicles and public transit.
- **Integrated Transport** Ensure efficient, comfortable, and safe shift from one transit to another.

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