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PROMOTING LOW CARBON TRANSPORT IN INDIA

LOW-CARBON COMPREHENSIVE MOBILITY PLAN

UDAIPUR

2013 - 41

Urban Mass Transit Company Limited

PROMOTING LOW CARBON TRANSPORT IN INDIA

Low Carbon Comprehensive Mobility Plan: Udaipur

Authors

Lead author

Ranjan Jyoti Dutta, Project Manager, Urban Mass Transit Company Ltd

Contributing authors

Rajat Bose, Shruti Mahajan, Durga Prasad Sunku, Yashwanth Namasani and Harshita M. Sarma

January 2015

UNEP DTU Partnership, Centre on Energy, Climate and Sustainable Development
Technical University of Denmark

This publication is part of the 'Promoting Low Carbon Transport in India' project.
This project is part of the International Climate Initiative (IKI). The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) supports this initiative on the basis of a decision adopted by the German Bundestag.

Supported by:

Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

based on a decision of the German Bundestag

ISBN: 978-87-93130-65-4

Design and production:

Magnum Custom Publishing
New Delhi, India
info@magnumbooks.org

Photo acknowledgement:
Front cover: Lead author's own photographs

Disclaimer:

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Foreword

Foreword by District Collector

Ashutosh A. T. Pednekar
IAS
Collector & District Magistrate

सत्यमेव जयते

Tel No. : 0294-2410834 (O)
2410285 (R)
0294-2410834 (Fax)
Udaipur (Raj.) - 313001
E-mai : dm-uda-rj@nic.in

Dated: 26-11-2014

During the last few decades, with rapid increase in urban population and income, Indian cities including Udaipur has been expreincing high usage of private vehicles resulting in ever inceasing congestion on the roads and air pollution. Despite the substantial efforts, the city is facing difficulty in coping with increase in private vehicles along with improving personal mobility.

Although the present emission levels in Udaipur are within the prescribed standards there is a growing concern of emission from the vehicles on road.

Low carbon Comprehensive Mobility Plan for the city of Udaipur is one of the initiatives that we have supported with the overall aim to achieve sustainable development for Udaipur. The LCMP for Udaipur, lays out a set of measured steps that are designed to improve the transportation infrastructure of the city in a sustainable manner. The plan integrates transport with land use and environment for its existing condition as well as models it for the future. The strategies proposed in the report to support walking, cycling and public transport which are environment friendly and highly relevant in present context of Udaipur City. The study was carried out by our consultant Urban Mass Transit Company Limited (UMTC) most scientifically supported by an extensive set of data collected during the study.

Its gives me immense pleasure that Udaipur had been selected for by UNEP for promoting low carbon transport in India along with two other counterpart cities. We are grateful to UMTC and UNEP for carrying out this study in such a detail and guiding us for driving the future urban and transport development of Udaipur.

(Ashutosh A.T. Pednekar)

www.udaipur.nic.in

Foreword by Secretary, Urban Improvement Trust, Udaipur

Ram Niwas Metha, RAS
Secretary,
Urban Improvement Trust,
Udaipur

Tel. No. 0294-2413735, 2425035
Fax No. 0294-2413735
Udaipur (Raj.) 313001
Email : uitudaipur@rediffmail.com

Date : 26-11-2014

With the rapid increase in urban population in the Indian cities, cities have been experiencing issues like congestion, increase in the usage of private vehicles, increased air pollution etc and Udaipur has been no different. Although at present emission levels are within the prescribed standards, yet there is a growing concern of increased emissions from the vehicles on road. Despite the substantial efforts, the city is facing difficulty in coping with increase in private vehicles along with improving personal mobility.

As a Secretary of Urban Improvement Trust, Udaipur, its gives me immense pleasure that UNEP has selected Udaipur as one of the three cities in India for promoting low carbon transport in India, under the initiative of which Urban Mass Transit Company Limited (UMTC) a joint venture company of Ministry of Urban Development, Govt. of India and IL&FS under the guidance and aegis of UNEP has carried out a scientific study for achieving sustainable urban development and has prepared this Low carbon Comprehensive Mobility Plan for the city of Udaipur. This Low carbon Comprehensive Mobility plan has spelled out number of intervention measures such as promoting public transport, non-motorized transport etc. aiming at achieving sustainable urban transport for Udaipur city.

I would like to congratulate the entire team from UMTC and UNEP for successful completion of this kind of in-depth scientific study, which can form the basis of decision making in the direction of sustainable transport in Udaipur.

I would also like to thank all those officials from UIT and officials from other concerned departments and agencies who have extended their kind support and co-operation for this study.

Ram Niwas Mehta
Secretary,
Urban Improvement Trust, Udaipur

Office Address : Saheli Marg, Udaipur (Raj.), Phone No.: 0294-2410428, Fax No.: 0294-2413735
Web Site: www.uitudaipur.com, E-mail: uitudaipur@rediffmail.com

Foreword by Ex-Secretary, Urban Improvement Trust, Udaipur

Dr. R.P. Sharma, RAS
Registrar

Phone : 0294-2470166, Fax : 0294-2471150
Emial: registrar@mlsu.ac.in
dr.sharma.rp@gmail.com
MOHANLAL SUKHADIA UNIVERSITY
UDAIPUR- 313001

Date : 26-11-2014

Indian cities have been experiencing rapid urbanization, this teamed up with the increased income levels have lead to the prominent issues that we witness on our roads every day, such as congestion, demand for more and more parking spaces, road fatalities, increased emission levels etc. Udaipur is no different from the other Indian cities as its also following the similar trend, although the issues at present are at manageable stage, however it may not be the same in the future years to come. This is where the interventions are necessary to guide the city towards sustainable development.

UNEP has selected Udaipur as one of the three cities in India for promoting low carbon transport in India, under the initiative of which Urban Mass Transit Company Limited (UMTC) a joint venture company of Ministry of Urban Development, Govt. of India and IL&FS under the aegis of UNEP has carried out a scientific study for achieving sustainable urban development and has prepared this Low carbon Comprehensive Mobility Plan for the city of Udaipur. The project is supported by International Climate Initiative (ICI) of the German Government as well as the implementing partners including UNEP, the UNEP Risoe center in Denmark (URC), the Indian Institute of Technology, Delhi (IITD), the Indian Institute of Management, Ahmedabad (IIMA) and CEPT University.

I as an individual and resident of the city which is popularly known as “City of Lakes”, feel proud being associated with this kind of highly appreciable scientific project as then Secretary of UIT and have participated number of seminars, workshops and stakeholder consultation meetings being organized by UMTC on the project.

The Low carbon Comprehensive Mobility Plan for Udaipur city has recommended number intervention measures which includes among others promotion of public transport, non-motorized transport etc. which are environment friendly and benefit the masses which aims at achieving sustainable urban transport for the city.

I wish my heart full congratulation to the entire team for successful completion of this project.

(Dr. R. P Sharma)
Ex - Secretary, Urban Improvement Trust, Udaipur and
Registrar, Mohanail Sukhadia University, Udaipur

Acknowledgement

At the outset, we would like to thank UNEP and UNEP Risø Centre, DTU Management Engineering Technical University of Denmark for providing us the opportunity to carry out this scientific study and preparation of a Low-carbon Comprehensive Mobility Plan (LCMP) for the city of Udaipur. We would also like to thank UNEP for giving us the opportunity to work on devising a new methodology and toolkit for comprehensive mobility plans.

Our sincere thanks to the Ministry of Urban Development, Government of India for appreciating this Low-carbon Comprehensive Mobility Plan and including it in the revised toolkit for preparation of comprehensive mobility plans.

Our honest and deepest gratitude to Dr. Subash Dhar and Dr. Sudhir Sharma from UNEP DTU Partnership for constant guidance, valuable suggestions and criticisms during the entire study, without which this study would not have streamlined to its present form.

We would like to thank the LCMP methodology team: Prof Geetam Tiwari from IIT-D, Prof. Darshini Mahadevia from CEPT University and Prof. P.R. Shukla from IIM-A for constant guidance and suggestions during the entire study. We would also thank Mr. Sarath Guttikunda for assisting us in estimating emissions in Udaipur.

We are highly obliged and acknowledge our sincere thanks to Mr. Vikas S. Bhale, then District Collector, Udaipur; Mr. Ashutosh A.T. Pednekar present District Collector, Udaipur; Dr. R. P Shrama, then Secretary, Urban Improvement Trust (UIT), Udaipur; Mr. Ram Niwas Mehta, current Secretary, UIT; Mrs. Rajni Dangi, Mayor, Udaipur; Mr. S. N Acharya, Commissioner, Udaipur Nagar Parishad for all the assistance and support towards the successful completion of this study.

We also acknowledge our sincere thanks to the officials from Town and Country Planning Department, Urban Improvement Trust, Udaipur (UIT), Urban Development and Housing Department, Rajasthan State Road Transport Corporation, Traffic Police, Regional Transport Authority, Udaipur, Public Works Department, Tourism Department, Rajasthan State Pollution Control Board, Railway Authority, Airport Authority, Rajasthan State Industrial Development & Investment Corporation (RIICO), Directorate of Petroleum, Rajasthan, Rajasthan Urban Infrastructure Development Board, Department of Energy, Government of Rajasthan, Department of Environment, Government of Rajasthan, Department of Forest, Government of Rajasthan, Department of Industries, Government of Rajasthan, Directorate of Economics and Statistics, Government of Rajasthan, Employment Department, Government of Rajasthan for their immense help and cooperation during the study.

Last but not the least we are also thankful to our management, particularly MD & CEO Mr. Ajai Mathur for inspiration, support and guidance towards the successful completion of this study.

Authors

Abbreviations

ATL	Average Trip Length
C/W	Carriageway
CDP	City Development Plan
CMP	Comprehensive Mobility Plan
CO_2	Carbon Dioxide
CO	Carbon Monoxide
HHs	House Holds
HIG	High Income Group
IPT	Intermediate Public Transport
JnNURM	Jawaharlal Nehru National Urban Renewal Mission
Kms	Kilometres
LCMP	Low-carbon Comprehensive Mobility Plan
LCV	Light Commercial Vehicle
LIG	Low Income Group
MIG	Medium Income Group
MNL	Multinomial Logit Model
NH	National Highway
NMT	Non-Motorized Transport
NoX	Oxides of Nitrogen
OD	Origin Destination
PCTR	Per Capita Trip Rate
PCUs	Passenger Car Unit
PHPDT	Peak hour peak direction trips
PM 10	Particulate Matter
Pph	Persons per hectare
PT	Public Transport
RoW	Right-of-way
SH	State Highway
TAZ	Traffic Analysis Zone
UCTSL	Udaipur City Transport Services Limited
UIT	Urban Improvement Trust
ULB	Urban Local Body
UMC	Udaipur Municipal Corporation
UNEP	United Nations Environmental Programme and UNEP Risø Centre, Denmark
VKT	Vehicle Kilometres Travelled

Urban Mass Transit Company Limited

Table of Contents

Urban Mass Transit Company Limited

List of Figures

Urban Mass Transit Company Limited

Urban Mass Transit Company Limited

List of Tables

Executive Summary

Background

The cities of fast developing countries like India continue to grow rapidly in terms of its spatial extent and population, as a consequent of growth of national of the country. During the last decade, the urban sprawl in Indian cities has extended far beyond the existing territorial jurisdiction of the city administration, resulting in an increase in vehicles numbers and energy consumption. The travel trends of previous decades indicate that there is a decline in the use of bicycles and public transport on one hand, and an increase in the share of 2Ws, 4Ws and 3Ws on the other hand. These trends have been contributing towards the consumption of fossil fuels by the transport sector, resulting in more vehicular emissions and air pollution. Consequently, the transport sector is also the largest consumer of fossil fuels and the biggest contributor to air pollution, in that land transport accounts for roughly 73 per cent of the sector's total CO_2 emissions (Ghate, 2011). The transport sector in India alone accounts for around 45 per cent of the country's total oil consumption, of which a large share is consumed for intra-urban trips (TERI, 2006). Thus, there is a need for strategic interventions in terms of policies or planning methods, in addition to reducing emissions and introducing energy conservation techniques.

In India, after 2005, urban mobility issues have been addressed by the preparation of mobility plans. The construct of these mobility plans has been explained in considerable detail in a toolkit prepared by the Ministry of Urban Development, Government of India, and Asian Development Bank (Co, 2008). Even though these Comprehensive Mobility Plans (CMPs) have helped the urban areas in cities to plan and channel resources and investment, they have not been able to address the issues related to inclusiveness, land use transport integration and measures that would promote use of non-motorized modes and public modes of transport. The CMPs consistently lack in the provision of strategies to enable safe and secure mobility and accessibility for all groups of people. Further, the CMP methodology lacks an approach to CO_2 mitigation from various scenarios. The Low-carbon Comprehensive Mobility Plan (LCMP) focuses more on the reduction of greenhouse gas (GHG) emissions without compromising the accessibility and mobility needs of all people.

The Low-carbon Comprehensive Mobility Plan incorporates into the existing methodology of CMP additional indicators of urban transport inclusiveness and measures that would lead to lower carbon emissions from transport. Within the LCMP framework, this initiative aims to address transportation growth, development challenges and climate changes issues in an integrated manner proposed by UNEP. The Risø Centre and Ministry of Environment and Forests in India (in consultation with IIT Delhi, CEPT University and IIM, Ahmedabad) have therefore produced a toolkit for preparation of LCMPs. They will collectively also show examples of plan preparation on three diverse cities of India: Vishakhapatnam, Rajkot and Udaipur. These plans will address the need for appropriate planning to ensure safe mobility and accessibility to people irrespective of their socio-economic background in a way that does not compromise the overall quality and health of the environment. The LCMP is also envisaged to be an effective decision-making tool that will help develop low-carbon mobility scenarios, and identify projects that will pave the way and earmark JnNURM funding for implementation. While doing so, it would ensure improved accessibility for the low-income households and women in the cities, who have constraints on accessibility. This report presents the LCMP plan for the city of Udaipur.

Study area

The area of study is the Udaipur Urban Control Area, which covers an area of 347.91km^2 (34791 Ha) and comprises Udaipur's urbanized and urbanizable area (as defined by UIT), Udaipur Municipal Area and 62 revenue villages. Udaipur is known as the city of lakes, and is the most famous destination in India for local and foreign tourists.

Udaipur is surrounded by hills and lakes, which physically hinder its growth along these directions. Therefore, the city is presently growing only towards the north-east and west along the National Highways NH8 and NH76.

Residential use has reduced from 47.6 per cent (1976-96 Master Plan) to 37.42 per cent (2001-21 Plan) due to the increase in the jurisdiction of the Udaipur Urban Control Area. There has been notable growth in the industrial activities towards the north-eastern part of Udaipur. The percentage of area under traffic and transportation use is 18.8 per cent as per the revised Master Plan for Udaipur.

Mobility indicators of the city

The number of vehicles in Udaipur has increased from 160,431 in 2004-05 to 339,594 in 2011-12, with a growth rate of 52 per cent. Private vehicles such as cars and 2Ws account for 90 per cent of the registered vehicles, whereas buses constitute only 1 per cent.

A detailed road inventory survey was undertaken, which revealed that the majority of the roads (56 per cent) in the study area have right-of-way (RoW) between 10m and 25m, followed by up to 10m (23 per cent) and 25m to 35m (18 per cent). In terms of carriageway, nearly 47 per cent of the network has 3 to 4-lane carriageway. Footpaths are present only on 4 per cent of the streets. The carriageway widths are further reduced due to the on-road parking across the various stretches in the city. Traffic flow in the city during the morning peak hour varies from the minimum of 1,673 passenger car units (PCUs) at UIT Circle to a maximum of 8,352 PCUs at Surajpole intersection. The composition of traffic at the various locations in the city was dominated by two-wheelers. The average journey speed was observed at 38km/h at various stretches in the city.

From the household survey, the following observations were made:

- The average per capita trip rate of the city was observed at 1.12 with walk trips, and 0.73 without walk trips
- Of the total trips made in the city, 48 per cent were made by walking, followed by two-wheelers with 34 per cent, intermediate public transport (IPT) with 11 per cent, public transport and NMT with 2 per cent each, and cars with 3 per cent of the total trips in the city
- The Average Trip Length (ATL) was observed at 5.09km in Udaipur city
- The Average Travel Time is observed at 11.87 minutes
- The Average Cost of Travel is observed at Rs. 10.50.

Challenges

The city of Udaipur also inherits a chaotic urban transport scenario characterized by heterogeneous and yet competitive road space users, resulting in inefficient usage for the public good. The city of Udaipur is completely devoid of an organized public transportation system, and has inadequate transport infrastructure for pedestrians and non-motorized transport users. Some of the issues identified are:

Land use: The city has been primarily developing towards the north, east and south, along the NH8 to Ahmedabad and NH76 to Chittorgarh. The development towards the west is constrained due to the presence of hill locks and lakes. The north-eastern part of Udaipur is plain and therefore secondary and tertiary activities are increasing in this directions. These establishments primarily contain small-scale industries and mineral activities. The majority of the trips from within the city are attracted by these establishments in the north-eastern part of the city. Other than industrial establishments, considerable trips are attracted by the city core, where the majority of the tourist hubs and activities are located.

Facilities for pedestrians: Although a sizeable trips, i.e. 48 per cent of the total trips, are by walking, only 4 per cent of the city's road network has footpaths, which are present only on the major roads of the city. Even the available footpaths have widths less than 1.5m, making it inconvenient to walk.

Facilities for non-motorized vehicles (NMVs)**:** The city has a significant number of trips by walking and non-motorized vehicles, i.e. 50 per cent of the total trips. Despite this, there is no specific attention given to the NMV infrastructure that would otherwise encourage the environment for the NMV movements as well as ensure the safety of the people.

Facilities for public transport: Due to the lack of the organized public transport, the current share of public transport is only 2 per cent, resulting in a dependency on two-wheelers and IPT modes. The trend will have significant implications for the emission levels in the city as well as increased congestion. The challenge is to reverse this trend and promote public transport, which is considered as the most efficient usage of road space.

Facilities for IPT: People in Udaipur considerably depend on IPT, or shared auto rickshaw, accounting for 11 per cent of the total trips in the city. Though shared autos have designated routes of operation, they do not operate on the same desiganted routes and create a chaotic scenario, which is visible in almost every part of the city. It has also been observed that most of these shared autos do not meet the desirable emission norms and constitute outdated technology.

Thus, while planning for the transport system for Udaipur, the above mentioned problems and issues need to be kept in consideration while keeping a check at the emission levels in the city.

Future growth and transport demand forecast

Udaipur is expected to experience high growth in the coming decades. The population of Udaipur is expected to grow from 637,717 in 2011 to 1,580,354 in 2041. The total employment is also expected to increase to 517,238 in 2041, with a workforce participation rate of 32.7 per cent. The revised Master Plan for Udaipur suggests various economic activities within the Udaipur Urban Control area. This will increase the employment opportunities especially in the tertiary and secondary sectors. Therefore it is prudent that a low emissions sustainable transport system be planned and developed for Udaipur to meet the transport demand up to 2041.

A four stage transport demand model has been developed to estimate the future transport demand for Udaipur for a horizon year of 2041. Considering the proposed land use developments as drafted in the revised Master Plan for 2031 and Urban Local Bodies (ULBs) of Udaipur, the Business as Usual (BAU) scenario has been developed to assess the impact of the proposed developments on the modal shares, trip lengths, accessibility, safety and emission levels.

Mobility strategy

Urban transport strategies can play an important role in tackling urban problems, traffic congestion and business inefficiencies that degrade the quality of life. Urban transport projects can reduce journey times and unpredictability, yeilding large savings in terms of travel time, vehicle operating costs and lower emission levels and thus releasing the city's economic and social potential. The urban transport problems of Udaipur have been analyzed in the context of area-wide issues and evolved transport strategies. The mobility goals for Udaipur need to be addressed through a multi-pronged approach. The following strategy options have been evaluated to meet the sustainable urban transport needs of Udaipur:

1. Land use development scenario
2. Public transport development scenario
3. Non-motorized development scenario

4. Technology scenario.

Land use development scenario: The land use development scenario is developed to intervene at a macro scale, constituting the city's size, shape, location and pattern across the city, and at the micro scale, encompassing population density, diversity and the type of land use. Udaipur exhibits a traditional growth pattern of a low-rise, low density and horizontally growing city. The old city area is highly dense, and the density gradually decreases towards the periphery. The land use development scenario focuses on the following strategies:

a. Infill and redevelopment of available land:
   - Change in land use pattern, which is condusive for smaller trips and shorter travel distances, reverses the current travel demand
   - Increase the intensity of the mixed land use to encourage shorter intra-zonal trips and walkable environments, such that the retail services and offices are located near the neighbourhoods with well-connected transportation infrastructure
b. New developments of higher density along major PT corridor:
   - New developments of higher density along the major PT corridor, which can discourage the dependency on the vehicular movements.

Public transport development scenario: The main idea of this scenario is to encourage sustainable public transport systems, including the allied infrastructure to support the public transport riderships. To promote public transport as a mode of choice, the focus is to be on the availability, accessibility, reliability and affordability of public transport. Under this scenario, focus is placed on the following strategies:

a. Reorganizing the existing IPT systems:
   - In order to regulate the Udaipur IPT system, the PT strategy proposes to organize the IPT system with fixed routes, frequencies and fare structures while replacing the old auto rickshaws with Bharat Stage IV emission norm vehicles
b. Introduction of the bus-based public transport systems.
   - It has been proposed that trunk PT routes would be introduced at various phases along the corridors with maximum demand, while the IPT would act as feeder service to the proposed city bus services
   - It is proposed to have the PT system operating at a minimum headway of 10 to 15 minutes in the initial stages of development, and minimum headway of 5 minutes by 2041
   - The organized public transport system needs to be encouraged, with the development of the following ancillary infrastructure and promotion methods:
      i. Development of support infrastructure for the bus systems

ii. Implementation of the Intelligent Transportation System (ITS) for improving the reliability of the public transport
iii. Promoting public participation and campaigning of mass awareness programme
iv. Encouraging the private sector in promoting public transport.

Non-motorized development scenario: NMT includes all modes of travel that do not rely on engines or motors for transport. This includes walking, cycles and cycle rickshaws, hand-drawn and animal-drawn vehicles, etc. NMT promotes short and accessible trips, which reduce CO_2 emissions. Under this scenario, a wide range of NMT measures have been envisioned, and some of the strategies are as mentioned below:

a. Development of footpaths: Though significant trips are made by walking, 96 per cent of the road network available has no footpaths or other allied facilities that would otherwise create an effective environment for walking
   - Development of footpaths with minimum width of 1.5 to 2.0 m
   - Development of obstruction-free footpaths
   - Demarcation of zebra crossings at major and minor intersections of the city
b. Pedestrian crossing facilities and street lighting facilities at important intersections. Pedestrians are considered to be the most vulnerable road users. To improve the share of walking as a mode of transport within Udaipur, it is suggested to equip 19 intersections with pedestrian signals. It is also proposed that for safety of the road users these 19 intersections also have semi-high mast lights
c. Development of cycle tracks: The share of the cycle as a mode of transport in the base year is as meagre as 3 per cent. In order to promote cycling, tracks are recommended of around 40km on either side of major roads along with support infrastructure
d. Introduction of a public bike-sharing scheme: Bike sharing refers to the introduction of the sharing of bicycles at different locations on a rental basis. Udaipur being a tourist city, it is recommended that a public bike-sharing scheme be introduced at locations like Sukhadia Circle, Court Circle, Suraj Pol and Goverdhan Vilas Chowk.
e. Development of a heritage walk: Most of the tourist locations within the city are located within the old city area. It is suggested that some of the roads within this area be made vehicle-free and that NMT and tourism be encouraged as part of a heritage walk.

Technology scenario: As part of promoting low-carbon transport in Udaipur, it is suggested that a combination of changing vehicle fuel types and engine types can reduce overall emissions in Udaipur.

Along with the above mentioned scenarios, a combined scenario was tested where all the above mentioned scenarios were evaluted together. The outcomes of the combined scenario are as follows:

1. The modal shares for the combined scenario show that there is an improvement in the mode shares of sustainable modes like bus, walk and cycle. After the introduction of a well organized and accessible public transport system, the share of PT increases up to 32 per cent in 2041 from 3 per cent in the base year
2. Business as usual (BAU) scenario in 2041, where the urban sprawl is encouraged, showed considerable increase in the average trip lengths as against the combined scenario, which encourages high intensity compact developments, in turn encouraging intra-zonal trips and shorter trips
3. With the introduction of the organized PT system, the accessibility improved from 60 to 83 per cent. The PT routes have been designed in such a way that 83 per cent of the households are acessible to PT within 10 minutes' walking distance
4. By providing infrastructure for the NMT modes, such as wide and continuous footpaths along with cycle tracks, there is an increased perception of safety to use NMT from 8 to 83 per cent
5. As in the case of the BAU scenario, the maximum vehicle kilometres travelled has been recorded, i.e. 2,559.9 million kilometres due to the increase in the number of private vehicles. However, with the organized PT system, the vehicle kilometres travelled has been recorded as lowest in the combined scenario at 1,335.2 million kilometres
6. In the BAU scenario, 26 per cent of the road network has a volume-to-capacity ratio (V/C ratio) of more than 1, which compares to the combined scenario, where a systematic PT system is introduced, and only 5 per cent of the road network has a V/C Ratio of more than 1
7. Regarding the reduction in emission levels, there is a considerable reduction in the noxious gases as well as reduction in the CO_2. The details of which are discussed in Chapter 6.

It has been observed that the combined LCMP scenario, which is a combination of land use, NMT, PT and technology scenarios, shows an improvement in the urban mobility scenario in Udaipur across the heterogeneous socio-economic groups and genders, along with overall reduction in emission levels.

Implementation program

The projects identified would be phased depending upon several criteria, like the urgency of implementation, ease of implementation, travel demand model, and environmental considerations. Phasing is generally done according to long term, medium term, short term and immediate term, as under:

1. Phase I: Immediate improvements during 2013-2015

2. Phase II: Short-term improvements during 2013-2018
3. Phase III: Medium-term improvements during 2019-2022
4. Phase IV: Long-term improvements during 2023 – 2041.

Within each phase, projects identified also need to be prioritized. As per National Urban Transport Policy (NUTP), the prioritization of projects is in the following order:

- High priority: This includes public transport and non-motorized transport
- Medium priority: This includes para transit facilities (IPT), travel demand management (TDM), parking facilities, development of terminal facilities, and intersection improvements
- Low Priority: This includes road development, bridges and flyovers.

Costing

The approximate cost, excluding land acquisition, for implementing the mobility plan is Rs. 22,152.4 million. Phase-wise costs are:

- Phase I (2013-2015):Rs. 4,462.7 million
- Phase II (2013-2018):Rs. 2,396.3 million
- Phase III (2019-2022):Rs. 7,032.2 million
- Phase IV (2023-2041):Rs. 8,261.1 million.

Funding options

As per the recommendations of the Working Group on Urban Transport for the 12th Five Year Plan, the paradigm of financing has to clearly move towards the non-user pays principle and the polluter pays principle. There is a need for a long-term sustainable and dedicated financing mechanism to address the rapidly worsening scenario in the field of urban transport. All the various components in which the investment would be required in the 12th Five Year Plan would need to be funded through a combination of funding from Government of India, State Government/urban local body, development agencies, property development, loans from domestic and financial institutions as well as PPP.

Institutional framework

There are multiple organizations at the city level that are involved in urban and rural planning for the city and region. Some of the broad issues related to organizations and their functioning within the city of Udaipur have been listed below:

1. There is no clear segregation between the planning and implementing bodies
2. There is a lack of coordination among all the departments in the urban transport sector
3. All departments related to urban transport do not function in coherence
4. Road projects are implemented in isolation with other projects, which should otherwise be an integral part of road development like footpaths, cycle tracks, pedestrian facilities, etc.

5. There is no control over mushrooming IPT modes in the city, which lead to issues of congestion along with contesting with the buses for passengers
6. Operation issues exist in public transport due to poor route and service planning
7. There is no dedicated organization that is in charge of long-term urban transport planning for the city.

Owing to the above, the need is felt for setting up an umbrella-level organization at the city level for overall planning and monitoring Urban Transport in Udaipur city and its immediate surroundings. The constituent members would be heads of various departments of the State Government, having direct or indirect roles in planning for transport for all the urban areas within the state.

It is further recommended that a separate collection of funds be generated locally. This fund is meant to be spent locally on development and maintenance of urban transport infrastructure. This fund can be managed by a professional fund manager (appointed by the city-level Unified Metropolitan Transport Authority) so that the balances in this fund can earn appropriate returns, in accordance with prevailing market potential.

Outcomes

During the last few decades, urban sprawls in Indian cities have been extending far beyond the existing territorial jurisdiction of city adminstrations, resulting in high usage of private modes. Despite substantial efforts, the cities are facing difficulty in coping with an increase in private vehicles along with improving personal mobility and goods distribution. Udaipur has been experiencing high population growth over the years, which can be attrituted to natural growth as well as the migrant populations from the adjacent rural areas and towns hoping for better employment and livelihood opportunities.

The rapid pace of urbanisation together with the increase in population and private vehicles in Udaipur city will pose an unimaginable load on the city's already struggling transport infrastructure. On the other hand, the share of public transport is also declining, leading to more usage of private vehicles for mobility needs and increased demand for parking of private vehicles.

The LCMP for Udaipur lays out a set of measured steps that are designed to improve the transportation infrastructure of the city in a sustainable manner.

Chapter 1. Introduction

This chapter gives a brief overview of the project, encapsulating the rationale behind it and laying down the project aim, objective, and methodology used to prepare the 'Low-carbon Comprehensive Mobility Plan' for the city of Udaipur. This chapter is further divided into nine sections. The first section gives a background to the study, followed by the planning area and horizon of the LCMP, the vision, objectives, and methodology of LCMP, followed by the study area delineation and data collection approach, stakeholder consultations and finally concluding with the organization of the report.

1.1 Background

The cities in fast developing countries like India continue to grow rapidly in both its spatial extent and population, as consequent of growth of national economy of the country. This has led to fast urban growth and urbanization. Urbanization has in turn led to an increase in the number of vehicles and energy consumption. The travel trends of previous decades indicate that there is a decline in the use of bicycles and public transport, and an increase in the share of two-wheelers and cars. These trends have significantly contributed to the consumption of fossil fuel by the transport sector, and also to air pollution from vehicular emissions. Consequently, the transport sector is also the largest consumer of fossil fuel and a big contributor to air pollution, as land transport accounts for roughly 73 per cent of the sector's total CO_2 emissions. The transport sector in India alone accounts for about 45 per cent of the country's total oil consumption, of which a large share is consumed for intra-urban trips. Thus, there is a need for strategic intervention in terms of policies or planning methods, in addition to reducing emissions and introducing energy conservation techniques.

In India, after 2005, urban mobility issues have been addressed by the preparation of mobility plans. The construct of these mobility plans has been explained in considerable detail in a toolkit prepared by the Ministry of Urban Development (MoUD), Government of India (GoI), and Asian Development Bank (Co, 2008). Even though these Comprehensive Mobility Plans (CMPs) have helped the urban areas in cities to plan and channel resources and investment, they have not been able to address the issues related to inclusiveness, land use transport integration and measures that would promote use of non-motorized modes and public modes of transport. The CMPs consistently lack in the provision of strategies to enable safe and secure mobility and accessibility for all groups of people. Further, the CMP methodology lacks an approach to CO_2 mitigation from various scenarios. The Low-carbon Comprehensive Mobility Plan (LCMP) focuses more on the reduction of greenhouse gas (GHG) emissions without compromising the accessibility and mobility needs of all people.

The Low-carbon Comprehensive Mobility Plan incorporates into the existing methodology of CMP additional indicators of urban transport inclusiveness and measures that would lead to lower carbon emissions from transport. Within the LCMP framework, this initiative aims to address transportation growth, development challenges and climate changes issues in an integrated manner proposed by UNEP. The Risø Centre and Ministry of Environment and Forests in India (in consultation with IIT Delhi, CEPT University and IIM, Ahmedabad) have therefore produced a toolkit for preparation of LCMPs. They will collectively also show examples of plan preparation on three diverse cities of India: Vishakhapatnam, Rajkot and Udaipur. These plans will address the need for appropriate planning to ensure safe mobility and accessibility to people irrespective of their socio-economic background in a way that does not compromise the overall quality and health of the environment. The LCMP is also envisaged to be an effective decision-making tool that will help to develop low-carbon mobility scenarios, and identify projects that will pave the way and earmark JnNURM funding for implementation. While doing so, it would ensure improved accessibility for the low-income households and women in the cities, who have constraints on accessibility. This report presents the LCMP plan for the city of Udaipur.

1.2 Planning Area

The area of study is the Udaipur Urban Control Area, which covers about 347.91km^2 (34,791 Ha). It comprises Udaipur's urbanized and urbanizable area (as defined by UIT), Udaipur municipal area and 62 revenue villages. Figure 1-1 shows the Udaipur Urban Control Area as the planning area for preparing LCMP.

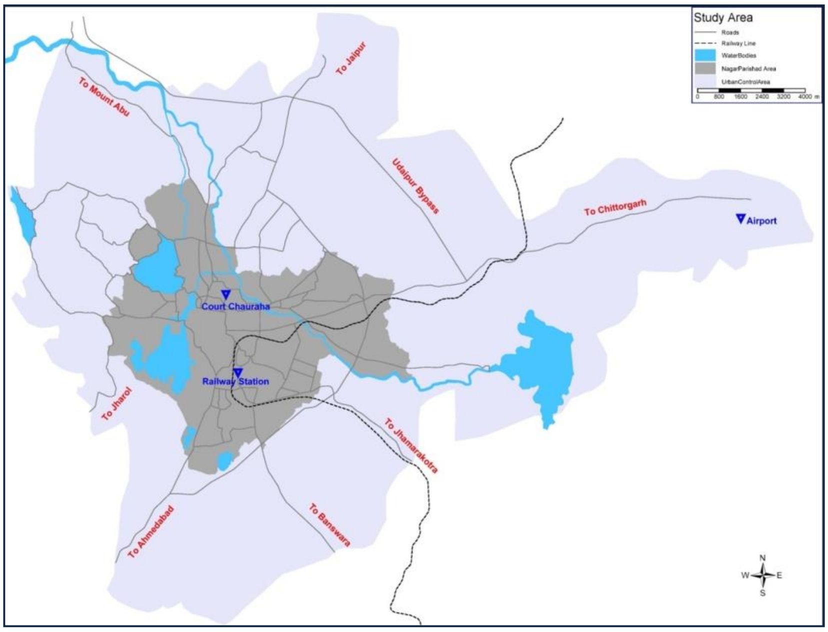

Figure 1-1: Udaipur Urban Control Area (study area for LCMP)

1.3 Planning Horizon

Planning is a process of rational decision-making for the future. Hence, the whole process of planning is useless until and unless a rational estimation is conducted of some crucial planning parameters, like future demand, which can be reflected by future population and economic status.

The estimation of present and future demand for transport services and transport-related infrastructural facilities, and the adoption of suitable action for low-carbon, safe, and efficient movement of passengers and goods, necessitates forecasting the future Udaipur population and economic status.

It has been ascertained that the overall goal of LCMP can be realized over a long-term horizon period of 30 years. The revised Master Plan has been prepared for 2031.

The proposed scheme of improvements mentioned in the Master Plan has been taken as the business as usual (BAU) scenario for the LCMP study.

Thus in consultation and agreement with UIT and the District Collectorate, Udaipur, a long-term planning horizon of 30 years has been envisioned to attain the goals of the LCMP. This timeframe has been divided into three time horizons. The three horizon periods are divided as follows:

1. Short-term: The short-term time horizon will last for five years, starting from 2013 to 2018. It will focus on short-term planning measures that include intersection improvements, signalisation of intersections, traffic circulation plans, parking plans, etc. The overall emphasis will remain on improving the safety and accessibility standards.
2. Medium-term: The time period for this horizon is ten years, till 2022. The focus will be on medium-term planning projects such as NMT corridors, city bus networks and NMT networks. The objective of medium-term planning is to arrest the current trend of heavy dependence on private vehicles and create the conditions for higher PT and NMT usage in the future.
3. Long-term: This is a 30-year period, lasting up to 2041 with a long-term vision of achieving the overall low-carbon mobility goals.

1.4 Vision and Objectives

1.4.1 Vision statement

"The Mobility Vision for Udaipur City is to provide Safe, Efficient and Environmentally Sustainable means of Transportation Systems for Improved Mobility and Accessibility of People and Goods across Gender and Heterogeneous Socio-Economic Groups."

1.4.2 Objectives

The objective of the Low-carbon Comprehensive Mobility Plan (LCMP) for Udaipur is to provide a long-term strategy, which ensures desirable mobility, safety and accessibility to people across gender and socio-economic groups while reducing carbon emissions. Sustainable mobility can only be ensured if the solutions are environmentally, socially, and economically sustainable, as presented in

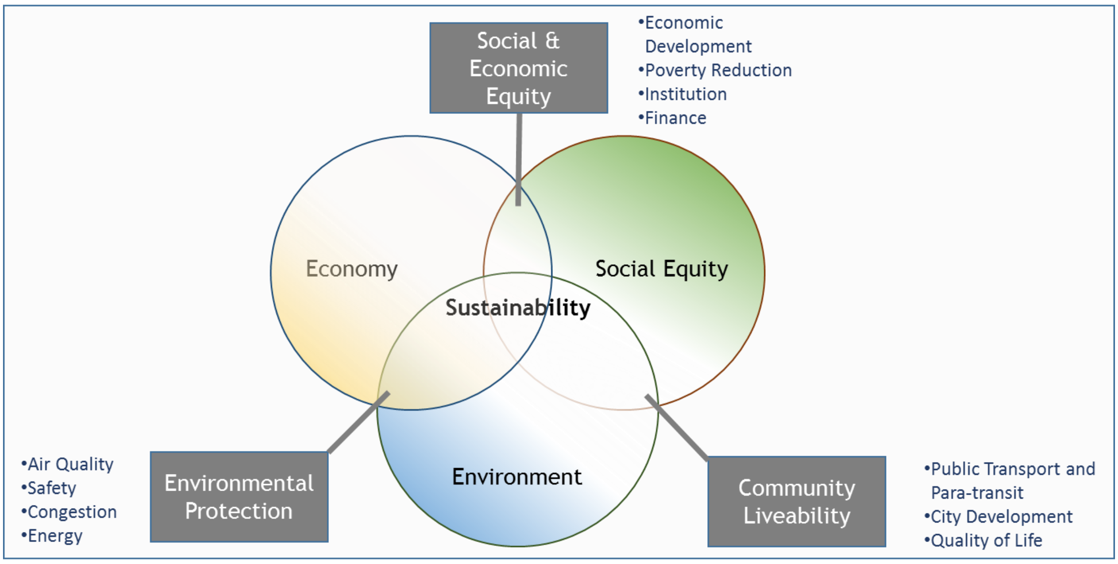

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Figure 1-2.

Figure 1-2: Sustainable mobility solutions

Thus, the LCMP to be prepared for Udaipur city will be a mobility plan that provides a roadmap for infrastructure development options, and an investment requirement to provide a desirable level of mobility and accessibility while minimizing carbon emissions.

1.5 Approach and Methodology

The methodology for preparing this LCMP has been formulated as per the guidelines by UNEP. An in-depth analysis based on the data collected on transport and the traffic situation has been carried out, identifying the urban transport characteristics and issues of the study area. The approach and methodology followed in preparing the Low-carbon Comprehensive Mobility Plan for Udaipur is given in Figure 1-3.

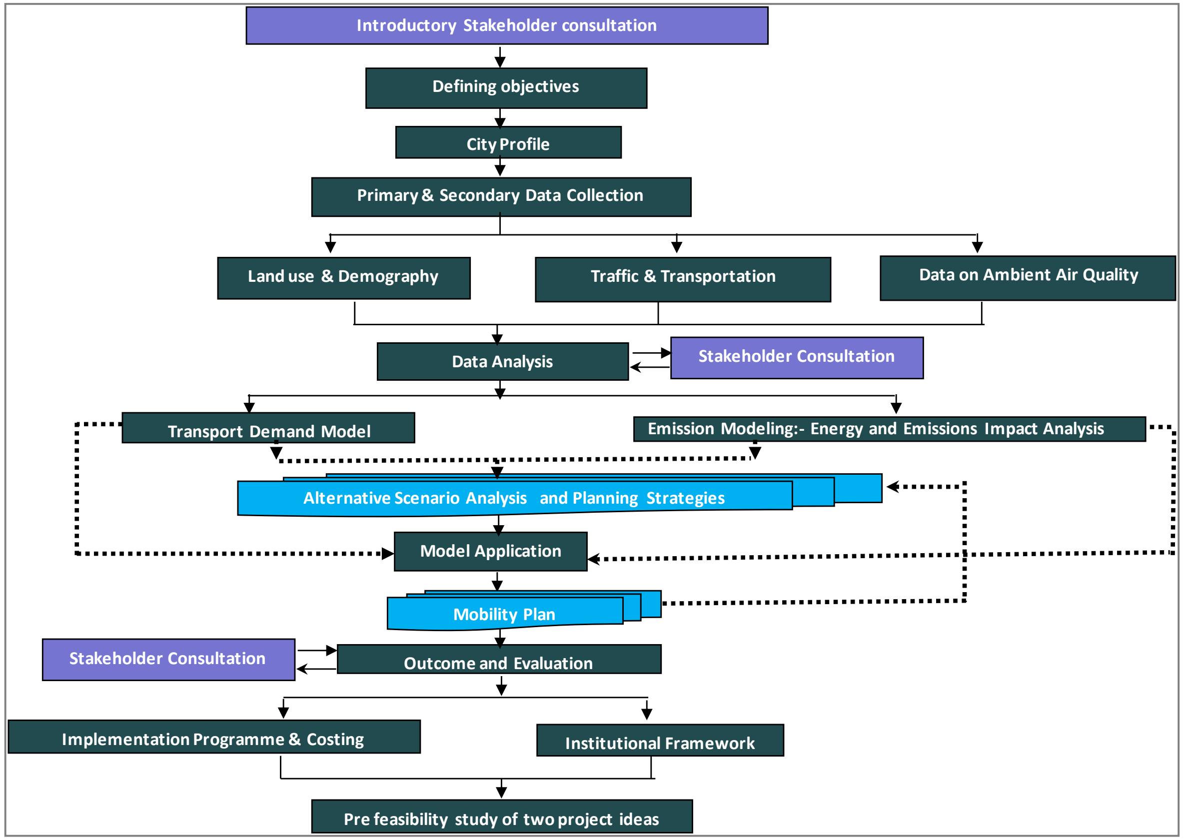

Figure 1-3: Approach and methodology flow chart

1.6 Study Area Delineation

The Low-carbon Comprehensive Mobility Plan will look into the development of transport infrastructure to meet the mobility needs of individuals irrespective of their economic status, making the environment sustainable for people living in the city. For achieving this project goal, it is mandatory to define a study area. As in the case of Udaipur, the Udaipur Urban Control Area was delineated for the study. The boundary consists of urbanized, urbanizable and municipal area along with 62 revenue villages. The study area has been divided into smaller areas called traffic analysis zones (TAZs) for analysis. The study area has been divided into 80 internal zones, and the external area is grouped into 9 zones. First, 55 internal zones are the municipal wards, and the remaining 25 zones are formed by grouping 62 villages in Udaipur. Table 1-1 shows the details of the TAZs with zone number.

Table 1-1: Description of traffic analysis zones

Sl. No.	Description of TAZ	No. of TAZs	Zoning principle
1	Udaipur Municipal Corporation Area (Municipal Wards)	55	Consistent with the existing administrative zone due to availability of data pertaining to demography, land use, etc., as per municipal wards records
2	Grouped Internal Zones (Grouping 62 Revenue Villages under Udaipur Urban Control Area)	25	In order to maintain homogeneity of TAZs in terms of certain parameters, such as level of population, land use, road network, etc., which are attributed as factors governing trip generation and attraction.

1.7 Data Collection Approach

The data required for the study was collected based on the methodology prescribed in the toolkit for preparing LCMPs.

1.7.1 Collection and review of existing secondary information

The secondary data required for the development of study have been collected from various sources, such as from numerous government/planning organizations. Data on existing land use and land use plans have been collected and presented through a detailed review of existing development plans, including the Master Plan and the City

Development Plan (CDP). During the process, Urban Mass Transit Company (UMTC) has identified the data gaps and additional data requirements. Further, following the guidelines for preparation of an LCMP as recommended by UNEP, and also following the toolkit for preparation of the CMP published by MoUD, GoI, UMTC has carried out several primary surveys.

1.7.2 Primary data collection

Primary surveys include classified traffic volume counts at outer cordon locations and at mid-block locations, passenger origin-destination surveys, parking surveys, etc., as discussed below in Table 1-2. The locations for these surveys have been marked and the Figures are represented in Chapter 3.

The formats for primary survey have been designed keeping in mind the objectives of the study. All the formats and a note on sampling method are attached in Annexure 1.

Table 1-2: Primary public transport surveys

Sl. No.	Type of survey	Location/ sample size	Duration	Day of week	Purpose
1	**Classified traffic volume count**	Outer cordon points Inner cordon points Mid-block locations	a) 24 hours b) 16 hours (06:00 to 22:00) c) 16 hours (06:00 to 22:00)	Weekday (one non-incident, non-event working day)	To obtain mode-wise volume of traffic, composition, hourly variation, directional flow
2	**Classified turning movement count**	At all the important intersections	a) 16 hours (06:00 to 22:00)	Weekday (one non-incident, non-event working day)	To obtain mode-wise volume of traffic, composition, hourly variation, directional flow, turning movements
3	**Origin-destination survey and**	Outer cordon points	a) 24 hours b) 16 hours	Weekday (one non-incident,	User profiling, commuter perception

Sl. No.	Type of survey	Location/ sample size	Duration	Day of week	Purpose
	occupancy survey (passenger & freight)	Inner cordon points (traffic signals intersections) Mid-block locations Terminals	(06:00 to 22:00) c) 16 hours (06:00 to 22:00) d) 24 hours	non-event working day)	and appreciation of needs, trip origin-destination details, travel characteristics
4	**Parking survey**	Along major road stretches and along major activity centres	a) 12 hours	Weekday (one non-incident, non-event working day)	To estimate parking duration, accumulation
5	**Speed and delay survey**	Major corridors	Peak and off-peak hours	Weekday (one non-incident, non-event working day)	Journey speeds, running speed duration and reasons of delays
6	**Survey of public transport and IPT users**	On different modes		Weekday (one non-incident, non-event working day)	User profiling, commuter perception and appreciation of needs, trip origin-destination details, travel characteristics
7	**Commuter survey**	Railway stations, bus terminals, airport, etc.	24 hours	Weekday (one non-incident, non-event working day)	User profiling, commuter perception and appreciation of needs, trip origin-destination details, travel characteristics
8	**Household Survey**	Household characteristics, socio-	-	-	User profiling, commuter perception

Sl. No.	Type of survey	Location/ sample size	Duration	Day of week	Purpose
		economic characteristics and travel characteristics of 12, 831 individuals were collected by conducting household survey in 2562 households. The stratified random sampling technique was used to select these 2562 samples. Stratification was done based on level of income and place of residence such as HIG, MIG, and LIG. Similarly, the whole population was grouped into urban and rural populations. Details of the household survey sampling technique are described in Annexure 1			and appreciation of needs, trip origin-destination details, travel characteristics
9	**Vehicle operators survey**	Survey of operators across the city (auto, other para transit,	-	-	To collect details of vehicles and their

Sl. No.	Type of survey	Location/ sample size	Duration	Day of week	Purpose
		mini buses, tempos and truck operators)			operational characteristics
10	**Terminal area survey**	Railway stations, bus terminals, airport, etc.	-	-	To assess the quality of infrastructure
11	**Pedestrian survey**	Major roads and intersections	16 hours (06:00 to 22:00)	Weekdays	To estimate the volume and direction of pedestrian flow
12	**Road network inventory survey**	Major road network			To assess the quality of road infrastructure
13	**Workplace (establishment) survey**	Important offices in central business districts	-	Weekdays	Trip attraction potential of activity centres
14	**Tourism survey**	At all major tourist locations			Nature of tourism, availability of supporting infrastructure, identify its role in the local economy
15	**Petrol pump survey**	At all major petrol pump stations	16 hours		To understand the vehicle characteristics of the city in terms age of vehicles, their efficiency in terms of mileage etc.

Figure 1-4: Photographs of primary surveys

1.8 Stakeholder Consultation

The Low-carbon Comprehensive Mobility Plan, being the long term vision document, relies on active participation and feedback from different stakeholders. Therefore, the process of preparing the Udaipur LCMP has involved consultation with all stakeholders in each stage of the process. The details of stakeholder consultation are as follows:

a. **Finalization of study area, horizon year, and scope of work stage:** Each and every aspect of the scope of services was discussed with the Urban Improvement Trust, Udaipur; Udaipur Nagar Parishad; and Town and Country Planning Department.
b. **Secondary data collection stage:** Secondary data was collected from various agencies and departments, along with their inputs, and these are:

   a. Town and Country Planning Department
   b. Urban Improvement Trust, Udaipur (UIT)
   c. Mayor, Udaipur Nagar Parishad
   d. Urban Development and Housing Department
   e. Rajasthan State Road Transport Corporation
   f. Traffic Police
   g. Regional Transport Authority, Udaipur
   h. Public Works Department
   i. Tourism Department
   j. Rajasthan State Pollution Control Board
   k. Railway Authority
   l. Airport Authority
   m. Rajasthan State Industrial Development & Investment Corporation (RIICO)
   n. Directorate of Petroleum, Rajasthan
   o. Rajasthan Urban Infrastructure Development Board
   p. Department of Energy, Government of Rajasthan
   q. Department of Environment, Government of Rajasthan

r. Forest Department, Government of Rajasthan
s. Department of Industries, Government of Rajasthan
t. Directorate of Economics and Statistics, Government of Rajasthan
u. Employment Department, Government of Rajasthan.

c. **Primary data collection stage:** As per the UNEP guidelines for preparing the LCMP, and also following the toolkit for preparing a CMP, published by MoUD, GoI, UMTC carried out numerous primary surveys (details of which are discussed in Chapter 2 of this report and in Annexure 2) in consultation with UIT, Traffic Police, Town and Country Planning Department, and Udaipur Nagar Parishad. The locations of primary surveys, such as traffic and travel surveys, were identified jointly by UMTC, Traffic Police, UIT, Udaipur Nagar Parishad, and Regional Transport Office (RTO).

d. **Data analysis stage:** The data collected from both secondary and primary sources were compiled and analysed. Based on the analysis of the data, inferences were drawn and broad recommendations were dovetailed. This was submitted to the UIT and Udaipur Nagar Parishad, along with UNEP in the form of an Interim Report – Preliminary Survey Analysis. The aforementioned Report was presented to the respective stakeholders. During the presentation of the Interim Report, UMTC received feedback and suggestions from various stakeholders.

Planning and proposal formulation stage: After incorporating the comments and suggestions, UTMC prepared a detailed Transport Demand Model (Draft Report for Trends and Current Situation) using transportation software, to replicate the base year ground situation. The base year transport model was calibrated and validated using several parameters, which was used to forecast the future transportation scenario (Draft Report – Future Scenarios) of Udaipur city. Based on the forecasted traffic and population, in consultation with stakeholders UMTC formulated various intervention measures for improving the accessibility and mobility across heterogeneous socio-economic groups and gender in Udaipur, along with reduction in

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emission levels. This was submitted in the form of a Draft Final Report. UMTC gave a presentation on the Draft Final Report to various stakeholders on 14 February 2014.

All the suggestions and comments received on the Draft Final Report were examined and studied, and the feasible suggestions and comments were incorporated into this Final Report of the Low-carbon Comprehensive Mobility Plan.

Rajasthan Patrika, dated 14th February, 2014

Dainik Bhaskar, Udaipur

1.9 Organisation of the Report

The process of preparing the Low-carbon Comprehensive Mobility Plan for Udaipur was completed in six stages, and accordingly six deliverables were submitted to the respective authorities. These six deliverables and their broad coverage are as follows:

1. **Inception Report:** The Inception Report covers various aspects of this study, such as understanding the scope of work, study area demarcation, defining the approach methodology for the study, defining the methodology for conducting the primary surveys to be conducted, identifying the secondary data to be collected, and also listing the stakeholders to be consulted.
2. **Interim Report – Preliminary Survey Analysis Report:** The Preliminary Survey Analysis Report covers the analysis of secondary and primary survey data, an evaluation of the existing transport scenario of the study area, and project concepts based on preliminary analysis and site observations.

3. **Draft Report – Trends and Current Situation Report:** The Trends and Current Situation Report covers the base year transportation and travel patterns in the city of Udaipur. This report also covers the development of the base year travel demand model using transport planning software.
4. **Draft Report – Future Scenario Report:** The Future Scenario Report covers the development of the travel demand model for the base year using transport planning software and also the projection of the horizon years, establishment of the traffic and transportation issues, and formulation of the alternate scenarios such as the business as usual (BAU) scenario, land use scenario, NMT scenario, PT scenario, technology scenario and a combined scenario.
5. **Draft Final Report:** The Draft Final Report covers the development of the travel demand model using transport planning software to project the transport scenario for the base year and horizon year, establishment of traffic and transportation issues, along with the reduction of emissions and formulation of draft proposals in respect to non-motorized transport strategies, public transport strategies, land use strategies, technology strategies and the formulation of combined LCMP strategies.
6. **Final Report:** Based on the feedback obtained from stakeholder consultation, the proposals discussed in the Draft Final Report were detailed and modified as required with detailed block cost estimates. A pre-feasibility study of two pilot projects was also conducted from the projects mentioned in this final report, and were prioritized by city authorities.

This Final Report consists of nine chapters: Introduction, Current Status – Udaipur, Data Analysis and Mobility Indicators, Base Year Travel Demand Model, Business as Usual Scenario, Alternative Development Scenario (Low-Carbon Development Scenario), Implementation Program and Block Cost Estimation, Institutional Framework and finally Outcomes and Conclusions.

The first chapter, ‘Introduction’, gives a brief overview of the project, encapsulating the rationale behind it as well as laying down the project aim, objective and the methodology used to prepare the Low-carbon Comprehensive Mobility Plan for the city of Udaipur.

The second chapter, ‘City Status – Udaipur’, gives an overall perspective regarding the demography, growth pattern and connectivity of the city. It also gives a brief overview of the land use pattern and most importantly, the economic and employment condition of the city. It basically gives an overall picture of the existing socio-economic and spatial characteristics of the city.

The third chapter, ‘Data Analysis and Mobility Indicators’, is divided into two sections: firstly transport system characteristics, which describes the existing infrastructure provided in the city for various competitive and heterogeneous users, such as pedestrians, cyclists, public transport users and private vehicle users; and secondly, travel pattern characteristics. This chapter concludes with the inferences on the gaps between the demand and supply of the transport infrastructure in the city.

The fourth chapter, 'Base Year Travel Demand Model', describes the process undertaken to develop the Base Year 4 Stage Travel Demand Model, assumptions made, the relationships between various indicators and validation of the modelled results as compared to the observed. In essence, this chapter gives an overall picture of the travel pattern of the city and its impacts on the city's road network.

The fifth chapter, 'Business as Usual (BAU) Scenario', gives an overall perspective regarding the growth pattern of the city for the horizon years in terms of demographic, land use and socio-economic parameters, which are used to develop the business as usual (BAU) scenario for the horizon years. The chapter summarizes the results of the same.

The sixth chapter, 'Alternative Development Scenarios (Low-Carbon Development Scenarios)', gives a detailed perspective regarding various standalone mobility improvement strategies, such as land use, public transport, non-motorized transport and technology interventions for promoting low-carbon transport in Udaipur. An in-depth comparision of the aforementioned strategies was conducted, followed by the development of a combined LCMP scenario.

The seventh chapter, 'Implementation Programme and Block Cost Estimation', defines phases for implementing the projects identified in the previous chapters, which are sustainable in the long term. This chapter also descibes the cost estimates associated with implementation of each project. The financing options to implement each of the projects is also described in this chapter.

The eighth chapter, 'Institutional Framework', descibes the existing city and state-level institutional structures responsible for managing and monitoring urban transport. This chapter recommends a number of reform measures for improving existing city and state-level institutional structures.

The ninth Chapter, 'Outcomes and Conclusions', describes the outcomes of the study and accordingly justifies the projects suggested in terms of their overall sustainable development.

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Chapter 2. City Status – Udaipur

This chapter gives an overall perspective regarding the demography, growth pattern and connectivity of the city. It also gives a brief overview of the land use pattern and most importantly, the economic and employment condition of the city. In essence, it gives an overall picture of the existing socio-economic and spatial characteristics of the city.

2.1 City Profile

2.1.1 Location of the city

Udaipur, the City of Lakes, is a city, a Municipal Council and the administrative headquarters of the Udaipur District in the State of Rajasthan. It is one of the most famous tourist destinations in India for local and foreign tourists. Udaipur inherits a rich historical and cultural heritage from its past as the capital of the erstwhile Mewar Kingdom. Its dominance in the region dates back to the mid-16th century. It is renowned for its Rajput-era palaces and picturesque lakes, including Pichola Lake, Fateh Sagar, Udai Sagar and Swaroop Sagar.

2.1.2 Regional connectivity

Situated in the north-eastern part of Girwa Tehsil of Udaipur District, and the south-western part of Rajasthan, Udaipur is historically and geographically the heart of the erstwhile Mewar State. Located almost at the midpoint of the Delhi-Mumbai National Highway (NH8), Udaipur is well connected to the state capital Jaipur (420km to the northeast) and Ahmedabad (250km to the southwest). Udaipur is connected to other prominent state centres by three state highways: SH-9 connecting Chittor; SH-32 connecting Banswara; and SH-32 connecting Mount Abu. It is also connected to Chittor via NH-76.

Udaipur is located in the centre of a saucer-shaped valley basin and is surrounded by the Aravalli hills. It lies in the western zone of India, and south-eastern side of the Aravalli range.

Table 2-1: Distance from other urban centres

Sl. No.	City	Distance (km)
1	Ahmedabad	252
2	Jodhpur	260
3	Kota	270
4	Jaipur	405
5	Delhi	664
6	Mumbai	797

- **By Air**: The domestic airport (Maharana Pratap Airport) is located 21km from the city centre on Chittorgarh Road (NH 76) near Dabok. It has flights operating in and out of the airport, connecting Delhi, Mumbai, Jaipur, and Jodhpur.
- **By Rail:** Udaipur city has direct trains on the broad gauge network. It has two main railway stations, Udaipur City Railway Station and Rana Pratap Railway Station (Pratap Nagar).
- **By Road:** Udaipur is well connected by roads with the rest of the country. It is located along the NH8 (Delhi-Mumbai) and NH76 along Chittorgarh, Dungerpur, and Banswara State Highways.

2.1.3 Growth pattern of Udaipur

Udaipur is developing primarily towards the north, east and south, along the NH-8 to Ahmedabad and NH-76 to Chittorgarh. The region towards the west did not develop further as it is blocked by hills and lakes. Figure 2-1 shows the major development and growth patterns. The north-eastern part of Udaipur is a plain area, and therefore secondary and tertiary activities are increasing in this direction. Amberi, Sukher, Sobhagpura, Raghunathpura and Bhuwana, located in the north/northeast direction of Udaipur, primarily contain small-scale industries and mineral activities. Hindustan Zinc Limited established its facility towards the east, along the Udai Sagar Lake. Major development activities have proliferated along the water bodies and highways.

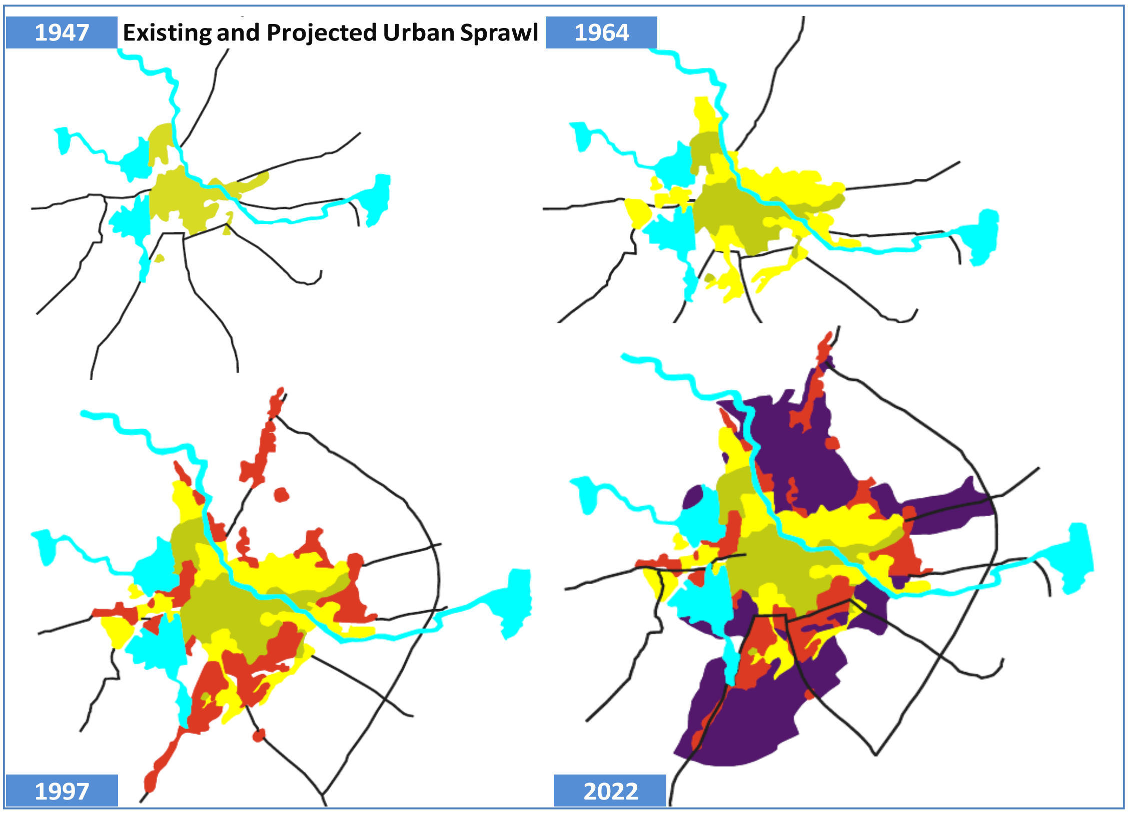

Figure 2-1: Urban sprawl of Udaipur (source: CDP Udaipur)

2.1.4 Demographic trends

The population in Udaipur municipal area has grown steadily since 1901, from 45,900 in 1901 to 308,000 in 1991. The growth was negative only during 1901 to 1911 when it fell to 33,000 from 45,000 in the previous decade. The negative growth rate was due to several epidemics and famines. Thereafter, the population increased steadily. The 1941-51 decade recorded a peak decadal growth rate of 50 per cent, which was essentially due to an influx of displaced persons on account of partition of the country in 1947.

The population of Udaipur has increased nearly threefold from 1961 to 1991. This can be attributed to economic factors leading to better employment opportunities. However, the 1981-91 decade experienced a decline in growth from 44.22 per cent to 32.67 per cent, suggesting a stabilizing growth trend for the city.

Table 2-2: Population statistics of Udaipur city (1931-2011)

Year	Population
1931	44,035
1941	59,648
1951	89,621
1961	111,139
1971	161,278
1981	232,583
1991	308,571
2001	389,438
2011	637,717

Source: Census of India, 2011.

According to the 2011 Census of India provisional data, Udaipur city has a population of 637,717 making it the sixth-largest city of Rajasthan.

2.2 City Structure

2.2.1 Population density

The city of Udaipur has gross city density of 61 persons per hectare. Table 2-3 shows the area-wise density. Referring to Figure 2-2, which shows the zone-wise population density, it is evident that the old city area has the maximum density.

Table 2-3: Areas and population of Udaipur Urban Control Area 2011

S. No.	Zone	Area (ha)	% of total area	Population 2011	% of total population	Gross density per ha
1	Village area	26,921	81	158,061	25%	20
2	Municipal area	6,202	19	479,656	75%	257

S. No.	Zone	Area (ha)	% of total area	Population 2011	% of total population	Gross density per ha
Total Urban Control Area		34,791	100%	637,717	100%	61

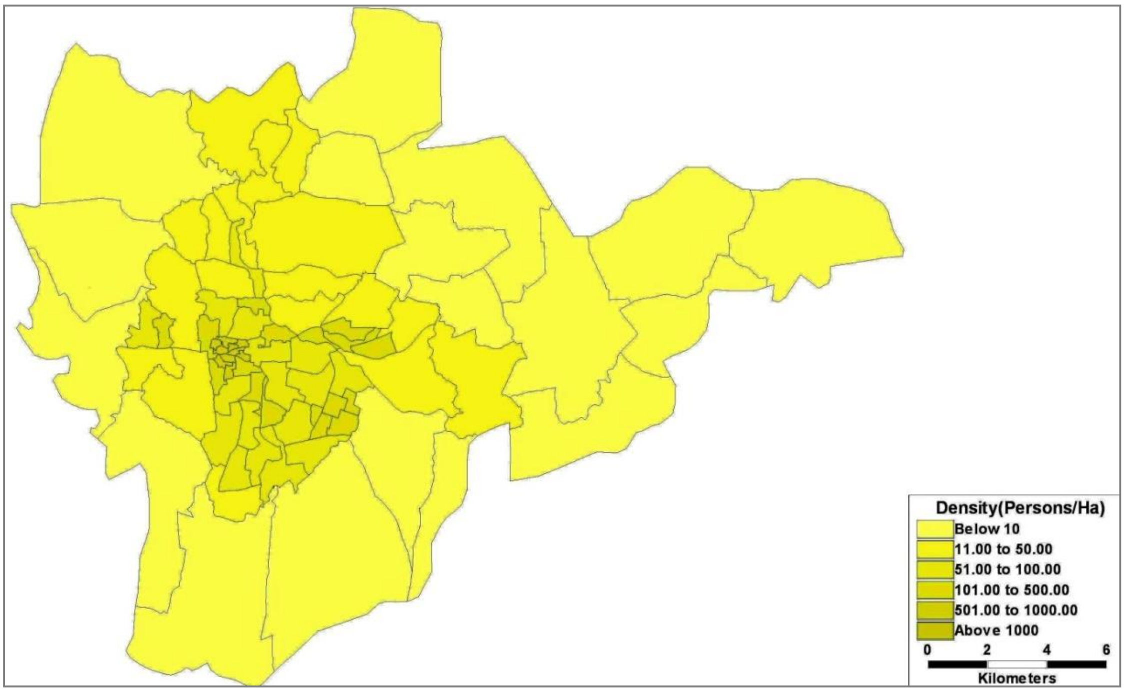

Figure 2-2: Density map of Udaipur

2.2.2 Land area and land use characteristics

2.2.2.1 Land area

The Udaipur Urban Control Area belt was created to curtail any unplanned development. This is a boundary with a radius of 3-4km around Udaipur. The boundary consists of urbanized, urbanizable and municipal area along with 62 revenue villages. The land within the Urban Control Area can be utilized for agriculture, dairy, horticulture, farm houses, resorts, motels, amusement parks, water parks and agriculture-based industries. The boundary of the Urban Control Area has been fixed to promote a planned development of villages. Figure 2-3 shows the Urban Control Area demarcated on the map and Figure 2-4 shows the urban structure of the city.

2.2.2.2 Land use characteristics

Udaipur is surrounded by hills and lakes, which physically hinder its growth along these directions. Therefore, the city is presently growing only towards the north-east and west along the two national highways NH-8 and NH-76.

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The Master Plan (1976-96) had proposed a land use pattern, where an area of 5,512 ha was demarcated as urbanizable. It proposed 4,153 ha as developed area, which was distributed as follows: 47.6 per cent was allocated for residential use, 13.6 per cent under circulation, 14.1 per cent as public and semi-public, 10.5 per cent as industrial, 5 per cent as commercial, and 1.2 per cent as governmental. The 1976-96 Master Plan was subsequently revised in 2001 to develop the current Master Plan until 2022. The Master Plan (2001) proposed a land use distribution of developed area as follows: 37.42 per cent was allocated for residential use, 18.8 per cent under transportation, 12.3 per cent as public and semi-public, 10.5 per cent as industrial, 3.82 per cent as commercial, 25.41 per cent as recreational and 1.2 per cent as government land.

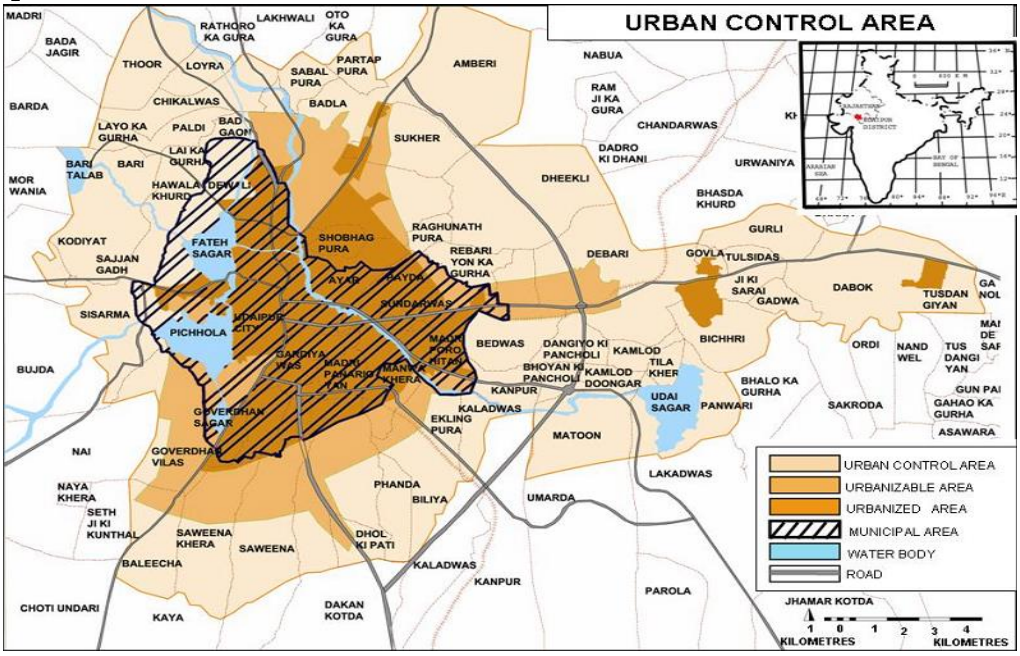

Figure 2-3: Urban Control Area

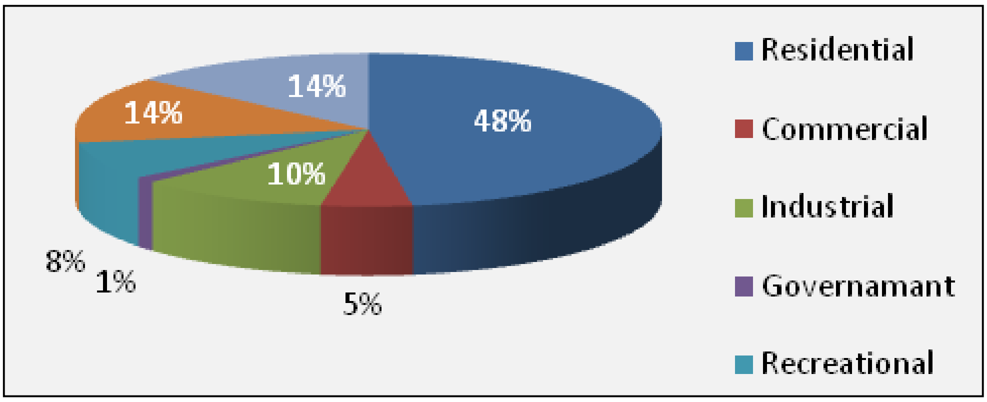

Figure 2-4: Urban structure of Udaipur city

As per the Master Plan of Udaipur Urban Control Area 2001, 37.42 per cent is allocated to residential, 18.8 per cent for transportation, 12.3 per cent for public & semi-public uses, 10.5 per cent for industrial, 3.82 per cent for commercial, 25.41 per cent for recreation, and 1.2 per cent for government land use.

2.2.3 Economic generators

The city forms the headquarters of Udaipur Division, which is comprised of five districts. The city is host to several state and regional public offices, including offices of the Director of Mines and Geology, Commissioner of Excise, Commissioner of Tribal Area Development, Hindustan Zinc Limited, and Rajasthan State Mines and Mineral Corporation Limited. Other district-level offices include the Collectorate, Public Works Department, Public Health and Engineering Department, Office of Senior Town Planner, etc.

The economy of Udaipur is diversified, with significant contributions from tourism, trade and commerce, and the industrial sector. Besides these, Udaipur is also an educational hub with three universities, six colleges and more than 160 high schools.

2.2.3.1 Tourism

Udaipur, with its picturesque landscape, lakes, and historic significance is a major destination for most tourists visiting Rajasthan. It offers an abundance of places of tourist interest, including the large man-made lakes Pichola and Fateh Sagar. The section on tourism and heritage explains the importance and potential of tourism and allied industries in the region. Udaipur receives the fourth-largest number of tourists in Rajasthan, following Mount Abu, Jaipur and Pushkar. The growth in tourism in Udaipur has been higher than the State average. On an average, 11 to 15 per cent of the total number of tourists visiting the State visit Udaipur. There has been a constant rise in tourists of both domestic and foreign visitors over last five years.

2.2.3.2 Trade and commerce

Udaipur serves as a market centre for the smaller towns of the region. The city has wholesale markets for various commodities, ranging from food grains to building materials. Krishi Upaj Mandi is a centralized wholesale market for grains. UIT has also planned to develop a large sub-city centre. This is essential to meet the growing need for a formal and organized commercial space in heart of the city and a decentralization of commercial activities from the walled city.

2.2.3.3 Industries

Industrial development in Udaipur began in earnest in 1950. Prior to 1950, only about 15 units were registered in Udaipur. These units were largely associated with processing and manufacturing mineral ores and metals, chemicals and pharmaceuticals, as well as wooden toys, oil, and food products. The most important milestone in the development of the mineral-based industries was the formation of Rajasthan State Mines and Minerals Corporation.

After 1955, various industries established themselves outside the city walls and near the railway station, along Udai Sagar Road. Most of these were associated with metals, automobiles, soapstone grinding, and repair workshops.

Udaipur is considered among the leading districts of the State in terms of industrial activity. This is due to the fact that Udaipur has a large variety of mineral resources and is well connected by both rail and road.

2.2.4 Income distribution

Based on the Udaipur City Development Plan (2009) estimates, Figure 2-5 shows the distribution of all households according to their income group[1]. It is evident that medium income groups are predominant, comprising 61 per cent of all households. High income groups form 13 per cent of all households.

Sixty-one per cent of households are Medium Income Groups, 26.6 per cent are Lower Income Groups, and 12.6 per cent are High Income Groups.

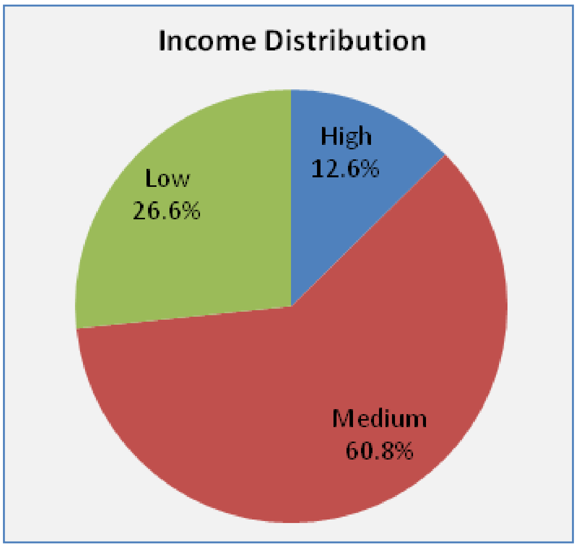

Figure 2-5: Distribution of households based on income

2.3 Conclusion

Udaipur is the sixth-largest city in the State, with a population of 637,717. It is the administrative seat of the Udaipur District and Municipal Council of Udaipur. It is a well-known tourist destination in India for domestic and international tourists. Udaipur inherits a rich historical and cultural heritage from its past as the capital of the erstwhile Mewar kingdom. The city is relatively compact with a dense road network, but is gradually growing in all directions through lower-density development. The presence of the natural geographic barriers has restricted the growth of the city. The city has a mixed use development, especially in the city core surrounding city palace. The city core is the hub of commercial activities, whereas the eastern part of the city is well known for industrial establishments.

[1] Source: Udaipur Nagar Nigam, Urban Improvement Trust, Udaipur (2012-2013)

Chapter 3. Data Analysis and Mobility Indicators

This chapter is divided into two sections: firstly transport characteristics and secondly travel pattern characteristics. The first section largely covers the existing traffic and transportation condition of the city, including infrastructure for pedestrians, cyclists, public transport, para transit and private motorized vehicles. Infrastructure for these modes is assessed in terms of its capacity, quality, safety, security and emissions. The second section explains the travel behaviour patterns of the resident population. The section gives a descriptive analysis of income and purpose-wise mode share, average trip length, PCTR, etc. This section also details the level of energy (electricity, fossil fuels) being used by the resident population and their consequent emission levels.

3.1 Background

Assessment of traffic characteristics within an urban area is an essential pre-requisite in appreciating the problems of traffic movement, and in understanding the need for organizing the same in an efficient and economical manner. Traffic characteristics help in appreciating the spatial and temporal features of travel within the area, the relationship between traffic intensity and network capacity, and the prevailing level of service obtained on various corridors of the network in the study area. This appreciation and understanding is essential for identifying the present conditions and constraints for formulating suitable policies and strategies, selecting relevant systems, and designing individual components of the system.

Apart from collection, compilation, and analysis of secondary data, in order to appreciate an in-depth and comprehensive traffic and transport system and to understand the mobility pattern of Udaipur, a number of primary surveys were conducted within the study area as mentioned in Chapter 1. Figure 3-1,

Figure 3-2,

Figure 3-3 and

Figure 3-4 represent the location of the primary surveys conducted within the study area.

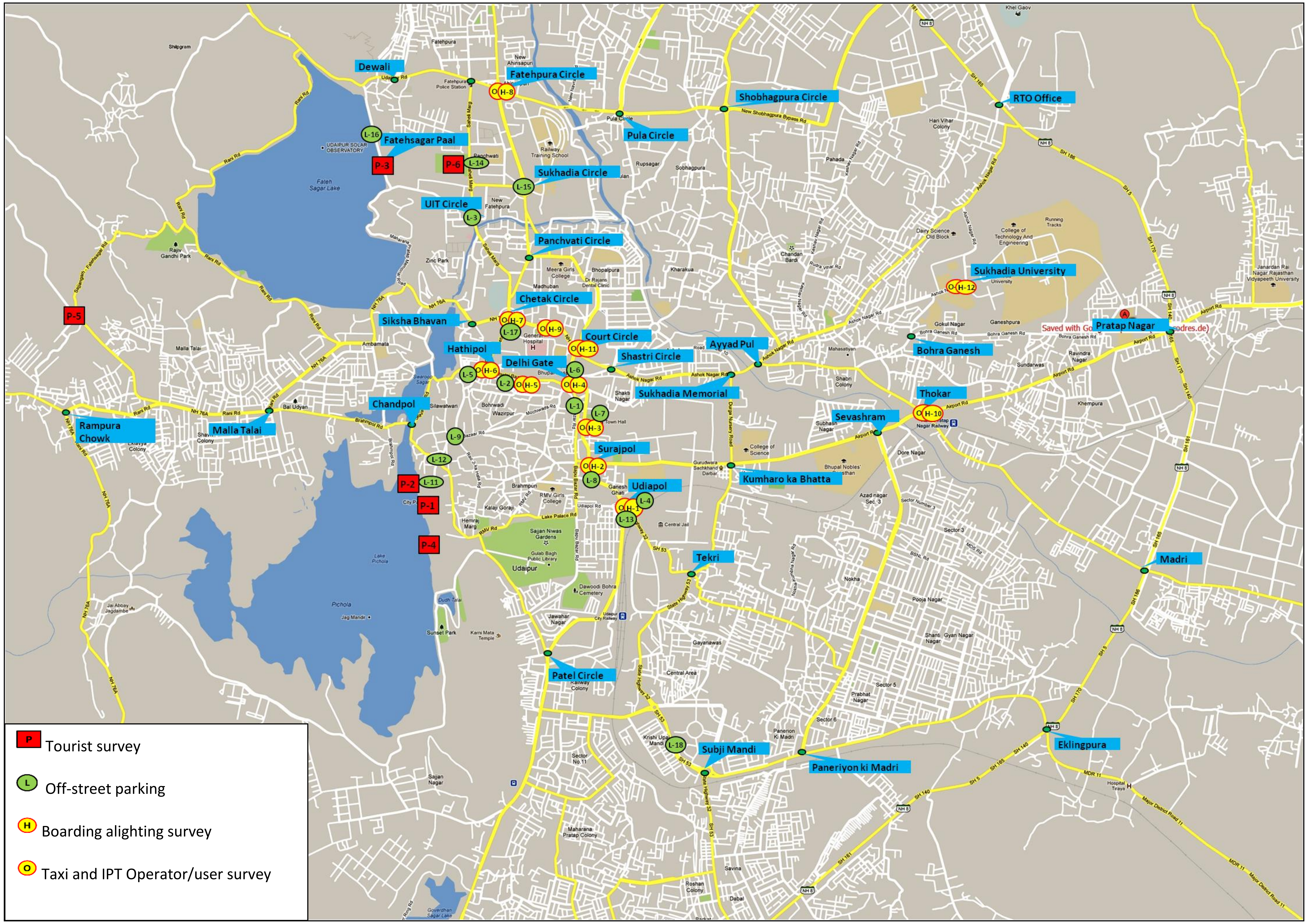

Figure 3-1: Primary traffic surveys (Map 1)

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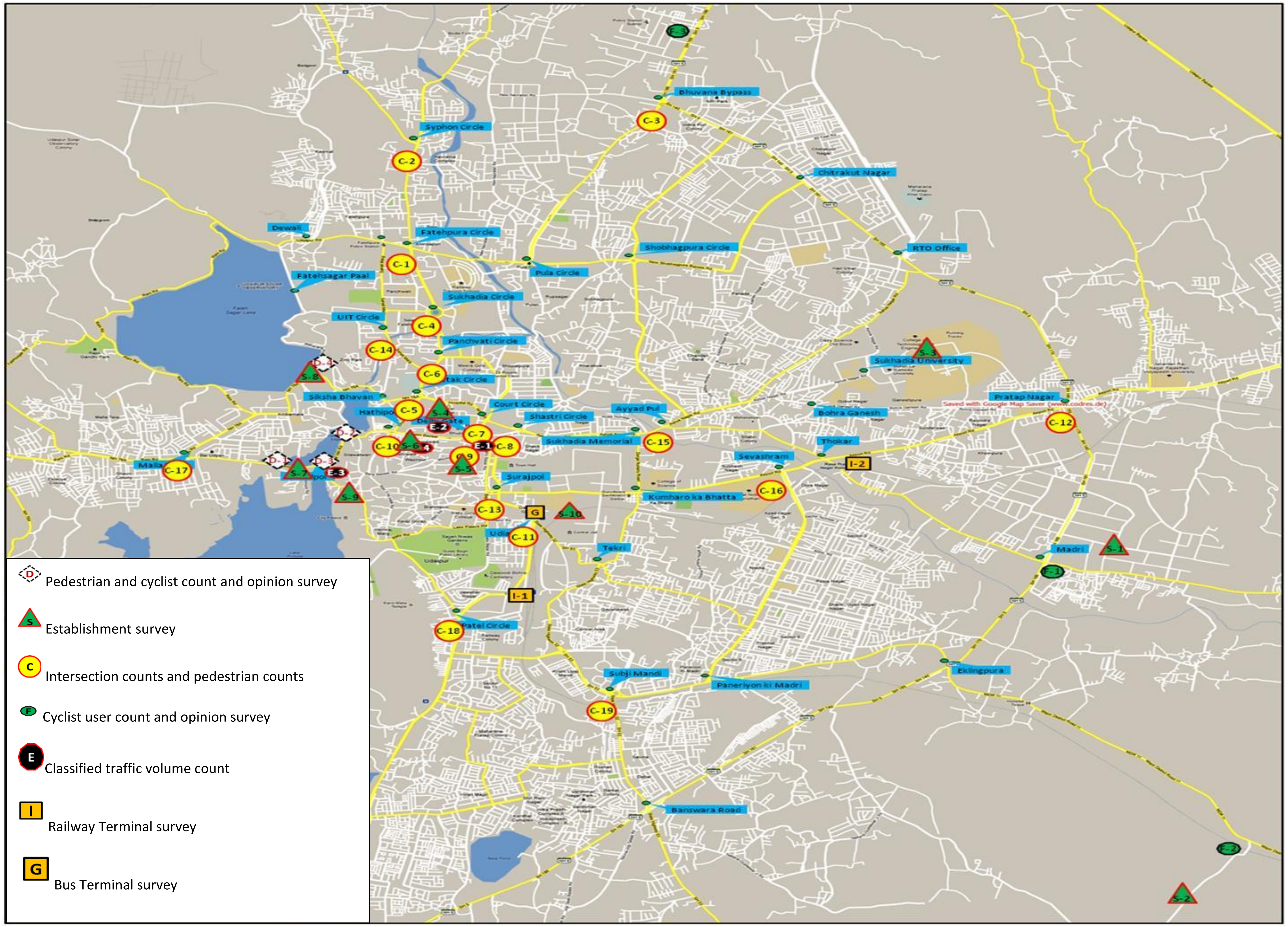

Figure 3-2: Primary traffic surveys (Map 2)

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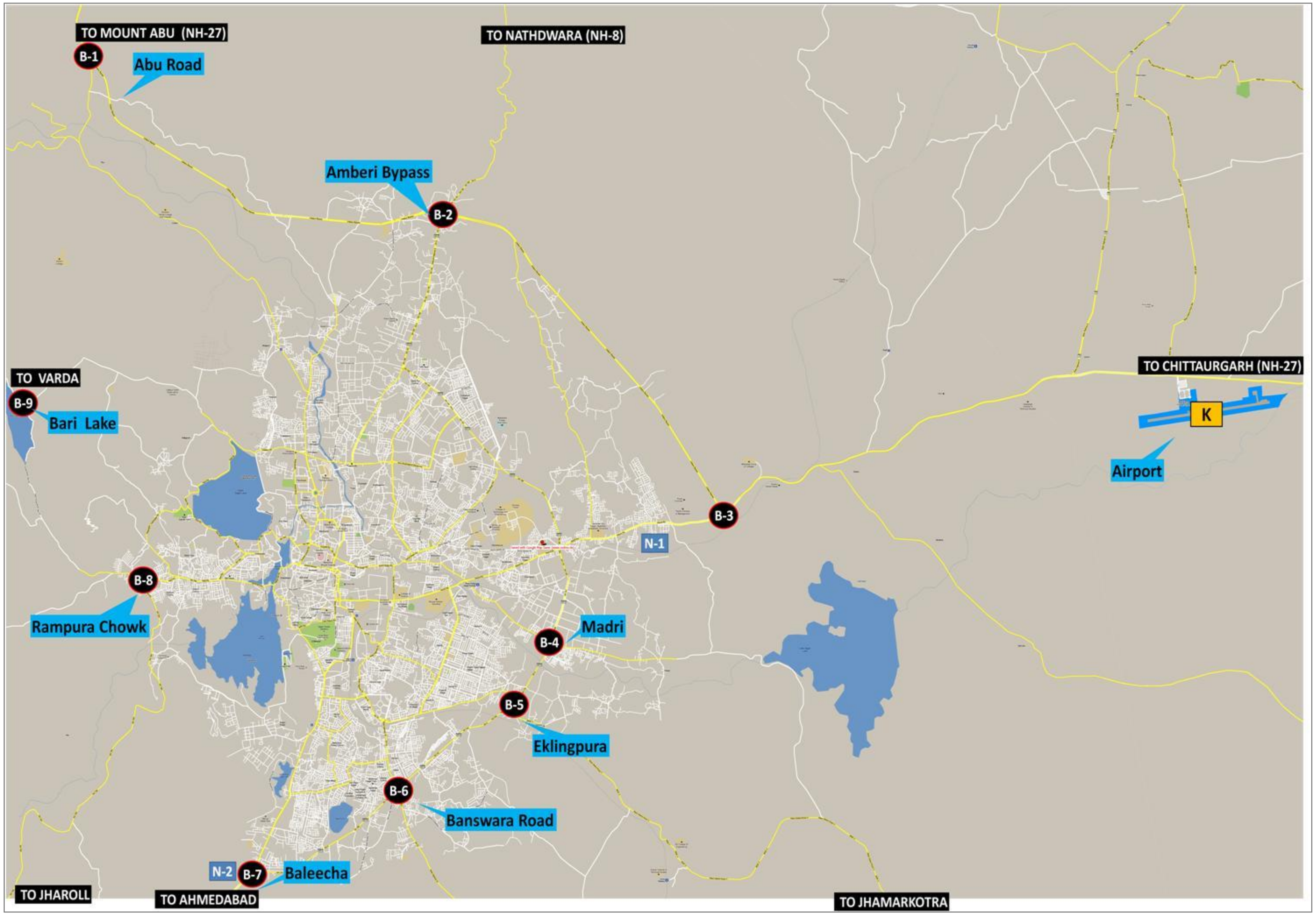

Figure 3-3: Primary traffic surveys (Map 3)

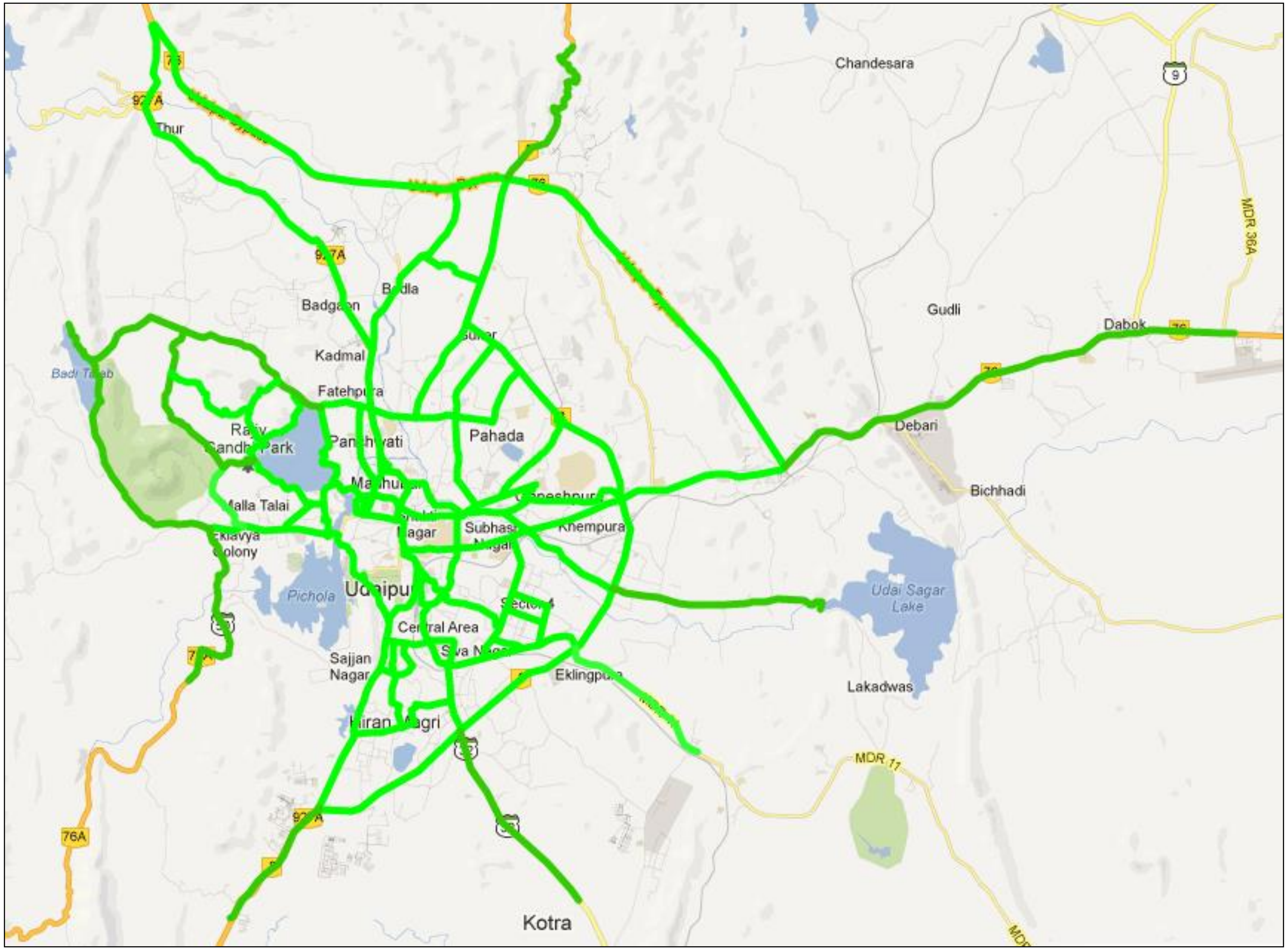

Figure 3-4: Primary traffic surveys (Map 4 for road network inventory and speed and delay survey)

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3.2 Transport Network Characteristics

3.2.1 Pedestrian facilities

3.2.1.1 Pedestrian characteristics (demand)

Pedestrian volume count surveys were conducted at 19 major intersections and four mid-block locations to assess the pedestrian volume and their vulnerability in terms of conflict with vehicular traffic at intersections/mid-blocks.

a. Pedestrian flow characteristics (intersection locations)

The findings from the pedestrian flow characteristics are presented below in Table 3-1.

Table 3-1: Total pedestrians at intersection locations

Sl. No.	Name of location	Daily pedestrian volume
1	Fatehpura Chauraha	14,077
2	Syphon Chauraha	5,963
3	Bhuwana	9,615
4	Sukhadia Circle	3,772
5	Chetak Circle	22,776
6	Panchawati Circle	7,609
7	Court Chauraha	16,003
8	Shastri Circle	18,530
9	Delhi Gate Chauraha	41,173
10	Hathipol Chauraha	18,035
11	Udiapol Chauraha	40,202
12	Pratapnagar Chauraha	24,494
13	Surajpol Chauraha	53,338
14	UIT Circle	4,601
15	Ayad Puliya	8,855
16	Shewasram Chauraha	17,188
17	Mallah Talai Chauraha	18,576
18	Patel Circle	7,783
19	Subji Mandi Chauraha	10,915

Source: Primary Survey 2013

It is observed that the total pedestrian traffic at the major intersections varies from a minimum of 4,601 at UIT Circle to a maximum of 53,338 at Surajpol Chauraha, followed by Delhi Gate Chauraha and Udiapol Chauraha.

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b. Pedestrian flow characteristics (mid-block locations)

An average of 2,600 pedestrians is observed at the surveyed locations, with a maximum at Nayapulia.

Table 3-2: Total pedestrians at mid-block locations

Sl. No.	Name of location	Daily pedestrian volume
1	Ambapol	2,696
2	Nayapulia	2,774
3	Chandpol	2,630
4	Bombiya Market	2,582

Source: Primary Survey 2013

3.2.1.2 Pedestrian and vehicular traffic conflict measured by PV^2

The Table 3-3 shows the calculations for $PV^2/(2*10^8)$ at 19 major locations. It was observed that of the 19 locations, 16 locations had $PV^2/(2*10^8)$ values higher than 1, which indicates a considerable need to improve the pedestrian crossing facilities.

Table 3-3: PV^2 values at some of the important intersections[2]

Sl. No.	Name of location	$PV^2/(2*10^8)$
1	Fatehpura Chauraha	9
2	Syphon Chauraha	4.7
3	Bhuwana	1.87
4	Sukhadia Circle	0.4
5	Chetak Circle	6.5
6	Panchawati Circle	0.77
7	Court Chauraha	3.1
8	Shastri Circle	9

[2] The degree of conflict between pedestrians and vehicles is determined by PV^2, where V is the two-way total hourly flow of vehicles and P is the two-way total hourly flow of pedestrians crossing the road within 50 m on either side of the site during peak hours. If the value of PV^2 exceeds 10^8 (or $1 = PV^2/10^8$) for an undivided road, or 2×10^8 (or $2 = PV^2/10^8$) for a divided road, then there is requirement for a pedestrian crossing facility.

Sl. No.	Name of location	$PV^2/(2*10^8)$
9	Delhi Gate Chauraha	12
10	Hathipol Chauraha	3.8
11	Udiapol Chauraha	12.2
12	Pratapnagar Chauraha	13.5
13	Surajpol Chauraha	37.1
14	UIT Circle	0.54
15	Ayad Puliya	3.8
16	Shewsram Chauraha	19.4
17	Mallah Talai Chauraha	2.4
18	Patel Circle	2.6
19	Subji Mandi Chauraha	1.4

Source: Primary Survey 2013

3.2.1.3 Pedestrian infrastructure (supply)

As observed in the previous chapter, in Udaipur there exists a high volume of pedestrian movement; however, the city lacks in terms of pedestrian infrastructure such as footpaths, etc.

a. Footpath

Only 4 per cent of the road network has footpaths, while 96 per cent is devoid of the same, as indicated in Figure 3-5.

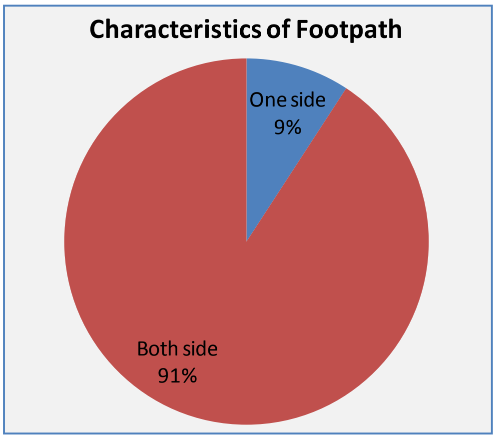

Figure 3-6: Characteristics of footpath

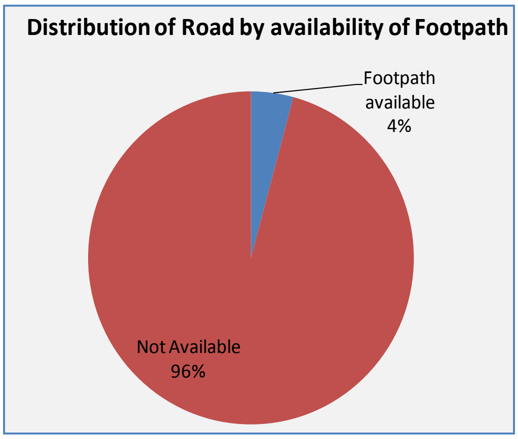

Figure 3-5: Distribution of road by availability of footpaths

3.2.2 Infrastructure quality for bicycles

3.2.2.1 Cyclist characteristics (demand)

Cyclist volume count surveys were conducted at four major locations in and around the walled city, and at three major industrial areas.

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a. *Cyclist volume count at mid-block locations (in and around the walled city)*

The findings from the cyclist volume count at the mid-block locations are presented below in Figure 3-7.

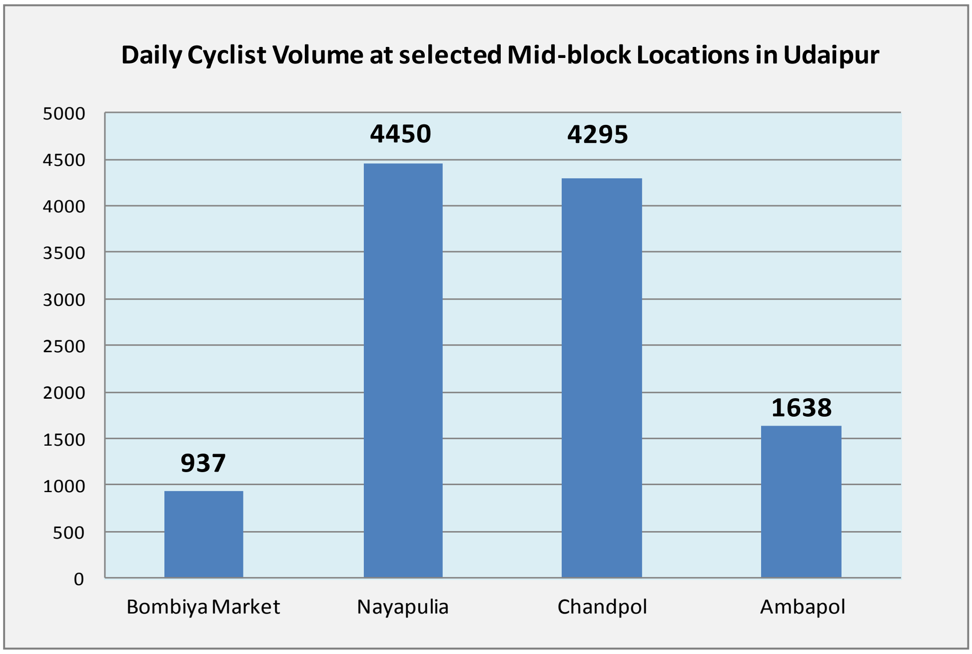

Figure 3-7: Daily cyclist volume at mid-block locations in Udaipur (in and around the walled city)

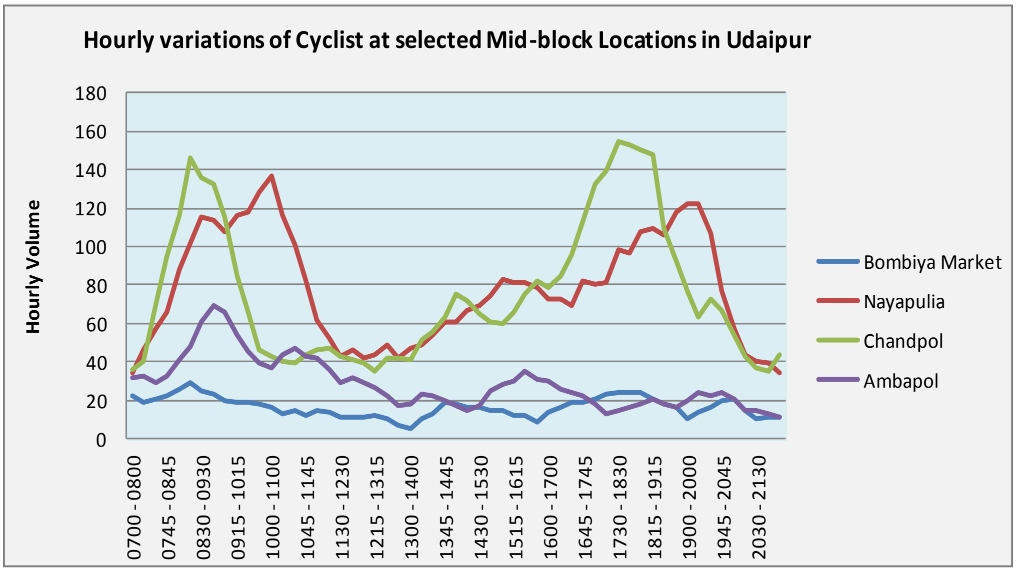

Figure 3-8: Hourly variation in the cyclist volume at mid-block locations in Udaipur (in and around the walled city)

It was observed that the maximum of 4,450 cyclists were observed at Nayapuliya, followed by 4,295 at Chandpol. Hourly variation data shows that on average, 6 per cent is the peak hour share. Nayapulia and Chandpol have distinctive morning and evening peaks, while Ambapol and Bombiya Market have morning peaks.

b. Cyclist volume count at mid-block locations (industrial area)

The findings from the cyclist volume count at the mid-block locations are presented below in Figure 3-9.

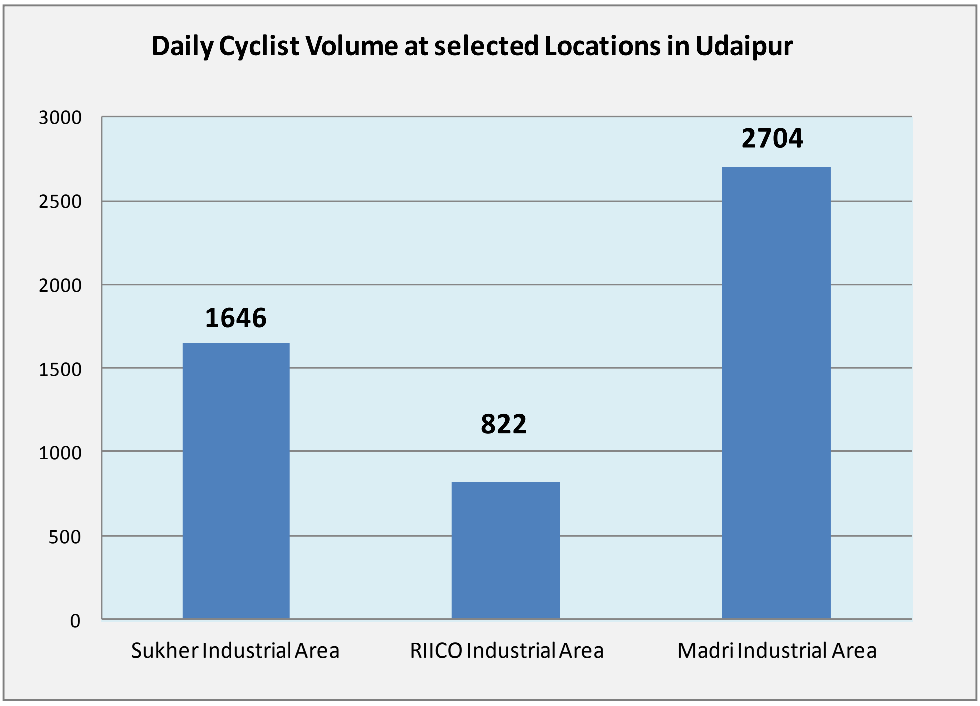

Figure 3-9: Daily cyclist volume at selected locations in Udaipur

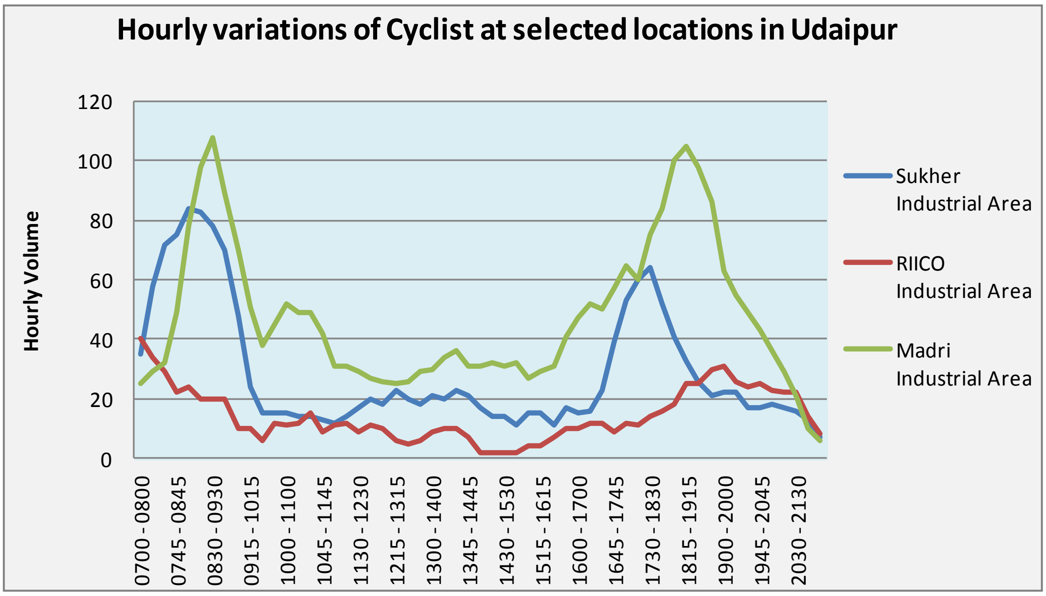

Figure 3-10: Hourly variation in cyclist volume at mid-block locations in Udaipur

A maximum of 2,704 cyclists were observed at Madri Industrial Area, and the smallest number were observed at RIICO Industrial Area.

3.2.2.2 Infrastructure for bicyclists (supply)

The city of Udaipur is completely devoid of bicycle-friendly facilities such as dedicated cycle tracks and parking lots for bicycles.

3.2.3 Public transport – level of service

Public transport in Udaipur is composed of a limited supply of city buses. There is a large supply of tempos and auto rickshaws. Tempos and auto rickshaws belong to the intermediate public transport (IPT) category; however, in Udaipur, they operate under a fixed-route and fixed-fare mechanism, and thus provide a public transport service.

3.2.3.1 City bus service

Public transport in Udaipur includes a limited supply of city bus services, managed by Udaipur City Transport Services Limited (UCTSL), a company formed by Udaipur Municipal Corporation (UMC). Currently, the city bus service is operating along five routes, as shown in the Table 3-4 below.

Table 3-4: Route details of Udaipur

Route No.	Origin	Destination	Route length (km)	Bus stops
1	Amabmata	Badgaon	18	25
2	Rampura	Dabok	14	23
3	Amberi	Balicha	14	22
4	Chetak Circle	Matoon	18	28
5	T.B.Hosp.	Gitanjali Hosp.	25	35

3.2.3.2 Para transit systems

The absence of a robust public transport system in the city has paved the way for intermediate public transport. Despite being permitted, the mini-buses do not operate within the city due to a lack of profitability. Instead, they operate from Udaipur to peripheral towns. People usually rely on auto rickshaws for shared and point-to-point journeys.

At present (as of 31 December 2012) 6,313 auto rickshaws operate in Udaipur city on an area-permit basis, and another 2,637 tempos operate on 27 designated routes.

3.2.3.3 Intercity bus transport

Numerous private buses operate from Udaipur for short and long distance travel. Currently, an authorized private bus terminal does not exist. Therefore, the private buses operate from on-street facilities near Udaipol, Surajpol and Delhi Gate junctions.

The route-wise distribution of RSRTC bus movement from Udaipur is as follows:

- 26 per cent towards Jaipur/Ajmer, along NH-8
- 25 per cent towards Chittorgarh/Kota, along NH-76
- 20 per cent towards Ahmedabad, along NH-8
- 13 per cent towards Mt. Abu
- 11 per cent towards Banswara
- 5 per cent towards Jharol.

3.2.3.4 Air transport

The airport is located 21km away from the city centre and on Chittorgarh Road, near Dabok. The airport provides no direct international connections. Though the city is connected to Jaipur, Delhi and Mumbai, the frequency of flights is low.

Currently, Air India and Jet Airways are serving as domestic air travel service providers. A lack of facilities at the airport, low frequency of flights and lack of international connectivity are the main issues of air transport in Udaipur city.

3.2.3.5 Rail transport

Udaipur has two main railway stations:

- Udaipur City Railway Station
- Rana Pratap Railway Station (Pratap Nagar).

3.2.3.6 Road transport

Udaipur is well connected by roads with the rest of the country: it is located along NH8 (Delhi-Mumbai) and NH76 along Chittorgarh, Dungerpur, and Banswara State Highways. Regional bus services are being operated by Rajasthan State Road Transport Corporation (RSRTC) and private operators to most of the neighbouring cities.

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3.2.4 Infrastructure quality for private motorized vehicles

3.2.4.1 Road characteristics

Udaipur has a ring radial road network pattern, which is expanding along its radials. A recent trend of rapid urbanization has led to an increase in vehicles, thus exceeding the capacity of the city's road network. The total road network in Udaipur is approximately 822km. It can be categorized in accordance with the following classifications:

- **Arterial roads**: Udaipur has 11 arterial roads covering 84.17 km. Most arterials form regional linkages to neighbouring major cities and towns
- **Sub-arterial roads:** The 26 sub-arterial roads connect the major residential areas to commercial and other areas of the city. Most sub-arterials are undivided, except for a few that connect major junctions.

3.2.4.2 Road area jurisdiction

The Public Works Department (PWD), Municipal Corporation of Udaipur, and Urban Improvement Trust are the main agencies responsible for the design, implementation and supervision of roads, bridges and other traffic engineering works. At present, a road length of 116.60km is maintained and managed by PWD. UIT and the Municipality have about 700km of road network under their jurisdiction.

3.2.4.3 Rotary intersection

The major rotary intersections of Udaipur are as follows:

1	Nimachmata	18	Udiyapol
2	Sewa Mandir	19	Sikh Colony Junction
3	Fatehpura	20	Ayurved Junction
4	Syphon	21	Thokar Junction
5	Bhuwana Bypass	22	Sukhadia Samadhi Junction
6	Sukhadia Circle	23	Anand Plaza Junction
7	Chetak Circle	24	Pratap Nagar
8	Lokkala Mandal	25	Bohara Ganeshji
9	Panchavati	26	Sector 4 & 5
10	UIT	27	Madri Purohitan Bypass Junction
11	Meera Girls College	28	Eklingpura Bypass Junction
12	Bhatt Ji ki Baadi	29	Sub City Centre Junction
13	Court Junction	30	Transport Nagar Bypass (Near Panchayat Samiti)
14	Shastri Circle	31	Patel Circle
15	Delhi Gate	32	Rampura Junction
16	Hatipol	33	Community Hall, Sector 14
17	Surajpol	34	Sector 8 (Jhamarkotda)

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3.2.4.4 Signalised intersections

The following is a list of signalized junctions:

1. Surajpol Junction
2. Delhi Gate Junction
3. Udiyapol Junction
4. Chetak Circle
5. Court Junction
6. Paras Cinema Junction
7. Pratapnagar Junction

3.2.4.1 Underpasses

The city has seven underpasses at the following locations:

1. Udaipol
2. RCA Hostel
3. Sikh Colony
4. Sewashram Junction
5. Hiran Magri Sector-11
6. Eklingpura
7. Debari

3.2.4.2 Road network characteristics

The data collected includes section length, cross-sectional details, right-of-way, carriageway width, road surface type, median width, service road width, footpath width, street lighting type/location, and predominant land use along the road network.

a. Length of right-of-way (RoW)

About 3 per cent of the road network has more than 35m right-of-way (ROW), 56 per cent has RoW between 10.1m and 25m, while 18 per cent has RoW of 25m to 35m, as indicated in Figure 3-11.

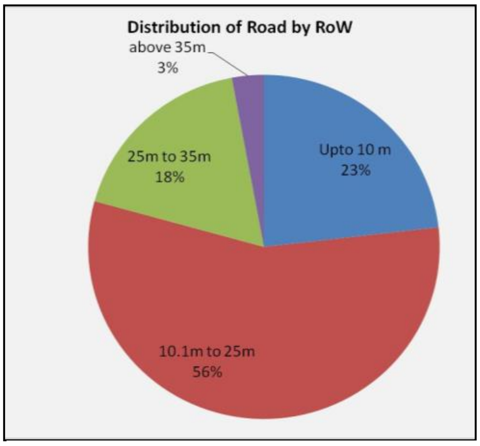

Figure 3-11: Distribution of road by right-of-way

b. Carriageway

Out of the total surveyed 212.20km of road network, 39 per cent of the road length has divided carriageway (C/W), and 61 per cent of the road length has undivided carriageway, as indicated in Figure 3-14. Referring to Figure 3-13, 47 per cent of the road network has carriageway of three to four lanes, 43 per cent has up to two lanes, and 10 per cent of the road network has carriageway of six lanes or more.

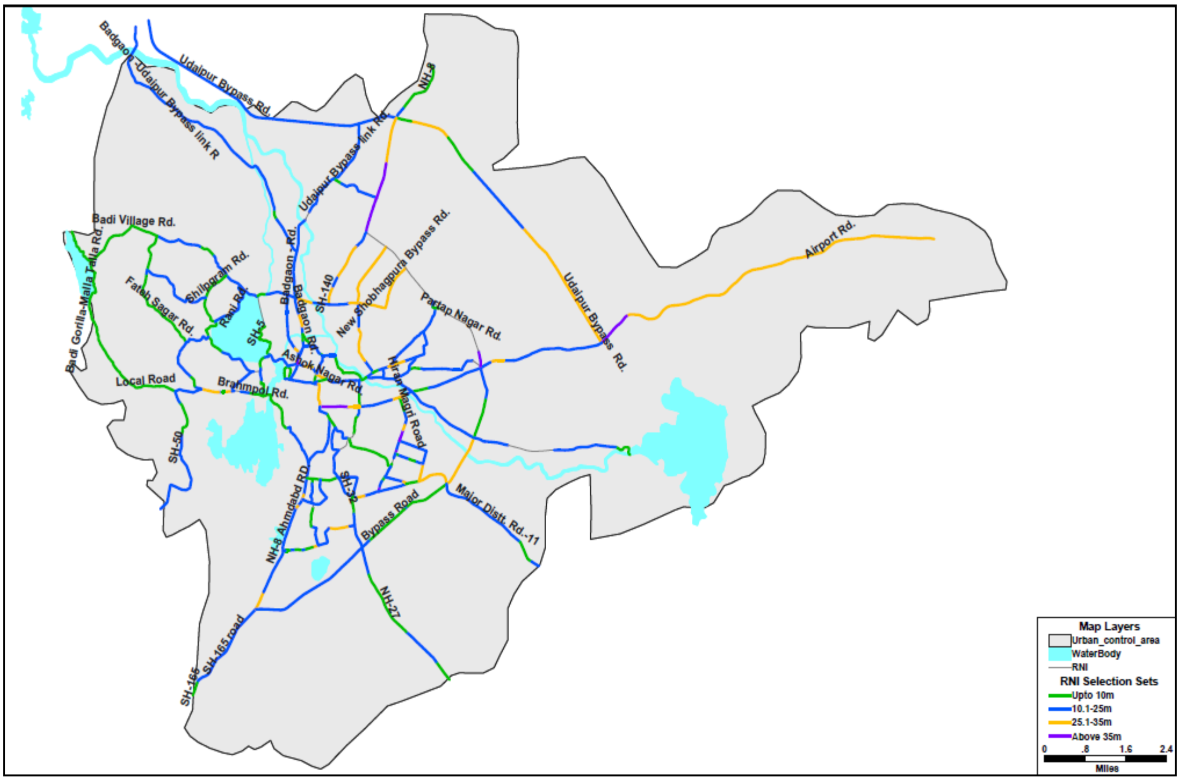

Figure 3-12: Road network by RoW

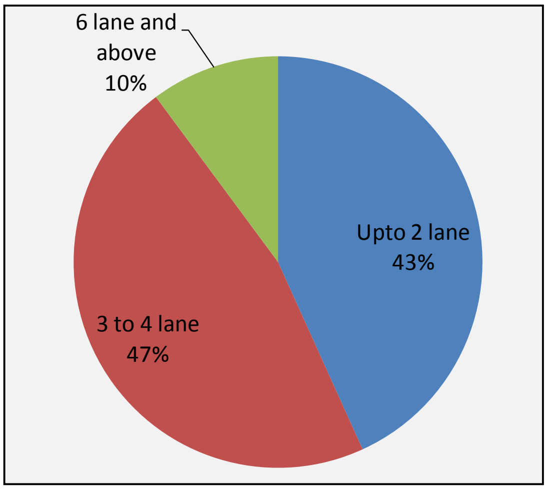

Figure 3-13: Carriageway characteristics

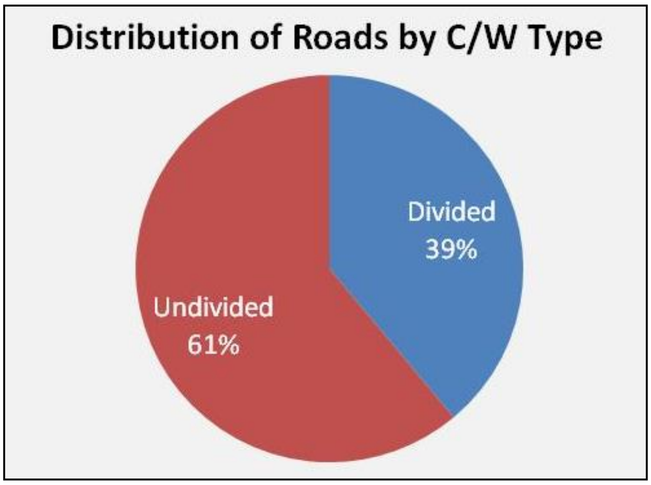

Figure 3-14: Distribution of road by carriageway

c. Street light

Sixty-three per cent of roads in the city do not have any street lighting facility. Only 37 per cent of the road network within the study area has street lighting facility.

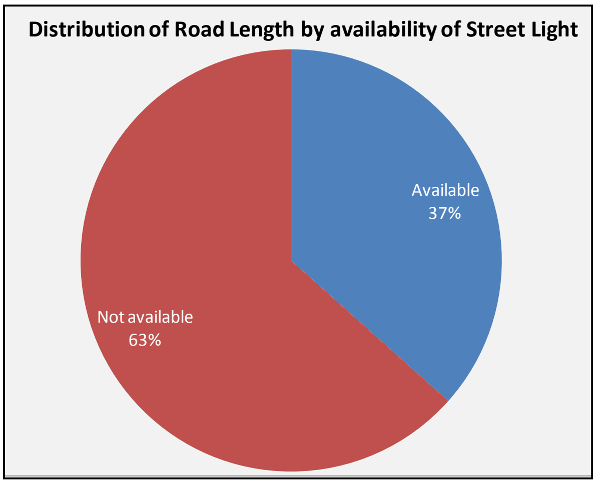

Figure 3-15: Distribution of road length by availability of street light

d. On-street parking

On-street parking exits along 33 per cent of the road network.

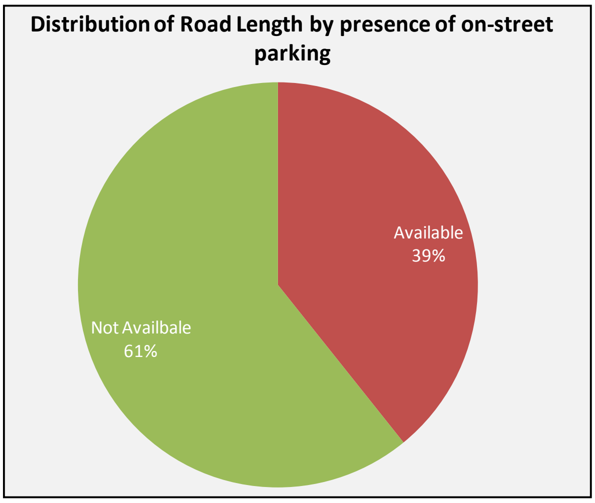

Figure 3-16: Distribution of road length by presence of on-street parking

e. Traffic signages

Only 9 per cent of the road network has traffic signages, while 91 per cent of the road network does not have any signage.

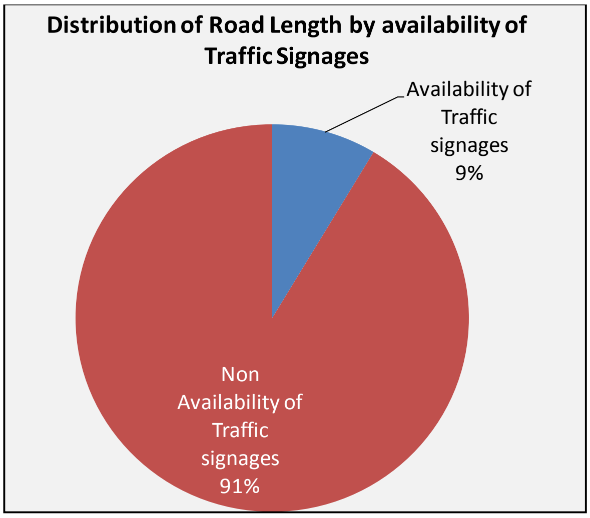

Figure 3-17: Distribution of road length by availability of traffic signages

3.2.4.3 Travel Speed

Travel speed is an important characteristic of traffic. Its measurement is important in transport planning, particularly to evaluate the road network system, provide vital inputs to the transport demand-modelling process, and assist in economic analysis of improvement plans. The speed and delay survey was carried out to assess the journey and running speeds along a complete road network within the study area. These surveys were conducted for bi-directional traffic movement streams during peak (morning and evening) and off-peak hours on a fair weather normal working day.

a. Journey speed

The surveys for the major traffic corridors were undertaken during peak periods. Figure 3-18 represents the journey speed characteristics of the general traffic stream along the surveyed road network.

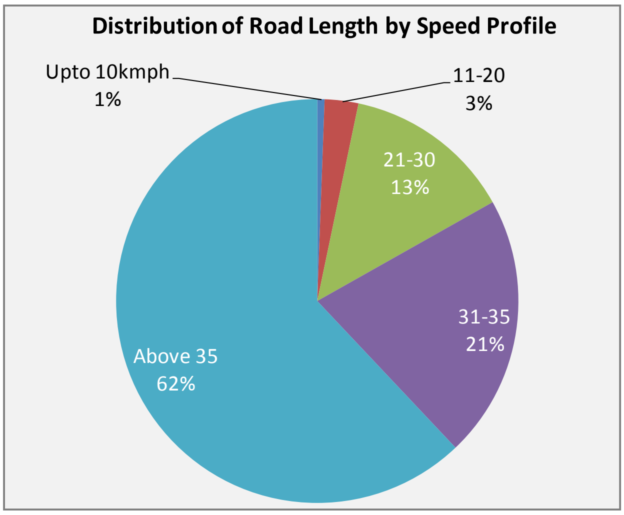

Figure 3-18: Distribution of road length by speed profile

The average journey speed was found to be 38km/h. In bottleneck points such as the old city area, Bapu Bazaar, Ashwani Market, and the area near Pratapnagar, etc., the journey speed is as low as less than 10km/h. It was observed that 4 per cent of the road network had a journey speed of less than 20km/h, 13 per cent was between 21 and 30km/h, 21 per cent was between 31 and 35km/h, while about 62 per cent was more than 35km/h during peak hour.

3.2.4.4 Traffic volume counts

a. Classified traffic volume counts at outer cordon points

The survey was conducted at nine cordon locations. It was observed that the traffic at different locations varies from 259 PCUs at Badi Lake to 44,932 PCUs along NH-8 at Balicha. The daily traffic composition at the outer cordon locations exhibits a predominance of fast-moving passenger traffic, consisting of two-wheelers, cars, jeeps/vans, etc., at all locations. Freight traffic and bus traffic movement varies at different locations.

b. Classified traffic volume counts at mid-blocks

It is observed that the traffic at different locations varies from 2,838 PCUs at Ambapol to 9,495 PCUs at Chandpol. Seventy-two per cent of the traffic observed at mid-block locations was composed of two-wheelers. Thirteen per cent of traffic constituted four-wheelers, including cars, jeeps and taxis. The traffic composition at mid-blocks is shown in Figure 3-19.

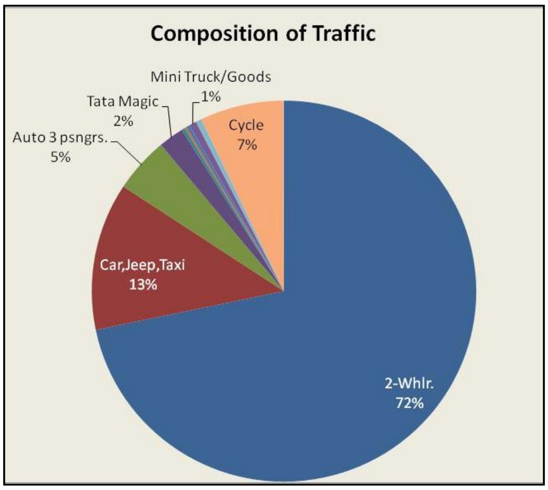

Figure 3-19: Traffic composition at mid-blocks

c. Classified turning movement counts

It is observed that the traffic at different locations varies from 21,501 PCUs at Syphon Circle to 90,528 PCUs at Surajpol. The morning peak hour volume varies from a minimum of 1,673 PCUs at UIT Circle to a maximum of 8,352 PCUs at Surajpol intersection. The evening peak hour volume varies from 1,942 PCUs at Sukhadia Circle to a maximum of 7,577 PCUs at Surajpol.

3.2.4.5 Parking characteristics

The existing parking system of Udaipur is decentralized, unmanaged and largely dysfunctional. A large number of small parking lots dominate the scenario. Haphazard street parking in major markets reduces the traffic carrying capacity of roads.

3.2.4.6 Terminal area characteristics

Truck terminals: The city has three truck terminals; however, they are not completely developed: Goverdhan Vilas Transport Nagar, Chittor Road Octroi Post Transport Nagar, and Automobiles/Truck Stand.

1. Bus stand and bus stops
2. Taxi/Pvt bus stands
3. Auto rickshaw stands
4. Shared auto taxi stands.

The detailed analysis for the traffic volume counts (outer cordon, mid-blocks), turning movement counts, parking survey analysis, and terminal area analysis is mentioned in the Annexure 2.

3.2.5 Energy and emissions

3.2.5.1 Energy consumption

Energy consumption in Udaipur defined in terms of consumption of electricity and consumption of fossil fuel, and is depicted in the table below.

Table 3-5: Energy consumption

Consumption of electricity (million units) in 2011	Consumption of diesel (Kilolitre) in 2011	Consumption of petrol (Kilolitre) in 2011
504	96,957	35,476

Source: Rajasthan Electricity Board, Indian Oil, Bharat Petroleum, Hindustan Petroleum, 2012-13

3.2.5.2 Vehicle population and efficiency

The number of registered vehicles in Udaipur has increased from 160,431 in 2004-05 to 339,594 in 2011-12.

Referring to Figure 3-21, private vehicles, including four-wheelers and two-wheelers, constitute about 90 per cent of the total registered vehicles.

Among these, two-wheelers constitute a majority at 78 per cent of total registered vehicles in Udaipur. Buses constitute only 1 per cent of the total registered vehicles.

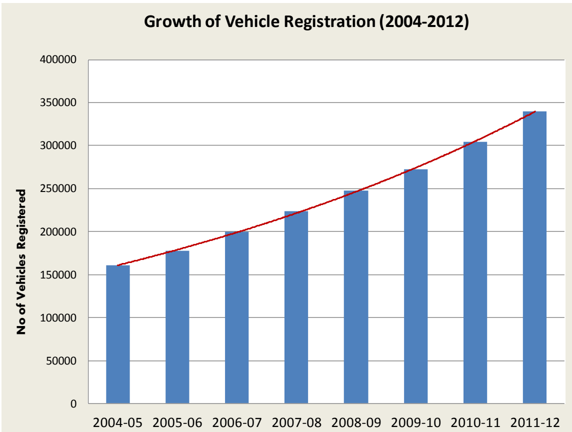

Figure 3-20: Growth of vehicle registration

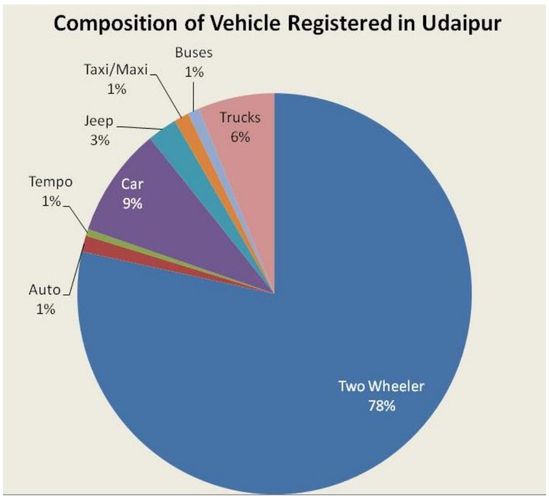

Figure 3-21: Composition of registered vehicles

Among cars, 60.64 per cent use petrol as fuel and 33.07 per cent use diesel, and nearly 6.29 per cent of cars use both LPG and petrol as fuel. All the registered two-wheelers are petrol-driven only, and buses are diesel operated. The type of fuel used by different vehicles is shown in Figure 3-22.

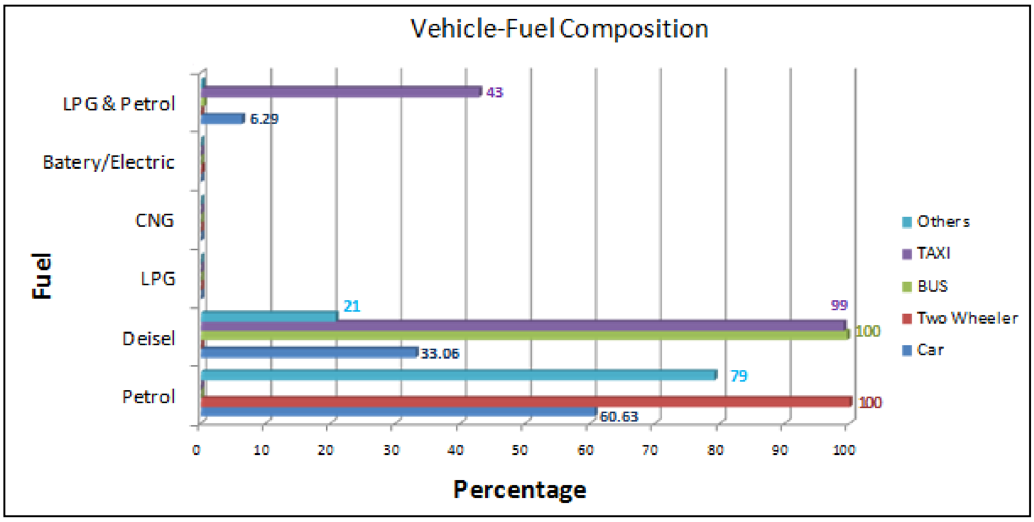

Figure 3-22: Vehicle-fuel composition

Table 3-6: Percentage-wise distribution of old vehicles (10 years or more) by type

Type of vehicle	Percentage-wise distribution of old vehicles
LCV	53.37
Truck	32.18
Bus	43.20
SUV	20.66
Auto rickshaw	40.48
Car	13.53
Two-wheeler	26.15

Referring to Table 3-6, from the survey of vehicles at the filling stations in Udaipur it was observed that on average 33 per cent of total registered vehicles in Udaipur are over 10 years old (old vehicles). In the case of private vehicles, residents of the city use mostly new vehicles; only 13.53 per cent of cars registered in Udaipur can be classified as old, which is lower than the average, similarly for two-wheelers the figure is 26.15 per cent. However, a large number of vehicles composed of mainly goods vehicles, buses and auto rickshaws, are old (10 years or more), which have lower fuel efficiency measured in terms of mileage.

3.2.5.3 Ambient air quality

Ambient air quality is an indicator of the impact of urbanisation on air quality. The emission level in the base year (2013) scenario has been calculated using SIM-air

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modelling, taking annual vehicle kilometres travelled (VKTs) as input. Table 3-7 shows the emission level.

Table 3-7: Base year scenario emission levels

Emission level NO_2 tons annually	Emission level CO_2 mil tons annually	Emission level of PM10 tons annually	Emission level of SO_2 tons annually	Emission level of CO tons annually
10,210	17	4,500	201	397,677

3.3 Travel pattern characteristics

3.3.1 Trip rate

Table 3-8 suggests that women and people belonging to lower income groups have lower trip rates. This lower trip rate for women and LIGs does not mean that these people have lower needs for mobility; on the contrary, the lower trip rate is depicting altogether a different scenario. Referring to the table, the difference between the 'Trip rate with walk mode' and 'Trip rate without walk mode' is comparatively higher in the case of females and LIG groups. In other words, LIGs and females are making more NMT trips, which due to non-availability of affordable modes of transport results in suppressed mobility, indicating the need of pro-poor and gender-friendly transportation infrastructure. (Note: Trip rate counts as one side of a journey. Return and intermediate trips are not counted in the trip rate).

Table 3-8: Trip rates across different income groups and gender (per capita trip)

Income group/gender	Trip rate with walk mode	Trip rate without walk mode	Difference
High income group (HIG)	**1.2**	**0.96**	**20%**
Female	0.75	0.48	36%
Male	1.57	1.34	15%
Medium income group (MIG)	**1.17**	**0.82**	**30%**
Female	0.71	0.34	52%
Male	1.55	1.21	22%
Low income group (LIG)	**0.96**	**0.43**	**55%**
Female	0.61	0.19	69%
Male	1.28	0.65	49%
City average	**1.12**	**0.73**	**35%**

3.3.2 Trip length, travel time, travel cost

The average trip length (ATL) for Udaipur is 5.09 km. The average travel time is observed to be 11.87 minutes, and the average cost of travel is Rs. 10.5. Mode-wise average trip lengths, travel time and travel cost details are given below in Table 3-9.

Table 3-9: Mode-wise ATL, travel time and cost

Mode	Mode-wise ATL (km)	Travel time (min/trip)	Average travel cost (in Rs./per trip)
Walk	2.54	27.72	Nil
Bicycle	5.08	18.66	Nil
Two-wheeler	5.22	9.21	7
Car	5.98	9.51	21.7
IPT	4.47	14.30	7
Bus	8.47	13.65	5
Average	5.09	11.87	10.5

The average trip length for buses is longer as compared to other modes, since these trips are along the NH-76 (Chittorgarh Road) where industrial, educational areas and Udaipur Airport are located. These areas are served by intercity buses operating to and from Udaipur city.

3.3.3 Modal share

In the absence of organized public transport, private vehicles consisting of cars and two-wheelers have a higher modal share. The share of trips in favour of public transport is as low as 2 per cent, while walking is another predominant mode of transport. Eighty per cent of intra-zonal trips, which are made within the neighbourhood with trip lengths varying from a few meters to a maximum of 1500 meters, are walk trips.

Table 3-10: Base year mode shares (all modes)

Mode	Mode shares		
	Total trips	Intra-zonal trips	Inter-zonal trips
Walk	48%	80%	25%
Cycle	2%	2%	3%
Two-wheeler	34%	14%	48%
Car	3%	1%	4%
IPT	11%	3%	18%
Buses	2%	0%	3%

The per capita trip rate of city is 1.12 with walking and 0.73 without walking. The average trip length of the city is 5.09km, while the average travel time is 11.87 minutes and the average travel cost is Rs. 10.5.
Walk trips constitute 48 percent of all trips, and two-wheelers constitute 34 per cent.

3.3.4 Overall demand

Overall demand for transport can be measured in terms of demand for public transport, demand for pedestrian and NMT facilities, demand for parking, etc.

Overall demand for transport can be measured in terms of peak hour peak direction traffic (PHPDT). Based on the survey results, it was found that there exists higher demand or higher movement along the east-west and north-south directions of the city. Airport Road, starting from the Airport to Surajpol via Pratap Nagar, experiences the maximum movement of traffic as this road forms one of the main arterials of the city, and a large number of major industrial, commercial and educational activities take place within proximity of this road.

Figure 3-23 shows the highest traffic movement corridors. Along these two corridors, there exists high demand for public transport. As the city is devoid of a public transport system, it should be developed along all roads which connect major residential areas and activity centres.

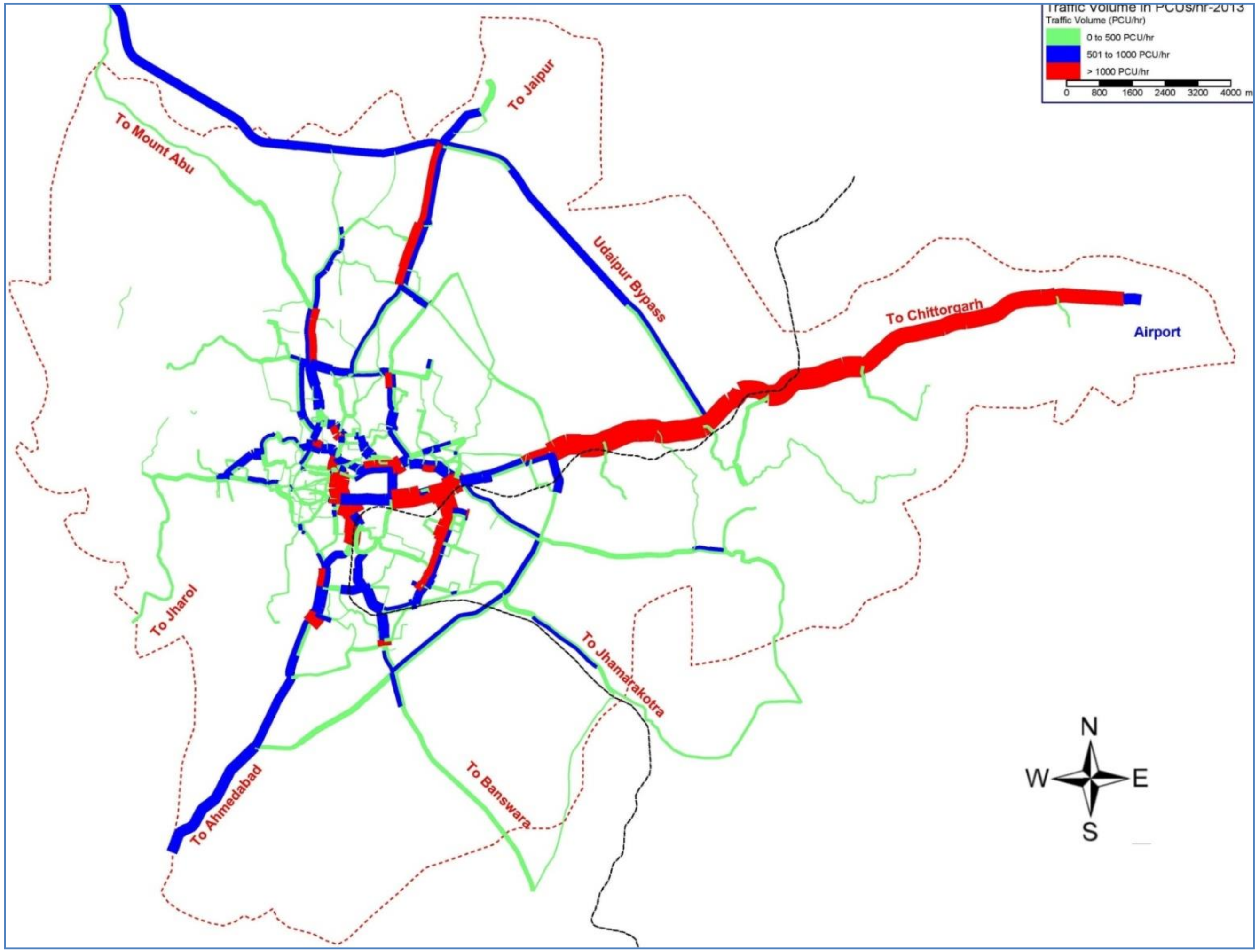

Figure 3-23: High-movement corridors

Demand for NMT facilities:

Referring to Table 3-3, the value of PV^2 is greater than 1 at 16 locations, which means there is a need to develop pedestrian crossing facilities at these locations. Further, only 4 per cent of the road network has footpaths, reflecting the need to develop footpaths for improved, safe and secure pedestrian mobility.

Demand for parking:

On-street parking is a crucial issue in Udaipur. Due to a lack of organization and availability of proper off-street parking facility, on-street parking takes place, which reduces the effective width of carriageway and creates congestion.

3.4 Indicator Analysis

A number of indicators have been calculated to depict the overall mobility characteristics of Udaipur, which are:

Indicator		Value	Conclusion	Detailed data reference
Mobility and accessibility				
Modal shares				
1	Modal shares by trip purpose	Work trips rely heavily on private vehicles, and while walking forms the second most preferred mode, the difference between two preferences is steep, i.e., 56% and 22%. PT, IPT and cycling have a very low share among these trips	It is evident that two-wheelers are the most preferred mode of travel among the working class. However, walking occupies an encouragingly high position in other travel purposes. It needs to be addressed and ascertained whether walking is out of compulsion due to a lack of bicycle and PT facilities or by choice. From the trend of IPT use by students, it seems that those who can afford not to walk choose to do so while others cannot. This can also be re-established by the fact that footpaths are available only on	For details refer to Table 3-11
		Students prefer walking the most (44%) followed by two-wheelers and IPT		
		Their trips rely heavily on walking (56%) followed by two-wheelers (24%)		

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Indicator		Value	Conclusion	Detailed data reference
			4% of the entire road network and the perception of safety during walking is rather low. (Refer Indicators below)	
2	Modal shares by social groups	Walk (LIG – 46%, MIG – 29%, HIG - 21%)	The share of NMT is significantly higher for the low-income groups as compared with the middle and high income groups, and the exact reverse is observed for private vehicles. It must be noted that cars are almost only reserved for the HIG, with even the MIG showing insignificant usage of the same	For details, refer to Table 3-12
		Cycle (LIG – 8%, MIG – 2% and HIG – 1%)		
		Shared Auto (LIG – 12%, MIG – 7%, HIG – 4%)	The buses are used equally by all the groups, however the shared IPT, which is the predominant replacement for PT, is most used by the LIG	
		Bus (LIG – 3%, MIG – 4%, HIG – 4%)		

Indicator		Value	Conclusion	Detailed data reference
		Two-wheeler (LIG – 16%, MIG – 46%, HIG – 39%)	It is evident that low-carbon NMT transport is not a choice but rather a compulsion for the lack of equity and lack of other resources, including PT. This re-enforces the findings from Indicator 1 above	
		Car (LIG – 0%, MIG – 3%, HIG – 27%)		
Travel times				
3	Average travel time by trip purpose	Travel time during peak hours for the purpose of work remains almost the same (20.4) for all income groups	The NMT trips involving walking are lower for all purposes, as compared to other modes. However, this cannot suggest that work, education and other facilities are located close by. It perhaps implies that those users that predominantly use walking as a means of transport to work live closer to their workplace. A similar conclusion can be drawn for students – perhaps	For details, refer to Table 3-15 and Table 3-16

Indicator		Value	Conclusion	Detailed data reference
			people prefer to study in close by education facilities	
			It has been observed that the trip length using bicycles is almost comparable to other modes for all purposes. This suggests there is a section of captive low income group bicycle users who are compelled to use bicycles due to their low purchasing power, and the inadequate supply of environment and poor friendly public transport system	
			There is a need to promote cycling as a preferred mode and provide better facilities for the same	
4	Trip purpose-wise average travel time, disaggregated by social groups		The variation in travel time for various social groups is not stark, indicating that most people live close to their work, education and other facilities	For details, refer to Table 3-15 and Table 3-16

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Indicator		Value	Conclusion	Detailed data reference
			While this can be interpreted as a good outcome, it may on the reverse be suggestive of concentrated residential pockets for different income groups. This will be re-enforced by the land use mix indicators to follow	
Trip length				
5	Average trip length frequency distribution	Average trip length (ATL) for Udaipur is 5.09km		For details, refer to Table 3-17
6	Mode-wise average trip length, by social groups		The higher NMT trip lengths for LIG suggest that last mile connectivity to places inhabited by this group is low by PT or IPT. The same is the reverse for HIG. It could also suggest that most poor people reach home by NMT and the rich take their personal vehicles. Low-carbon transport is therefore not a preferred	For details, refer to Table 3-18

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Indicator		Value	Conclusion	Detailed data reference
			choice for those who can afford faster means	
Affordability				
7	Affordability of PT and para-transit fare by social groups	On average, 1.9% of household income will be spent on travelling if the resident population uses PT/IPT as the mode of transport. The HIG section of society will spend on average 1.42% of their household income on travelling, while, MIG and LIG groups will spend 1.93% and 5.51% of their household income on travelling respectively	The LIG section of society uses NMT as their predominant mode of transport due to their poor purchasing power. Thus, it is necessary to improve the quality of both NMT and public transport so they can afford and use a safe and secure mode of transport	
8	Cost of commuting	The HIG section of society spends on average 10% of their household income on travelling, while MIG and LIG groups spend 26.5% and 0.96% of their household income on travelling respectively	As the LIG population uses NMT as their mode of transport, the proportion of their household income spent on travelling is less	
Infrastructure and land use				
9	Average speed on roads, for different modes	The average journey speed observed in Udaipur is 38km/h		Refer to Table 3-20

Indicator		Value	Conclusion	Detailed data reference
10	The percentage of HH within 10 minutes' walk for PT/para-transit	69%	This suggests that one-third of the population does not have convenient access to transit facilities. It seems that the paucity of PT facilities may be the major reason for this	
11	Average number of interchanges per PT trip	97% – no interchange, 3% – 1 interchange	This shows that people primarily use a single mode for travel. While in some cases this could show good last-mile connectivity, but as is evident from other indicators and data, this suggests that people of different incomes choose different modes for travel, usually NMT for LIG and private or IPT for MIG and HIG. People's choices suggest that Udaipur lacks a sophisticated and robust PT system, and thus there is no need for interchanges between trips	

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Indicator		Value	Conclusion	Detailed data reference
12	Accessibility of disadvantaged groups by different modes	Not available		
Land use				
13	Land use mix intensity	Although the total area under residential land use is about 48%, only 1% of the total area of the city has only residential land use, and the remaining areas have mixed land use. Mixed land use is conducive for shorter trip lengths	The revenue villages have lower population density, and agricultural activity is the predominant land use	Refer to Figure 3-24 and Figure 3-25
14	Income level heterogeneity	13% of the total population belongs to HIG, 61% to MIG and the remaining 27% belong to LIG		For details, refer to Annexure 2 for the income level distribution in each zone
15	Density of roads, junctions, PT stops	The average kernel density is 8.75 per km		Refer to Figure 3-26
Safety				
16	Risk exposure mode-wise	Refer Table 3-19	Cars are involved in the highest number of fatal accidents	
17	Risk imposed by modes	Refer Table 3-19		

Indicator		Value	Conclusion	Detailed data reference
18	Overall safety			
19	Speed limit restrictions	Not available		
20	Quality of footpath infrastructure	4% of roads have footpaths, out of which less than 1% of footpaths have width ≥ 2m	Provision of footpaths should be considered an immediate priority to improve pedestrian facilities across the city	
Security				
21	Percentage of road that is lighted	37%	Lighting across the rest of the streets should be an immediate priority in order to enhance the safety of NMT users and reduce accidents on roads	
22	Percentage of footpaths lighted	Separate lighting facility is not available for footpath	No additional light for footpaths is available except the light from the road. Footpaths, along with better lighting, are a must to increase a feeling of security for encouraging walking, which is currently not perceived as very safe	

Indicator		Value	Conclusion	Detailed data reference
23	Percentage of people feeling safe to walk/cycle and use PT	The results from the household survey point to the fact that walking is presumed to be a very unsafe mode in Udaipur. Both the genders consider walking and cycling as an unsafe mode. In case of public transport, 63% of male population feel using a bus is safe and only 44% female population feel using a bus is safer mode of transportation.	Walking and cycling are considered rather unsafe by both women and men. This is expected due to the lack of footpaths and lighting, as is observed in indicators for infrastructure. However, using buses is considered to be highly safe across the genders This suggests that a combined approach towards providing a good bus-based PT system and adequate pedestrian facilities, including footpaths along with good street lighting, can prove an effective approach towards enhancing low-carbon transport in the city	Refer to Table 3-13
Environmental impacts				
24	Emissions	Base year emission levels		

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Indicator		Value	Conclusion	Detailed data reference
		• Oxides of nitrogen (NOX) level – 10,210 tons annually • SO_2 level – 201 tons annually • CO_2 level – 17 million tons annually • PM10 level – 4,500 tons annually • CO level – 397,677 tons annually		
25	Depletion of land resources	Not available		
26	Health hazards	Not available		
Economic				
27	Investment			
Cost borne by operators				
28	Tax burden – mode-wise	Not available		
29	Other charges levied	Not available		
Fare policy				
30	Percentage of subsidies granted		A fare policy does not exist in Udaipur, as there is no robust PT system	
31	Percentage of population owning passes			

3.4.1 Mobility indicators

Table 3-11: Mode-wise and trip purpose-wise distribution of all trips

Mode	Trip purpose		
	Work	Education	Other
Walk	22%	44%	56%
Bicycle	5%	3%	1%
Auto	3%	12%	4%
Taxi	0%	2%	0%
Bus	3%	6%	2%
Shared auto	6%	12%	8%
Two-wheeler	56%	19%	24%
Car	4%	1%	5%
Tempo/mini bus	1%	1%	0%

Table 3-12: Mode-wise and income group-wise distribution of all trips

Mode	High	Medium	Low
Walk	21%	29%	46%
Bicycle	1%	2%	8%
Auto	2%	7%	5%
Taxi	1%	1%	0%
Bus	4%	4%	3%
Shared auto	4%	7%	12%
Two-wheeler	39%	46%	16%
Car	27%	3%	0%
Tempo/mini bus	1%	1%	10%

Table 3-13: Distribution of safety ratings for walking, non-motorized modes and PT/IPT modes

	Gender	Male					Female				
	Rating	1	2	3	4	5	1	2	3	4	5
Mode	**Walk**	55%	19%	9%	9%	8%	53%	22%	8%	10%	7%
	Bicycle	28%	38%	18%	9%	7%	28%	43%	13%	9%	7%
	Bus	2%	4%	6%	25%	63%	1%	4%	6%	45%	44%

A survey to assess the safety of using different modes was conducted using a revealed preference method, wherein people were asked to rate the safety level of using a particular mode. A rating from 1 to 5 was given to rank safety level, 1 being the least safe mode perceived for travelling, and 5 being the safest mode. It was observed (Table 3-13) that irrespective of gender, the majority of people feel unsafe to use walking as a mode of travel.

Table 3-14: Number of interchanges per trip in PT trips

No. of interchanges for PT trips	0	1
% of total PT trips	**97%**	**3%**

Table 3-15: Mode and purpose-wise average travel time (minutes)

Mode	Travel time in minutes		
	Work	Education	Other
Walk	13.2	12.5	14.4
Bicycle	21.9	19.8	23.3
Auto	24.9	20.9	17.9
Taxi	17.0	25.8	30.0
Bus	28.6	28.2	36.0
Shared auto	21.9	22.2	24.0
Two-wheeler	22.2	22.5	21.3
Car	24.4	33.9	31.4
Tempo/mini bus	24.4	29.6	30.0

Table 3-16: Average travel time (minutes) by trip purpose and social groups

Mode	Trip purpose		
	Work	Education	Other
High	20.4	20.5	19.4
Medium	20.4	17.6	17.7
Low	20.3	18.5	19.1

Table 3-17: Average trip length (km) disaggregated by mode and social groups

Mode	Social groups		
	High	Medium	Low
Walk	0.8	1.1	1.6
Bicycle	3.0	3.6	3.7
Auto	2.0	4.5	5.8
Taxi	1.0	3.4	7.6
Bus	8.0	7.9	9.8
Shared auto	4.7	4.1	5.3
Two-wheeler	4.9	5.0	6.6
Car	5.9	5.9	0.0
Tempo/mini bus	0.0	6.8	4.8

Table 3-18: Average trip length (km) by trip purpose and social groups

Mode	Trip purpose		
	Work	Education	Other
High	4.8	4.8	2.6
Medium	4.4	4.4	2.8
Low	4.3	4.3	2.5

Table 3-19: Accident profile

Mode	% accident victims
Walk	48%
Cycle	**2%**
Two-wheeler	34%
Car	**3%**
IPT	11%
Buses	**2%**

Table 3-20: Mode-wise travel speed

Mode	Travel speed (km/h)
Walk	4.3
Cycle	13.1
2W	34.0
Car	37.7
IPT	18.8
Bus	37.2
Average	38.0

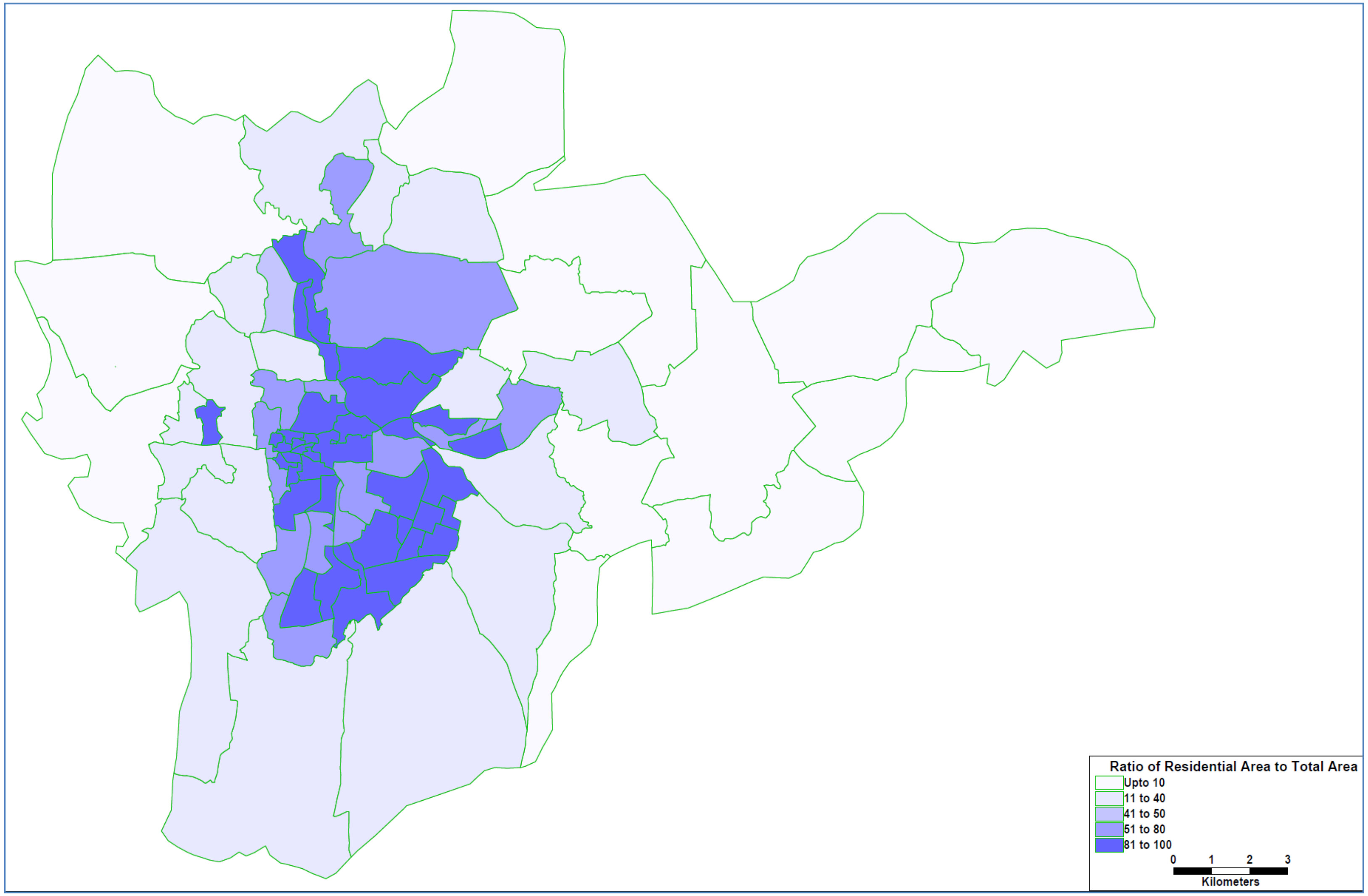

Figure 3-24: Ratio of residential area to total area

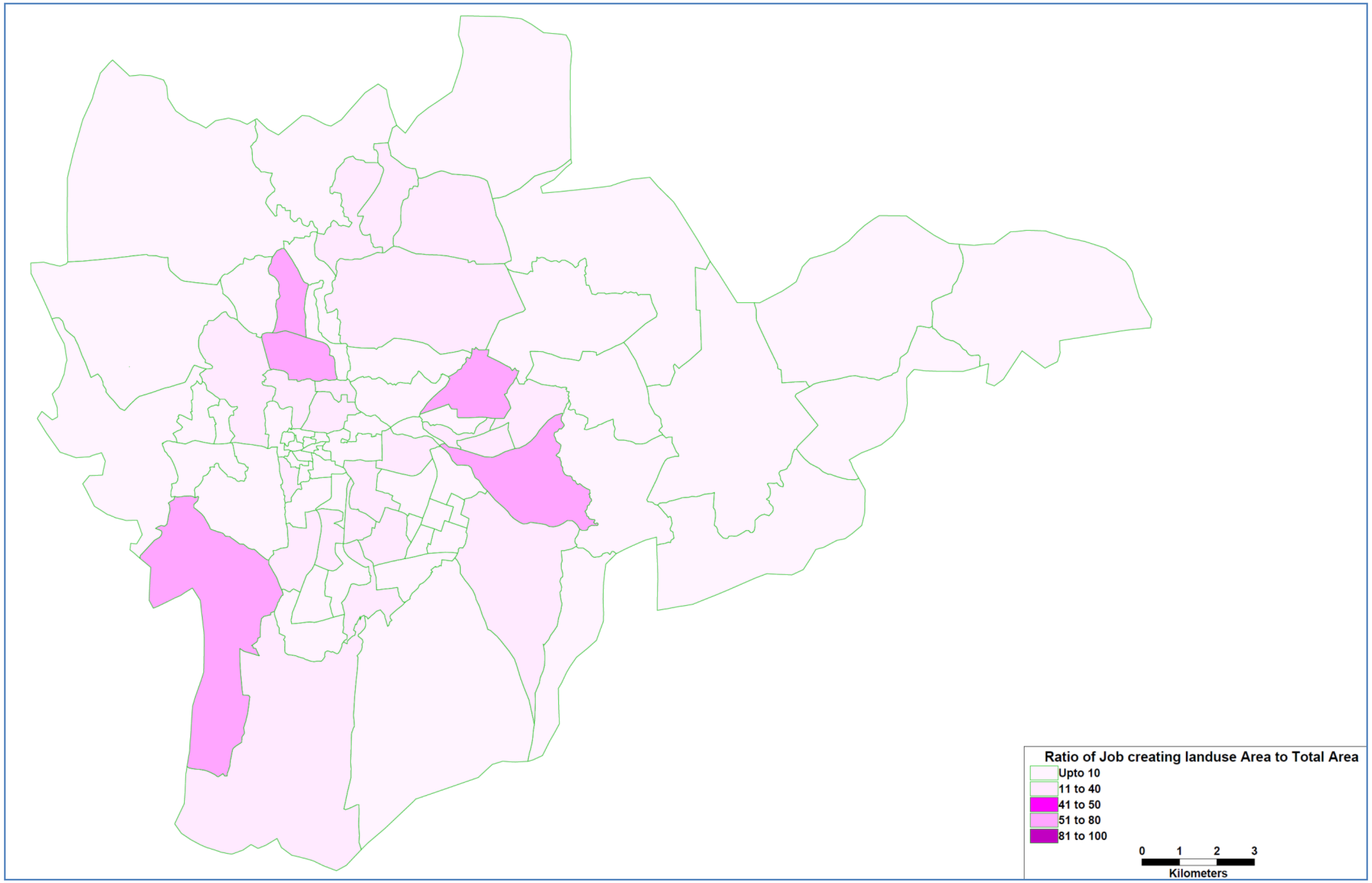

Figure 3-25: Ratio of job-creating land use area to total area

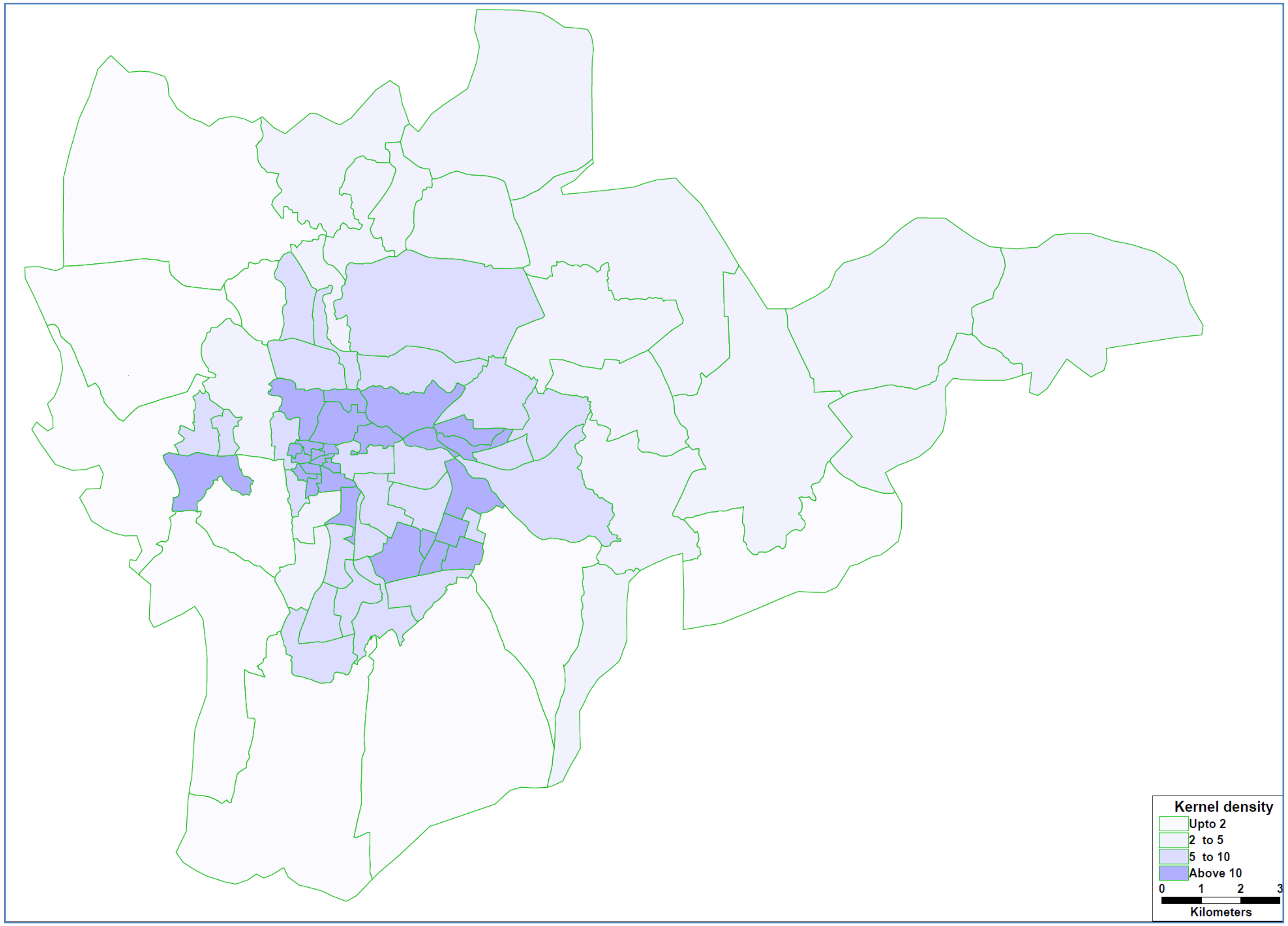

Figure 3-26: Kernel density of road

3.5 Conclusions

Like other medium-sized cities in India, Udaipur inherits a chaotic urban transport scenario, characterized by heterogeneous and yet competitive road space users, resulting in an inefficient use of the public good. Udaipur is completely devoid of an organized public transportation system, and has inadequate transport infrastructure for pedestrians and non-motorized transport users. The following table depicts the traffic and transportation scenario in Udaipur.

Facilities for pedestrians	Although a sizeable trip (48% of the total trips) are by walking, only 4% of the city road network has footpaths, which are present only on the major roads of the city. Footpaths have widths less than 1.5m, making it inconvenient to walk
Facilities for non-motorized vehicles	There are no cycle lanes or other allied infrastructure for encouraging environment-friendly NMV movements
Facilities for public transport	Due to the lack of an organized public transport system, only 2% of total trips are made by public transport, while the promotion of public transport is considered as the most efficient use of road space.
Facilities for IPT	Although sizeable trips (11% of the total trips) are by IPT, there is no dedicated IPT infrastructure such as parking

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Chapter 4. Base Year Travel Demand Model

This chapter details the process undertaken to develop the Base Year 4 Stage Travel Demand Model, the assumptions made, the relationships between various indicators and validation of the modelled results as compared to the observed. This chapter essentially gives an overall picture of the travel pattern of the city and its impacts on the city's road network.

4.1 Introduction

For the purpose of assessing the overall city-level analysis and modelling the future impacts of the options to be tested, as well as extracting the inputs for understanding the air quality analysis, a transport simulation model has been developed. The model broadly consists of two major components:

- **Demand component** – This includes the process of subdividing the city into homogeneous spatial entities called traffic analysis zones (TAZs), and identifying the movement between these zones
- **Supply component** – This includes the transport component, reflecting the availability of roads, railway, etc., and their capacities and regulations. These are required to undertake the movements identified in the demand component.

This section of the report will discuss the process of developing these models, the assumptions made, the indicators and relationships estimated, and the validation results of these modelled results, compared against the observed numbers.

4.2 Transportation Study Process

The transportation study process consists of developing models that enable future travel demand to be forecasted and alternative strategies for handling this demand to be assessed. It is not just one model, but a series of interlinked and interrelated models of varying levels of complexity, dealing with travel demand. Through these models, the transportation study process as a whole is checked and calibrated before it is used for future travel predictions. For Udaipur, this has been done by synthesizing the present day movement patterns and adjusting the same until they represent observed conditions. Only when the formulae have been adjusted or calibrated, so that they can adequately predict the present day travel movements, are they used in true a predictive mode to determine future conditions.

In the present study, an attempt has been made to develop operational models. The normal and easily available planning variables at zonal levels, such as population, employment, number of workers residing, number of students residing and student enrolment have been used in this transport analysis.

4.3 Study Area Zoning

Before embarking on developing the travel demand model, it is necessary to generate the network model representing the road network of Udaipur. It is necessary to divide the city into smaller homogeneous units, referred to as traffic analysis zones (TAZs). The detailed principles of making TAZs are discussed in Chapter 1.

The study area has 80 internal zones and 4 terminal zones. The area outside the Urban Control Area is grouped into 8 external zones.

Figure 4-1 shows the TAZs with zone number for the study area. The zone parameters such as population and number of households for these TAZs are given in Annexure 3.

4.4 Network Development

For the purpose of developing the simulation network of Udaipur, a geographic information system (GIS)-based tool has been used (VISUM 12.5 software). This enables us to represent the detailed network character and behaviour, and present the information in a geographic manner that is easily understandable by the policy makers. The coded highway network for the study area primarily consists of nodes (intersections), and links (roads) connecting the nodes. Connectivity between the network and zones is provided through imaginary centroid connectors. Based on the network inventory, each link has been assigned attributes such as the number of lanes, divided or undivided carriageway, one-way/two-way, encroachments, availability of footpaths, etc. Figure 4-2 shows the base year road network for the study area. The network attributes linked with geographic files have been used to develop the transport model using VISUM 12.5 software.

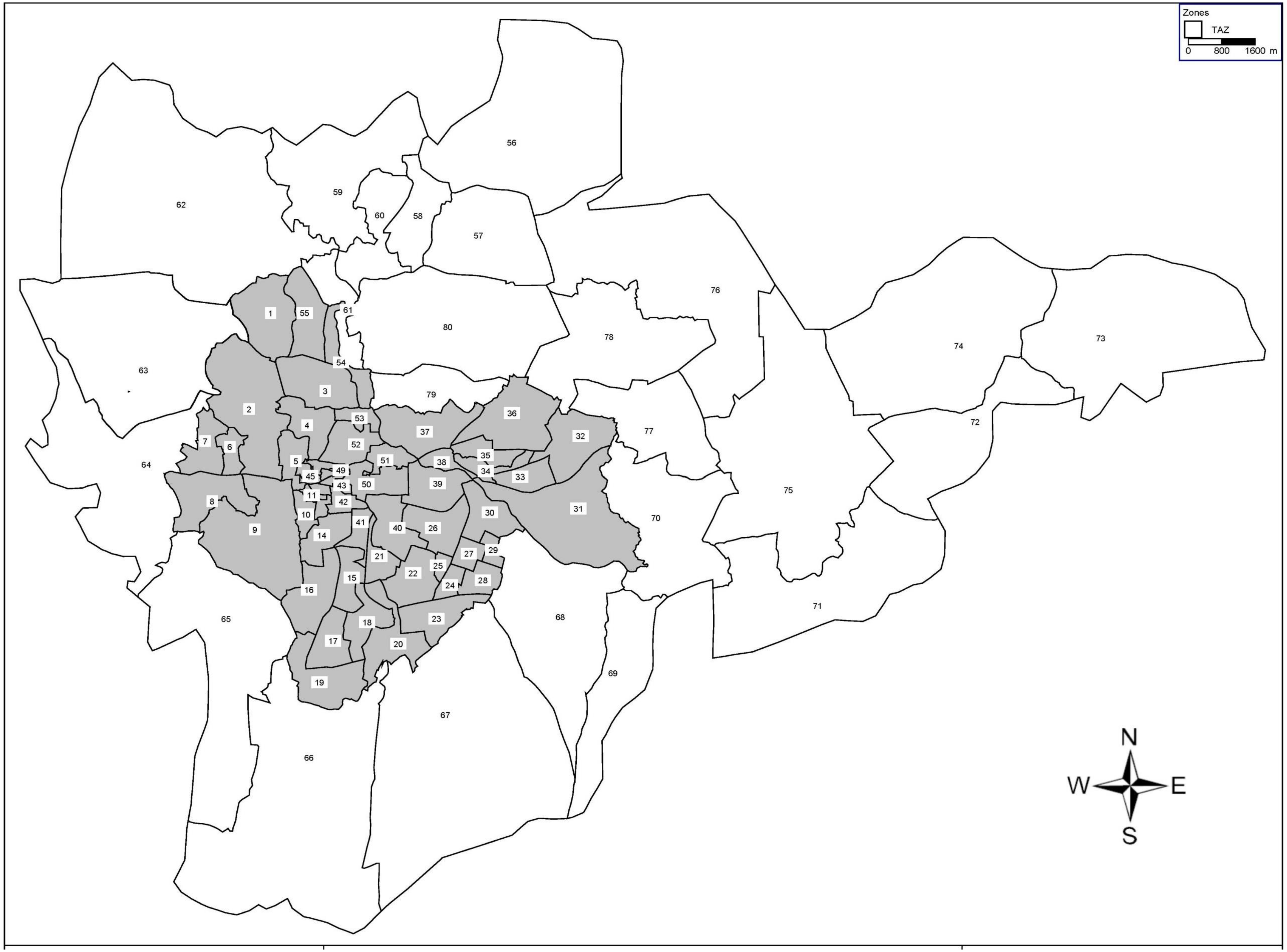

Figure 4-1: TAZs for Udaipur Urban Control Area

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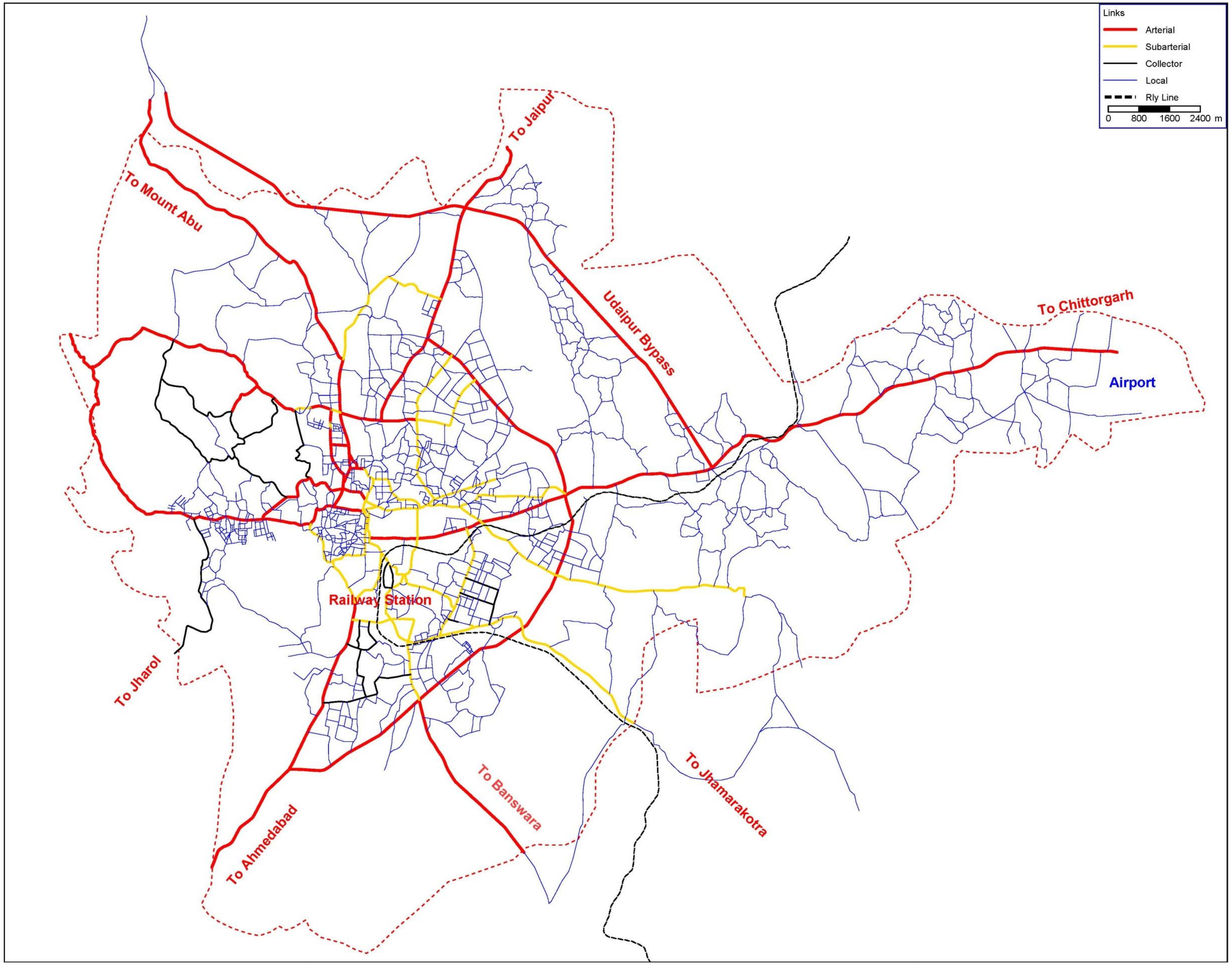

Figure 4-2: Udaipur road network

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4.5 Base Year Travel Pattern

The base year trip matrices have been developed using the data compiled from household surveys, terminal surveys and the roadside interview survey. Mode-wise peak hour matrices were extracted and expanded from these surveys. The corresponding mode-wise matrices were added to get a combined matrix that represents the trip movements for the entire Udaipur control area. Each mode-wise matrix consists of movements between internal zones and internal zones (I-I), internal and external zones (E-I and I-E), and external movements (E-E). From the household survey, it is observed that out of the total one-way trips, 27.39 per cent move in the common peak hour (10:00 to 11:00). These prior matrices thus derived from household, terminal, and outer cordon surveys have been calibrated to the counts observed on links and turns using the TFlow Fuzzy process (a concept explained in Annexure 3) available in VISUM. This process has been explained below. Table 4-1 gives the Geoffrey E. Havers (GEH) statistic value for different modes in Udaipur.

Table 4-1: GEH statistic for Udaipur

Mode	Comparison	GEH < 5%	GEH > 10%
Cycle	Link volumes	82%	1%
	Turn volumes	81%	2%
Two-wheeler	Link volumes	84%	5%
	Turn volumes	80%	5%
Other buses	Link volumes	84%	2%
	Turn volumes	83%	2%
Cars	Link volumes	81%	2%
	Turn volumes	80%	3%
Goods	Link volumes	81%	3%
	Turn volumes	83%	3%
IPT	Boarding	83%	8%
	Alighting	92%	0%

4.6 Model Structure

Using the components discussed above, as well as the socio-economic data collected from Udaipur, a conventional four stage transport demand model has been developed. The broad model structure is shown in the following figure, and each component of this model has been discussed in the subsequent sections. The model structure is based on a conventional four stage transport model approach (refer to Figure 4-3).

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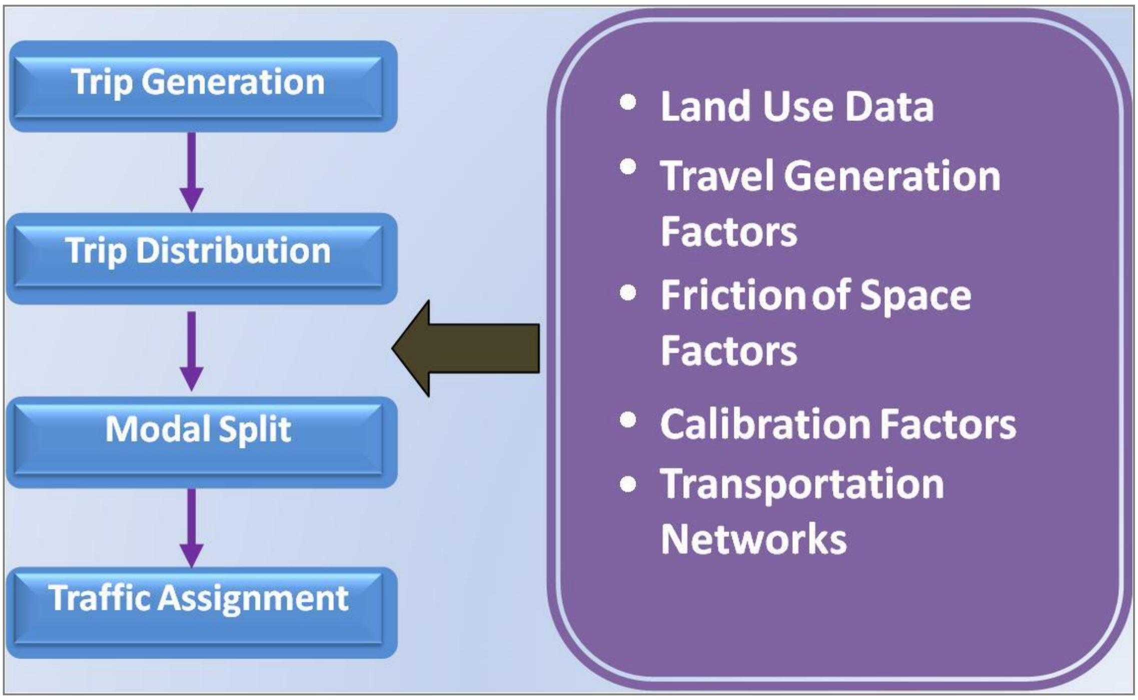

Figure 4-3: Four stage transport model structure

- Trip generation – calculating the number of productions and attractions for each zone
- Trip distribution – distributing these productions and attractions for each origin-destination (OD) pair
- Mode choice – determining the mode for each trip (two-wheeler, car, cycle, IPT)
- Assignment – assigning passengers to their respective highway and transit networks.

The values of various constants and parameters estimated for each step of the base year model are explained in this section. These were checked against the observed values of variables, obtained from the surveys of actual travel patterns. Once satisfactory estimates of the parameters for each stage were obtained, the models were checked to ensure that they adequately performed the functions for which they were intended.

4.6.1 Trip generation calibration and validation

Journeys are out way movements from a point of origin to a point of destination, whereas the word 'trip' denotes an outward and return journey. If either the origin or destination of a trip is the home of the trip maker, then such trips are called home-based trips, and the rest of the trips are called non-home-based trips. Trip production is defined as all the trips of home-based trips, or as the origin of the non-home-based trips. Trips can be classified by trip purpose, trip time of day, and by person type. Trip generation models are found to be accurate if separate models are used based on trip purpose. The trips can be classified based on the purpose of the journey as trips for work, education, shopping, recreation, and other trips.

Among these, the work and education trips are often referred to as mandatory trips, and the rest as discretionary trips. All the above trips are normally home-based trips, and constitute about 80 to 85 per cent of trips. The rest of the trips, namely non–home-based trips, being a small proportion are not normally treated separately.

The first of the sub-models in the conventional four step travel demand modelling process predicts the number of trips starting and finishing in each zone. The developed techniques attempt to utilize the observed relationships between travel characteristics and the urban environment and are based on the assumption that trip making is a function of three basic factors:

1. The land use pattern and development in the study area
2. The socio-economic characteristics of the trip making population of the study area
3. The nature, extent and capabilities of the transportation system in the study area.

Mathematically, trip generation can be expressed as:

Trips generated = Function (socio-economic variables, etc.)

In most of the studies conducted so far, generally the least square regression analysis technique has been used to develop trip generation models. For the purpose of the present study, the regression analysis technique has been adopted for the development of trip generation sub-models for home-based trips for various purposes. Attempts have been made to develop simple equations using normally available variables, which can be forecasted with a reasonable degree of accuracy.

A typical regression analysis trip generation model might be:

$G = a1x1 + a2x2 + \ldots\ldots\ldots\ldots + akxk + a0$

Where G = the number of trips per zone for a specified purpose
a0, a1, a2, ak = coefficients determined by regression analysis
x0, x1, x2, ….., xk = zonal planning input factors (independent variables).

The following independent variables are considered for Trig Generation calibration:

- Population
- Number of cars
- Number of two-wheelers
- Total vehicles
- Zone-wise number of households
- Number of high income group workers residing in the zone
- Number of medium income group workers residing in the zone
- Number of low income group workers residing in the zone

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- Number of high income group students residing in the zone
- Number of medium income group students residing in the zone
- Number of low income group students residing in the zone
- Employment
- Student enrolment
- Number of female workers in the household
- Number of female students
- Number of households per zone
- Vehicle ownership/household.

Various permutations and combinations of the available variables were tested to fit a multiple linear regression equation. However, many variables were ignored due to low R-Squared values, with insignificant t-statistic (t-stat less than 1) and auto correlation errors with other similar variables. For example, the variables ‘Number of high income group workers’ and ‘Number of medium income group workers’, when taken separately, had insignificant t-stats (less than 1). However, after combining, their t-stat was significant (t-stat = 10.14). The following table gives the details of variables tested and their statistical significance.

Table 4-2: Statistical significance of various trip production variables

Variables	Population			Zone-wise number of households	Vehicle ownership per household (number of cars/two-wheelers/total vehicles)
	Number of workers based on income groups (LIG, MIG, HIG)	Number of students (LIG family, MIG family, HIG family)	Number of trips made by females (purpose-wise:-work, education, and other purpose)		
Considered for regression analysis	✓	✓	✓	×	×
Results/ observations	R-square >0.5	R-square >0.5	R-square <0.1	The number of workers and number students form a subset of the number of households	Since income level grouping is done on asset owning criteria (includes vehicle ownership)
	T-stat value – significant	T-stat value – significant	T-stat value – insignificant	Auto correlation error	Auto correlation error
Applied	✓	✓	×	×	×

From the above table, it is observed that the 'Number of trips by females' variable is showing an R-square value of less than 0.1, along with insignificant t-stat. Hence, this variable is ignored. The land use pattern of the zones expressed in terms of student enrolment (with further categorization of income group) and employment are used as variables for the trip attraction regression equation. The R-squared values were observed as over 0.5, and their t-stats were also significant.

The following table shows the description of trip attraction variables under the land use category.

Table 4-3: Trip attraction variables

Variables	Land use	
	Educational/institutional land use	Commercial/industrial land use
	Student enrolment based on income level (LIG, MIG, HIG family) (education attraction trips)	Employment generated (work attraction trips)
Considered for regression analysis	✓	✓
Results/ observations	R-square > 0.5 T-stat value – significant	R-square > 0.5 T-stat value – significant
Applied	✓	✓

From all the variables tested, it was found that only a few variables were statistically significant. The selected trip end models developed for various purposes are presented in Table 4-4.

Table 4-4: Calibrated trip end models

Home-base work productions	R-Square	t-stat
Work productions = 18.94 + 1.5039 * Number of high and medium income group workers residing + 1.486* Number of low income workers residing	0.7	10.14 (HIG and MIG workers) 5.98 (LIG workers)
Home-based work attractions	**R-Square**	**t-stat**
Work attractions = 1207.4 + 0.8869 * Employment	0.76	15.39
Home-based education productions	**R-Square**	**t-stat**
Education productions = 105.06 + 1.1655 * Number of high and medium income group students residing + 1.5273* Number of low income group students residing	0.7	10.14 (HIG and MIG students) 5.98 (LIG students)
Home-based education attractions	**R-Square**	**t-stat**
Education attractions = -172.91 + 1.5926 * Student enrolment	0.9	26.42
Home-based other productions	**R-Square**	**t-stat**

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Other productions = -205.56 + 0.364 * Number of workers residing	0.52	8.31
Home-based other attractions	**R-Square**	**t-stat**
Other attractions = 244.64 + 0.1505 * Employment	0.5	8.21

It was observed from all the models tested that the variables 'Number of high and medium income group workers residing', 'Number of low income group workers residing' are highly significant in estimating one-way work trips produced from a zone. Similarly, the variables 'Number of high and medium income group students residing', 'Number of low income group students residing' are highly significant in estimating one-way education trips produced from a zone. (Comparison of the modelled production-attraction with the observed production-attraction and trip distribution calibration and validation is explained in Annexure 3).

Table 4-5: Modelled average trip lengths

Purpose	Modelled average trip length (km)
Home-based work trips	4.75
Home-based education trips	4.23
Home-based other trips	3.95
Total trips	4.49

4.6.2 Mode choice analysis

The modal split for person trips (all purposes) as observed in the base year (2013) was 50 per cent by non-motorized modes, and 50 per cent by motorized modes. The observed mode split is shown in Table 4-6 and Table 4-7. There is no organized public transport system in Udaipur, however share autos (IPT) operate as an informal public transport system without standard frequencies. The relatively high share of private modes (52 per cent in the case of inter-zonal trips) is not a desirable mode share, as the road space would not be sufficient to hold the increased number of vehicles. Moreover, it would lead to an increase in the overall emission level. The absence of organized public transport coupled with consumers' purchasing power, is leading to an increase in the number of two-wheeler and car users. (Utility theory for mode choice modelling is explained in Annexure 3).

Table 4-6: Base year mode shares (all modes)

Mode	Mode shares		
	Total trips	Intra-zonal trips	Inter-zonal trips
Walk	48%	80%	25%
Cycle	2%	2%	3%
Two-wheeler	34%	14%	48%
Car	3%	1%	4%

Mode	Mode shares		
	Total trips	Intra-zonal trips	Inter-zonal trips
IPT	11%	3%	18%
Other buses	2%	0%	3%

Table 4-7: Base year mode shares (motorized modes)

Mode	Mode shares		
	Total trips	Intra-zonal trips	Inter-zonal trips
Two-wheeler	68%	77%	67%
Car	5%	6%	5%
IPT	23%	15%	24%
Other buses	4%	2%	4%

From the above tables, it is observed that 25 per cent of the trips are performed using walk mode for inter-zonal trips. This share goes to 80 per cent for intra-zonal trips. Hence, NMT infrastructure facilities are required for Udaipur to improve the mode shares of walk and cycle significantly.

4.6.2.1 Multinomial logit model for Udaipur

The revealed preference (RP) data captures observed or reported actual behaviour. On the basis of the household surveys, 3,561 choice set data points for inter-zonal trips were collected. Four separate models were run for respondents who indicated they had no access to any individual vehicle, and for those who indicated that they had access to cycles, two-wheelers, and cars. The results of the calibrated multinomial logit model (MNL) are shown in Table 4-8.

Table 4-8: MNL results from Udaipur households surveys (2013)

MNL results for households with no access to individual vehicles		
Parameter	**Estimate**	**t-stat**
Log (generalized cost)	-2.875635	-8.22
Constant (walk)	-3.167187	8.80
MNL results for households with access to cycles		
Log (generalized cost)	-0.157742	-0.65
Constant (cycle)	-0.117913	-0.27
Constant (walk)	0.185411	0.67
MNL results for households with access to two-wheelers		
Log (generalized cost)	-0.000170	-0.009716
Constant (walk)	0.259138	3.66
Constant (cycle)	-1.918456	-13.22
Constant (two-wheeler)	1.269361	21.45
Constant (other buses)	-1.558235	-13.11
MNL results for households with access to cars		
Log (generalized cost)	-0.049174	-0.82
Constant (walk)	0.520880	2.55

Constant (cycle)	-2.045763	-4.51
Constant (two-wheeler)	1.798944	10.47
Constant (car)	1.115314	6.17
Constant (other buses)	-0.648829	-2.46

The generalized cost for each mode is calculated as follows:

Generalized cost = (Value of time * Travel time) + Travel cost

The following are the assumptions regarding travel cost calculations for each mode.

Table 4-9: Assumptions for travel cost calculation

Mode	Cost	Remarks
Two-wheeler	Rs. 1.875 per km	Cost of petrol = Rs. 75/litre and mileage = 40km/l
Car	Rs. 6.25 per km	Cost of petrol = Rs. 75/litre and mileage = 12km/l
IPT	As per prevailing fare	
Other buses	Rs. 20 per trip flat fare	Based on average school/college fee for buses

Based on the calibrated MNL models, the aggregate modal shares are estimated and the following table gives the comparison of aggregate observed and modelled modals shares.

Table 4-10: Comparison of aggregate inter-zonal modal shares

Mode	Observed mode shares	Modelled mode shares
Walk	25%	25%
Cycle	3%	2%
Two-wheeler	47%	49%
IPT	18%	16%
Car	4%	5%
Other bus	3%	3%

4.6.3 Traffic assignment and analysis

Traffic assignment is the process of allocating a given set of trip interchanges to a specific transportation system, and is generally used to estimate the volume of travel on various links of the system to simulate present conditions.

The process requires as input a complete description of the existing transportation system, and a matrix of inter-zonal trip movements. The output of the process is an estimate of the trips on each link of the transportation system.

The purposes of trip assignment are broadly explained as follows:

- To evaluate the effects of limited improvements and extensions to the existing transportation system by assigning estimated future trips to the network
- To test alternative transportation system proposals with systematic and readily acceptable procedures
- To provide design hour volumes and turning movements.

The corrected peak hour mode-wise demand matrices were assigned onto the supply road network. The volume-to-capacity (V/C) ratios for a few selected corridors are shown in Table 4-11. The V/C ratios close to 0.9 indicate that the operating conditions are close to capacity, which is not desirable. V/C ratios between 0.71 and 0.8 indicate that there is less freedom to manoeuvre and a high density of traffic volume.

Table 4-11: Average V/C ratios on selected corridors for base year

Sl. No.	Road name	V/C ratio
1	RNT Medical College Road	0.78
2	Road opposite Udaipur Bus Terminal	0.67
3	Bapu Bazaar Road	0.70
4	Hiran Mangari Police Station Road	0.88
5	ROB near Geetanjali Medical College (NH8)	0.86
6	Bara Bazaar Road	0.70
7	Silavat Vari Road	0.76

The saturation (V/C) map of Udaipur is shown in Figure 4-4, and the traffic volume is shown in Figure 4-5.

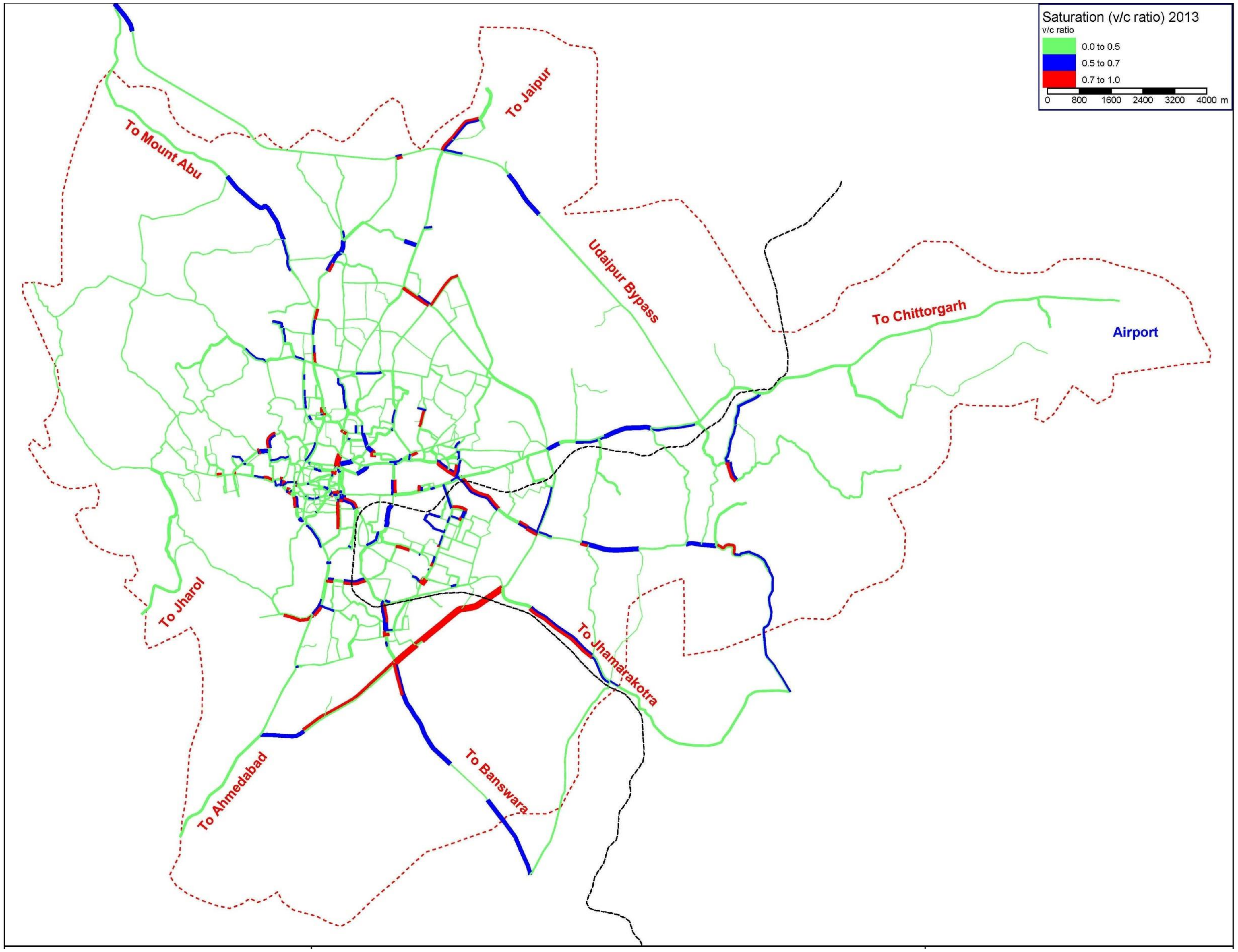

Figure 4-4: Saturation level (V/C) for Udaipur roads (2013)

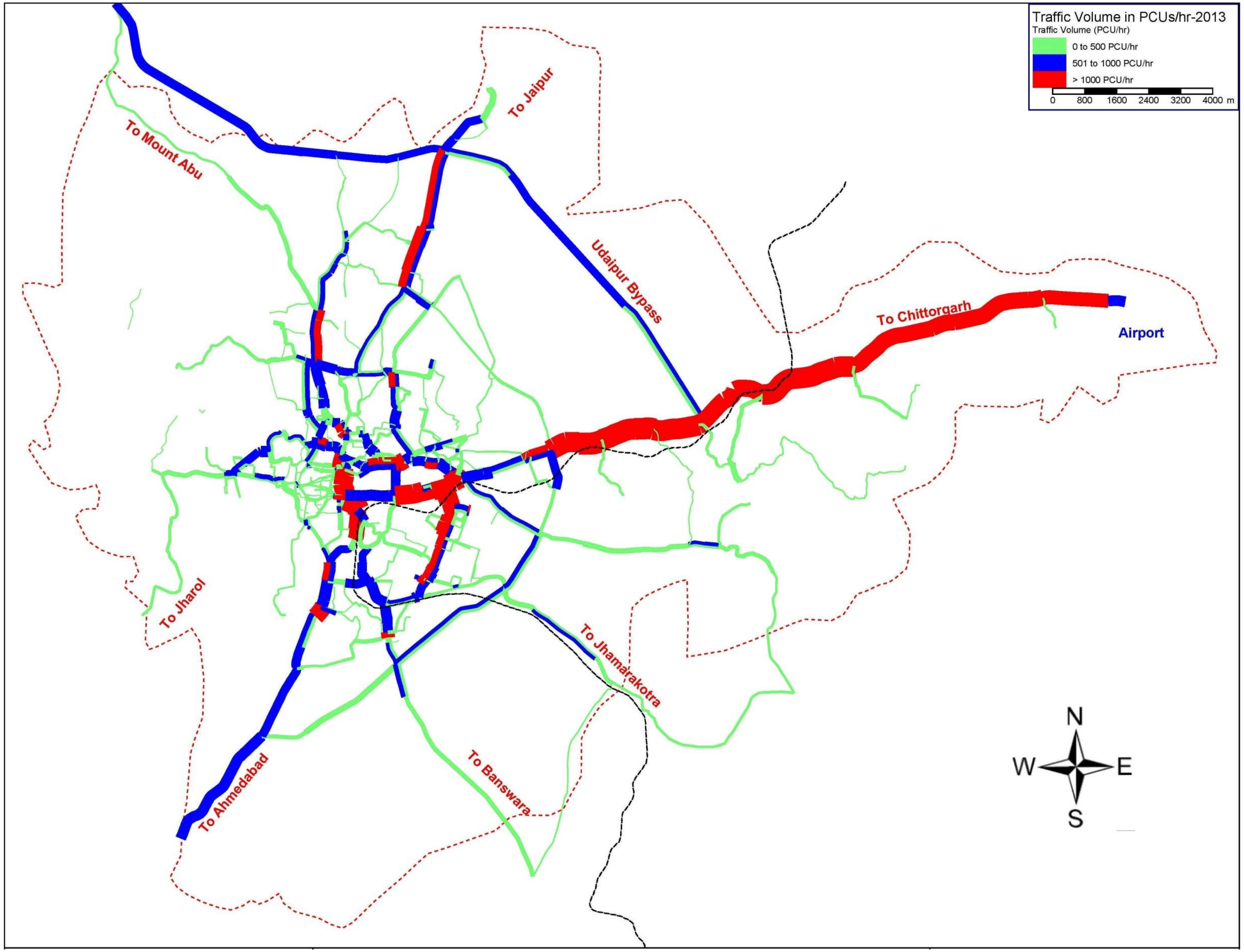

Figure 4-5: Traffic flow map for Udaipur (2013)

From the traffic flow map above, major traffic flow is observed on NH-76 from Pratapnagar to Udaipur Airport. The Bapu Bazaar Road, University Road, and Durga Nursery Road are experiencing heavy traffic during peak hours. The Linematic Road (NH-8) from Sukher to Bhrahmanon ka Gurha also observed high traffic volumes.

NMT trips

The non-motorized modes in Udaipur are walk and cycle. The presence of cycle rickshaws is insignificant. Figure 4-6 shows the TAZ map with daily (one-way) NMT productions for the base year (2013). It is observed that ward numbers 4, 5, 6, 26, 50 and 51 are producing more than 4,000 NMT trips per day. However, ward numbers 2, 21, 28, 58, 76, 77, 78 are producing few NMT trips (< 500 trips per day).

Similarly, Figure 4-7 shows the TAZ map with daily (one-way) NMT attractions for the base year (2013). It is observed that ward numbers 4, 5, 6, 26, 50 and 51 are attracting more than 4,000 NMT trips per day. However, ward numbers 2, 21, 28, 58, 76, 77, 78 are attracting few NMT trips (< 500 trips per day).

Another key analysis during the stage of model development is to understand the key movement corridors and depict this relationship correctly. This shows the major zones that are producing and attracting trips. This will also show how far people are prepared to travel to access certain zones. This is depicted in the form of 'desire lines', where the thickness of lines represents the intensity of trips between different zones. Figure 4-8 shows the desire line diagram of inter-zonal NMT trips. From the modal share analysis, it is evident that 11 per cent of the total daily trips are NMT trips. It is observed that most of the NMT trip interchanges are performed from ward number 50, where many educational institutes are available. The zones along Pichola and Fateh Sagar lakes produce and attract many NMT trips. NMT infrastructure along these lakes is desirable to improve the NMT trips share significantly.

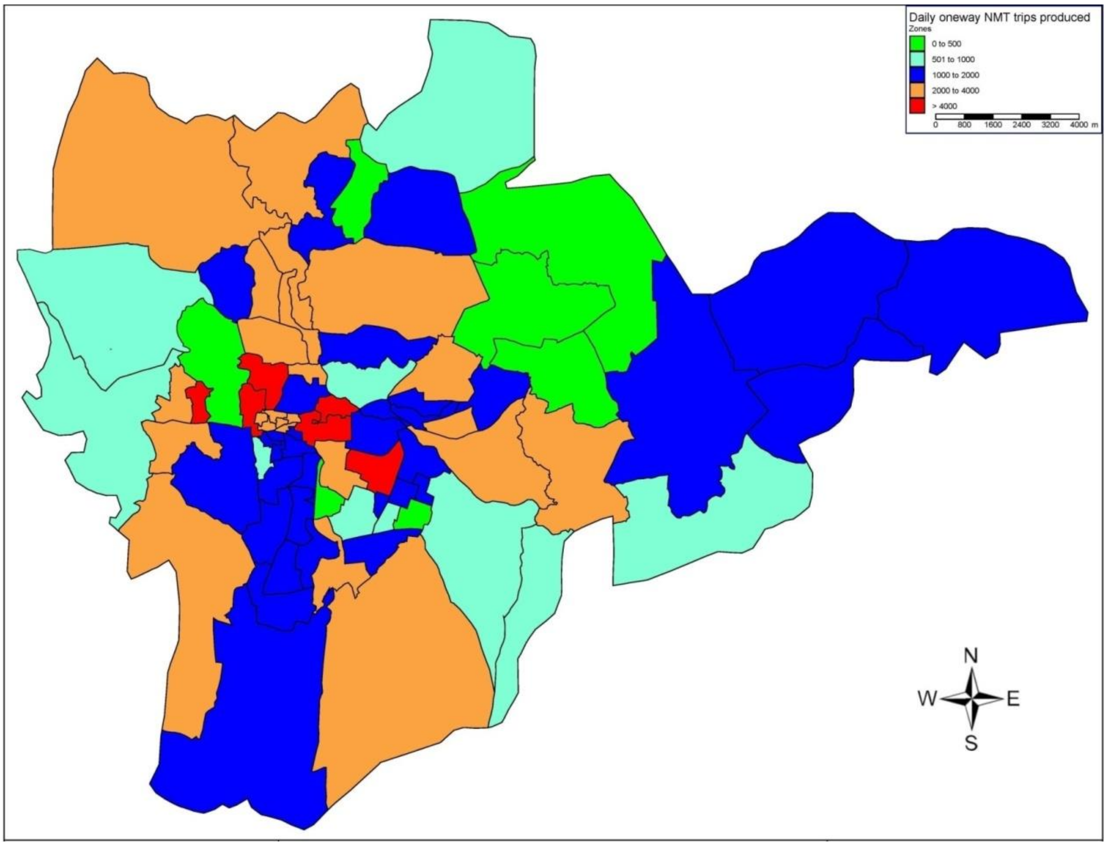

Figure 4-6: TAZ map showing NMT trips produced

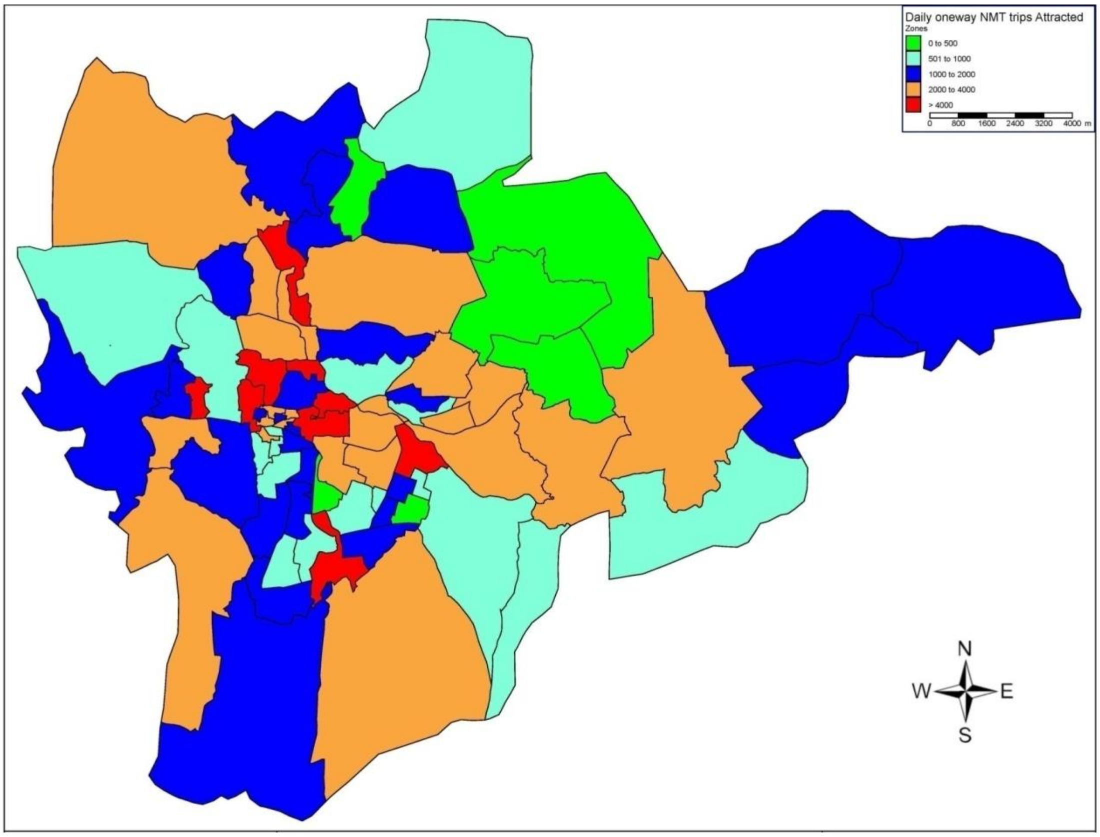

Figure 4-7: TAZ map showing NMT trips attracted

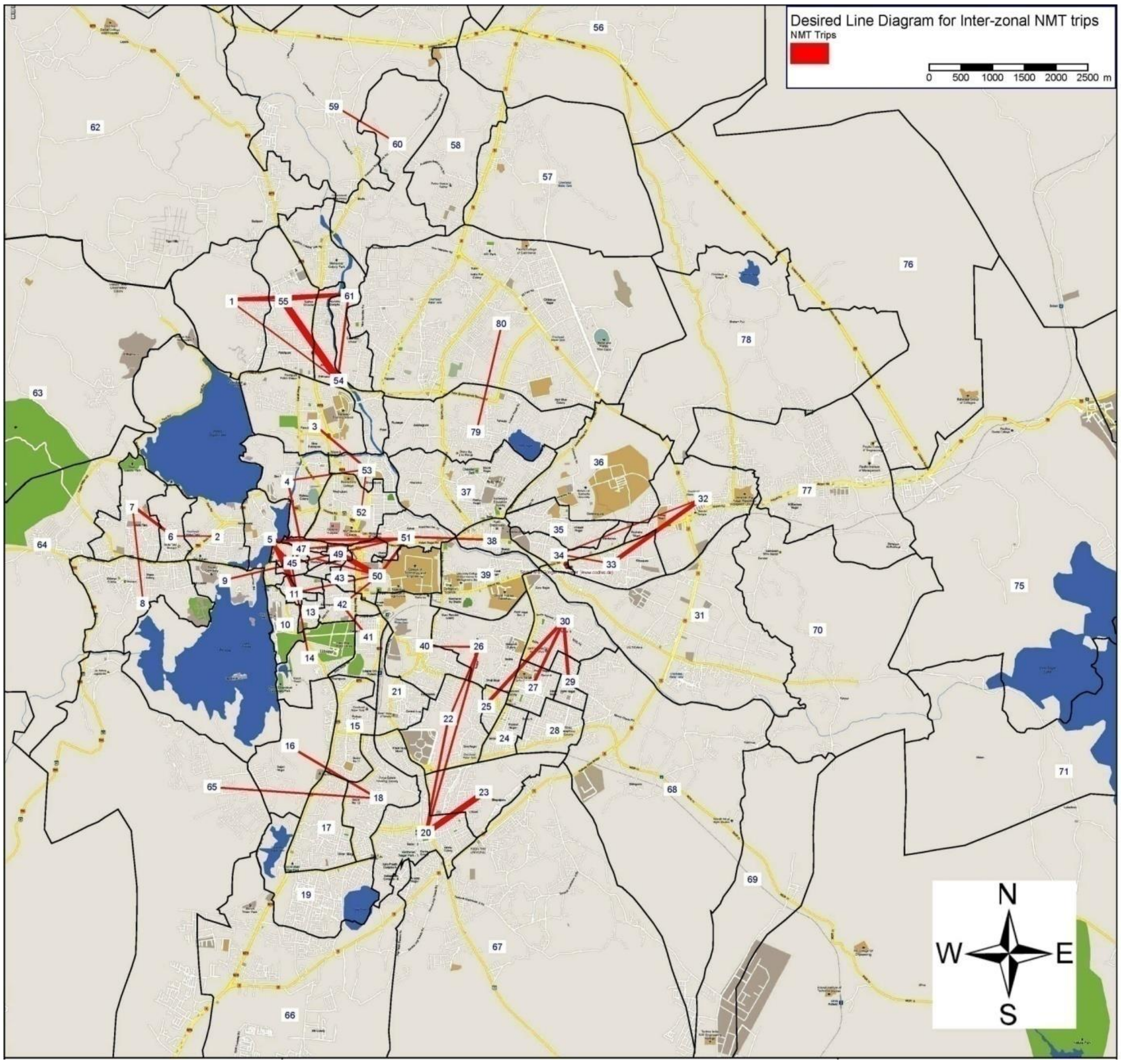

Figure 4-8: Desire line diagram for inter-zonal NMT trips

4.7 Conclusions

The base year model gives an overall idea of the situation prevailing in Udaipur and its impact in the base year. With the base year model, the actual condition on the road has been developed, disaggregating it by income, purpose, and gender, total number of trips made in a day, the mode used in each trip, distance travelled during each trip, the number of vehicles or volume on each road, as well as the emission levels in 2012-13.

Chapter 5. Business as Usual (BAU) Scenario

This chapter gives an overall perspective regarding the growth pattern of the city for the horizon years in terms of demographic, land use and economic parameters, which will be further used to develop the business as usual (BAU) Scenario for the horizon years. The Chapter summarizes the results of the BAU Scenario.

5.1 Background

Planning is a process of rational decision-making for the future. Hence, the whole process of planning becomes useless until and unless a rational estimation is conducted of some crucial planning parameters like future demand, which can be reflected by future population and economic status of the population.

The estimation of present and future demand for transport services and transport-related infrastructural facilities, and the adoption of suitable action for the low carbon, safe, and efficient movement of passengers and goods, necessitates forecasting Udaipur's future population and the future economic status of the population.

It has been ascertained that the overall goal of LCMP can be realized over a long-term horizon period of 30 years. The revised Master Plan has been prepared for 2041.

Thus, in agreement with UIT and the District Collectorate, Udaipur, a long-term planning horizon of 30 years has been envisioned to attain the goals of the LCMP.

This timeframe has been divided into three time horizons, which are as follows:

1. Short-term: The short-term time horizon will last for five years from 2013 to 2018. It will focus on short-term planning measures that include intersection improvements, signalization of intersections, traffic circulation plans, parking plans, etc. The overall emphasis will remain on improving safety and accessibility standards
2. Medium-term: The time-period for this horizon is ten years, until 2022. The focus will be on medium-term planning projects such as NMT corridors, city bus networks and NMT networks. The objective of medium-term planning is to arrest the current trend of heavy dependence on private vehicles and create the conditions for higher PT and NMT usage in the future
3. Long-term: This is a 30-year long period lasting up to 2041, with a long-term vision of achieving overall low-carbon mobility goals.

5.2 Business as Usual (BAU) Scenario

The objective of developing the BAU Scenario for this LCMP study is to create a hypothetical scenario for understanding Udaipur city in the horizon year in terms of the overall development of the city in general, and urban transport in particular. It is based on the assumption that the factors/parameters, such as growth of population, employment generation, vehicle registration and intensity of land use, etc., which effect the growth and development pattern of a city, tend to follow the prevailing trend and pattern along with the assessment of probable impacts of the ongoing and proposed intervention measures to be undertaken by concerned city authorities.

The BAU scenario is assessed in terms of selected parameters such as modal shares, trip lengths, accessibility, safety, and emission levels, etc.

5.2.1 Planning forecast

5.2.1.1 Demographic forecast

The revised Master Plan has projected the future population as follows:

Table 5-1: Forecasted population (Master Plan Udaipur)

Year	Population
2021	759,000
2031	1,002,000
2041	1,580,354

Source: Master Plan Udaipur

The revised Master Plan has suggested the overall average city density of 285 persons per hectare by the year 2013, and divided the whole city into four different zones based on maximum allowable density.

Referring to Figure 5- and Figure 5-1, these zones are:

1. Lower density area with density of 87 persons per hectare, consisting of peripheral areas located about 12km away from the city centre
2. Low density area with density of 198 persons per hectare, consisting of peripheral areas located about 9km away from the city centre
3. Medium density area with density of 296 persons per hectare, consisting of areas which lie from 3 to 6km from the city centre
4. High density old city area, with density of 494 persons per hectare.

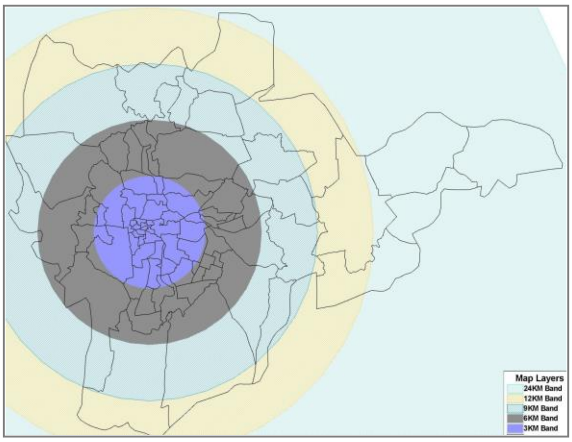

Figure 5-1: Areas with distance from city center and density

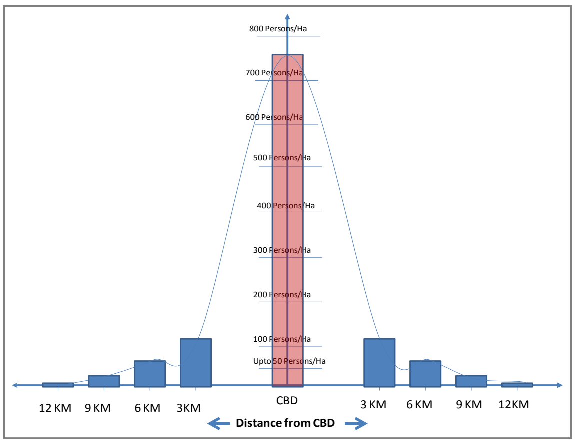

Figure 5-2: Distance from city center and density

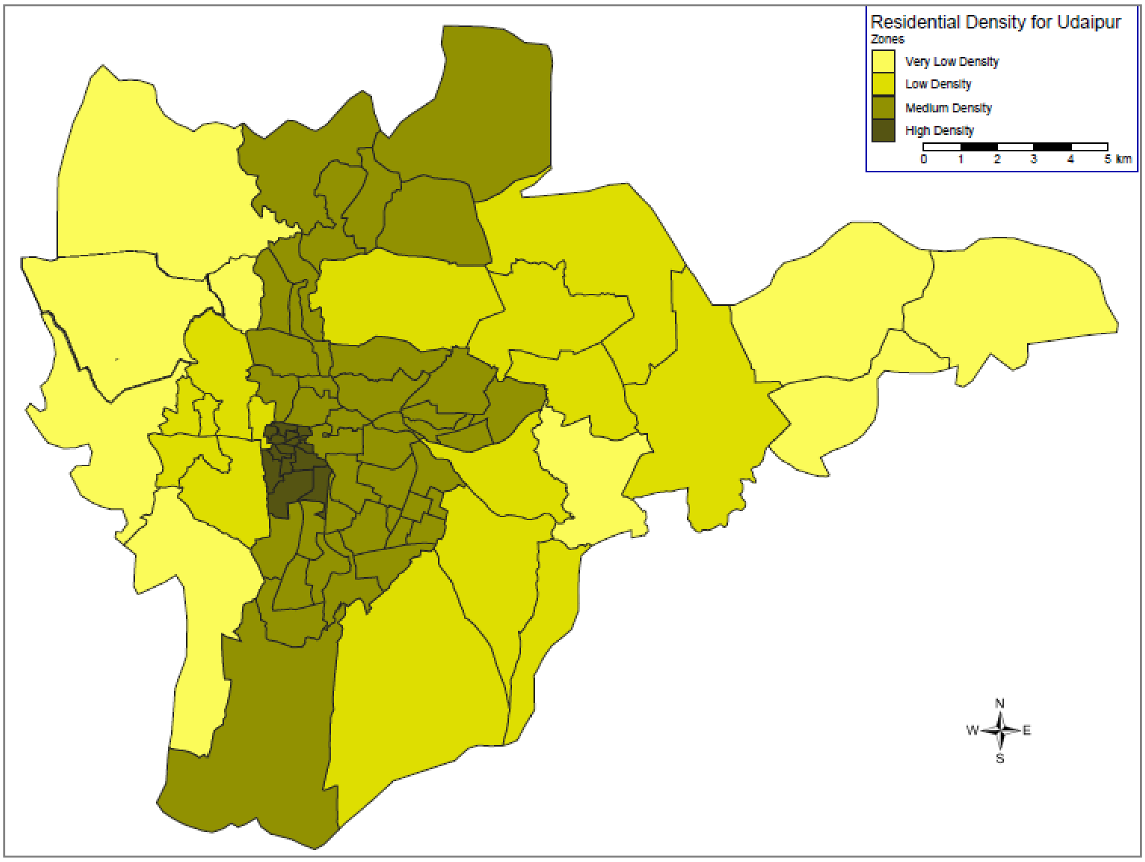

Figure 5-1: Zone-wise density

5.2.1.2 Economic forecast

In economic forecasting, the future employment, work force participation, and share of different sectors to the economy of Udaipur as forecasted by the revised Master Plan are used in the transport model.

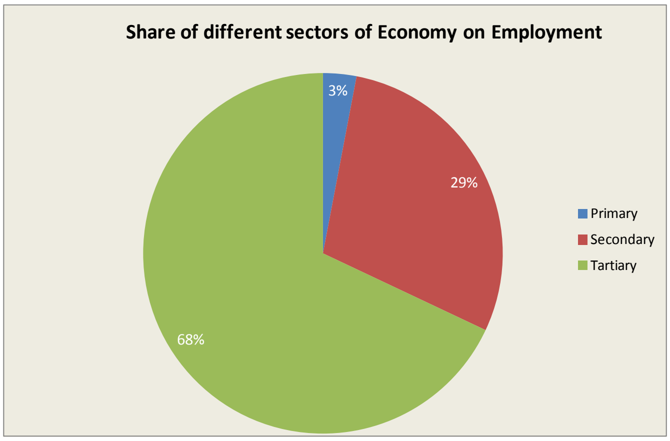

Figure 5-2: Share of different sectors of economy

As per the revised Master Plan for Udaipur, the total employment in 2041 is estimated at 517,238, with a work force participation rate of 32.7 per cent. Referring to Figure 5-4, the tertiary sector will generate the maximum employment opportunity, followed by the secondary sector.

5.2.1.3 Land use in horizon year

Udaipur City has been developing on the eastern (Airport side) and southern side (Ahmedabad Road side). The less pronounced growth in other directions could be due to natural terrain constraints. The past growth pattern of Udaipur is shown in Figure 5.5.

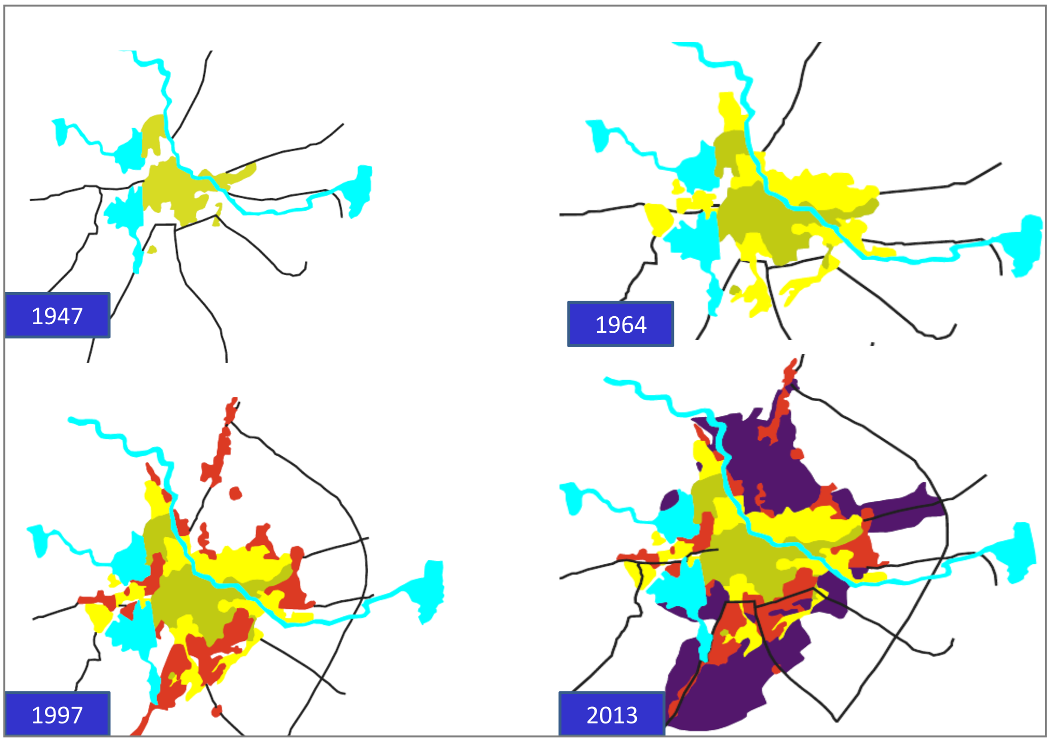

Figure 5-3: Growth pattern of Udaipur city

The revised Master Plan, 2031, has suggested 60 per cent of land will be under residential use, 11 per cent will be under traffic & transportation, 11 per cent under parks and open space, 7 per cent under public and semi-public and 3 per cent under commercial use. Refer to Figure 5.6.

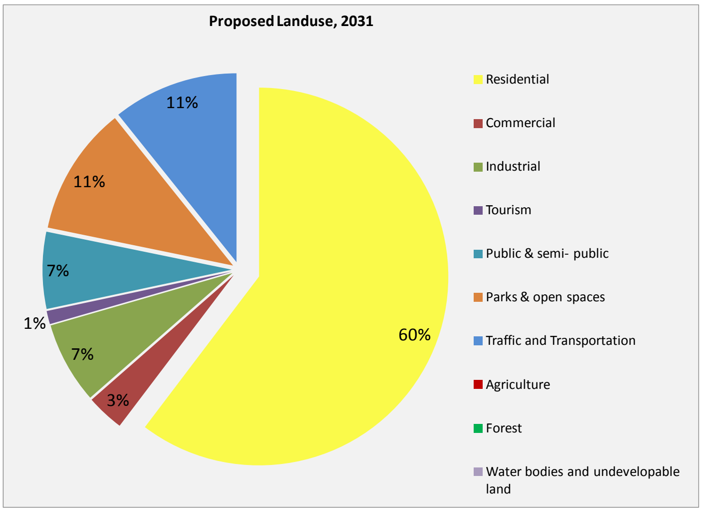

Figure 5-4: Proposed Land Use Pattern

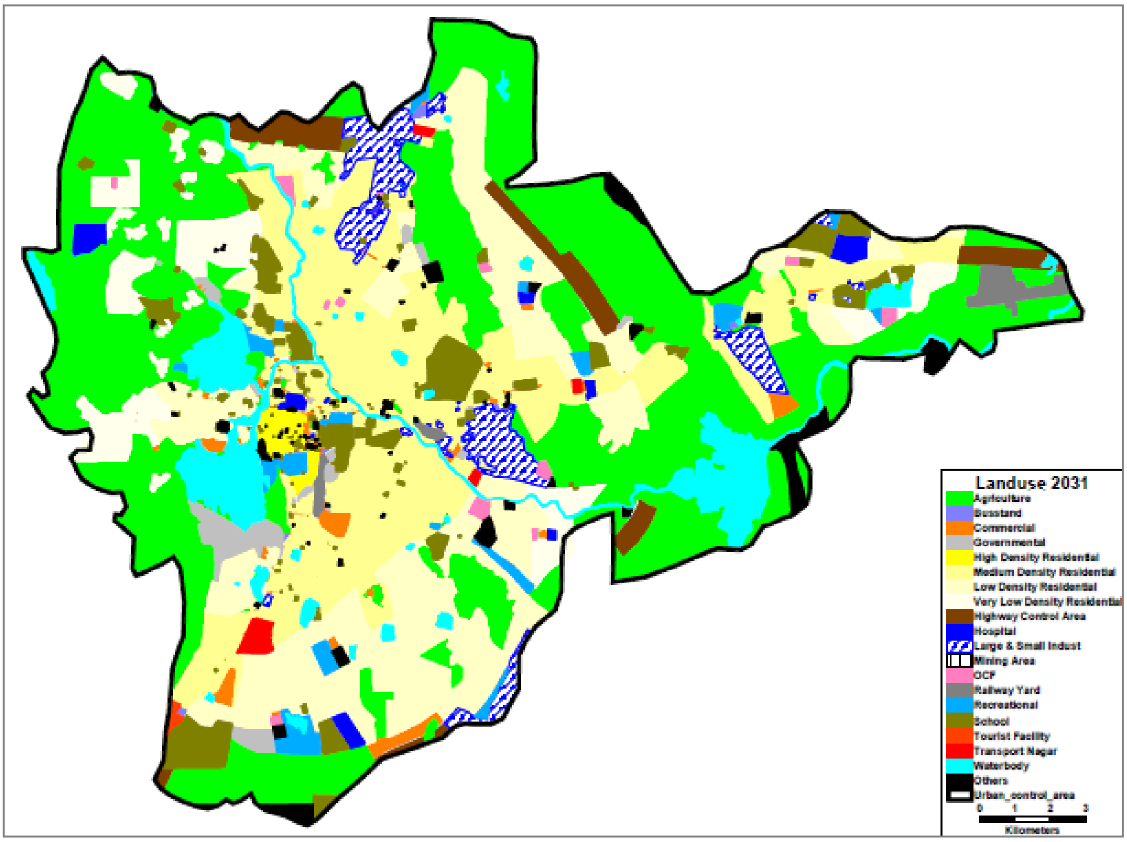

Figure 5-5: Proposed land use plan

The number of trips produced and attracted from each zone depends on the corresponding zone population, employment, etc. Based on the revised Master Plan, these trip generation variables (population, employment, etc.) were estimated. During the assignment stage of travel demand modelling, these trip productions and attractions were transformed to hourly traffic in terms of PCU/hr on each link, from which the impact of each strategy was tested. The detailed zone-wise trips generated are mentioned in Annexure 3.

5.2.2 Proposed and ongoing intervention measures by city authorities

The proposed and ongoing intervention measures by city authorities under the BAU scenario include the projects identified by Udaipur's local authorities: UIT, Nagar Nigam, State Government, etc. These projects include road widening, new links, flyovers and transport terminals. Further details of these projects are explained in this section.

a. *Proposed new roads and road widening*

Table 5-2 shows the list of roads proposed as shown in Figure 5-8. In the interest of traffic moving from Pratap Nagar Chowk to Balicha Chowk, this road will be widened from four to six lanes, and a flyover is proposed at Pratap Nagar Chowk.

Table 5-2: Proposed roads as per revised Master Plan (2031)

Sl. No.	Road category	Right-of-way (m)	Description
1	National Highway/State Highway/bypasses	60	• NH-8 from Debari to Kaya Village • SH-32 from Eklingpura to Banswara • From Hiran Talai to Fanda Talab • From Sukher Bypass via Ladiya kheda Gudli Industrial Area
2	Arterial roads	36	• From Naula Bypass, Jogi Village Talab • From Nela talab bypass to Nava Talab • From Balicha Junction to Jogi Talab • From Police Lines to Hiran Mangari Sector 3 • From Thokar Chowk to Madri Junction • From Siphon Circle to Thur • From Thur to Rampura Circle • From Rampura Circle to Big Talab
3	Sub-arterial and other major roads	30	• From Sobhagpura Circle to bypass • From RK Circle to University Road • From Maharana Games Village to Dhikali Bypass • From Geetanjali College to Fanda Talab • Behind IIM to Jaisandh Road • From Goverdhan Sagar to Futiyaan Talab • From Savina bus stand to Rundela Talab • From Hiran Mangari Sector 4 to Manva Kheda Circle

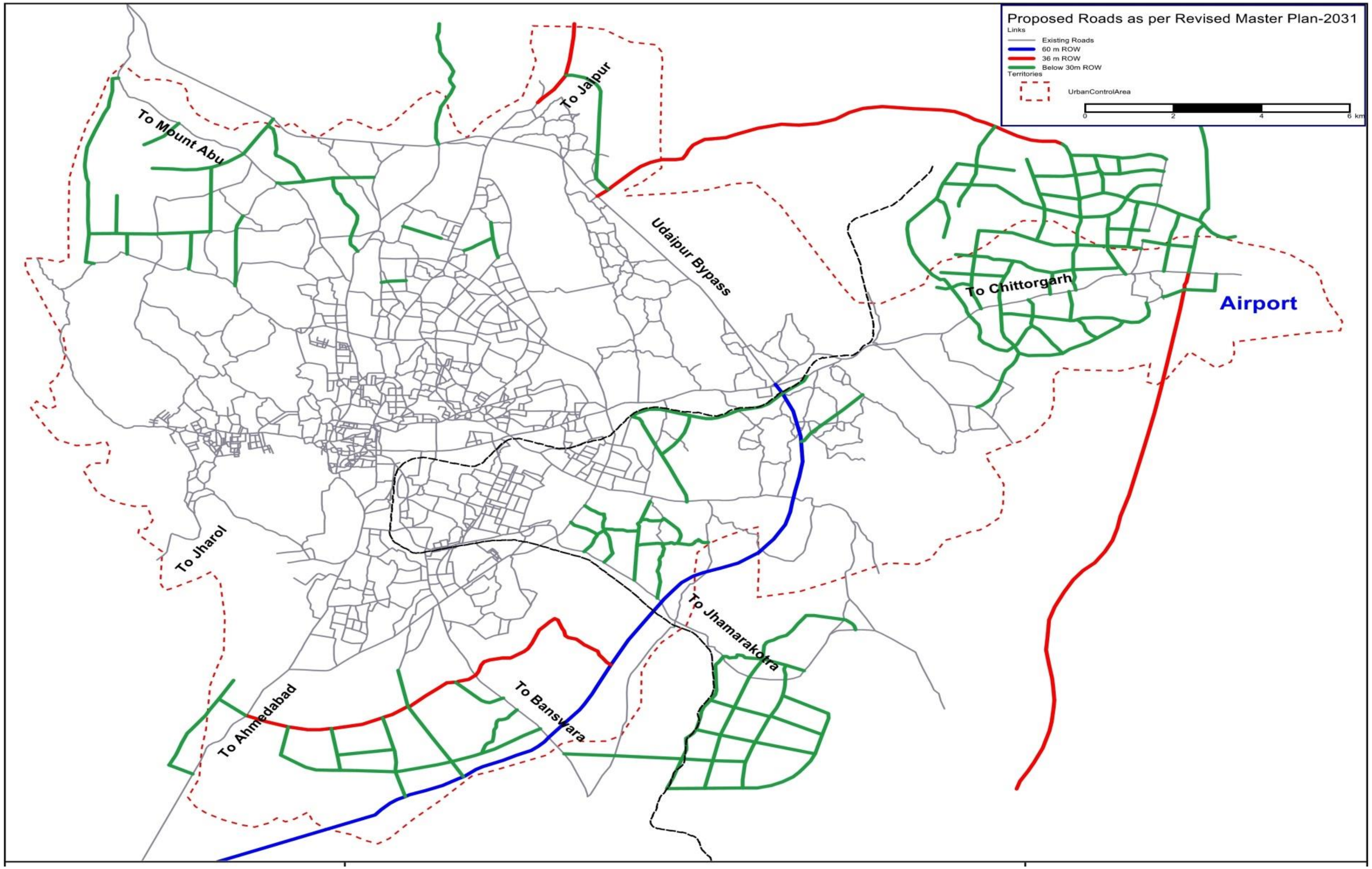

Figure 5-6: Proposed roads as per revised Master Plan (2031)

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b. *Proposed bus terminals and transport nagar*

Based on the development and expansion of Udaipur, the revised Master Plan has proposed six new bus terminals on those roads connecting Udaipur with external areas. Table 5-3 shows the list of bus terminals along with the approximate area available in acres. The total area sanctioned for these bus terminals is around 75 acres.

Table 5-3: Proposed bus terminals as per revised Master Plan (2031)

Sl. No.	Name of the road	Bus terminal location	Area (acres)
1	Nathdwara Road	Near Highway crossing	35.4
2	Ahmedabad Road	Near Roadways workshop	2.5
3	Ahmedabad Road	Near IIM	19.0
4	Jaisamand Road	Near Savina Kheda	3.3
5	Chittorgarh Road	Near Pratapnagar Bypass Junction	13.3
6	Seesarama Road	Near Seesarama Junction	2.0

Apart from the above mentioned proposals, an interstate bus terminus (ISBT) is proposed near the intersection of NH-8 and Udaipur Bypass Road, near Amberi Junction. This ISBT will have all modern amenities for passengers and bus operators. An area of around 35 acres is sanctioned as per the revised Master Plan 2031.

Modernization of the existing bus terminal near Udaipol is proposed for the benefit of passengers. An area of around 80 acres is sanctioned for trucks especially carrying food grains near Hindustan Zinc Limited.

The BAU scenario further assumes that vehicle population will grow at 6 per cent per annum along with improvements in vehicle technology conforming to the latest emission norms.

5.2.3 *Travel demand model*

The trip productions and attractions estimated using the forecasted value is used as an input for predicting the trip distribution matrix for each horizon year, assuming the same gravity model formulation parameters (as observed in the base year). The mode choice model is useful in predicting mode-wise matrices. It takes as inputs the generalized cost skims for each mode based on the network-level changes in each horizon year and total trip matrix (output of trip distribution). It is assumed that the multinomial logit (MNL) parameters estimated for the base year will remain the same in the future also. The mode-wise matrices obtained from the mode choice model for each horizon year are assigned onto the corresponding year road network to check the results. The network-level changes for the BAU scenario are based on the new road proposals as per the revised Master Plan 2031.

The outcomes of the BAU scenario in terms of mobility and accessibility are presented as modal share tables, V/C ratio, flow pattern, different plots, IPT/PT accessibility, and kernel density maps. These results are explained in the subsequent sections.

5.2.3.1 Modal shares

Comparison of modal shares for the base year with BAU-2021, BAU-2031 and BAU-2041 shows that there is further deterioration of the traffic situation, with an increase in private vehicle mode shares and decrease in NMT mode shares. Table 5-4 gives the comparison of mode shares in the base year and BAU scenario.

Table 5-4: Modal share comparison of base year and BAU scenarios

Mode	Base year (2013)	BAU (2021)	BAU (2031)	BAU (2041)
Walk	25%	24%	21%	20%
Cycle	3%	3%	2%	2%
Two-wheeler	47%	48%	50%	51%
IPT	18%	18%	20%	21%
Car	4%	4%	4%	4%
PT	3%	3%	3%	2%
Total	100%	100%	100%	100%

It has been observed that in the business as usual scenario for 2021, 2031, and 2041, the modal share of PT would further reduce from 3 to 2 per cent, and two-wheelers would increase from 47 to 51 per cent.

5.2.3.2 V/C ratio and traffic flow pattern

As the population grows, under the BAU scenario there will be a huge growth of private vehicles leading to higher emission levels. The saturation (V/C ratio) and flow diagrams (flow in PCU/hr) as shown from Figure 5-7 to Figure 5-12 pictorially indicate the level of traffic congestion in Udaipur city for different horizon years.

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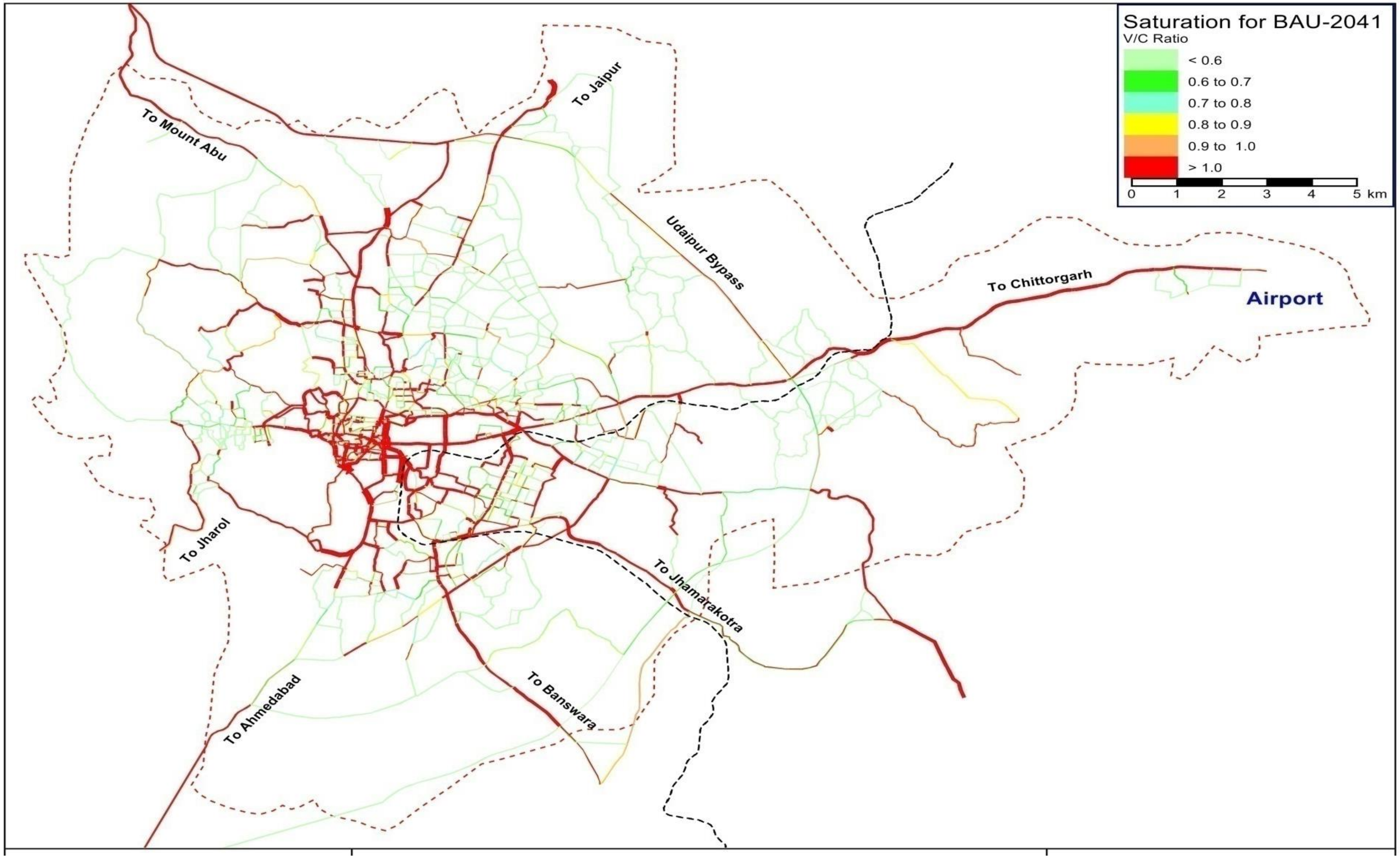

Figure 5-7: V/C Ratio under scenario BAU (2041)

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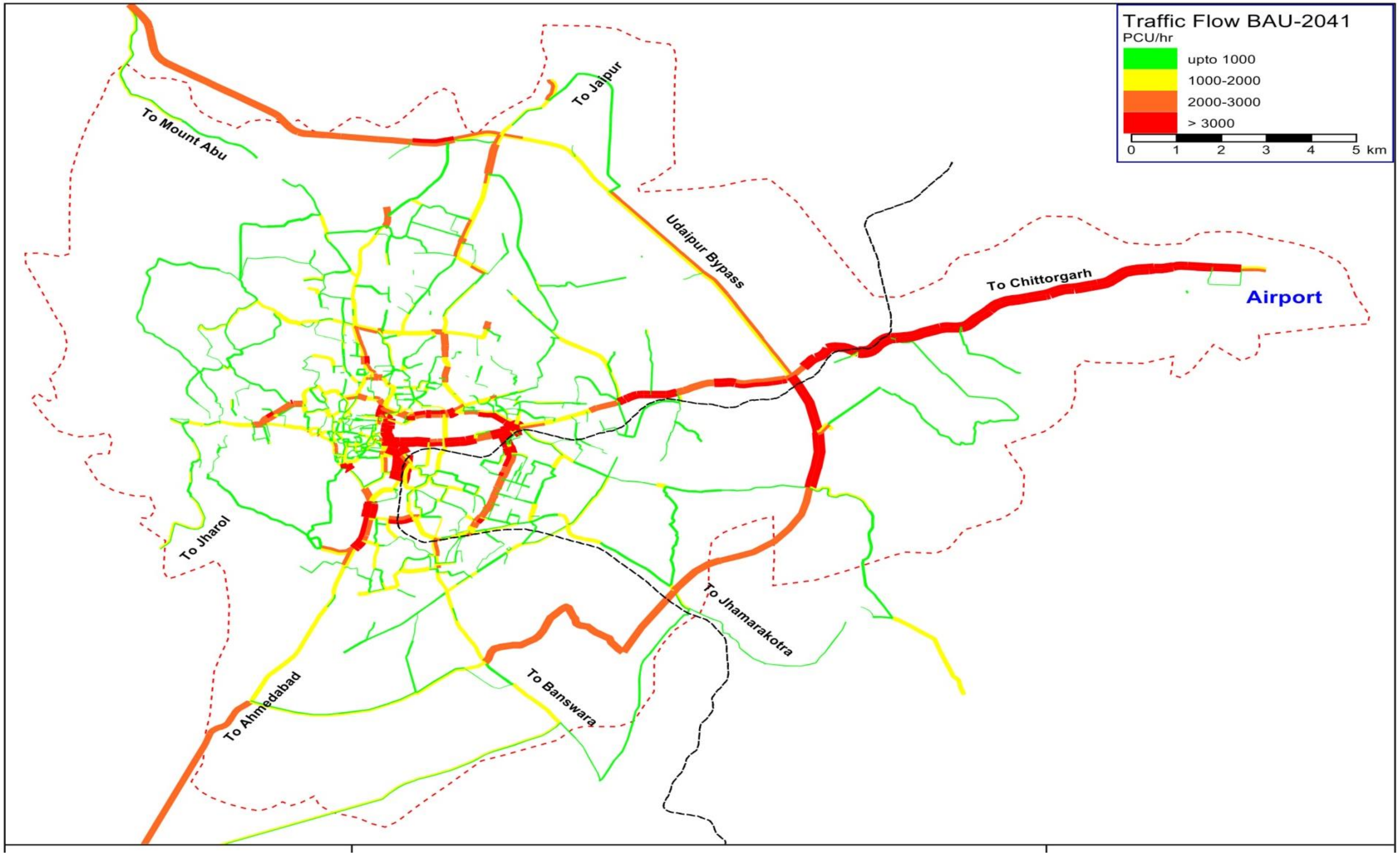

Figure 5-8: Traffic flow (PCU/hr) under scenario BAU (2041)

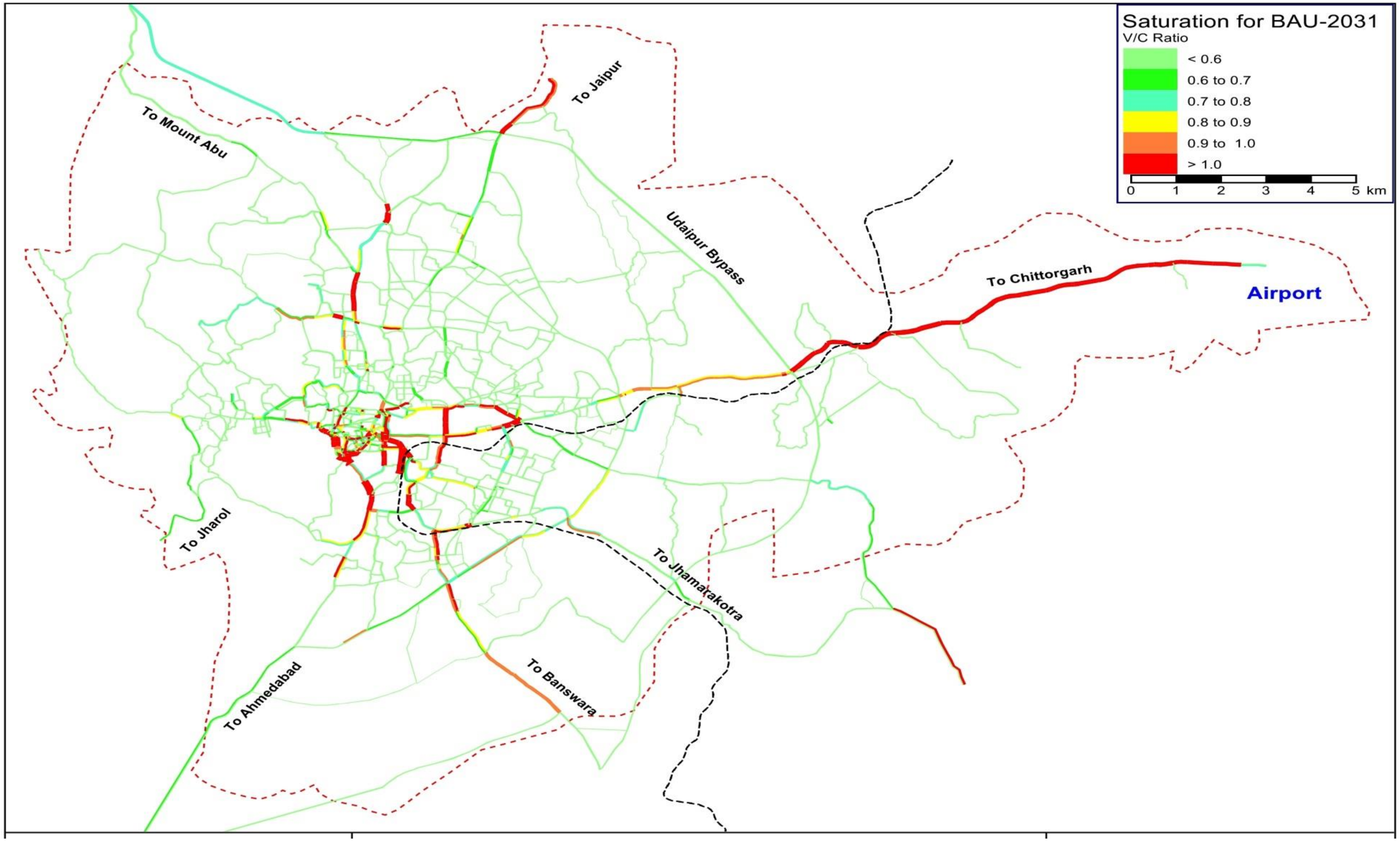

Figure 5-9: V/C ratio under scenario BAU (2031)

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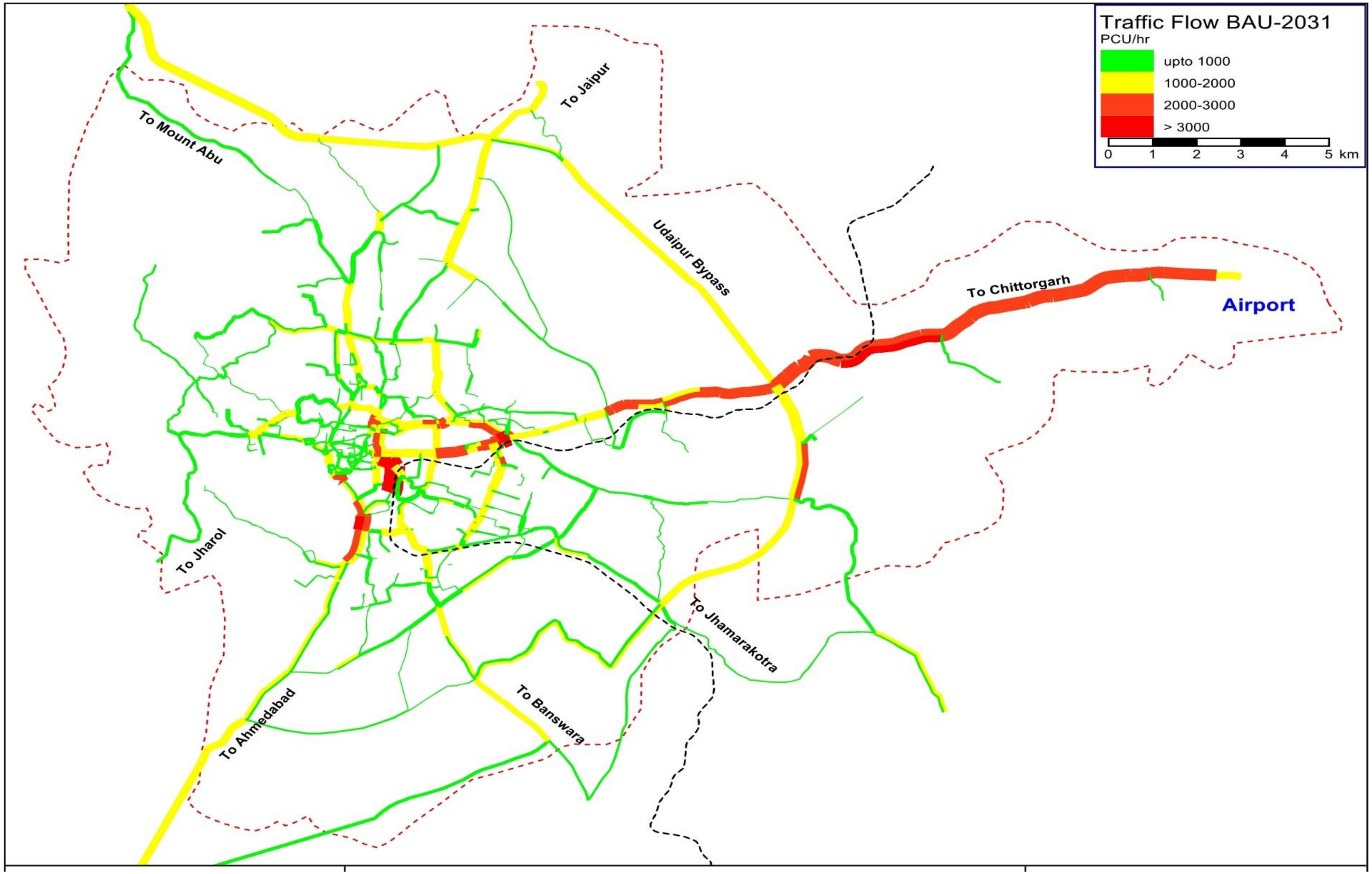

Figure 5-10: Traffic flow (PCU/hr) under scenario BAU (2031)

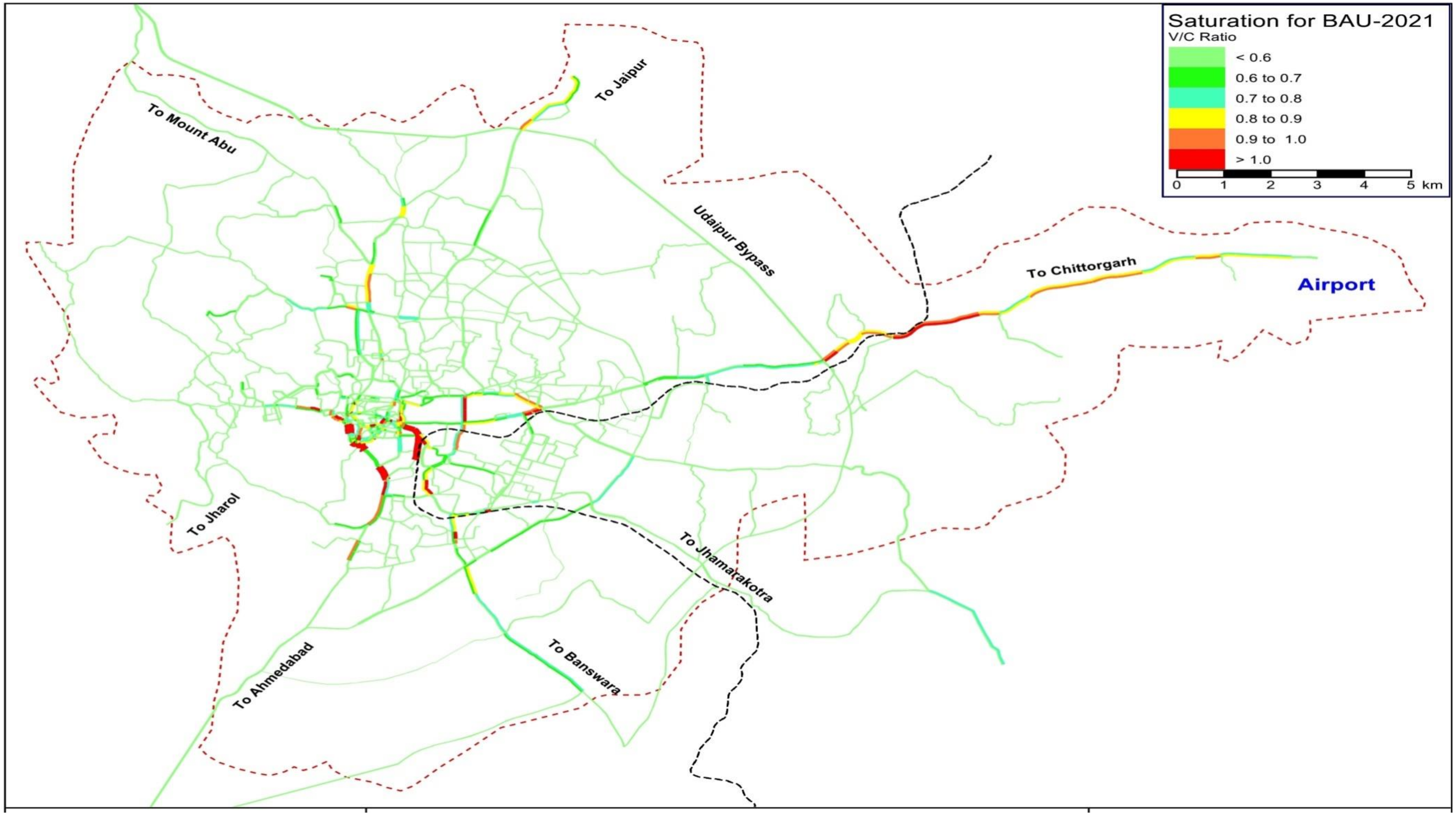

Figure 5-11: V/C ratio under scenario BAU (2021)

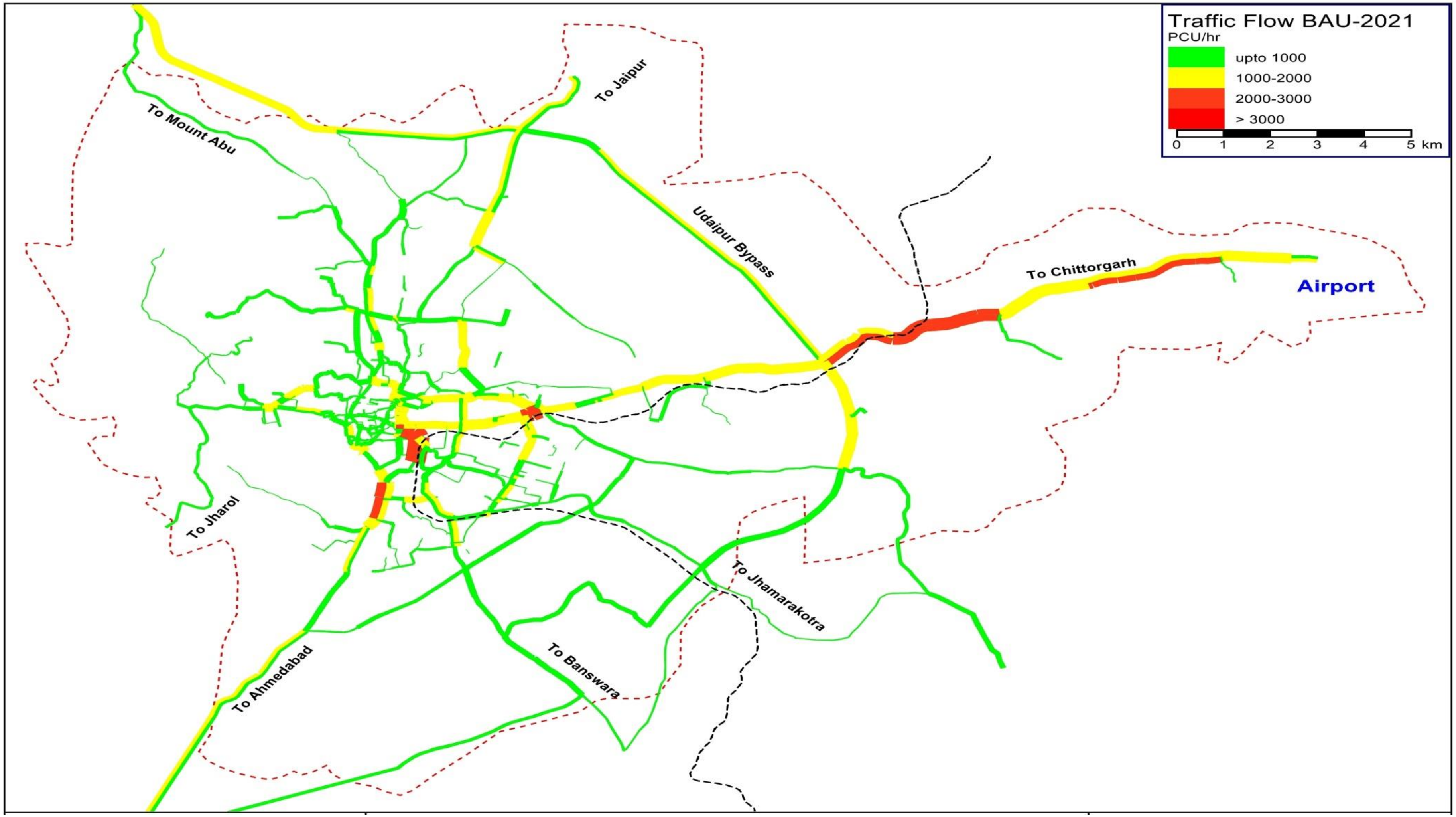

Figure 5-12: Traffic flow (PCU/hr) under scenario BAU (2021)

5.2.3.3 Difference Plots

The difference plot is an easy graphical representation of flow pattern under different scenarios. The journey times in all routes actually used are equal and less than those which would be experienced by a single vehicle on any unused route. Each user non-cooperatively seeks to minimize his cost of transportation. The traffic flows that satisfy this principle are usually referred to as 'user equilibrium' (UE) flows, since each user chooses the route that is the best. Specifically, a user-optimized equilibrium is reached when no user may lower his transportation cost through unilateral action. This concept is based on Wardrop's first principle, and the travel demand model for Udaipur has adopted this method of user equilibrium assignment. The difference plot shows the difference in flow on each link between the compared scenarios. Based on the flow difference, the effect of increases in population or the effect of any scheme can be assessed. Figure 5-13 and Figure 5-14 show the difference plots, comparing BAU scenarios for horizon years 2021, 2031 and 2041. In fact, at a few road sections, the total traffic has been reduced even after an increase in the total trips. This is due to the change in the route decisions of individuals, which was modelled based on Wardrop's first principle.

5.2.3.4 IPT/PT accessibility (percentage of HH within 10 minutes' walking distance)

The existing IPT system is not accessible to many zones in Udaipur. A route rationalization procedure needs to be followed in order to improve the situation. Under the BAU scenario, as the proposed intervention measures exclude any improvement in IPT operation and regulation, it is assumed the base year situation will prevail in the BAU scenario also. Figure 5-15 shows the IPT/PT accessibility for the year 2041.

5.2.3.5 Kernel density:

Kernel density is defined as the ratio of the length of the road network in a particular zone versus the area of the zone. The units for kernel density are km/km^2. This kernel density indicates the length of roads available in a particular area. The average kernel density is given in Table 5-5 and Figure 5-18, and shows the average kernel density value for the base year and BAU scenarios. As there is no significant increase in the road network or the road length in the Udaipur Urban Control Area, as per the Master Plan, the kernel density has a negligible change.

Table 5-5: Kernel density values for different scenarios

Sl .No	Scenario	Average kernel density (km/km^2)
1	Base year	5.44
2	BAU 2041	5.53

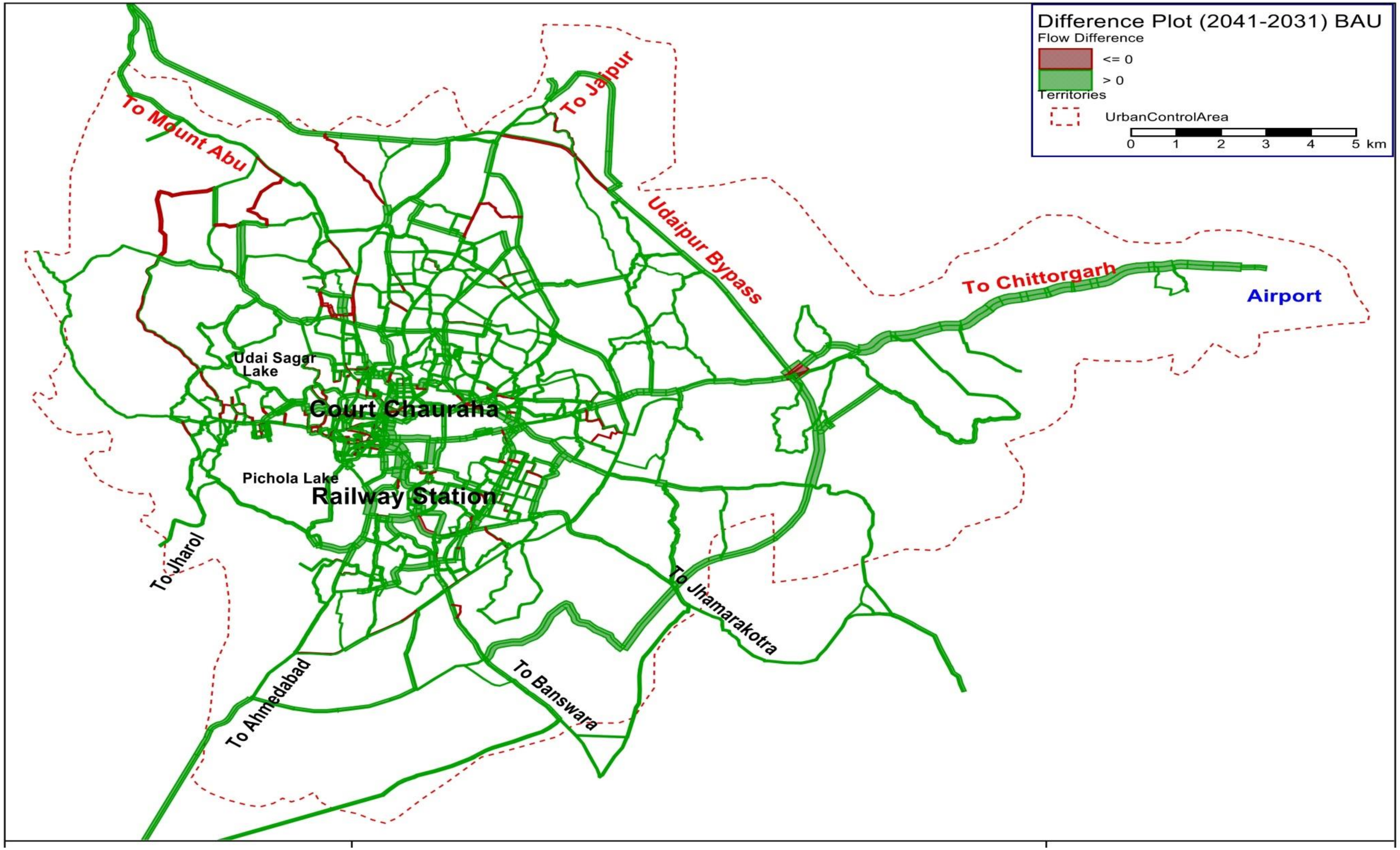

Figure 5-13: Difference plot (PCU/hr) for BAU (2041)-BAU (2031)

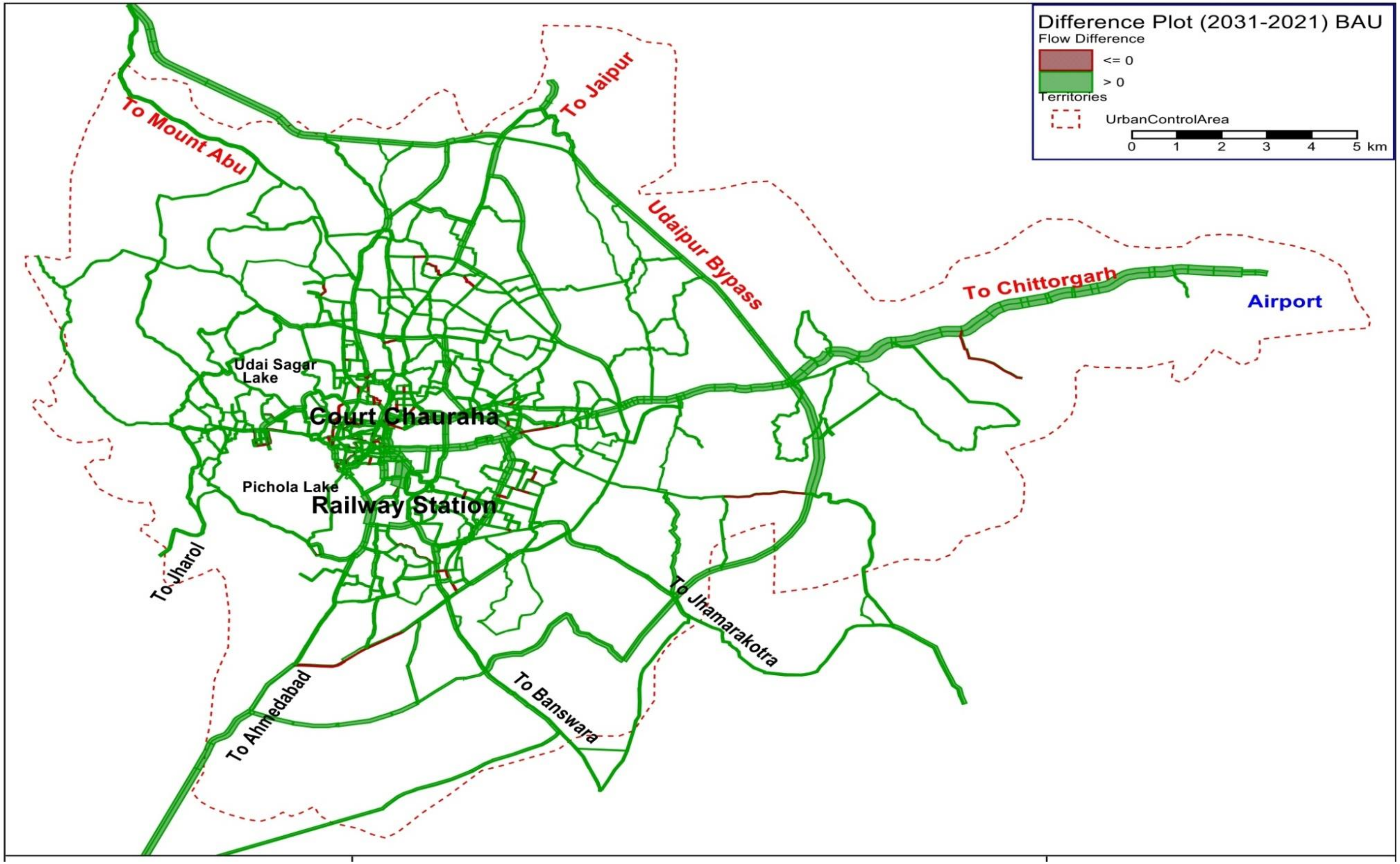

Figure 5-14: Difference plot (PCU/hr) for BAU (2031)-BAU (2021)

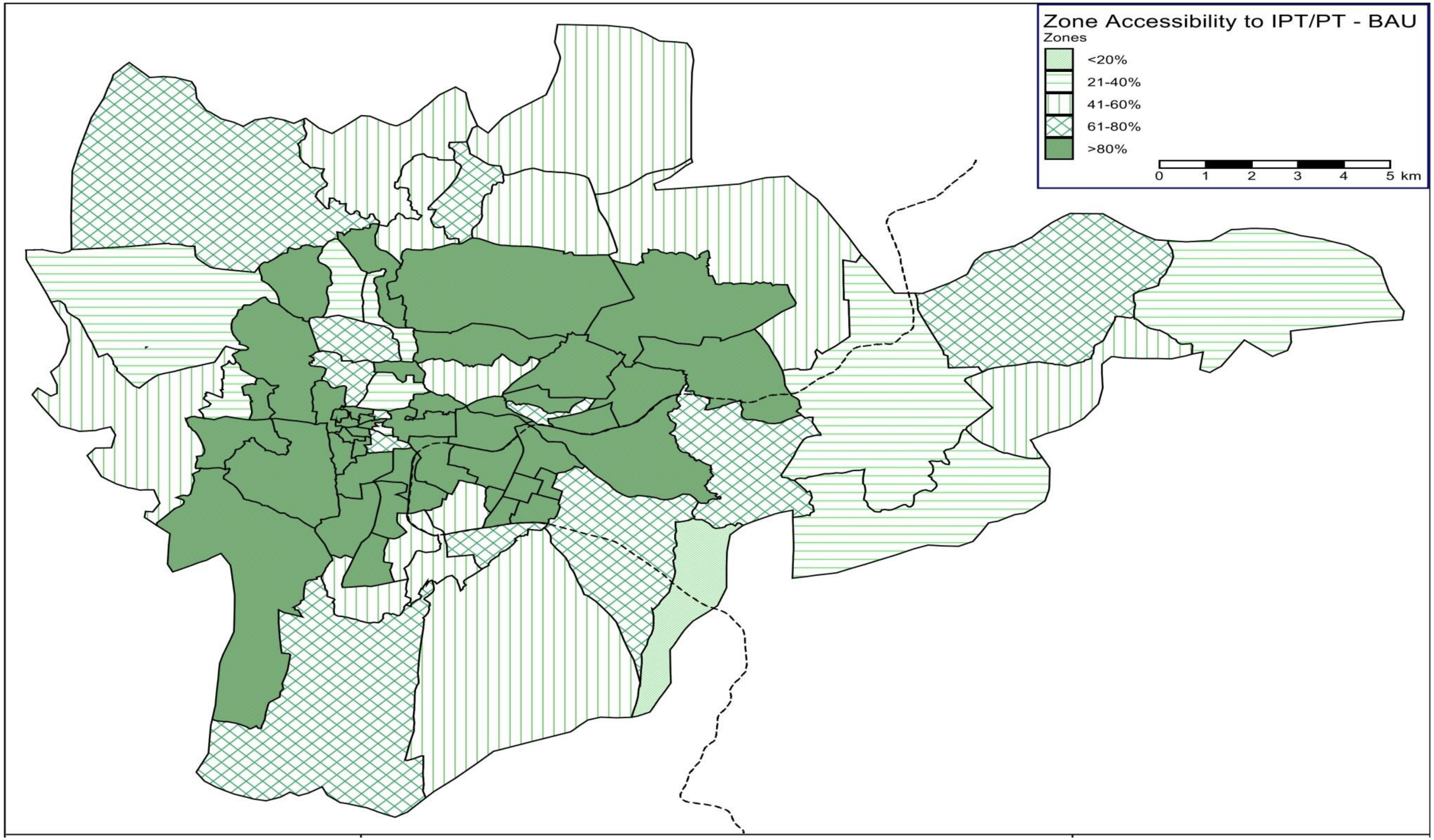

Figure 5-15: IPT/PT accessibility for the entire BAU scenario

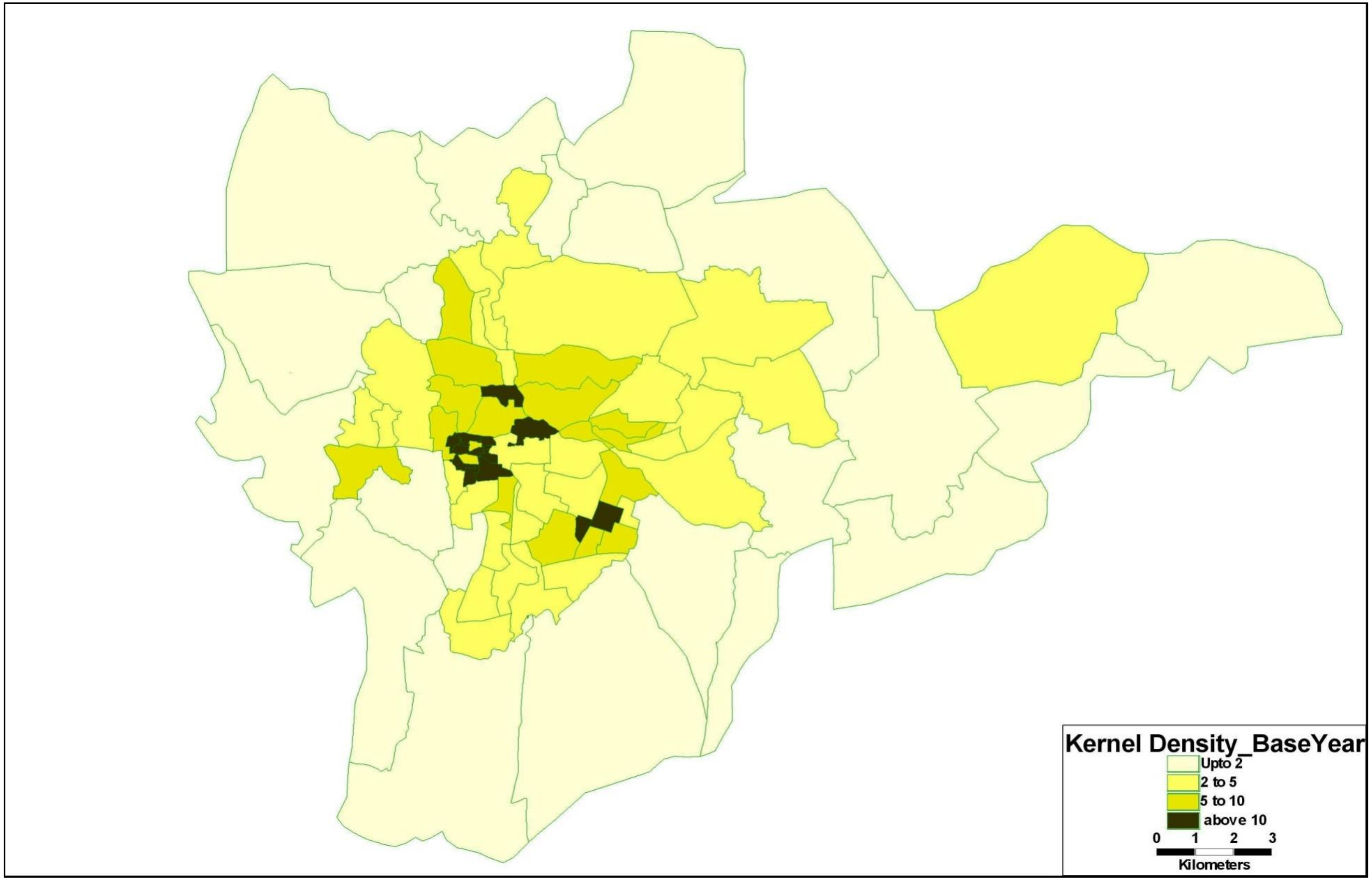

Figure 5-16: Kernel density for base year

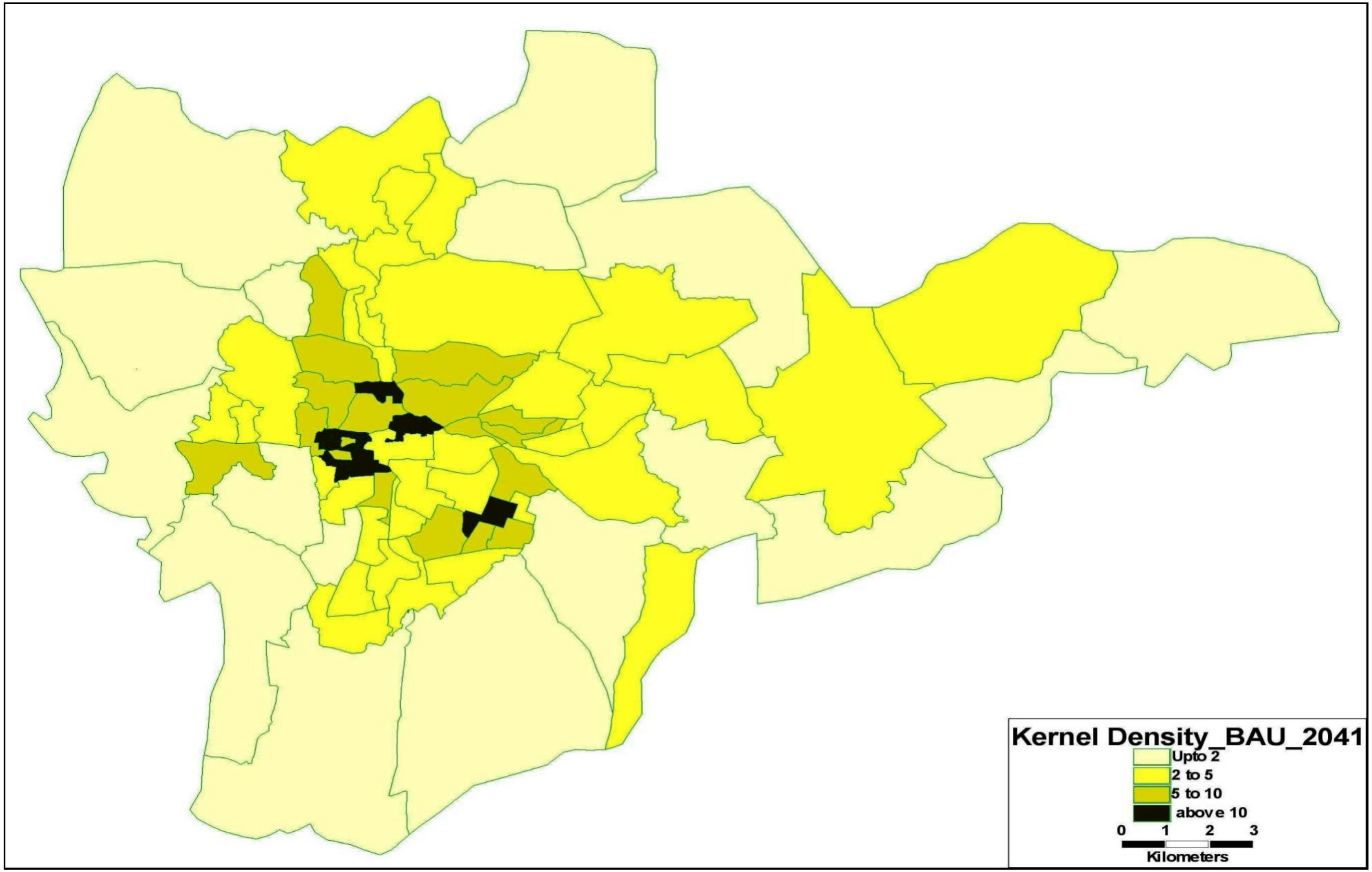

Figure 5-17: Kernel density for BAU (2041)

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5.2.4 Outcomes of BAU scenario

Udaipur is a typical Indian city with its inherited problems. The city lacks an organized public transport system and NMT infrastructure. However, the BAU scenario proposals do not support sustainable modes of transport. Hence, the outcomes show that the current situation further deteriorates with implementation of BAU scenario proposals. The comparison of the base year and BAU scenario outcomes are shown in Table 5-6.

Table 5-6: Outcomes of BAU scenario as compared to base year

Indicator/values	Base year (2013)	BAU (2041)
Modal share		
Modal share of walk	25%	20%
Modal share of cycle	3%	2%
Modal share of two-wheeler	48%	51%
Modal share of IPT	18%	22%
Modal share of car	4%	4%
Modal share of PT	3%	2%
Trip length (km)		
Walk	1.18	2.06
Cycle	2.37	3.65
Two-wheeler	5.54	5.92
IPT	4.52	5.55
Car	7.06	7.51
PT	-	5
Accessibility		
Percentage of HH within 10 minutes' walking distance to access PT (IPT for base year)	69%	60%
Level of Service (LOS) of PT facilities as per MoUD Service Level Benchmark (SLB) Handbook	4	4
Land use mix intensity		
Increase in the percentage of intra-zonal trips as compared to base year (base year value is 19%)	-	16%
Safety to use NMT		
Walk	7.50%	7.50%
Cycle	7%	7%
Total motorized vehicle kilometres (million km)	880.5	2559.9
LOS of NMT facilities as per MoUD SLB Handbook	4	4
Congestion level		

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Indicator/values	Base year (2013)	BAU (2041)
Road length (km) with value of V/C ratio equal to 1 or more	-	26%
	Emission levels	
NO_2 tons annually	10,201	61,261
CO_2 million tons annually	17	33
PM10 tons annually	4,500	18,000
SO_2 tons annually	201	802
CO tons annually	397,677	695,935

5.2.4.1 Emissions of CO_2 and local pollutants

a. Emission levels

The emission level in the BAU scenario has been calculated using SIM-air modelling, taking annual vehicle kilometres travelled (VKTs) as input. The table shows the emission level in the BAU scenario.

Table 5-7: BAU scenario emission levels (2041)

Emission level NO_2 tons annually	Emission level CO_2 million tons annually	Emission level of PM10 tons annually	Emission level of SO_2 tons annually	Emission Level of CO tons annually
61,261	33	18,000	802	695,935

5.3 Conclusion

> *Based on the comparison of emission levels of 2013 and 2041, it was observed that the emission levels would increase approximately by 64 per cent in the city of Udaipur.*

For the BAU scenario, the results of the model for the horizon years depicts probable pressure on the transport infrastructure in Udaipur city. This scenario assumes the development pattern in line with the proposals of the Master Plan, and the proposals being undertaken by various city authorities only. From the previous sections it could be concluded that the usage of private vehicles is going to increase, as little or no emphasis is given to the pedestrian, NMT and public transport users in the Master Plan and proposals being undertaken by city authorities, resulting in higher emission levels and a chaotic mobility scenario.

Chapter 6. Alternate Development Scenario (Low-Carbon Scenario)

This chapter gives a detailed approach and perspective on promoting low-carbon transport in Udaipur city by adopting various alternative development scenarios such as land use, public transport, non-motorized transport, technology, and a combined LCMP intervention. The chapter summarizes the likely outcomes of these interventions.

6.1 Background

From the outcomes of the business as usual scenario (BAU), it is evident that it is not an ideal option for the development of the city of Udaipur. The transport sector is considered to be the fifth-highest carbon emitting sector due to the ever increasing vehicle ownership and use of private vehicles.

The alternate development scenarios in this study evaluate and assess the various interventions, such as land use, public transport, non-motorized transport, and technology scenarios. This chapter explains these alternate scenarios of development for the city of Udaipur, and their likely outcomes in terms of modal shares, trip lengths, accessibility, safety, and emission levels, etc.

6.1.1 Land use scenario

It has been traditionally observed that an individual’s travel and mode chosen for different trips depends on the structure of the city, spatial spread of the city, intensity of population distribution, employment generation, and its road network pattern, including the public transport facilities available within the city in which the individual resides. Udaipur exhibits a traditional growth pattern with low-rise and low density development, coupled with the ever increasing spatial spread of the city. The land use scenario developed for Udaipur city aims at adopting a two-pronged approach: firstly at the macro-scale, it defines the shape and growth pattern, structure and distribution of the land use typologies across the city. Secondly, at the micro-level, the scenario strives for achieving sustainable neighbourhood development based on intensity of land use and population bearing capacity of the area defined by density, through emphasis on infill and redevelopment of the available land.

6.1.2 Public transit scenario

Public transport is considered to be a sustainable mode of transport as it occupies less road space and carries more people at a given point of time as compared to any other modes of transport. The objective of this scenario is to evaluate and assess the impacts of an organized public transport system in the city of Udaipur, where the majority of the trips are dominated by the private modes, especially by two-wheelers. As part of this scenario, the emphasis is laid on a safe, reliable, accessible and affordable public transport system.

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6.1.3 Non-motorized transport

Non-motorized transport (NMT), which includes all forms of travel that do not rely on an engine or motor for movement, is the most environmentally friendly mode of transport. This includes walking, cycling, rickshaws, hand-drawn and animal-drawn carts, etc. Various studies have revealed that to increase the probabilities of a modal shift towards NMT uses, the provision of a safe environment to walk and cycle by developing footpaths and NMT corridors, etc., is essential, along with the emphasis on land use parameters such as a diversification of land uses and higher densities. This environment for movement by walking and cycling will play an important role in reducing VKT and indeed lower emission levels. As part of this scenario, the emphasis is laid on the wide and barrier-free footpaths, cycle tracks, safe crossing facilities at intersections, etc.

6.1.4 Technology scenario

As per the report, 'Promoting Low Carbon Transport in India. Low Carbon City: A Guidebook for City Planners and Practitioners', published by UNEP DTU Partnership on Energy, Climate and Sustainable Development Technical University, Denmark, at present in India, 8 per cent of CO_2 emissions are generated by the transport sector, which is also responsible for 10 per cent of total energy demand.

Thus, introducing changes to the types of fuel (energy efficient) and engine (energy efficient with lesser emission) can play a significant role in overall effort of emission reduction.

6.2 Urban Structure (Land Use Strategy) Strategy for Low-Carbon Scenario

6.2.1 Definition

The increasing sprawl of urban areas due to development activities adversely affects the environment, as the human footprint spreads over a larger area resulting in increased movement from one point to another. Further, rising incomes and a lack of proper planning can result in an unsustainable and automobile-dependent society. Land use has a crucial impact on travel demand, and therefore it is vital that there is effective integration between land use and transport.

As urbanization takes place with rising income levels, in the absence of proper planning, this leads to an unsustainable automobile-dominated and dependent society. Figure 6-1 describes unplanned urban transport and its consequences.

In the wake of the emerging importance to control urban sprawl and provide environmentally sustainable development, it is necessary to adopt all urban issues in an integrated manner. Land use has a crucial impact on travel demand, and can guide the future travel demand.

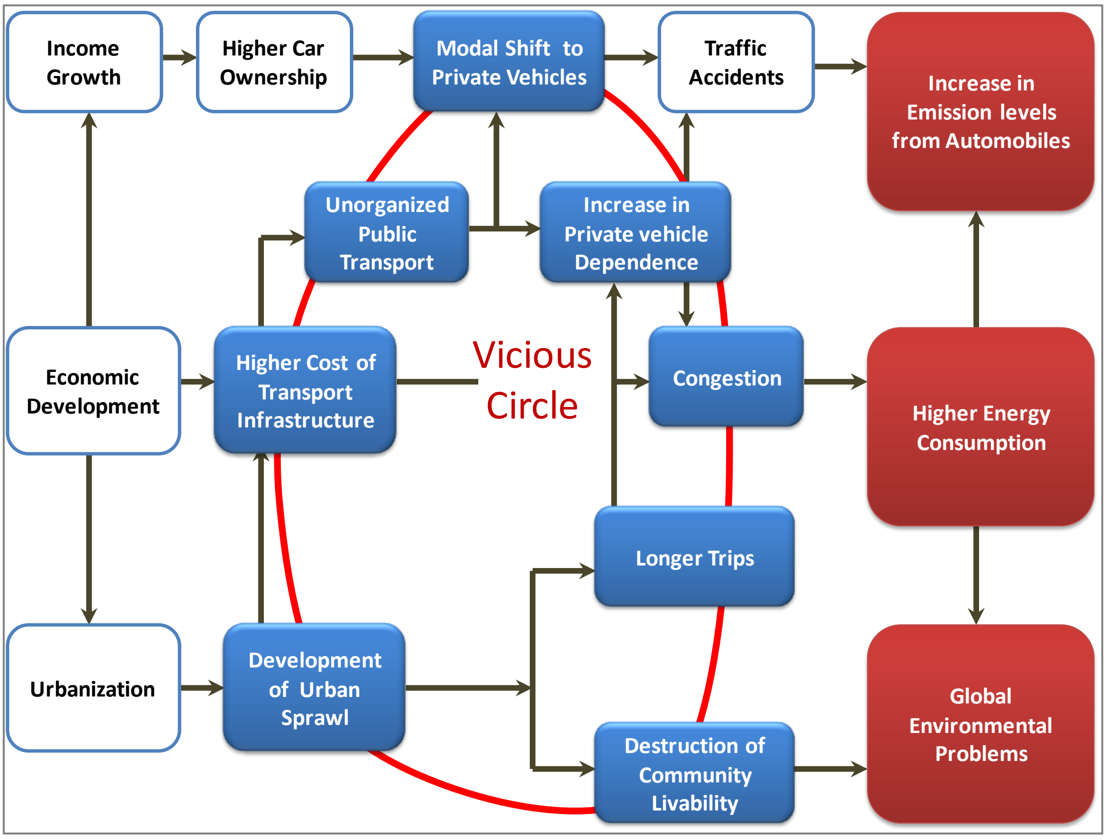

Figure 6-1: Relationship between urbanization and transport

An optimal mixed land use integrated with transport reduces the trip length and the overall travel demand in turn. Accordingly, the objective of land use strategy is defined to achieve a sustainable mobility scenario with lower emission levels and improved mobility and accessibility.

To reduce the vehicle kilometres travelled and increase the probability shift towards NMT and PT as a mode choice, an iterative process has been adopted where the appropriate land use mixes have been tested to arrive at optimum intra-zonal trips by NMT modes and the attainment of a minimum possible level of ATL. Based on the results of the iteration, the feasible strategies are as mentioned in further sections.

6.2.2 Objectives

- Increase in the percentage of intra-zonal trips for each zone
- Optimal use of vacant land to provide mixed land use in order to decrease the overall trip length of users
- Provide necessary NMT infrastructure for intra-zonal trips.

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6.2.3 Detailed Strategy

1. Infill and redevelopment on available land
   - Change in land use pattern conducive for smaller trips and shorter travel distances reverses the current travel demand
   - Increment in intra-zonal trips by increasing intensity of mixed land use and by making neighbourhoods identifiable and walkable
   - Making better connections between jobs from retail sector and housing
   - Using serviced land efficiently to help create a more compact urban form.
2. New development of higher density along major PT corridor
   - Decrease auto dependency by providing increased and self-contained neighbourhood and travel options for those not owning cars.

6.2.4 Input to the travel demand model

The input for the travel demand model to assess the urban structure strategy includes an adoption of robust land use strategies for the city, mentioned in the previous section along with strategies considered in the BAU scenario.

The strategy-specific inputs are as follows:

- Increase in area under commercial (retail), education and recreational land use, such as parks, etc., by 40 per cent
- Increase in residential density along public transport corridor three times the existing gross density
- Provision of NMT-friendly neighbourhood (development of pedestrian crossing facilities).

As per the existing land use of Udaipur, there are 24 zones where more than 50 per cent of the land is vacant, and there are 55 zones where the land is vacant up to 50 per cent. Figure 6-2 shows the vacant land details of each TAZ for the base year.

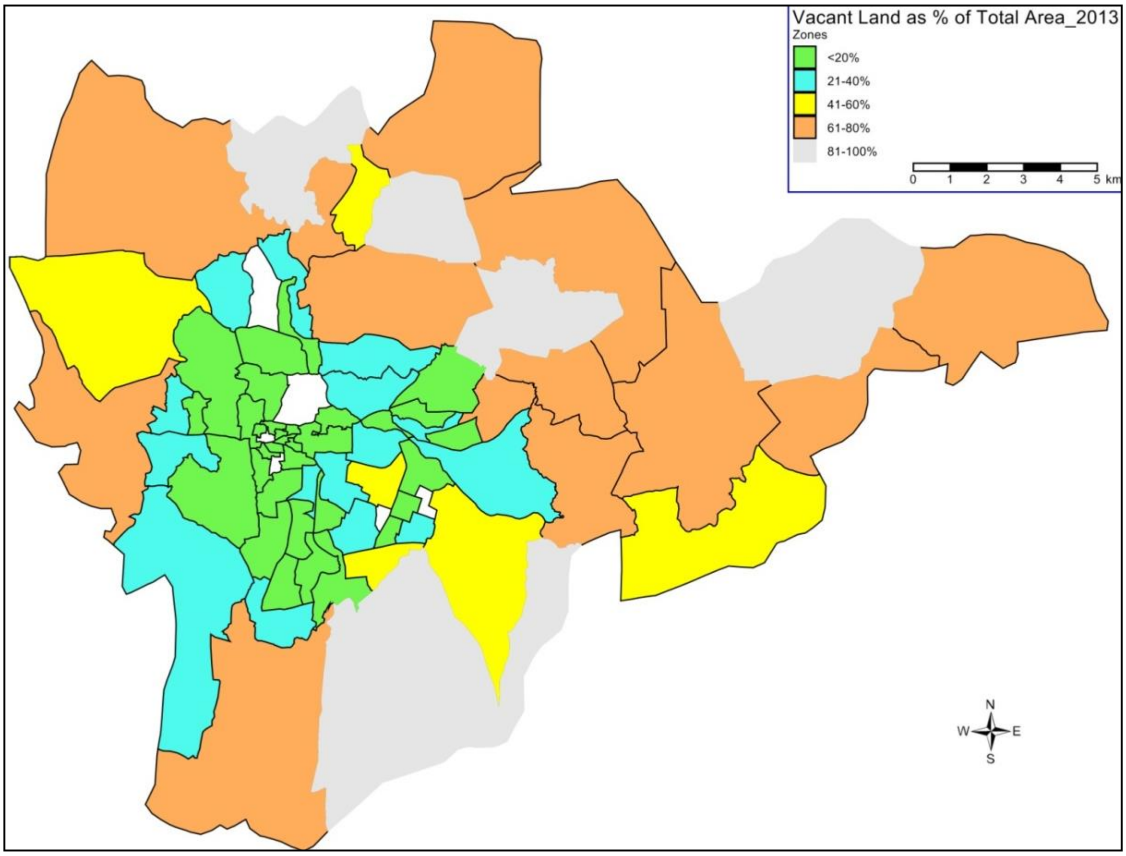

Figure 6-2: Vacant land use as percentage of total zone area for the base year

From the base year calibration and validation, it was observed that only 18 out of 80 zones produced intra-zonal trips more than 50 per cent of the total trips produced from that zone. Figure 6-3 shows the intra-zonal trips as a percentage of the total trips for the base year.

Further, under the BAU scenario many zones fall under completely residential land use, which encourages people to travel long distances to fulfil their day-to-day travel requirements to commercial spaces, educational and medical institutes, with their personalized vehicles and this is not desirable to achieve the low carbon strategy.

The revised Master Plan 2031 for Udaipur recommends a land use structure that increases the average trip length as the city grows. Figure 5- and Figure 5- show density decay from the CBD.

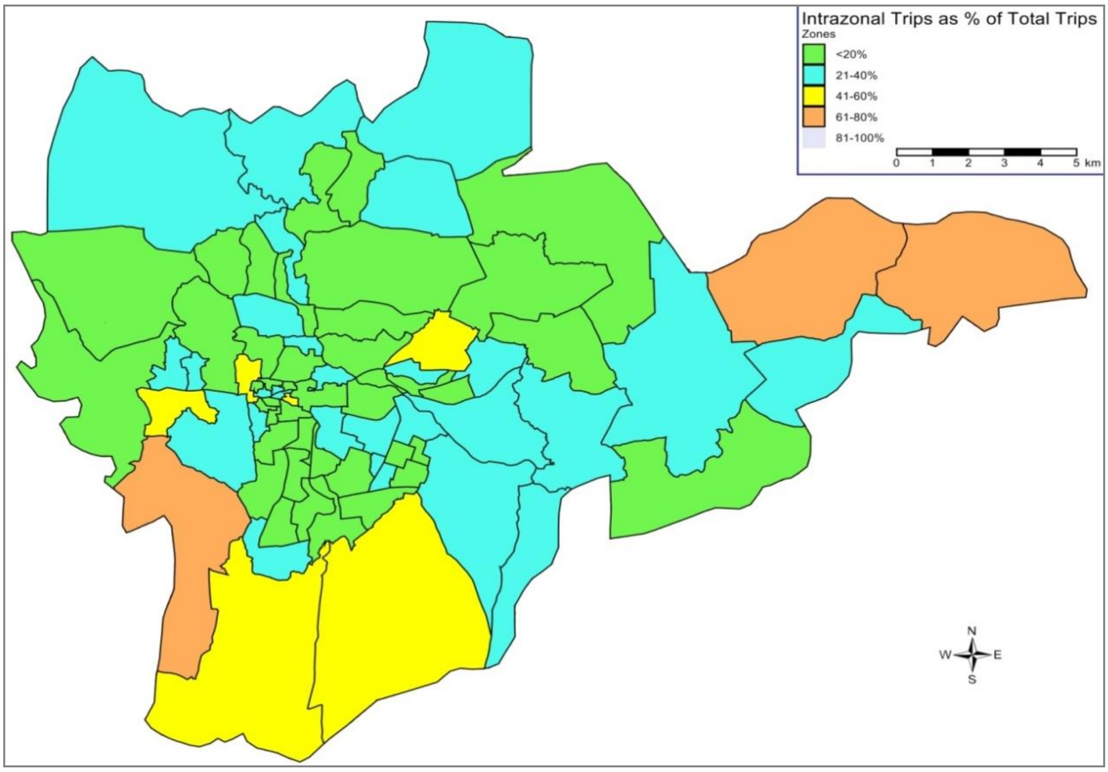

Figure 6-3: Intra-zonal trips as percentage of total trips for BAU scenario (2041)

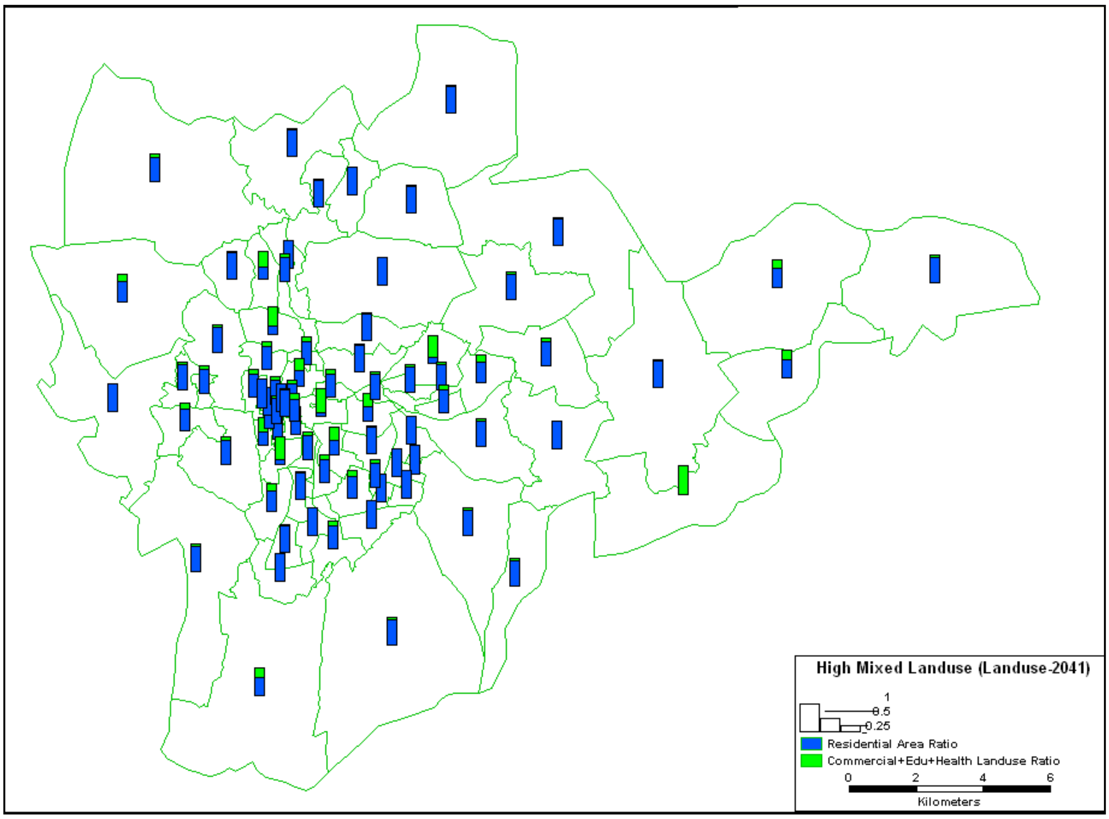

Figure 6-4: Intensity of mixed land use under land use scenario (2041)

Owing to the vacant land available in many zones, under the land use strategy, the intensity of mixed land use (residential with commercial/educational/health) is proposed to be increased. Figure 6-4 shows the map with bar charts for each zone, with the ratio of residential use with the commercial, educational and health land use facilities.

As a result of an increase in the mixed land use, the intra-zonal trips increase and Figure 6-6 shows the intra-zonal trips as a percentage of total trips for the year 2041 under the land use strategy. The percentage of intra-zonal trips of 40 zones became more than 50 per cent as compared to 18 zones in the BAU scenario.

In order to decrease automobile-dependency and provide travel options for those not owning cars, a self-contained neighbourhood is provided along the PT corridors.

Accordingly, under the land use scenario, it has been proposed to increase the residential density of those zones that fall within 500 metres' walking distance of the proposed trunk PT corridors (details of trunk PT corridors are discussed under 'Public transport strategy' in Section 6.3. Figure 6-7 provides a comparison map of residential density along trunk PT corridors under the BAU and land use scenarios for 2041.

This increased residential density would enable users to access PT routes within 10 minutes of walking.

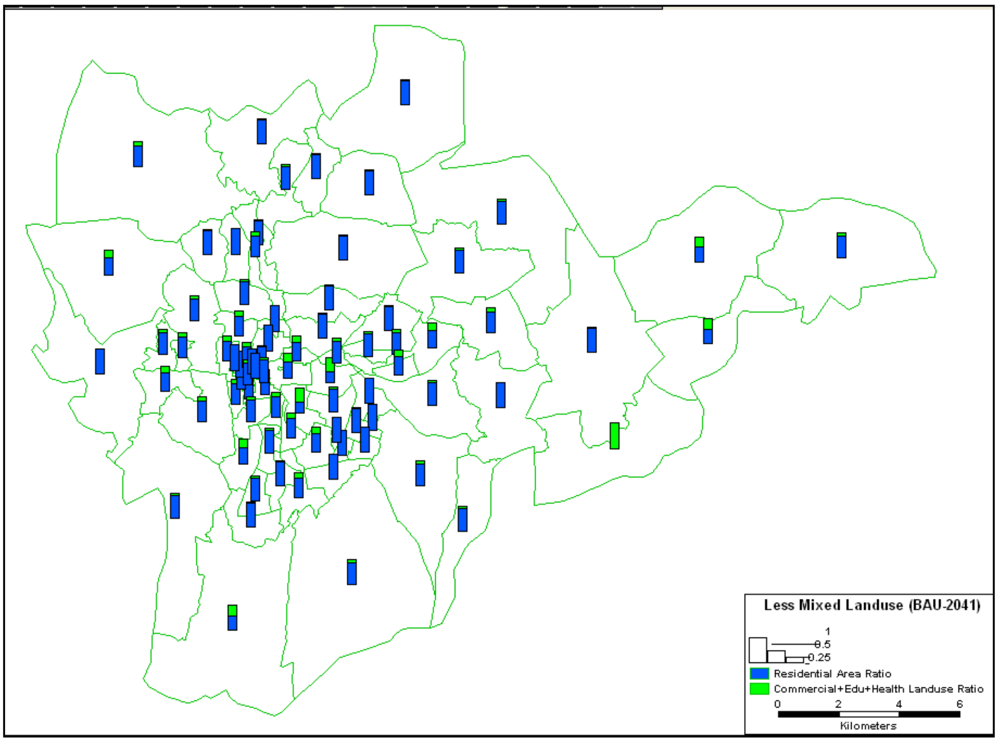

Figure 6-5: Intensity of mixed land use under BAU scenario (2041)

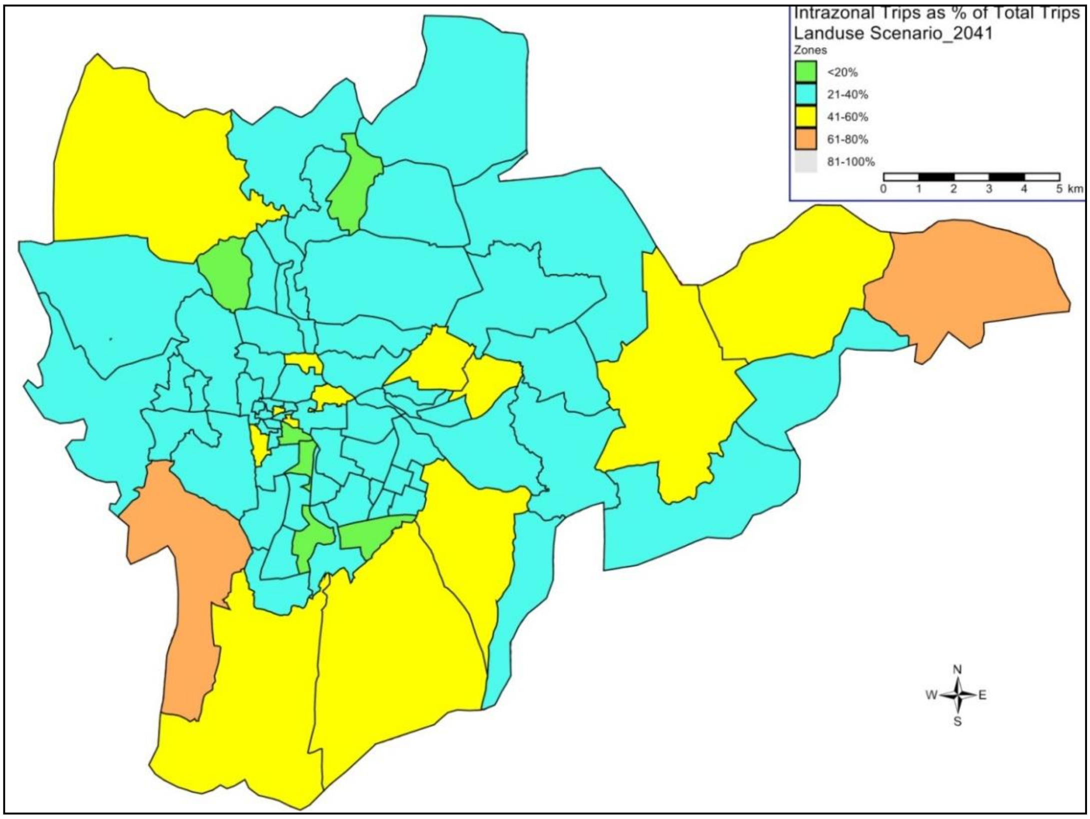

Figure 6-6: Percentage of intra-zonal trips under land use scenario (2041)

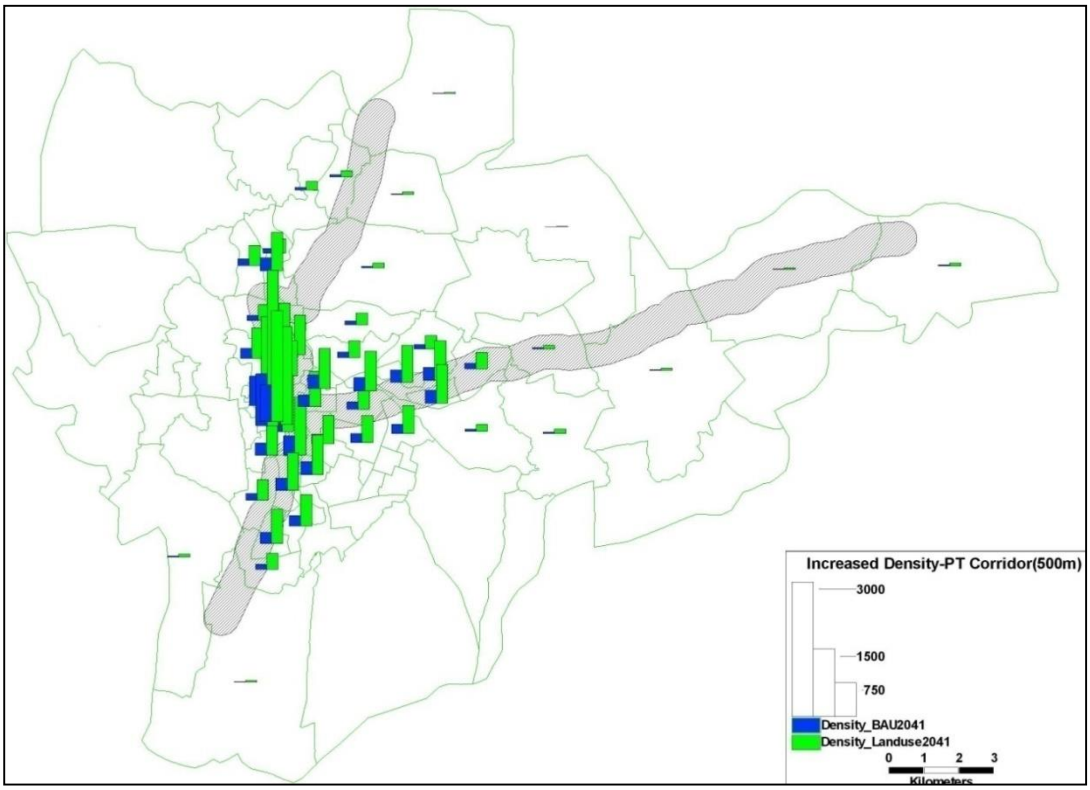

Figure 6-7: Trunk PT corridor and comparison of residential density in the BAU and land use scenarios (2041)

6.2.5 Outcomes of land use strategy

The outcomes of the land use scenario have been classified into two categories: mobility and accessibility results, and emission levels. These results are presented in the subsequent sections as follows.

6.2.5.1 Mobility and accessibility results for land use scenario

a. Modal shares

Table 6-1 compares the mode shares in the base year, BAU scenario (2041) and land use scenario (2041).

Table 6-1: Modal share comparison of BAU and land use scenarios

Modal share in %	Base year (2013)	BAU (2041)	Land use scenario (2041)
Walk	25%	20%	29%
Cycle	3%	2%	6%
Two-wheeler	47%	51%	41%
IPT	18%	21%	18%
Car	4%	4%	2%
PT	3%	2%	4%
Total	100%	100%	100%

b. Trip lengths

Table 6-2 compares the trip lengths in the base year, BAU scenario (2041) and land use scenario (2041).

Table 6-2: Trip length comparison of BAU and land use scenarios

Mode	Base year (2013)	BAU (2041)	Land use scenario (2041)
Walk	1.18	2.06	1.62
Cycle	2.37	3.65	3.13
Two-wheeler	5.54	5.92	5.56
IPT	4.52	5.55	5.24
Car	7.06	7.51	6.98
PT	-	5	5
Average	4.13	4.94	4.58

c. Increased density along PT corridors

The density of those zones where the trunk PT corridor is passing was increased. Figure 6-8 shows the comparison map of density along truck PT corridors under the BAU and land use scenarios for 2041.

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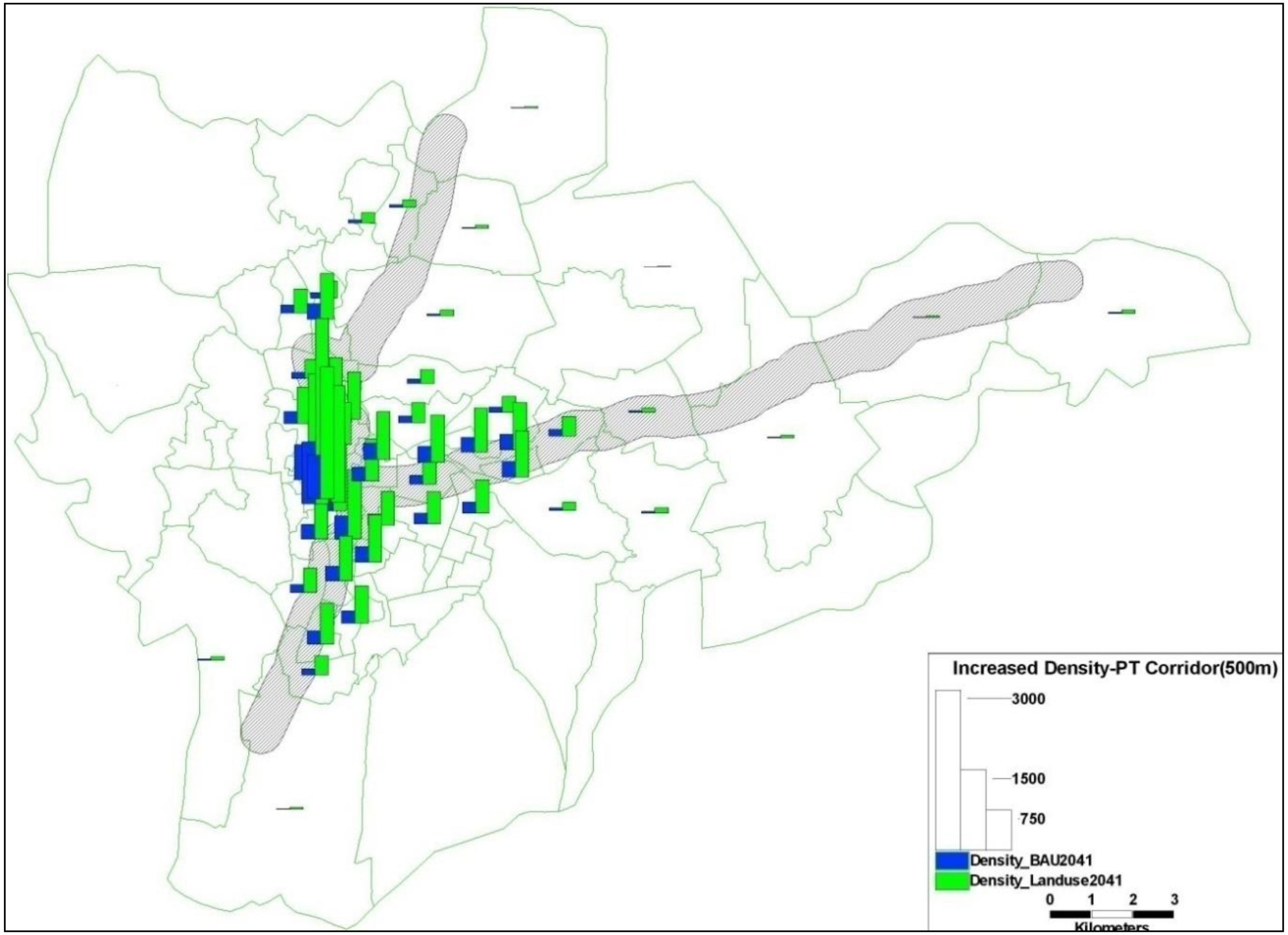

Figure 6-8: PT corridor and the comparison of density in BAU and land use scenarios (2041)

a. Increased intensity of mixed land use

As a result of this land use strategy the intensity of mixed land use was increased, and Figure 6-9 shows the map with bar charts for each zone, which gives the ratio of residential use with the commercial, educational and health land use facilities.

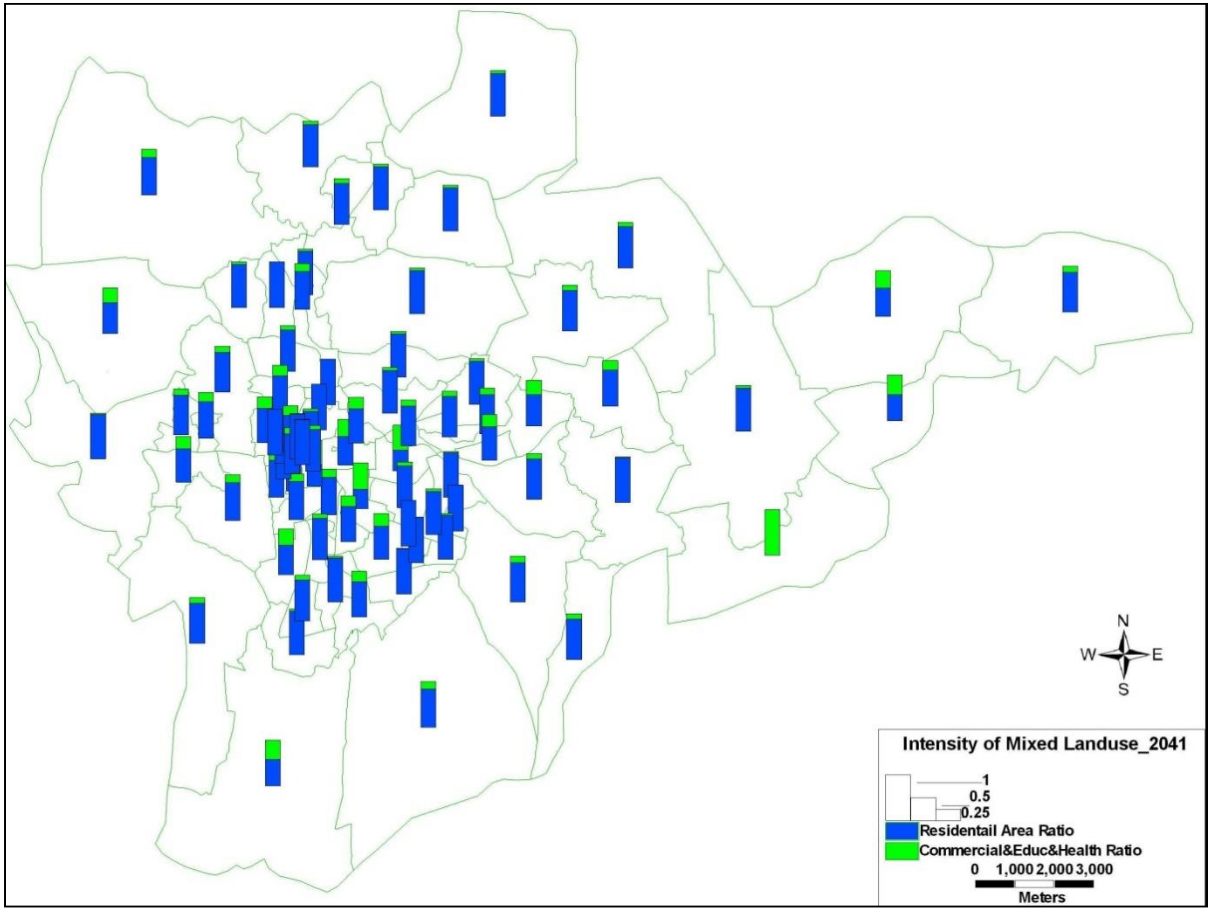

Figure 6-9: Intensity of mixed land use under land use scenario (2041)

d. Intra-zonal trips as percentage of total trips

As a result of the land use strategy, the percentage of intra-zonal trips of 40 zones exceeded 50 per cent, as compared to 18 zones in the BAU scenario. Figure 6-10 shows this change in intra-zonal trips percentage under the land use scenario.

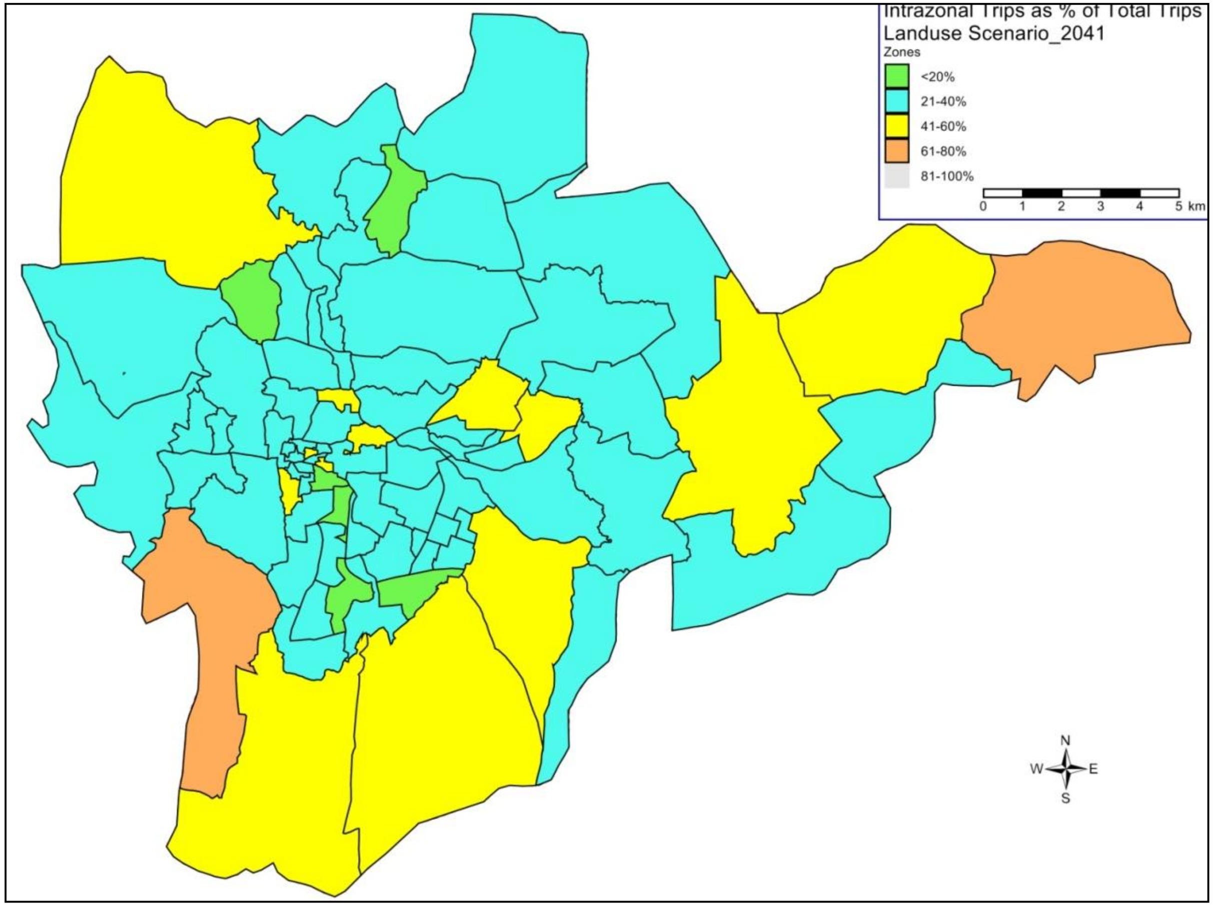

Figure 6-10: Percentage of intra-zonal trips under land-use scenario (2041)

e. V/C ratio and traffic flow pattern

Figure 6-11 and Figure 6-14 show the V/C ratio and flow pattern for the land use scenario. The relevant changes made under the land use scenario resulted in the following flow diagrams.

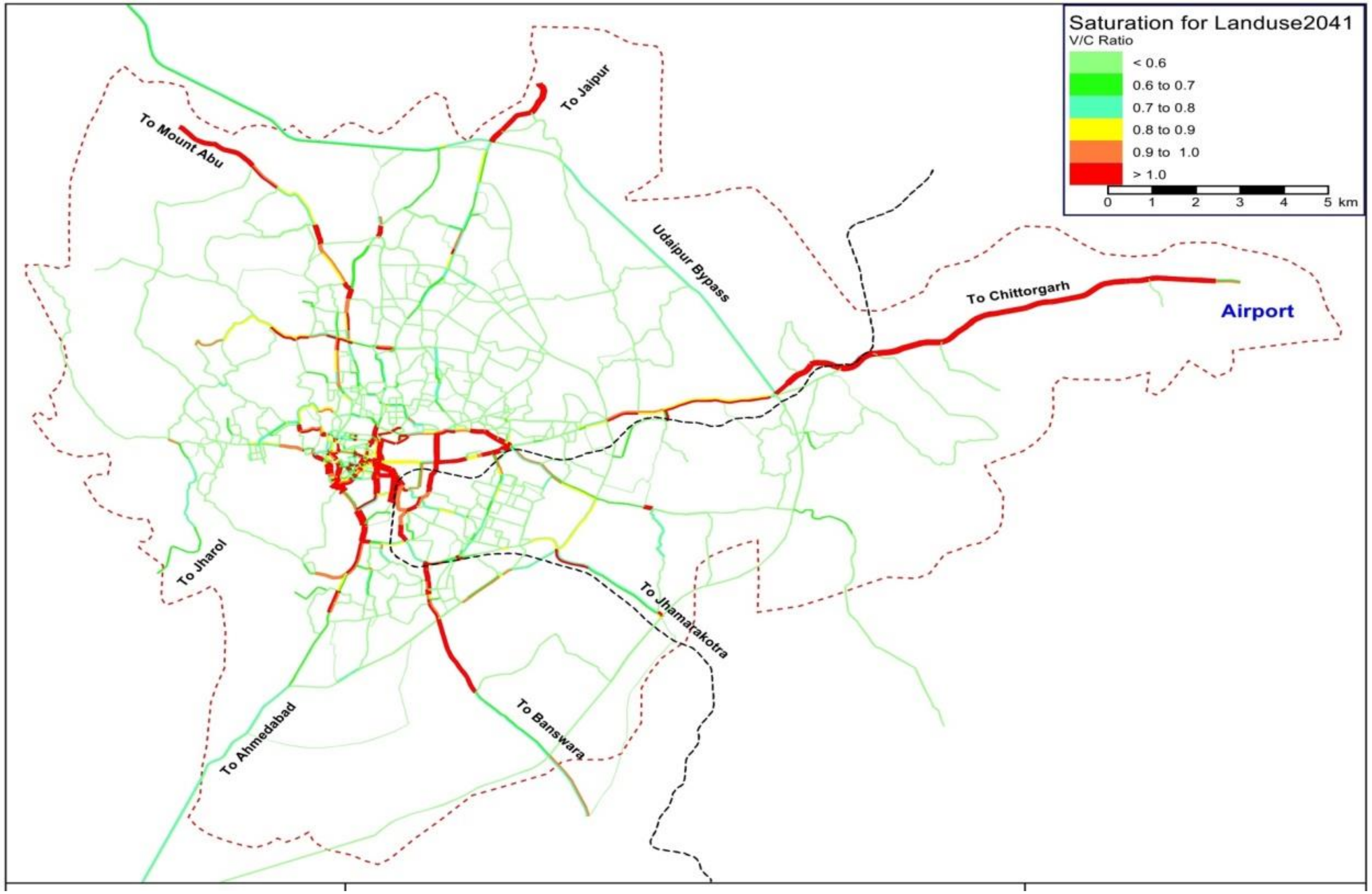

Figure 6-11: V/C ratio under land use scenario (2041)

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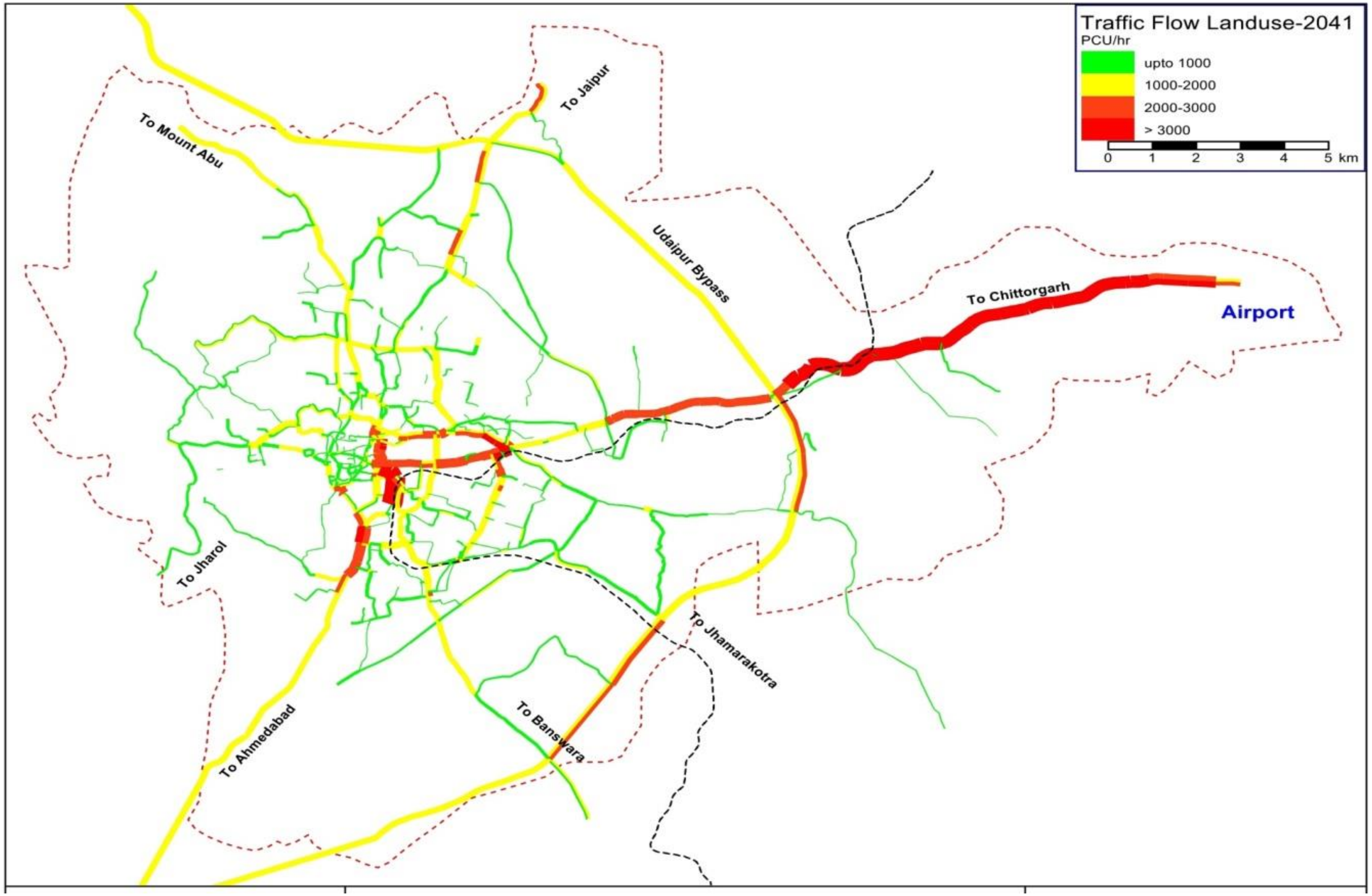

Figure 6-12: Traffic flow (PCU/hr) under land use scenario (2041)

f. Difference plots and kernel density

The difference plot is an easy graphical representation of flow pattern under different alternate scenarios. The user equilibrium assignment is based on Wardrop's first principle, which states that no driver can unilaterally reduce his/her travel costs by shifting to another route. Hence, under each scenario, the link flow is different. The best alternative scenario can be decided by observing the different plots of each alternate scenario and the BAU scenario. Figure 6-12 shows the difference plots comparing the land-use and BAU scenarios.

Kernel density is defined as the ratio of the length of the road network in a particular zone versus the area of the zone. The units for kernel density are km/km^2. This kernel density indicates the length of roads available in a particular area. Figure 6-14 shows a kernel density map under the land use scenario 2041. The average kernel density value for the land use scenario is 5.45km/km^2.

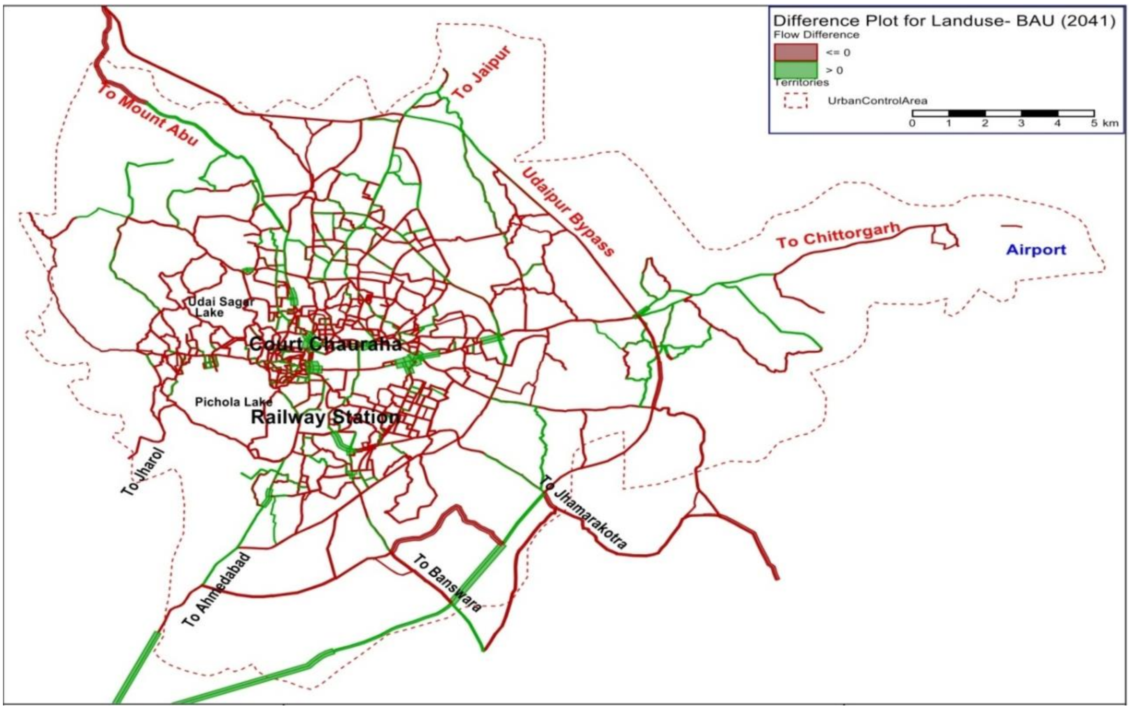

Figure 6-13: Traffic flow difference plot between land use and BAU scenarios (2041)

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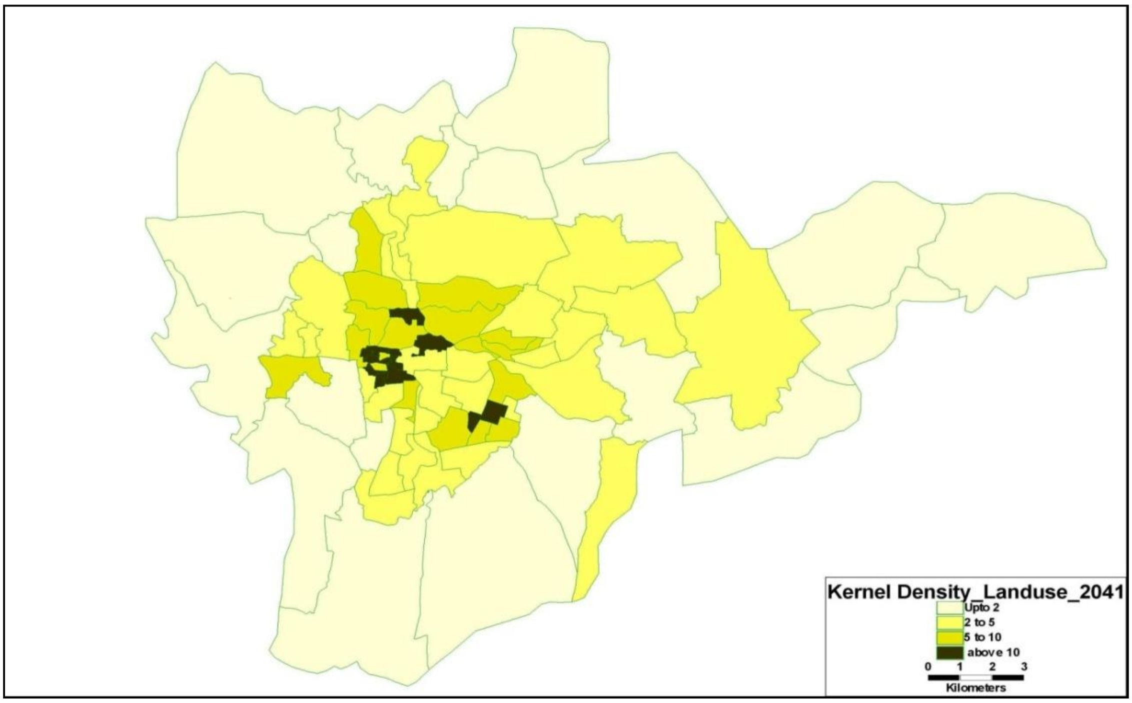

Figure 6-14: Kernel density for land use scenario (2041)

6.2.5.1 Emission level

Table 6-3 shows the emission level.

Table 6-3: Land use scenario emission levels

Emission level NO_2 tons annually	Emission Level CO_2 million tons annually	Emission level of PM10 tons annually	Emission level of SO_2 tons annually	Emission level of CO tons annually
57,597	32	16,696	805	617,936

The overall outcomes in terms of modal share, trip lengths, etc., are shown in Table 6-4. The modal share of walking has increased by 9 per cent as compared to the BAU scenario, while the trip length has decreased from 2.06 to 1.62 km.

Table 6-4: Outcomes of land use scenario as compared to base year and BAU scenario

Indicator/Values	Base Year (2013)	BAU (2041)	Land-use Intervention Scenario (2041)
Modal Share in %			
Modal Share of Walk	25%	20%	29%
Modal Share of Cycle	3%	2%	6%
Modal Share of Two Wheeler	48%	51%	41%
Modal Share of IPT	18%	22%	18%
Modal Share of Car	4%	4%	2%

Indicator/Values	Base Year (2013)	BAU (2041)	Land-use Intervention Scenario (2041)
Modal Share of PT	3%	2%	4%
Trip Length (Kms)			
Walk	1.18	2.06	1.62
Cycle	2.37	3.65	3.13
Two Wheeler	5.54	5.92	5.56
IPT	4.52	5.55	5.24
Car	7.06	7.51	6.98
PT	-	5	5
Accessibility			
% of HH within 10 minutes of walking to access PT (IPT for Base Year)	69%	60%	80%
LOS of PT facilities as per MoUD SLB Handbook	4	4	-
Land-use Mix Intensity			
Increase in the % of Intra-Zonal Trips as compared to Base Year (Base year value is 19%)	-	16%	68%
Safety to use NMT			
Walk	7.50%	7.50%	50%
Cycle	7%	7%	55%
Total Motorized Vehicle Kilometers (Million Kms)	880.5	2559.9	2159.6
LOS of NMT facilities as per MoUD SLB Handbook	4	4	3
Congestion Level			
Road Length (KM) with value of V/C ratio is equal to 1 or more	-	26%	14%

With the interventions suggested in the land use scenario, it was observed that:

- *Intra-zonal trips increase from 16 per cent in the BAU scenario to 68 per cent in the land use scenario*
- *Average trip length for all modes reduced approximately by 11 per cent in the land use scenario as compared to the BAU scenario*
- *High density compact development*
- *The PT share would increase to 4 per cent in the land use scenario as compared to the BAU scenario*
- *Due to the high density compact development, the VKT is reduced by 18 per cent in the land use development as compared to the BAU scenario.*
- *The overall emissions are reduced by 6 per cent in the land use scenario as compared to the BAU scenario.*

6.2.6 Conclusions of urban structure scenario

With the infill and redevelopment of the vacant lands, as well as the encouragement of new developments along the proposed PT corridors/existing IPT corridors in Udaipur as part of the urban structure (land use) scenario, the growth of the city can be made more compact and uniform in general. Moreover, the existing residential neighbourhood can be made more self-reliant and sustainable in particular, which is evident from the fact that there has been an increase in the intra-zonal trips (predominantly NMT trips) from 16 per cent in the BAU scenario to 68 per cent in the land use scenario, and a comparatively reduced average trip length (ATL). It is observed that the average trip lengths for all the modes reduced approximately by 11 per cent as compared to the BAU scenario. With the encouragement of high density compact development, 80 per cent of households could be made within 10 minutes of walking from existing IPT routes or proposed PT corridors. As a result of this, the share of public transport can increase up to 4 per cent from 2 per cent for the same BAU level of public transport intervention measures to be undertaken by the relevant city authorities.

The accessibility to the existing IPT or proposed public transport has increased due to a higher concentration of mixed activities along the proposed public transport corridors, with improvement in last mile connectivity. However, the motorized vehicle kilometres are reduced only by 18 per cent as compared to the BAU scenario, which is due to the fact that there has been improvement in first mile and last mile connectivity only. Conversely, the main line haul trips would still be characterized by existing IPT and proposed public transport like in the BAU scenario only, as there is little or no focus for public transport in the proposed BAU intervention measures. As there has been a marginal change between the BAU scenario and land use scenario in terms of motorized vehicle kilometres travelled, this scenario reduces emissions by 6 per cent only. However, the land use scenario could be a more judicious choice compared to the BAU scenario for achieving low-carbon transport development and lower emission levels, reduced ATL and a comparatively higher modal share in favour of PT and NMT.

6.3 Public Transit Strategy for Low-Carbon Scenario

Over the past decade it has been observed that the cities have been growing beyond their existing jurisdiction, and a large category of the city population are shifting to these areas from the city centre. Non-motorized transport can fulfil the travel needs between shorter distances, but longer distances can be covered by a sustainable mass transit system either by bus or rail. Since Udaipur is a medium-sized city, the need of the city can be well catered by introducing an organized bus-based public transport system. Due to the absence of a reliable PT system in Udaipur, the city has been witnessing an increase in private vehicle ownership.

Under this scenario, focus has been towards strengthening the existing intermediate public transport (IPT), and introducing an organized PT system in a gradual phase-wise manner in sync with the increase in anticipated travel demand. The inputs for the travel demand model to assess the public transit strategy are as mentioned in the following sections.

6.3.1 Objectives

- Managing the existing IPT system with fixed routes, schedules and fare structure
- Phase-wise introduction of new bus-based PT system
- Provide accessibility and integration to the bus system with other modes of transport
- Provide reliability of PT system using advanced ITS facilities
- Provide affordable PT system for all socio-economic groups.

6.3.2 Detailed strategies

The inputs for the travel demand model to assess the public transit strategy included the BAU scenario, along with strategy-specific inputs. The strategy specific inputs are as follows:

1. Functionalization of special purpose vehicle (SPV)
2. Re-organization of existing IPT Systems
3. Introduction of bus-based public transport system
4. Development of support infrastructure for bus system
5. Depots and terminals

6. Development of bus shelters
7. Implementation of ITS for improving reliability of public transport
8. Promotion of public participation and campaigning for the mass awareness programme
9. Encouraging private sector in promotion of public transport.

Functionalization of the special purpose vehicle (SPV): Udaipur City Transport Services Limited (UCTSL), is a company formed by Udaipur Municipal Corporation (UMC) to monitor, manage and regulate the city bus service in the city. With the introduction of an organised public transport system under an apex body like UCTSL (the SPV for the city bus service under the proposed umbrella organisation of the Unified Metropolitan Transport Authority) for the improved service coverage and supply, and rationalisation and modernisation of the existing IPT system, it is expected that the sustainability of public transport would improve along with an improvement in mobility and accessibility. A detailed description of the strategy-specific inputs is provided below. The SPV will be responsible for operation and maintenance of the IPT and city bus service under the PPP framework, while the role of a proposed Unified Metropolitan Transport Authority (UMTA) will be planning, monitoring, coordinating and controlling, regulating and managing urban transport-related projects and policies for the city of Udaipur. The SPV will provide Secretarial and technical support to the UMTA. The functions of UMTA are discussed in Chapter 8.

a. *Re-organizing the existing IPT system*

Currently, the IPT system in Udaipur is not organized properly, the existing system consists of old, polluting and unsafe shared three-wheeler auto rickshaws, which compete with each other for passengers. Although Udaipur Regional Transport Office has devised 25 fixed routes for operations, the IPT operators do not follow the fixed routes, resulting in a chaotic scenario created by shared auto rickshaws. The existing IPT vehicles are also major sources of emissions, as these vehicles are old and do not comply with the current emission norms.

In order to access the existing IPT system, many users need to walk more than 10 minutes (>500m). Other than the zones adjacent to CBD, many zones are inaccessible for IPT. This situation is pictorially shown in Figure 6-15.

In order to manage and regulate the IPT system in Udaipur, it is proposed that the IPT systems be organized with fixed routes, frequencies and fare structure, along with replacing old shared three-wheeler auto rickshaws with modern Bharat IV emission norm four-wheeler vehicles. It is proposed that IPT will operate along the notified routes to increase accessibility. It is estimated that approximately 1,803 vehicles will require replacement on 25 routes covering a total route length of 231.5km. This will increase IPT accessibility and decrease carbon emissions. The Figure below represents the proposed IPT routes and its accessibility.

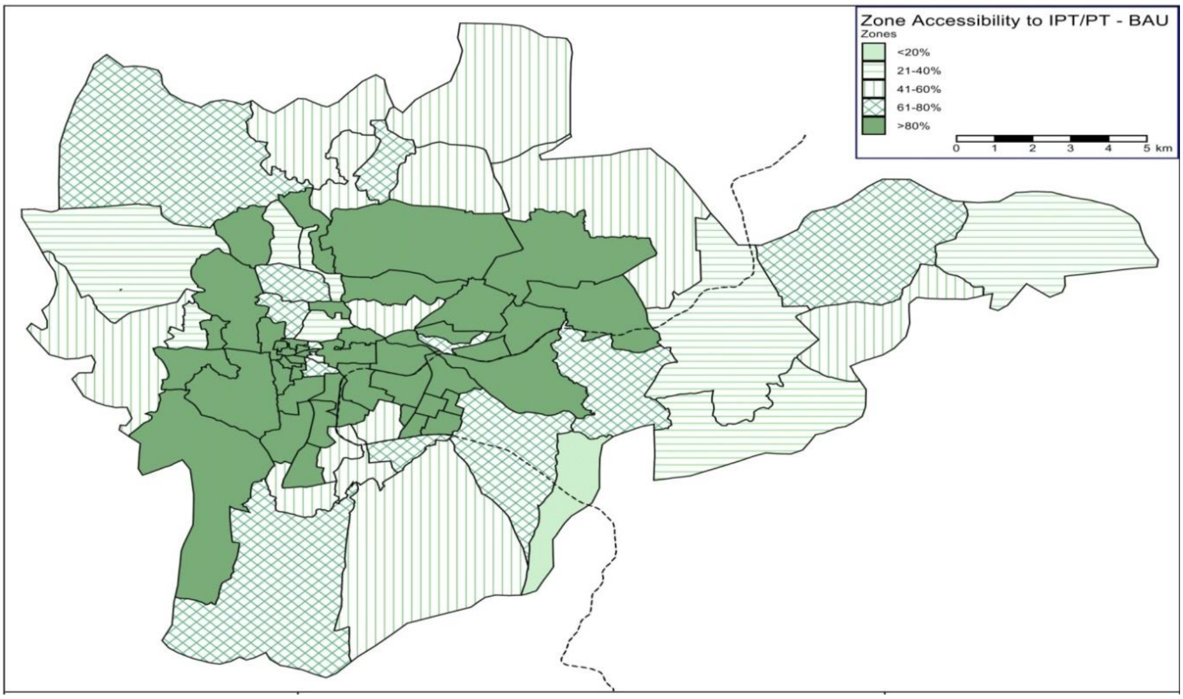

Figure 6-15: Existing IPT accessibility (base year 2013)

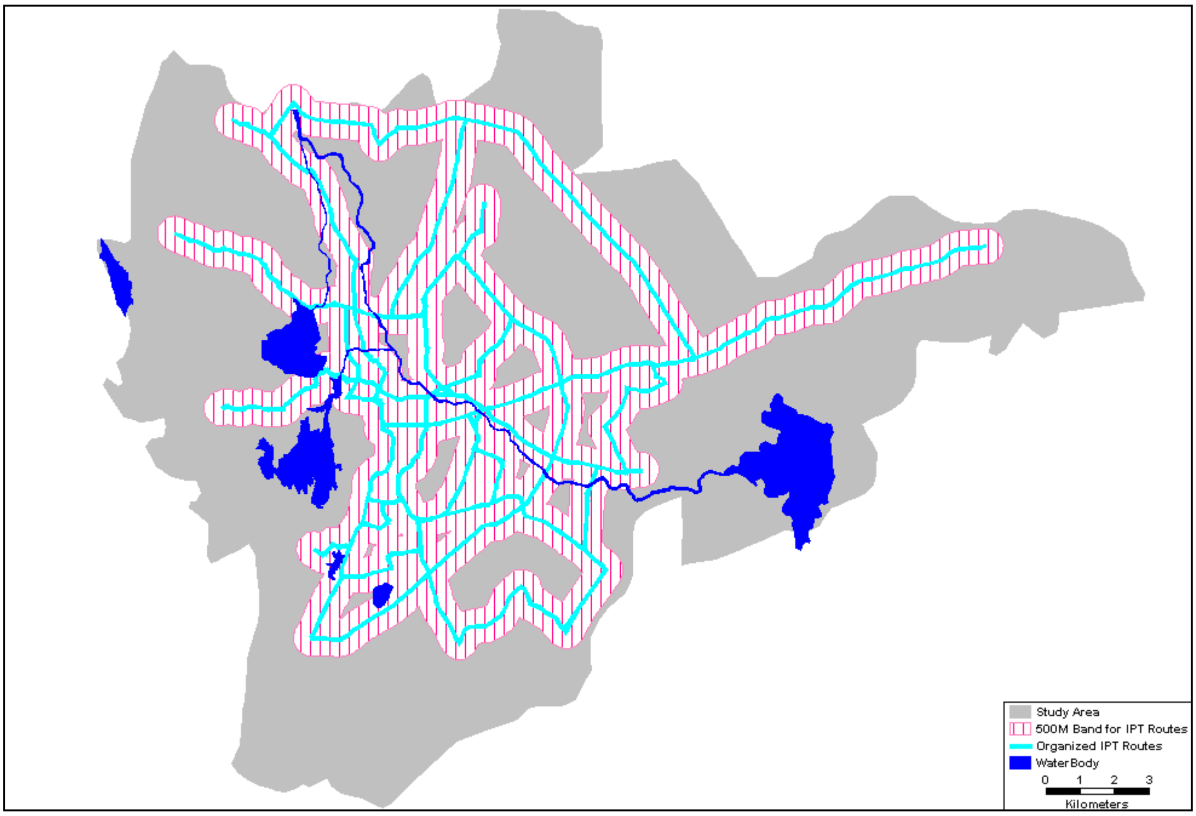

Figure 6-16: Proposed IPT routes and their accessibility

b. Introduction of bus-based public transport system

As demand will grow over time, the IPT system (with capacity of carrying 7 to 12 passengers) will not be able to cater to the growing travel demand in Udaipur. The existing traffic flow pattern shows Airport Road from Surajpol to the Airport and parts of Ahmedabad Road carries heavy traffic of more than 1000 PCUs in the peak hour per direction, and from the main arterial road of Udaipur city, which connects all the major activities in the city educational institutions and industrial areas, etc. Hence, these two arterials are identified as trunk public transport corridors under the public transport strategy.

It has been proposed to operate a city bus service with a proposed headway of 10 to 15 minutes in the initial stage of development, and five minutes by the year 2041 as the demand grows. All the new buses will be as per urban bus specifications and as per the latest guidelines by the Ministry of Urban Development (MoUD), Government of India. The trunk PT corridors are shown in the Figure below. The route length of proposed PT trunk route is 45km.

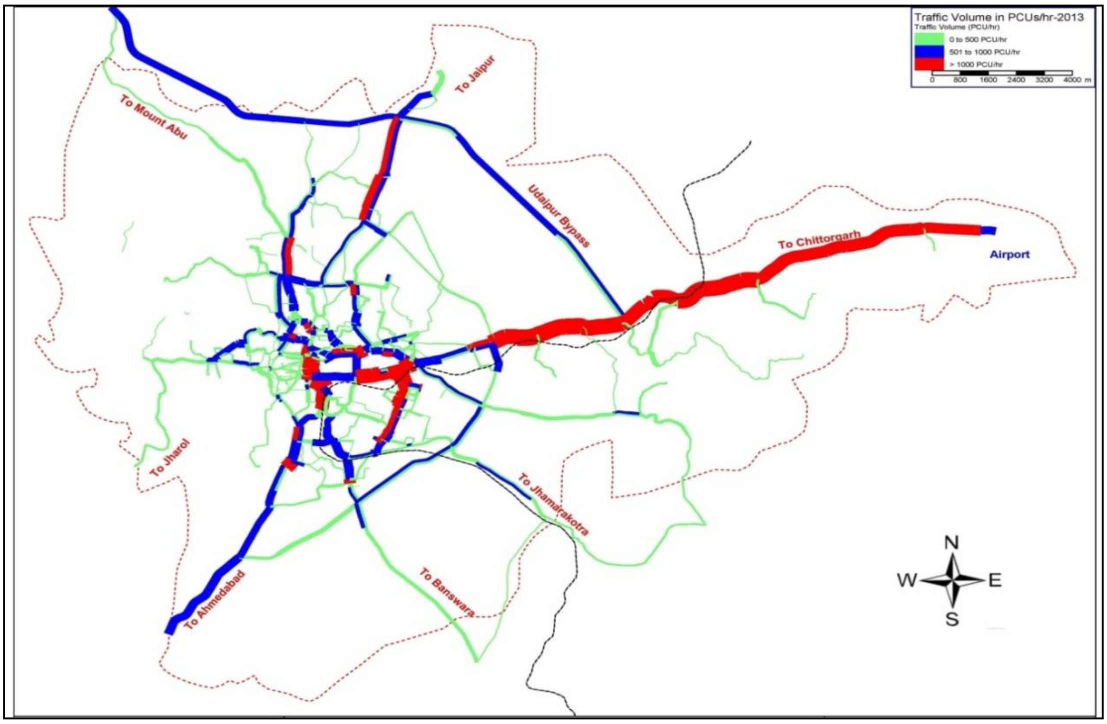

Figure 6-17: Traffic flow (PCU/hr) for base year (2013)

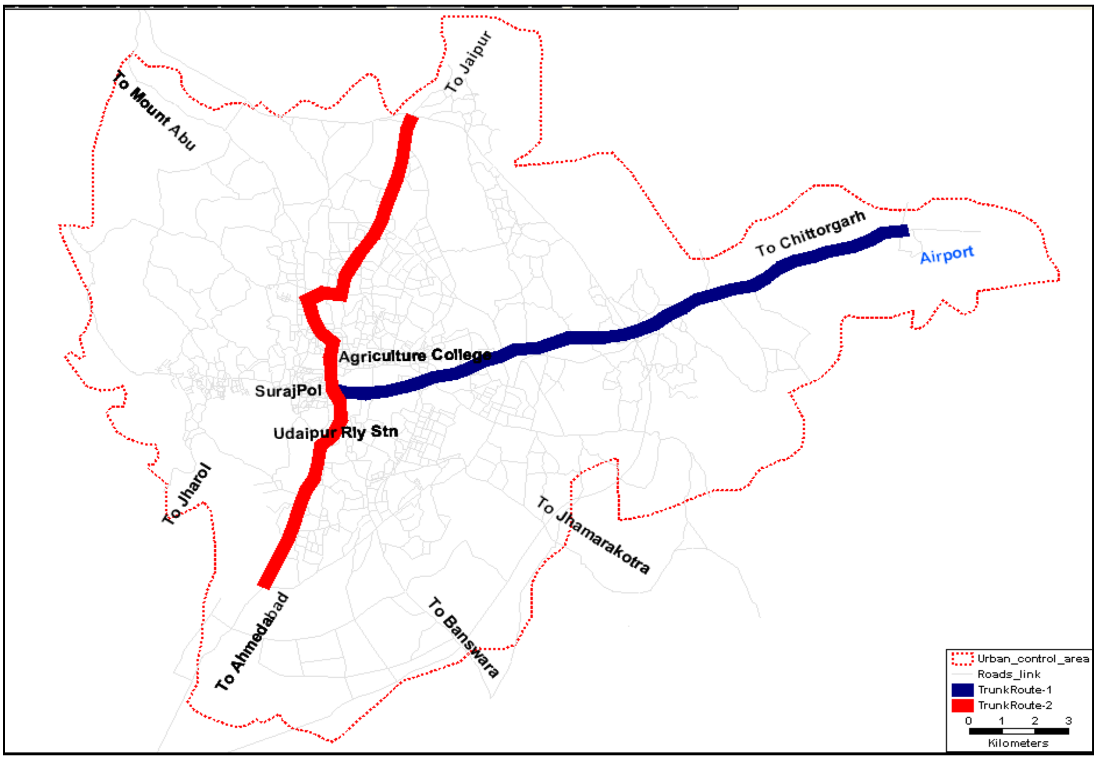

Figure 6-18: Proposed trunk bus-based PT corridors

High frequency trunk routes will be sustainable only with a good feeder service. If the bus service is operated only on trunk routes, zones far off from these routes will not be accessible to the bus system. Hence, different feeder routes are identified to feed the trunk routes with the objective of catering to demand and connectivity.
Seven feeder routes are proposed for Udaipur under the PT strategy. These feeder routes will be operated with headway of 15 minutes. The route length of feeder routes is 133km. The identified bus routes are given in Table 6-5.

Table 6-5: Identified bus routes for Udaipur

Sl. No.	Route type	Route details	Route length (km)
1	Trunk Route 1	Suraj Pol to Moti Khera near Airport	18.5
2	Trunk Route 2	Arihant Tiles and Marbles to Shankar filling station on Ahmedabad Road	18
3	Feeder Route 1	Loyara Village to St. Maris High School	21.7
4	Feeder Route 2	Rampura Circle to Kanpur village	13.8
5	Feeder Route 3	Saras Dairy (Ahmedabad Road) to Bhairav Garh Resort	15.7
6	Feeder Route 4	Animal Aid near Badi talv to Shankar filling station on Ahmedabad Road	26.1
7	Feeder Route 5	Sajjan Nagar to RTO office	11.3

Sl. No.	Route type	Route details	Route length (km)
8	Feeder Route 6	Fatehpura to Aravalli Management Institute	15.5
9	Feeder Route 7	Darshan Dental College to St. Maris High School	40.5
Total			181.1

Introduction of bus-based public transport system with trunk and feeder bus routes has increased the accessibility to the PT system as shown in Figure 6-19.

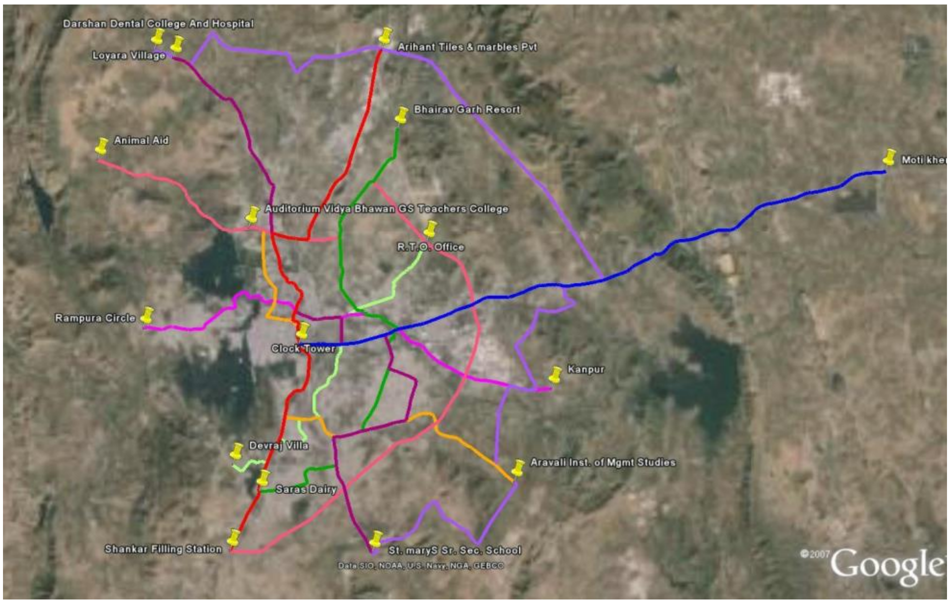

Figure 6-19: Identified bus routes for Udaipur (2041)

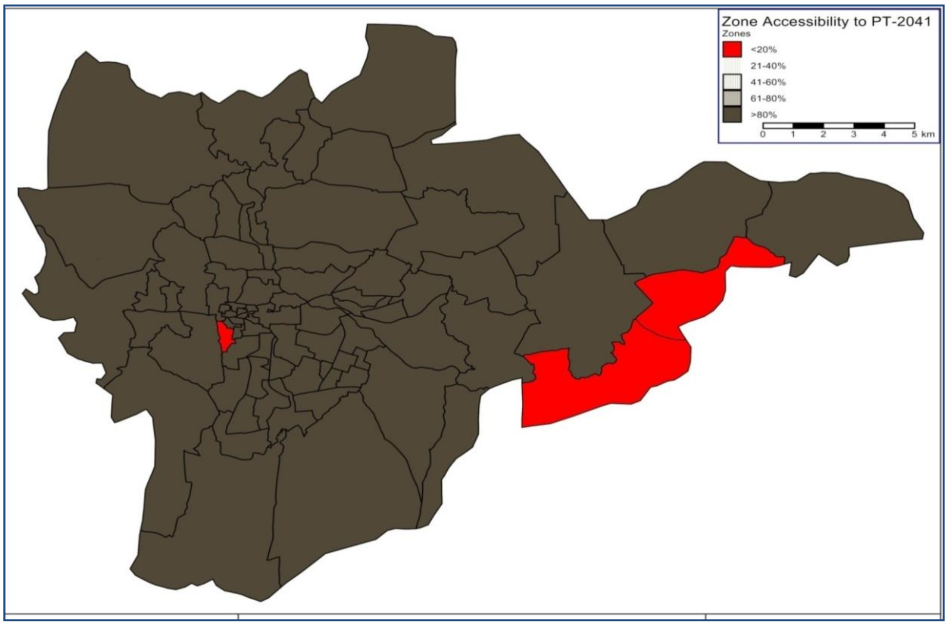

Figure 6-20: Zone map showing PT accessibility in Udaipur (2041)

c. Development of support infrastructure for bus system

i. Depots and terminals

Support infrastructure for city bus services such as bus shelters, depots, terminals and ITS facilities are essential for any city bus service to operate successfully. Without these support facilities, the system is incomplete and will fail to attract commuters. Bus depots not only serve as idle parking facilities for buses, but also houses facilities for day-to-day servicing, repair and maintenance of buses besides providing space for administrative and operations planning, monitoring and control activities. Bus terminals and depots are proposed in Udaipur as mentioned in Table 6-6. These depots and terminals and identified as per the availability of land and distributed across Udaipur to decrease the dead mileage. Components of the standard depot are discussed in Annexure 4).

Table 6-6: Proposed bus depot and terminals under the PT strategy

Sl. No.	Proposal	Road	Location	Area (acres)
1	Bus Depot cum Terminal	Nadwara Road	Near Highway crossing	35.4
2	Bus Terminal	Ahmedabad Road	Near Roadways workshop	2.5
3	Bus Depot cum Terminal	Ahmedabad Road		19.0
4	Bus Terminal	Jaisamand Road	Near Savina Kheda	3.3
5	Bus Depot cum Terminal	Chittorgarh Road	Near Pratapnagar Bypass Junction	13.3
6	Bus Terminal	Seesarama Road	Near Seesarama Junction	2.0

ii. Development of bus shelters

Bus stops are the most frequently used elements of transit by the public. The public transport strategy proposes that these bus stops should be enabled with pedestrian facilities and parking facility for IPT modes to provide interchange facilities and improve the mobility of the city. Construction of bus shelters is proposed with the provision of:

- An appropriately designed bus bay(s) for stoppage of buses and with platform for convenient boarding and alighting of commuters, including those with disabilities
- Covered roof
- Proper sitting space for passengers
- Adequate space for displaying passenger-oriented information

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- Suitable space for display of commercial hoardings to generate revenue
- An area to house telecommunication gadgets for vehicle tracking, etc.
- A sturdy structure to support the above
- Space for easy ingress and egress of commuters from the bus stops.

It is proposed that there should be a standard bus stop at every 500m on all the identified bus routes in Udaipur. Approximately 360 bus shelters have to be constructed in Udaipur (considering both sides of the road for the benefit of bus users by 2041.

d. Implementation of ITS for improving reliability of public transport

Udaipur city lacks a history of an organized public transport system, and therefore the city has been experiencing mushrooming growth of IPT and private modes.

In order to promote public transport in general and a city bus service in particular, improving the quality of service, efficiency, reliability and safety is of utmost importance in creating wider acceptance of the service. Installation of ITS will improve the efficiency, reliability, and safety of the city bus service, which will add value to the service and thereby contribute to an increase in ridership. The LCMP for Udaipur has a proposed phase-wise installation of ITS for improving the quality of the city bus service and to promote public transport (detailed in Annexure 4).

1. Passenger information system (PIS) at all bus stops
2. Central control facility
3. Fare collection system
4. Onboard ticket vending and verification.

e. Promoting public participation and campaigning for the mass awareness programme

For successful implementation of any transport project in general and public transport project in particular, it is necessary to promote public awareness and create a sense of public ownership of the project. It is necessary to evolve an outreach and education strategy for public transport. The outreach and education goals need to be defined at the planning stage of the public transport strategy itself to focus the efforts of the project implementation team. To secure the support of the public for the public transport facilities and obtain acceptance thereof, the outreach and education goals are defined in Annexure 4.

f. Encouraging the private sector in promoting public transport

Traditionally, the responsibility of providing public transport lies with the Government, being financed and operated using resources from taxes and various levies. Over the years, experience has shown that important urban utility services like urban transport are controlled by multiple institutions resulting in a fragmentation of functional responsibilities and large scale inefficiencies in service delivery. In order to improve the quality of service delivery of public transport and to effectively infuse and utilize private funding for supplying public transport, participation of private players should be encouraged through adopting various Public Private Partnership (PPP) models.

6.3.3 Outcomes of PT scenario

The outcomes of the PT scenario have been classified into two categories: mobility and accessibility results, and emission levels. These results are presented in the subsequent sections as follows:

6.3.3.1 Mobility and accessibility results for the PT scenario

a. Modal shares

Table 6-7 compares the mode shares of the base year, BAU scenario (2041) and PT scenario (2041).

Table 6-7: Modal share comparison of base year and PT scenarios

Modal share	Base year (2013)	BAU (2041)	PT scenario (2041)
Walk	25%	20%	27%
Cycle	3%	2%	9%
Two-wheeler	47%	51%	21%
IPT	18%	21%	12%
Car	4%	4%	1%
PT	3%	2%	30%
Total	100%	100%	100%

b. Trip lengths

Table 6-8 compares the average trip lengths of the base year, BAU scenario (2041) and PT scenario (2041).

Table 6-8: Trip length comparison of BAU and land use scenarios

Mode	Base year (2013)	BAU (2041)	PT scenario (2041)
Walk	1.18	2.06	1.78
Cycle	2.37	3.65	3.35
Two-wheeler	5.54	5.92	5.63
IPT	4.52	5.55	4.98
Car	7.06	7.51	7.77
PT	-	5.00	5.75
Average	4.13	4.94	4.87

c. V/C ratio, traffic flow pattern and difference plot:

The results under the PT scenario are presented in Figure 6-21 to Figure 6-25.

d. ***Kernel density:***

Kernel density is defined as the ratio of the length of the road network in a particular zone versus the area of the zone. The units for kernel density are km/km^2. This kernel density indicates the length of roads available in a particular area. The average kernel density value for the PT scenario is $5.45 km/km^2$. Figure 6-25 shows the kernel density map for the PT Scenario 2041.

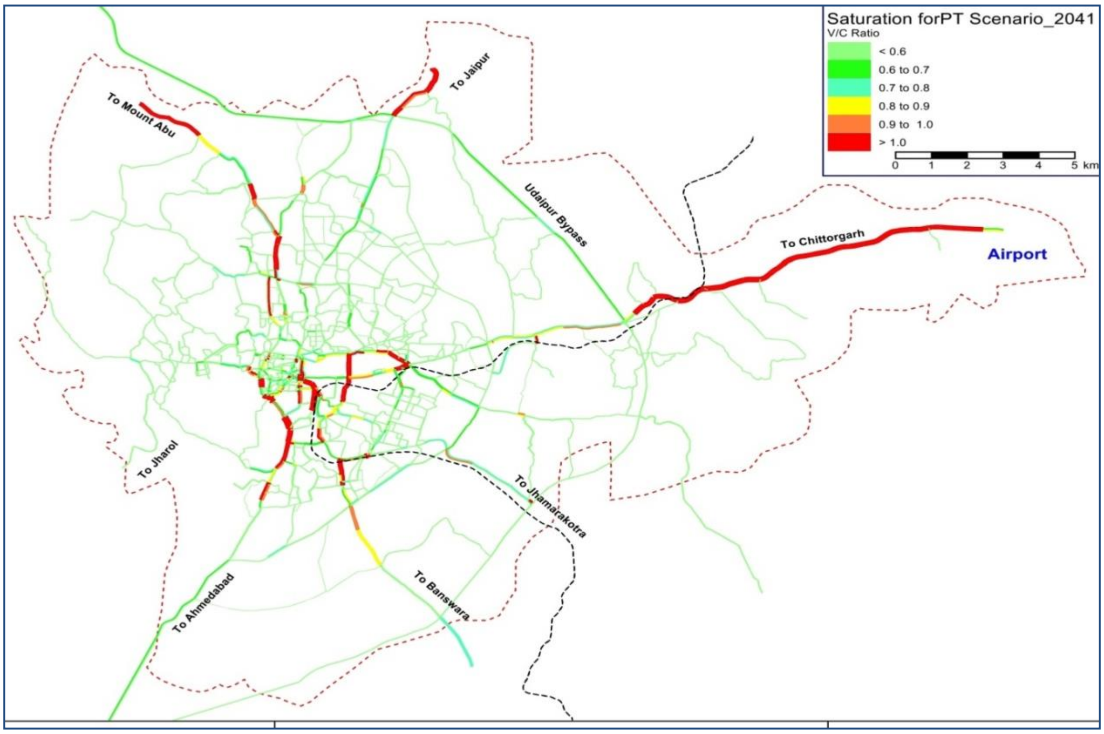

Figure 6-21: V/C ratio under PT Scenario (2041)

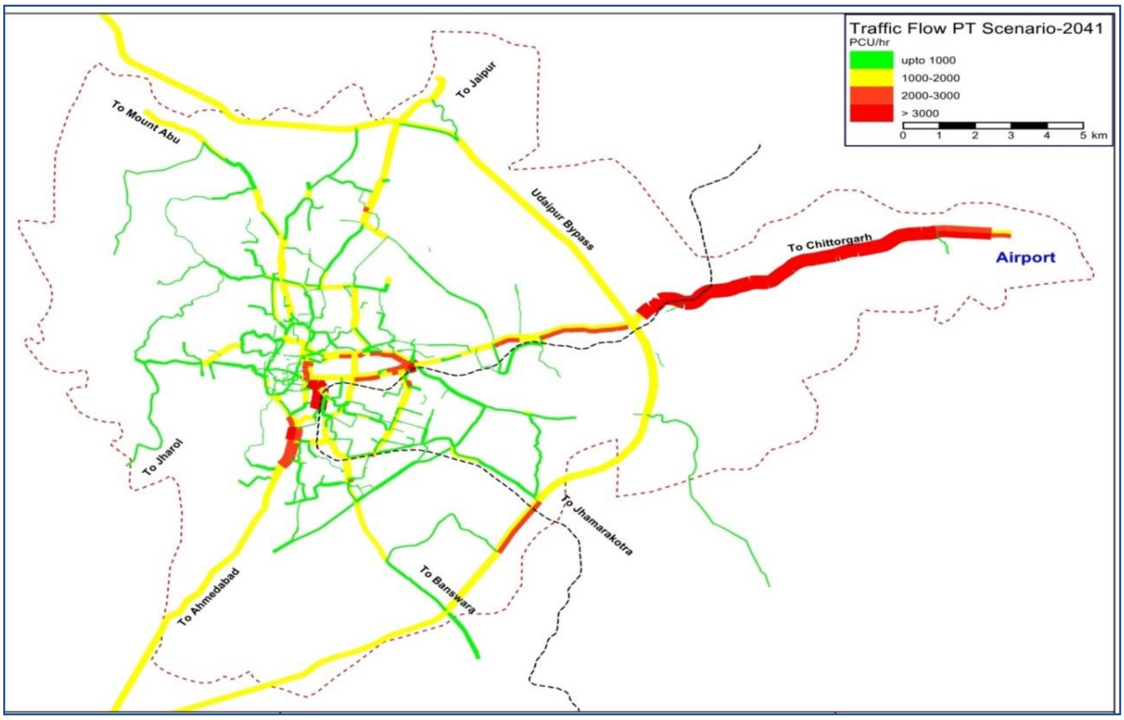

Figure 6-22: Traffic flow (PCU/hr) under PT scenario (2041)

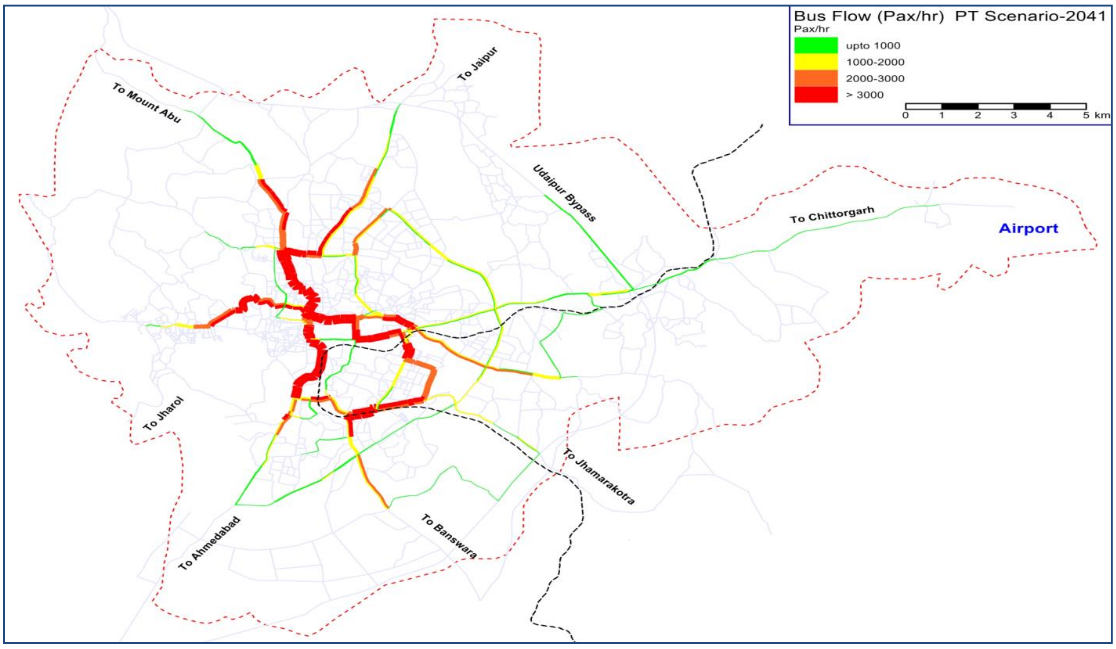

Figure 6-23: PT ridership for PT scenario (2041)

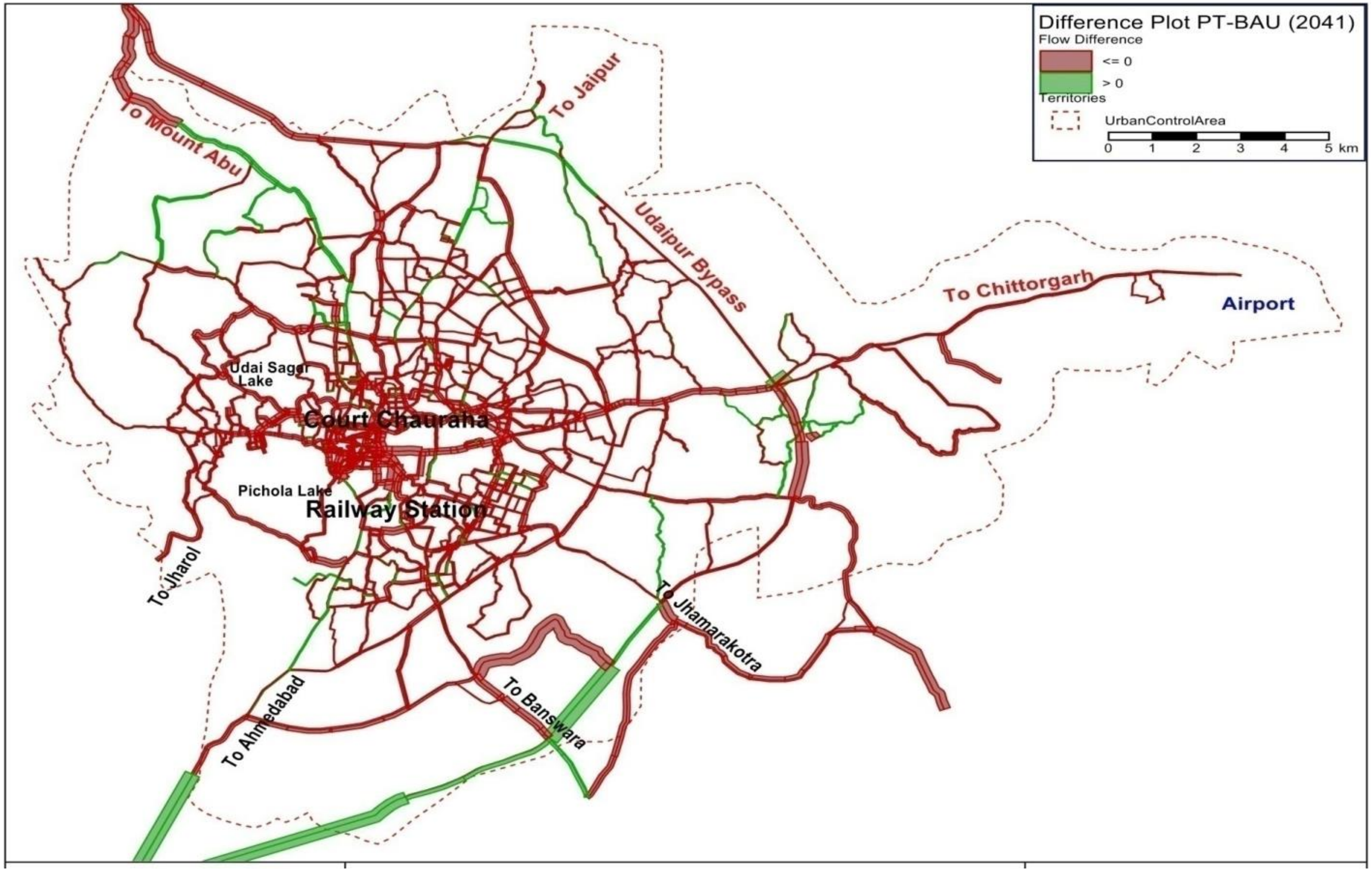

Figure 6-24: Difference plot for PT scenario and BAU scenario (2041)

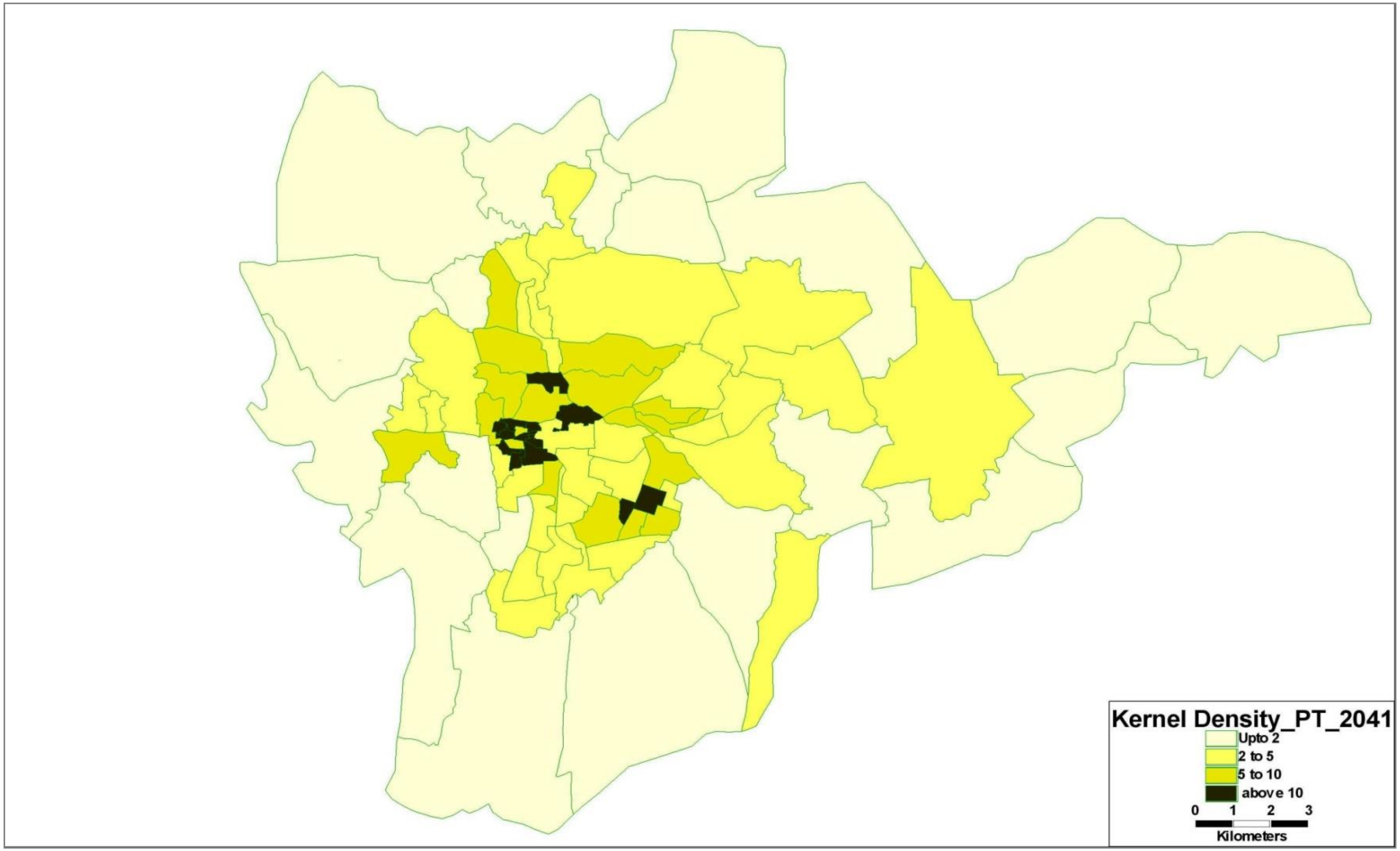

Figure 6-25: Kernel density for PT scenario (2041)

6.3.3.2 Emission level

Table 6-9 shows the emission level.

Table 6-9: Public transport scenario emission levels

Emission level NO_2 tons annually	Emission Level CO_2 million tons annually	Emission level of PM10 tons annually	Emission level of SO_2 tons annually	Emission level of CO tons annually
46,947	26	13,523	784	485,139

The overall outcomes in terms of modal share, trip lengths, etc., are shown in Table 6-10. The modal share of PT has increased by 28 per cent as compared to the BAU scenario due to the introduction of an organized PT system with trunk and feeder routes.

Table 6-10: Outcomes of PT scenario as compared to base year and BAU scenario

Indicator/values	Base year (2013)	BAU (2041)	Public transport intervention scenario (2041)
Modal Shar			
Modal share of Walk	25%	20%	27%
Modal share of Cycle	3%	2%	9%
Modal share of Two-wheeler	48%	51%	21%
Modal share of IPT	18%	22%	12%
Modal share of Car	4%	4%	1%
Modal share of PT	3%	2%	30%
Trip Length (km)			
Walk	1.18	2.06	1.78
Cycle	2.37	3.65	3.35
Two-wheeler	5.54	5.92	5.63
IPT	4.52	5.55	4.98
Car	7.06	7.51	7.77
PT	-	5	5.75
Accessibility			
Percentage of HH within 10 minutes of walking to access PT (IPT for base year)	69%	60%	83%
LOS of PT facilities as per MoUD SLB Handbook	4	4	2

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Indicator/values	Base year (2013)	BAU (2041)	Public transport intervention scenario (2041)
Land use mix intensity			
Increase in the percentage of intra-zonal trips as compared to base year (base year value is 19%)	-	16%	16%
Safety to use NMT			
Walk	7.50%	7.50%	-
Cycle	7%	7%	-
Total motorized vehicle kilometres (million km)	880.5	2559.9	1691.6
LOS of NMT facilities as per MoUD SLB Handbook	4	4	-
Congestion level			
Road length (km) with value of V/C ratio equal to 1 or more	-	26%	10%

With the interventions suggested in the public transport scenario, it was observed that:

- *The PT share would increase from 2 per cent in the base year to 30 per cent in the PT Scenario*
- *The average trip lengths of all the modes are reduced by approximately 4 per cent in the PT scenario*
- *The vehicle kilometers travelled value is reduced by 51 per cent in the PT scenario as compared to the BAU scenario*
- *The overall emissions are reduced by 27 per cent in the public transport scenario as compared to the BAU scenario.*

6.3.4 Conclusions of PT scenario

In the absence of an organized public transport system, the mobility needs of the city are catered to by ever increasing numbers of private vehicles (comprising mostly of

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two-wheelers followed by cars) and by an unorganised, unsafe and polluting IPT system.

With the increase in income levels, people's social aspirations for raising their standard of living by attaining vehicle ownership can lead to increased unsustainable chaotic congestion and poor ambient air quality.

The provision of organised public transport will act as an incentive for the populace of the city to make a shift towards a comparatively more affordable and environmentally friendly mass transportation system, and avoid the use of unsafe and costlier private vehicles. An organised public transport system could be provided in the form of modernizing the existing IPT system. This would involve adhering to fixed routes and fares, along with replacing old and unsafe polluting three-wheelers with safe, less polluting BS IV four-wheelers in the short run to cater the existing travel demand. It would later involve a gradual phase-wise introduction of a city bus service to cater to the anticipated growth of travel demand in the medium and long run.

A considerable increase was observed in the modal share of PT from 2 per cent in the BAU scenario to 30 per cent in the PT scenario. Accordingly, there has been a considerable shift towards walk, cycle and IPT modes, and a reduced dependency on private modes. Thus the PT scenario can be considered a more sustainable scenario than BAU; however, integration of land use, improvement of NMT and PT infrastructure can lead to a more desirable choice for the city authority.

It is observed that on the average, the average trip length for all modes is reduced by approximately 4 per cent compared to the BAU scenario. While for the walk mode, the average trip length is reduced by approximately 11 per cent, the ATLs for PT and car modes have increased by 13 and 3 per cent respectively. The increase in ATL for the PT system has resulted from more induced travel in the PT system, which was previously catered to by the existing IPT system (refer to Table 6-10 for the increase in ATL for PT, and its associated decrease in ATL for IPT).

With the high density compact development, the number of households residing within 10 minutes' walk of a PT system would increase from 16 per cent in the BAU scenario to 80 per cent in the PT scenario. It is observed that the total motorized vehicle kilometres travelled is reduced by 51 per cent as compared to the BAU scenario, resulting in a reduction of emissions by 27 per cent.

6.4 Non-Motorized Transport Strategy for Low Carbon Scenario

An increased shift towards walking and cycling could be achieved only with the development of the necessary infrastructure, such as footpaths, cycle tracks, public spaces, pedestrian crossings, road markings, road signage, and street lighting, etc., which can ensure safe and secure movements for the public. This environment would increase the shift towards walking and cycling activity, which would indeed help reduce the VKT. As part of the scenario, it is envisaged that the infrastructure for walking and cycling should be developed based on the demand to access various destinations. Objectives

- Increase in the mode share of cycle and walk modes by providing the necessary infrastructure
- Providing safety for NMT users
- Increase the intra-zonal trips to encourage NMT trips.

6.4.1 Detailed strategies

The above strategies are explained in detail as follows:

a. Improvements of old footpaths and development of new footpaths

There are significant NMT trips being made in Udaipur under intra-zonal trips. Figure 6-26 shows the daily NMT trips produced by each zone, while Figure 6-27 shows the intra-zonal trips percentage for each zone in the base year.

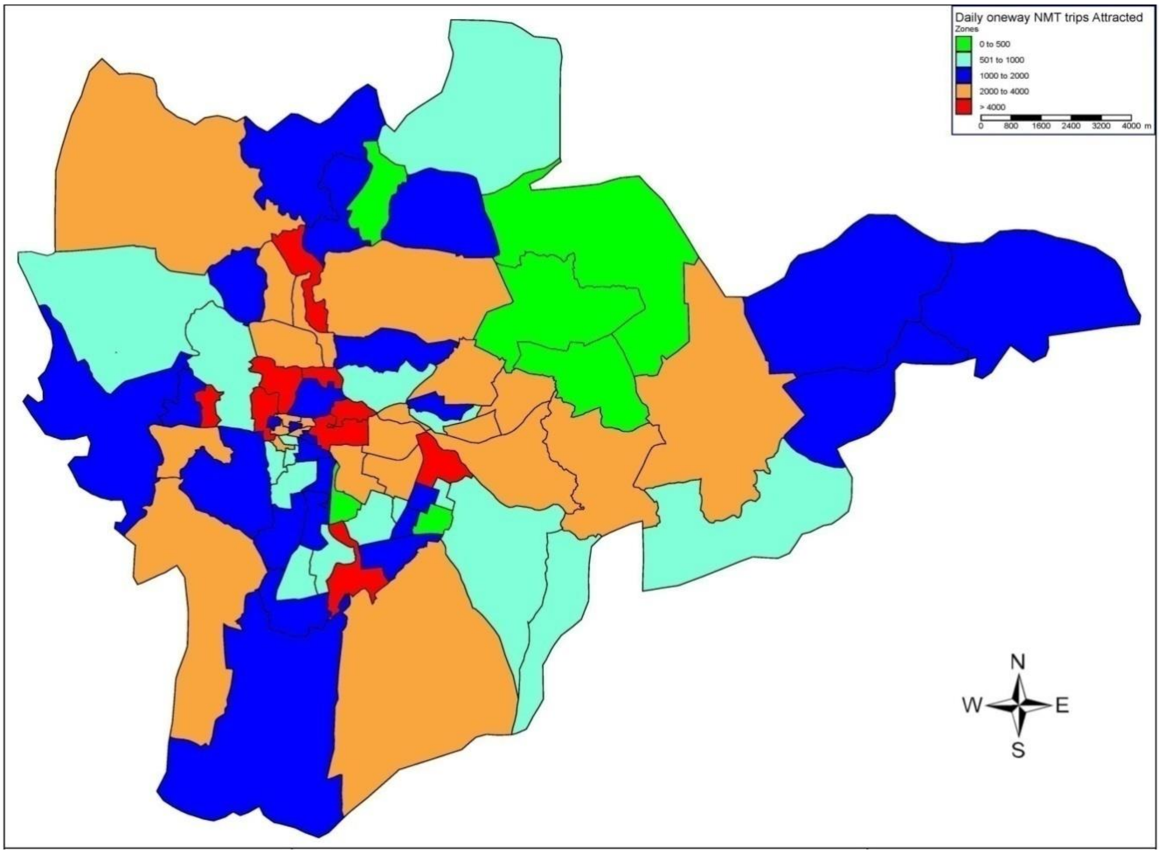

Figure 6-26: Daily NMT trips attracted zone-wise for base year (2013)

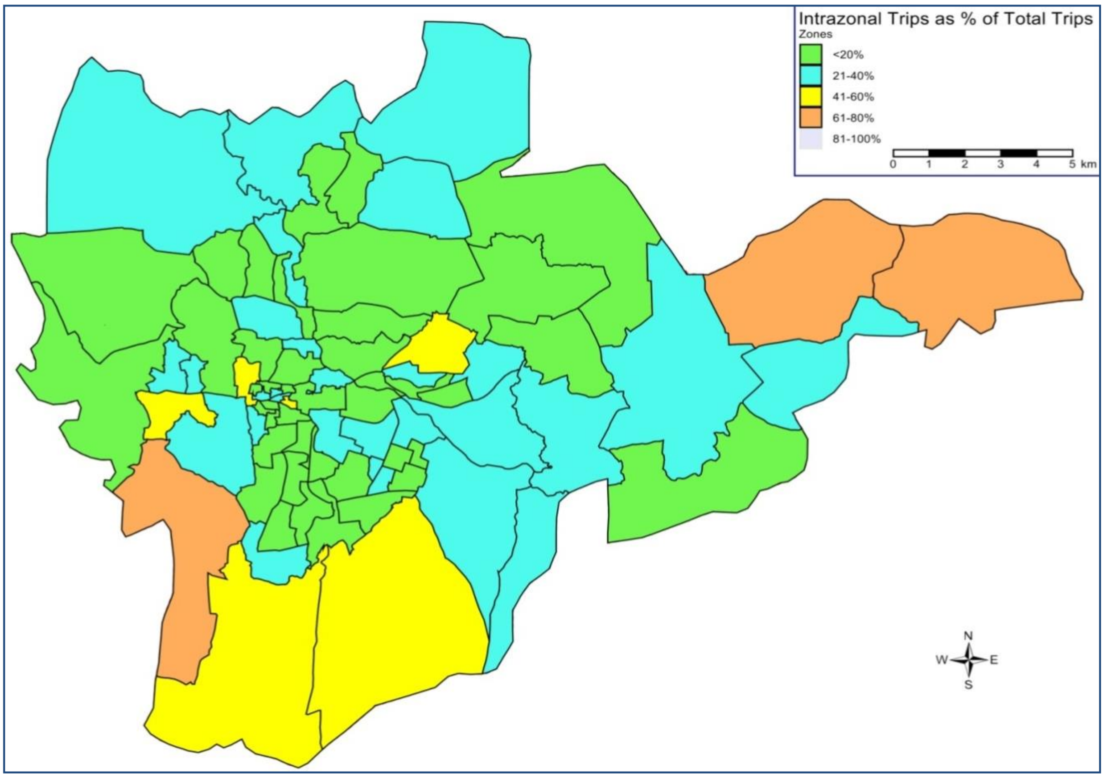

Figure 6-27: Intra-zonal trips as percentage of total trips for base year (2013)

The total walk mode share in Udaipur for the base year is 25 per cent; however, almost 96 per cent of the road network does not have footpaths. The primary and secondary data collected indicates that 50 per cent of road accident victims are NMT users. The primary survey data indicate that the percentage of NMT users feeling safe is as little as 7.5 per cent for pedestrians and 7 per cent for cyclists. Hence, under the NMT strategy, 133km of footpath is proposed and around 10km of existing footpaths will be improved with a minimum width of 1.5m. The following measures have been proposed as a part of improving pedestrian mobility:

- Construction of footpaths on the proposed roads as shown in Figure 6-28
- It should also be created on all the residential roads, wherever possible
- A minimum usable width of 1.5m should be provided for footpaths
- It is desirable to have a footpath width of 2.0m for all roads
- Obstructions on footpaths must be relocated. The footpath must be cleaned and even made comfortable to walk on
- Footpath design must discourage two-wheelers using the footpath during periods of congestion
- At signalized intersections, pedestrian zebra crossings must be clearly marked
- Footpaths at all busy intersections must be provided with handrails to force pedestrians to cross at zebra crossings.

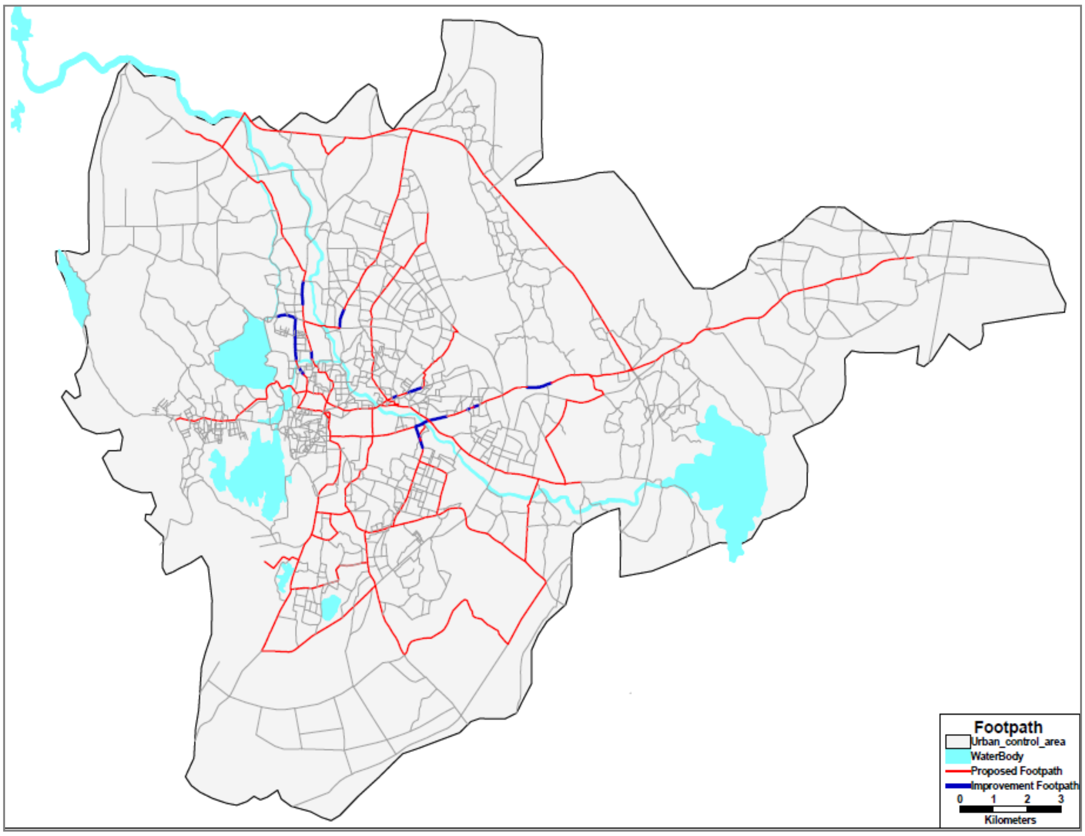

Figure 6-28: New footpaths provided and improved footpaths under the NMT strategy

b. Pedestrian crossing signal and street lighting at important intersections

Table 6-11 shows the calculations for $PV^2/(2*10^8)$ at Fatehpura Chauraha, Syphon Chauraha, Bhuwana, Chetak Circle, Court Chauraha, Shastri Circle, Delhi Gate Chauraha, Hathipol Chauraha, Udiapol Chauraha, Pratapnagar Chauraha, Surajpol Chauraha, Ayad Puliya, Shewsram Chauraha, Mallah Talai Chauraha, Patel Circle and Subji Mandi Chauraha. If PV^2 is higher than 1, it indicates a need for improvement in pedestrian crossing facilities.

Table 6-11: PV^2 values at some of the important intersections

Sl. No.	Location	PV^2
1	Fatehpura Chauraha	9
2	Syphon Chauraha	4.7
3	Bhuwana	1.87
4	Sukhadia Circle	0.4
5	Chetak Circle	6.5
6	Panchawati Circle	0.77
7	Court Chauraha	3.1
8	Shastri Circle	9
9	Delhi Gate Chauraha	12
10	Hathipol Chauraha	3.8

Sl. No.	Location	PV^2
11	Udiapol Chauraha	12.2
12	Pratapnagar Chauraha	13.5
13	Surajpol Chauraha	37.1
14	UIT Circle	0.54
15	Ayad Puliya	3.8
16	Shewsram Chauraha	19.4
17	Mallah Talai Chauraha	2.4
18	Patel Circle	2.6
19	Subji Mandi Chauraha	1.4

The safety of pedestrians is an important factor for improving the share of walk mode in Udaipur. Hence, provision of signals for pedestrian crossings is proposed at 19 intersections to decrease crossing time and increase safety. Figure 6-29 shows the locations of pedestrian crossing locations.

Apart from providing signals, to improve safety during night-time semi-high mast lights are proposed at all of these 19 intersections.

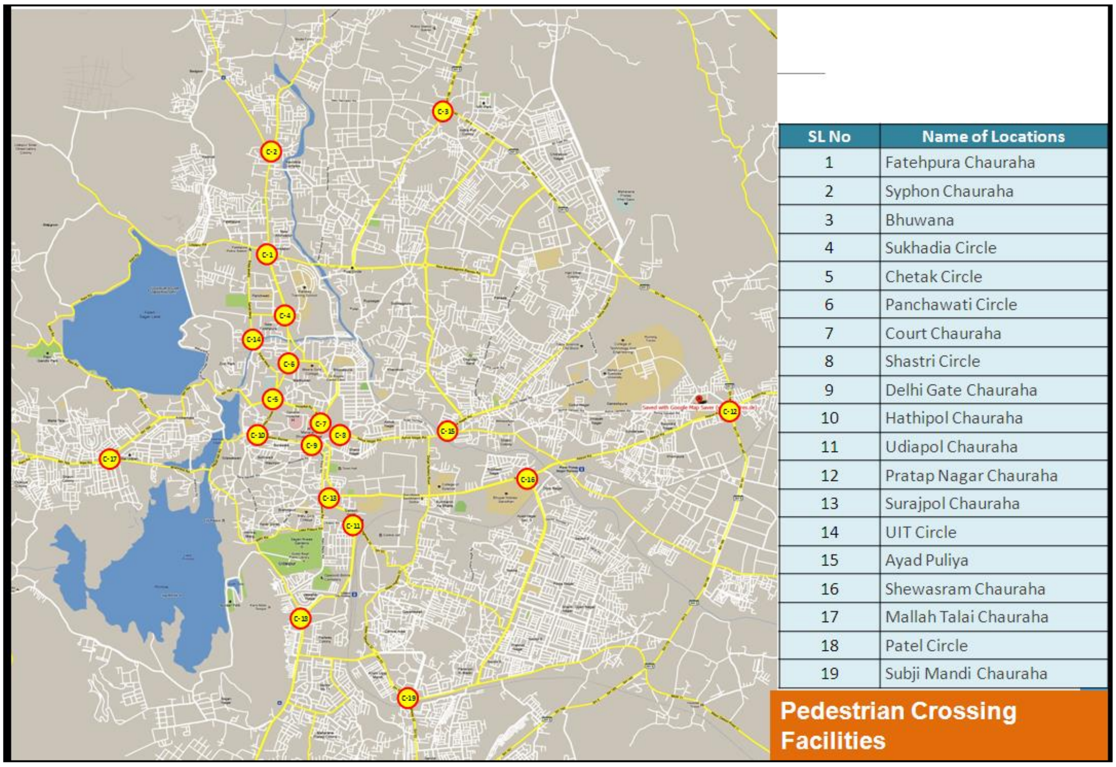

Figure 6-29: Pedestrian crossing locations identified for Udaipur

c. *Development of cycle track*

Cycling is one of the non-polluting modes of transport in Udaipur. However, due to safety issues and terrain constraints, the share of cycle mode is as low as 3 per cent in the base year.

In order to promote the use of bicycles in Udaipur, the NMT strategy proposes cycle tracks of around 40km on a few major roads. Table 6-12 shows the list of cycle tracks and their respective road length in kilometres. Cycle tracks will be provided on both directions of road. The necessary support infrastructure will also be provided along these routes. Figure 6-30 shows the proposed cycle tracks.

Table 6-12: Cycle track locations along with road lengths

Sl. No.	Location details	Road length (km)
1	Devali to Sukhadia Circle	1.96
2	Sukhadia Circle to Fatehpura Police Station (Saheli Marg)	1.36
3	Court Circle to Ayad Pul	1.69
4	University to Thokar Chowk via Ayad Pul	3.25
5	Suraj Pol to Pratap NagarJunction	5.32
6	Sewashram Chowk to Krishi Upaj Mandi	3.89
7	Goverdhan Vilas Chowk to Savina	2.75
	Total	20.22

d. Introduction of bike sharing scheme

Bike sharing refers to the introduction of sharing bicycles at different locations on a rental basis. Revenue from advertisements at bike parking lots and rental revenue from bicycles are used to partly meet the operation and maintenance expenditure. Bike sharing schemes help in promoting the environmentally friendly NMT mode, and also help in promoting tourism. Given Udaipur is a tourist city, the LCMP has suggested the interlocution of a bike sharing scheme.

Bike sharing parking lots are proposed at following locations:

a. Sukhadia Circle
b. Court Circle
c. Suraj Pol
d. Goverdhan Vilas Chowk.

e. Development of heritage walk

City Palace Museum is the major tourist attraction point of Udaipur, and is surrounded by narrow roads being a part of old city. In order to promote NMT and tourism, a heritage walk is proposed wherein a few roads will be made vehicle-free. Table 6-13 shows the heritage walk routes proposed and their location while the pictorial representation is shown in Figure 6-31.

Table 6-13: Heritage walk routes proposed for Udaipur

Proposed route	Sites to be covered	Route length (in metres)
Route 1	City Palace, Jagdish Temple, Gangur Ghat Temples	1000
Route 2	Havelies/Old Residence. Tourist (Arts & Craft) Market, etc.	1200
Route 3	Badi Pol Temples, Ghanta Gahar, etc.	1000

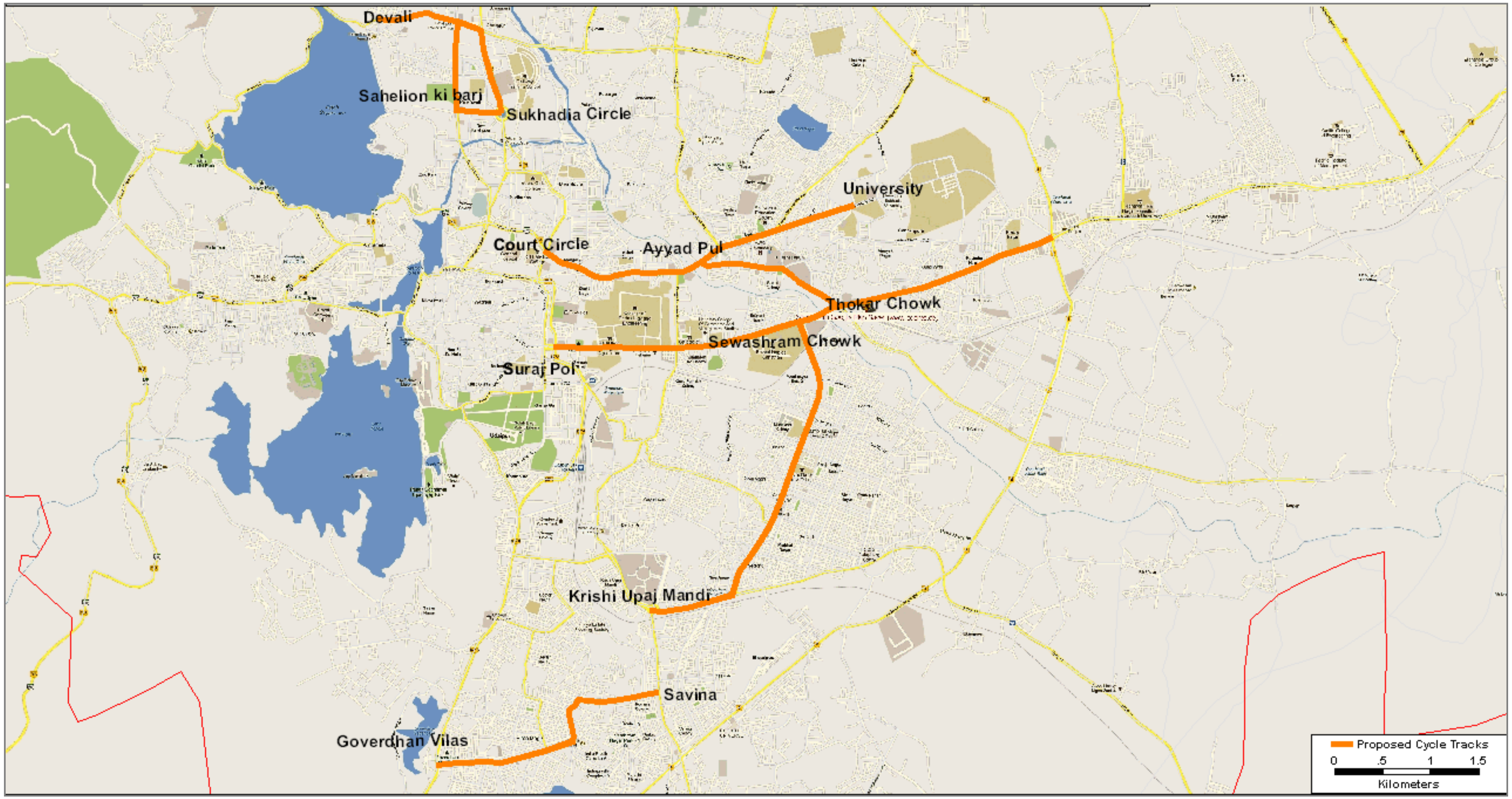

Figure 6-30: Proposed cycle tracks for Udaipur

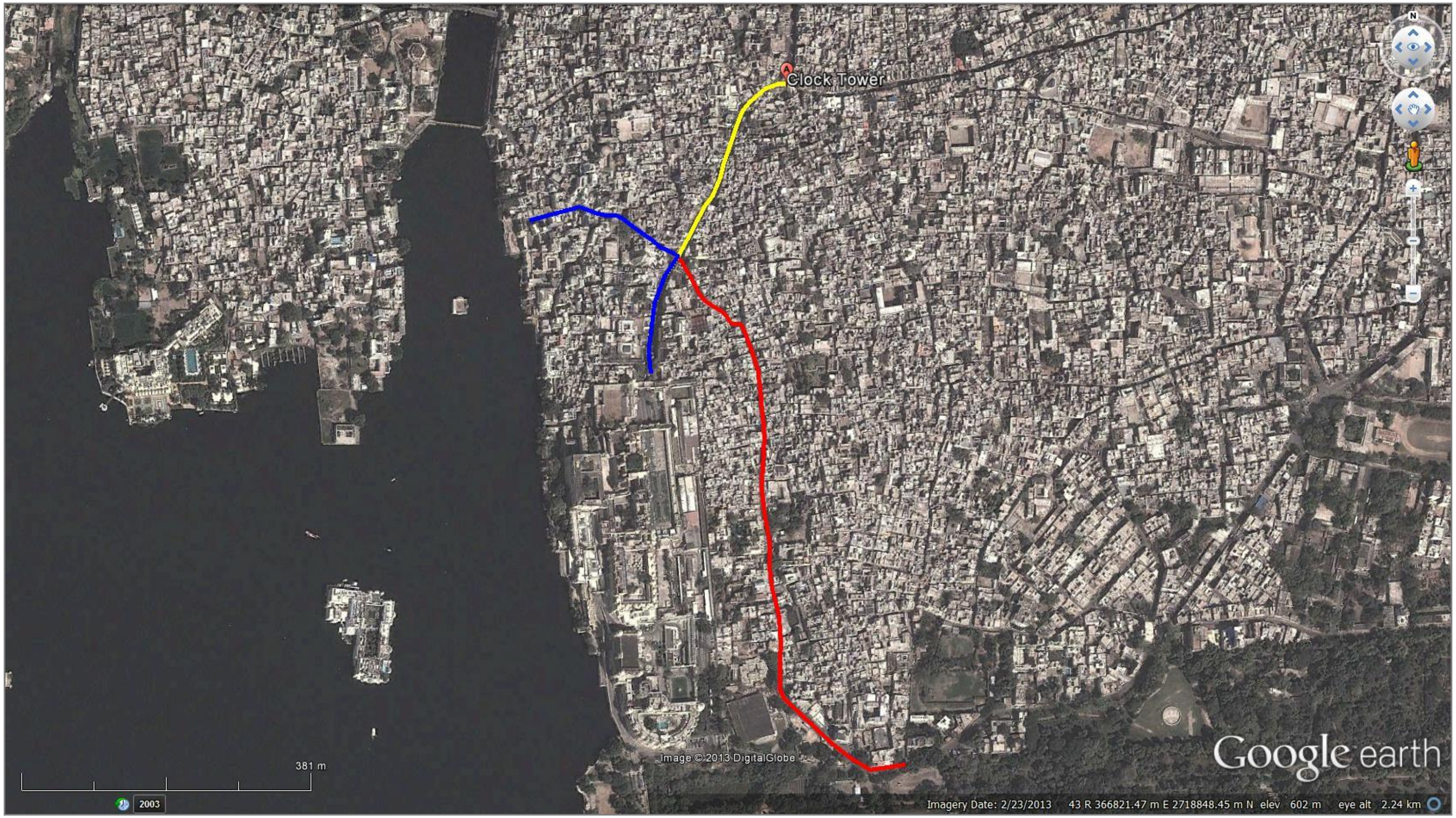

Figure 6-31: Proposed heritage walk map for Udaipur

6.4.2 Outcomes of the NMT scenario

The outcomes of the NMT scenario have been classified into two categories: mobility and accessibility results, and emission levels. These results are presented in the subsequent sections as follows:

6.4.3.1 Mobility asnd accessibility results for the NMT scenario

a. Modal shares

Table 6-14 compares the mode shares of the base year, BAU scenario (2041) and NMT scenario (2041).

Table 6-14: Modal share comparison of base year, BAU and NMT scenarios

Modal share	Base year (2013)	BAU (2041)	NMT scenario (2041)
Walk	25%	20%	38%
Cycle	3%	2%	9%
Two-wheeler	47%	51%	31%
IPT	18%	21%	15%
Car	4%	4%	2%
PT	3%	2%	5%
Total	100%	100%	100%

b. Trip lengths

Table 6-15 compares the mode shares of the base year, BAU scenario (2041) and NMT scenario (2041).

Table 6-15: Trip length comparison of BAU and NMT scenarios

Mode	Base year (2013)	BAU (2041)	NMT scenario (2041)
Walk	1.18	2.06	3.31
Cycle	2.37	3.65	4.08
Two-wheeler	5.54	5.92	6.30
IPT	4.52	5.55	5.51
Car	7.06	7.51	7.68
PT	-	5.00	5.00
Average	4.13	4.94	5.31

c. V/C ratio and traffic flow pattern:

Figure 6-32 and Figure 6-33 show the V/C ratio and flow pattern for the NMT scenario. The relevant changes made under the NMT scenario resulted in the following flow diagrams.

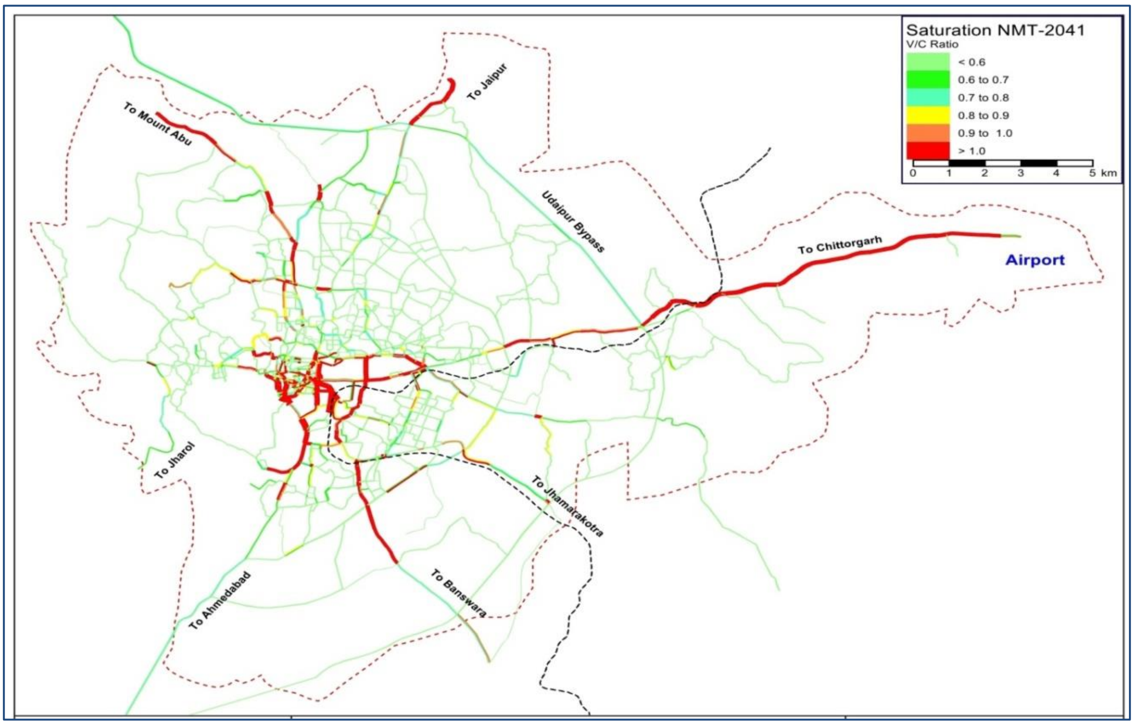

Figure 6-32: V/C ratio under the NMT scenario (2041)

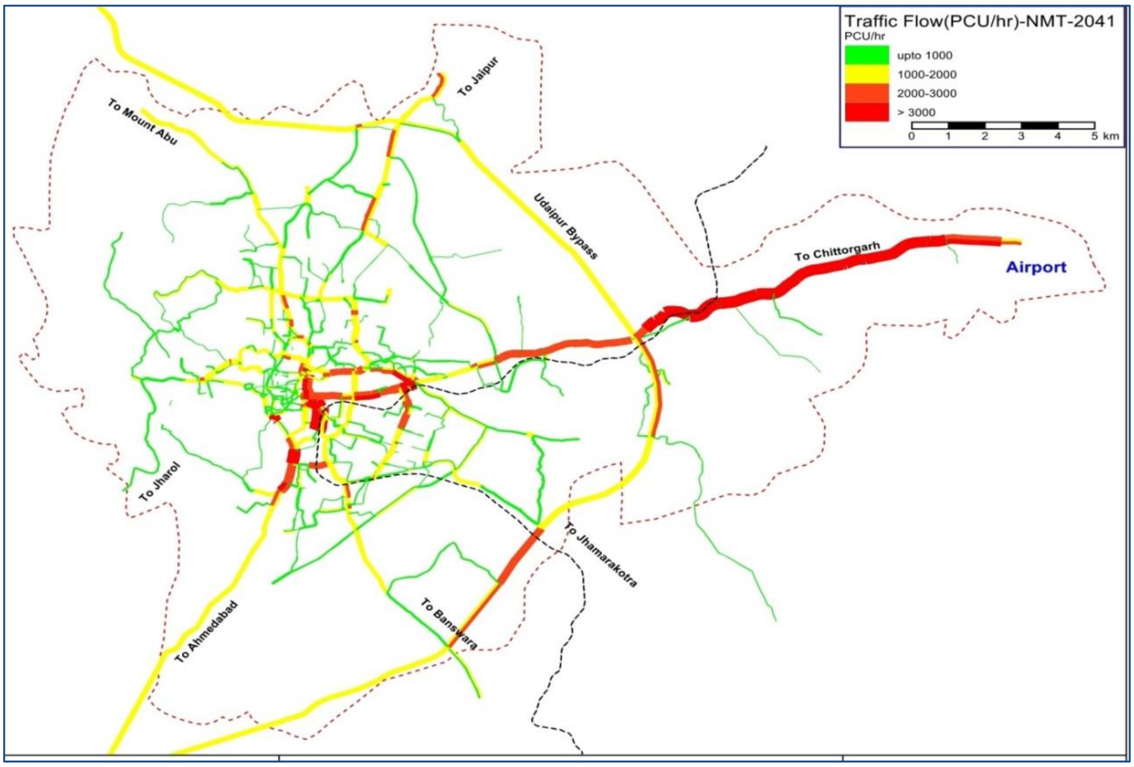

Figure 6-33: Traffic flow (PCU/hr) under the NMT scenario (2041)

d. Difference plots

The difference plot is an easy graphical representation of flow pattern under different alternate scenarios. The user equilibrium assignment is based on Wardrop's first principle, which states that no driver can unilaterally reduce their travel costs by shifting to another route. Hence, under each scenario, the link flow is different. The best alternative scenario can be determined by observing the different plots of each alternate scenario and BAU scenario. Figure 6-34 shows the difference plots comparing the NMT scenario with the BAU scenario.

e. Kernel density:

Kernel density is defined as the ratio of the length of the road network in a particular zone versus the area of the zone. The units for kernel density are km/km^2. This kernel density indicates the length of roads available in a particular area. Figure 6-35 shows the kernel density value for the NMT scenario in 2041. The average kernel density achieved is 5.72km/km^2.

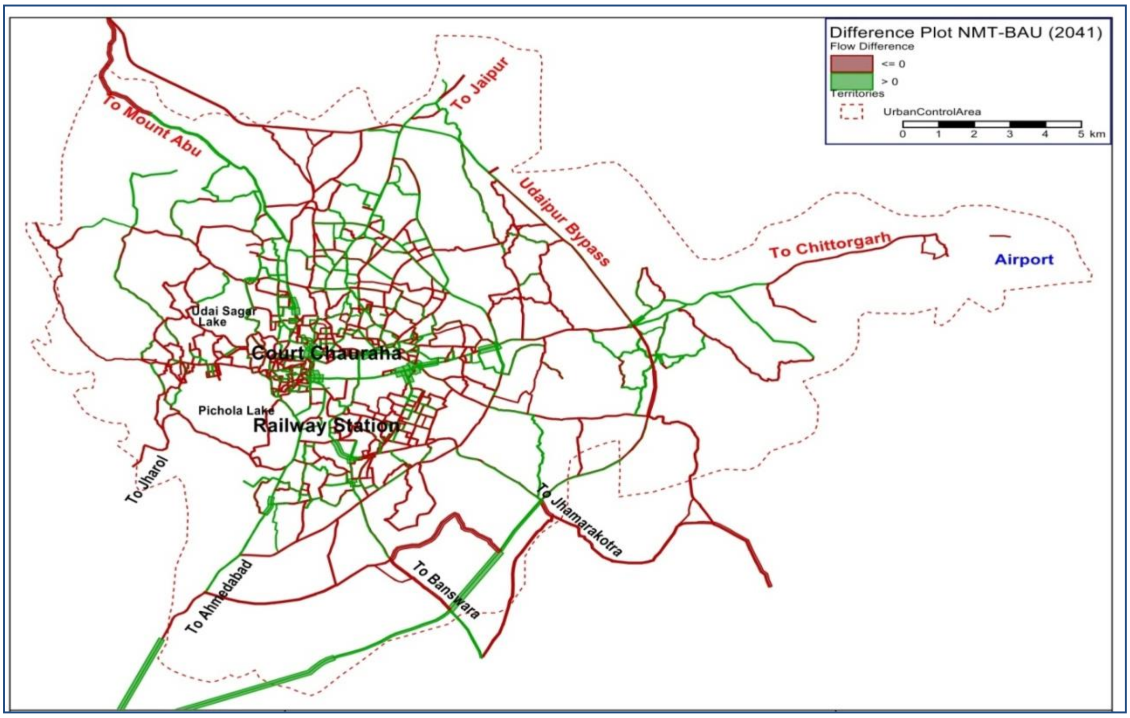

Figure 6-34: Traffic flow difference plot between the NMT and BAU scenarios (2041)

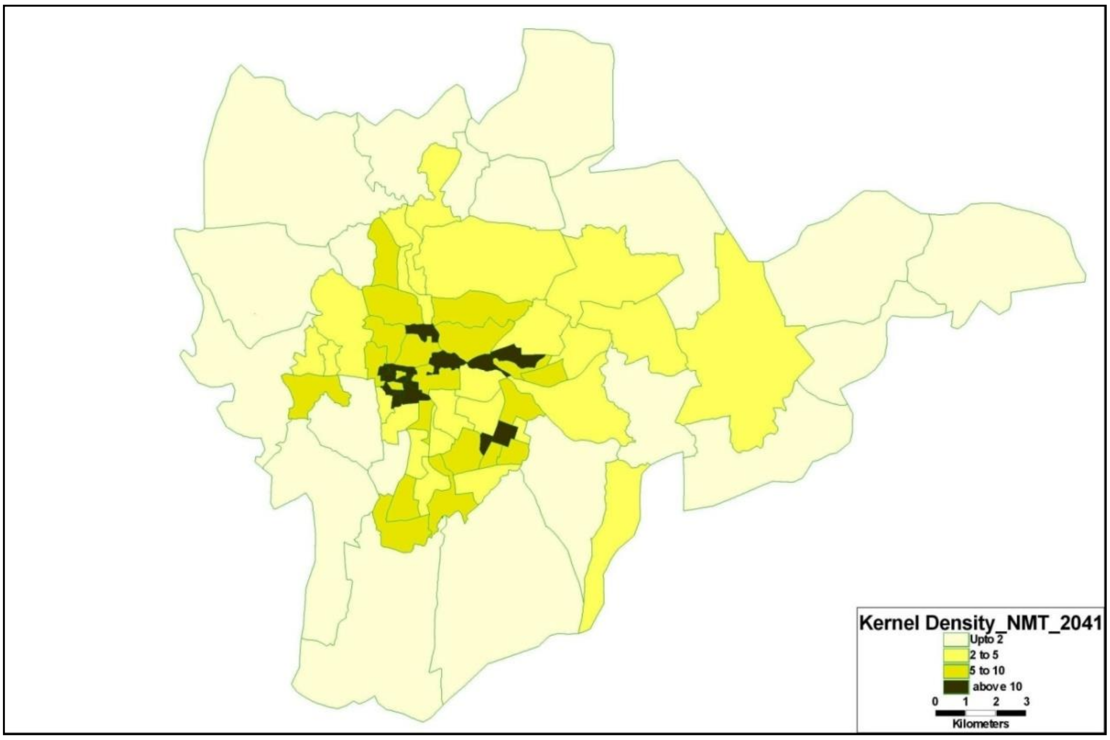

Figure 6-35: Kernel density for NMT (2041)

6.4.3.2 Emission level

Table 6-16 shows the emission level.

Table 6-16: Non-motorized transport scenario emission levels

Emission level NO_2 tons annually	Emission level CO_2 million tons annually	Emission level of PM10 tons annually	Emission level of SO_2 tons annually	Emission level of CO tons annually
60,866	33	17,253	792	681,136

The overall outcomes of the NMT strategy are shown in Table 6-17. The walk mode share has increased by 18 per cent as compared to the BAU scenario due to the NMT interventions proposed, which is desirable in terms of low-carbon emissions.

Table 6-17: Outcomes of the NMT strategy as compared to BAU and base year

Indicator/values	Base year (2013)	BAU (2041)	NMT intervention scenario (2041)
Modal Share			
Modal share of walk	25%	20%	38%
Modal share of cycle	3%	2%	9%
Modal share of two-wheeler	48%	51%	31%
Modal share of IPT	18%	22%	15%

Indicator/values	Base year (2013)	BAU (2041)	NMT intervention scenario (2041)
Modal share of car	4%	4%	2%
Modal share of PT	3%	2%	5%
Trip length (km)			
Walk	1.18	2.06	3.31
Cycle	2.37	3.65	4.08
Two-wheeler	5.54	5.92	6.3
IPT	4.52	5.55	5.51
Car	7.06	7.51	7.68
PT	-	5	5
Accessibility			
Percentage of HH within 10 minutes' walking distance to access PT (IPT for base year)	69%	60%	78%
LOS of PT facilities as per MoUD SLB Handbook	4	4	2
Land use mix intensity			
Increase in the percentage of intra-zonal trips as compared to the base year (base year value is 19%)	-	16%	16%
Safety to use NMT			
Walk	7.50%	7.50%	83%
Cycle	7%	7%	80%
Total motorized vehicle kilometres travelled (million km)	880.5	2559.9	2341.3
LOS of NMT facilities as per MoUD SLB Handbook	4	4	2
Congestion level			
Road length (km) with value of V/C ratio equal to 1 or more	-	26%	16%

With the interventions suggested in the non-motorized transport scenario, it was observed that:

- *The modal share of cycling would increase from 3 per cent in the base year to 9 per cent in the NMT scenario, whereas the modal share of walking would increase from 25 per cent in the base year to 38 per cent in the NMT scenario*
- *The average trip lengths of walking and cycling increased by 38 per cent and 11 per cent in the NMT scenario*
- *Due to the dominance of non-motorized modes, the VKT is reduced by 9 per cent in the NMT Scenario as compared to the BAU scenario*
- *The overall emissions are reduced by 2 per cent in the NMT scenario.*

6.4.3 Conclusions of the NMT scenario

In the base year, the modal share of walking and cycling is 25 and 3 per cent respectively, while the provision of NMT infrastructure is evidently poor and inadequate. Only 4 per cent of the total road network has footpaths, there are no proper pedestrian crossing facilities at major junctions, and an absence of cycle lanes and street lighting facilities. This has made NMT users, which are the most environmentally friendly of commuters, as the most vulnerable road space users, which is evident from the fact that about 48 per cent of road accident victims are pedestrians. The prevailing poor status of NMT usage in terms of both safety and social considerations in the perception of the local populace has resulted in a decreased share of NMT usage in the BAU scenario, as the BAU scenario has no emphasis on improvement of the NMT infrastructure.

Given that the hypothetical scenario is developed with the provision of quality NMT infrastructure, the NMT scenario tries to address these issues by explicitly spelling out several NMT intervention measures. These measures include developing footpaths and cycle tracks, introducing a bicycle sharing scheme, and redesigning street furniture in favour of NMT users, such as providing pedestrian crossing facilities at junctions, street lighting facilities, etc. This will have a significant impact on the mobility scenario in Udaipur, which is reflected in the travel demand model results.

A considerable increase is observed in the modal share of NMT from 2 per cent in the BAU scenario to 9 per cent, while the modal share of walking has increased from 20 per cent in the BAU scenario to 38 per cent in the NMT scenario. In the BAU scenario, it is observed that the average trip lengths of walking and cycling remained at 2.06km and 3.65km, while in the NMT Scenario the ATL of walking and cycling trips has increased by 38 and 11 per cent respectively. The increase in ATL for NMT is due to the increase in road lengths becoming more accessible and comparatively safe for NMT usage in the NMT scenario as compared to the BAU scenario.

By making more road length accessible by NMT mode, the number of households residing within the 10 minutes' walk of a PT system would increase from 16 per cent in the BAU scenario to 78 per cent in the NMT scenario.
Despite accessibility to the existing IPT or the proposed public transport having increased due to improvement in last mile connectivity with the provision of NMT infrastructure, motorized vehicle kilometres reduced only by 9 per cent as compared to the BAU scenario. This is due to the fact that there has been improvement in first mile and last mile connectivity only, while the main line haul trips would be still characterized by the existing IPT and proposed public transport of the BAU scenario only, as there is little or no focus for public transport in the proposed BAU intervention measures. Given the marginal change in motorized vehicle kilometres travelled between the BAU and land use scenarios, this scenario reduces emissions by 2 per cent only.

6.5 Technology Strategy for Low-Carbon Scenario

6.5.1 Definition

The technology intervention considered for promoting low-carbon mobility in Udaipur city is based on the ongoing and proposed policy initiatives and directions of the Government of India. The detailed policy initiative being undertaken by the Government of India is given in Annexure 5.

6.5.2 Objective

- Minimization of vehicular emissions.

6.5.3 Detailed strategy

1. Introduction of vehicles that are energy efficient and emit less pollutants and greenhouse gases.
    - Under the head of IPT modernisation drive, the LCMP has suggested an introduction of modern IPT, which qualifies as meeting better fuel norms.
    - Introduction of city bus services with a fleet of buses that qualifies as meeting better fuel norms.

As per the report, 'Promoting Low Carbon Transport in India. Low Carbon City: A Guidebook for City Planners and Practitioners', published by UNEP DTU Partnership on Energy, Climate and Sustainable Development Technical University, Denmark, at present in India 8 per cent of CO_2 emissions are generated by the transport sector, which is also responsible for 10 per cent of the total energy demand.

Thus, bringing in change in the type of fuel (energy efficient) and engine (energy efficient with lower emissions) can play a significant role in the overall effort of emission reduction.

In the LCMP scenario, inconsistent with the ongoing and proposed policy initiatives and directions of the Government of India on emission norms and the adoption of fuel policy, the transportation sector in Udaipur will have minimal diversification in terms of fuel type use (two-wheelers run on electricity). However, the LCMP study has recommended the use of vehicles with energy efficient engines through replacement of old polluting vehicles with modern BS IV vehicles.

As discussed in the public transport strategy, the LCMP has recommended a modernisation of the existing unorganized IPT system through the replacement of old three-wheelers with BS IV four-wheelers. It has further recommended the introduction of a city bus service with buses that comply with Urban Bus Specification (UBSII) norms published by the Ministry of Urban Development, Government of India, which are fitted with energy efficient engines along with other improvements in comparison to the existing buses operating on Indian roads.

The fuel mix considered for the BAU scenario, 2041, and for the LCMP scenario, 2041, are shown in Table 6-18 and Table 6-19.

Table 6-18: Fuel mix for the BAU scenario (2041)

Vehicle type	VKT for BAU scenario, 2041 (in million km)	Percentage of fuel type					
		Petrol	Diesel	Gas	Electric	Bio	AAA
2Ws	1242.2	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Cars	602.9	60.64%	33.07%	6.29%	0.00%	0.00%	0.00%
3Ws	254.6	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%
Buses	78.3	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%
Trucks	381.9	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%

Table 6-19: Fuel mix for LCMP scenario (2041)

Vehicle Type	VKT for LCMP scenario, 2041 (in million km)	Percentage of fuel type					
		Petrol	Diesel	Gas	Electric	Bio	AAA
2Ws	392.2	99.98%	0.00%	0.00%	0.02%	0.00%	0.00%
Cars	291.0	60.64%	33.07%	6.29%	0.00%	0.00%	0.00%
3Ws	161.3	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%

Vehicle Type	VKT for LCMP scenario, 2041 (in million km)	Percentage of fuel type					
		Petrol	Diesel	Gas	Electric	Bio	AAA
Buses	118.5	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%
Trucks	372.1	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%

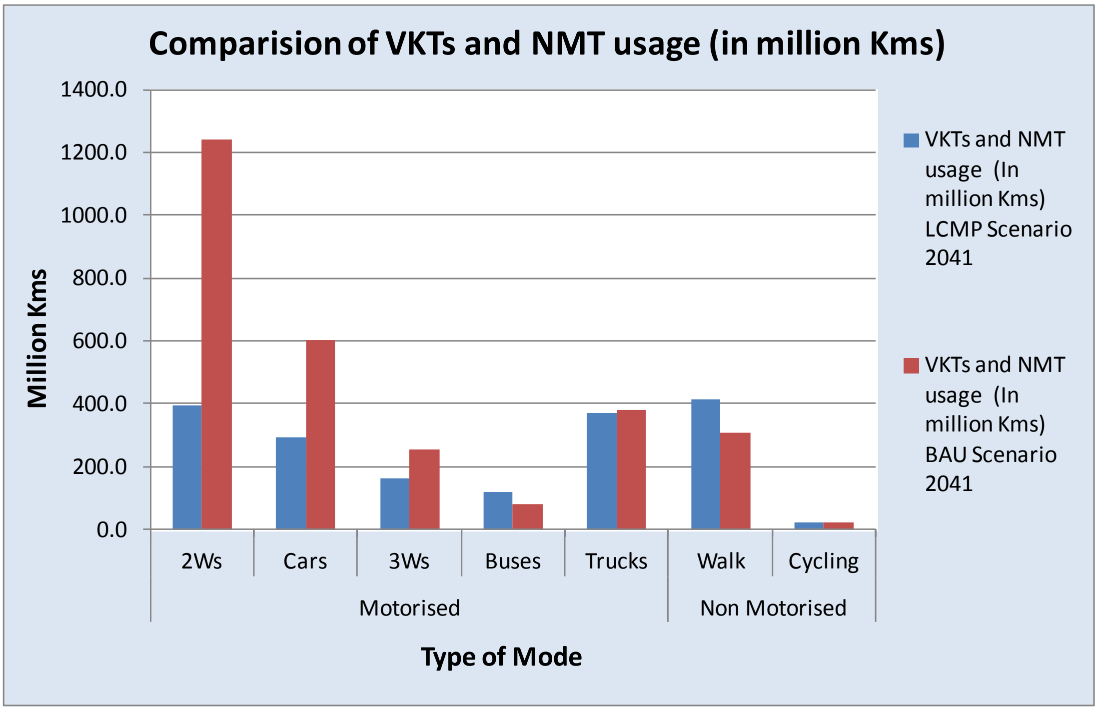

Figure 6-36: Comparison of VKTs and NMT usage

The fuel mix for the LCMP scenario is developed considering combined impacts of all the intervention measures suggested in the land use, PT and NMT scenarios, which will ensure a reduction in overall demand for transport and thereby a reduction in emissions. This would be an outcome of the development of self-sufficient neighbourhoods ensuring the compact, intensive and economized spatial development of the city, and promotion of public transport and environmentally friendly non-motorised transport.

Figure 6-36 shows the comparison of VKTs and NMT usage, which clearly reflects the reduction in motorized VKTs and increase in usage of environmentally friendly NMT, which is an outcome of the integrated approach as suggested in this LCMP study towards attaining sustainable and inclusive mobility. The decrease in VKTs has resulted in corresponding reductions in emission levels. The detailed reduction in emission levels of various noxious gases and CO_2 is discussed in section 6.7, 'Emission level – comparison for all scenarios'.

6.6 Low-Carbon Scenario (LCMP scenario) – Land Use Intervention, Public Transport Intervention, Non-motorized Transport Intervention, and Technology Intervention

The vision for this study of a Low-carbon Comprehensive Mobility Plan is to: "Provide safe, efficient and environmentally sustainable means of transportation system for improved mobility and accessibility of people and goods across gender and heterogeneous socio-economic groups", with a broader goal of promoting low-carbon transport in the Indian city of Udaipur. Promoting low-carbon transport is associated with the decline in motorized vehicle kilometres travelled without compromising the accessibility and mobility needs of the local populace.

Land use transport integration planning is the prerequisite pillar for developing a compact city, which can result in lower VKT due to reduced ATL, which in turn is a consequence of city compactness in terms of both geographical spread and intensified mixed land use activities. Thus, under the aforementioned hypothetical land use interventions scenario, the objective was to create a compact Udaipur city with self-sustainable neighbourhoods. The travel demand model results show that there has been a decline in VKT with a comparatively improved mobility situation relative to the BAU scenario. However, it is also observed from the land use interventions scenario that a significant number of trips will still be performed by private modes (two-wheelers and cars), which are inefficient road space users with poor occupancy ratios. The average occupancy for cars and two-wheelers in Udaipur are 2.5 and 1.6 respectively.

An organized public transport system is considered the backbone of improved mobility and accessibility for the masses. Provision of a public transport system is indispensable for achieving a private automobile-independent society. Thus, as an intervention strategy, a scenario with the provision of public transport is tested under the head of public transport interventions. Based on the travel demand results fed by the survey of preference for choice mode, it is apparent that the introduction of an organized public transport system in Udaipur lowers the modal share of private vehicles (from 3 per cent in the BAU scenario to 1 per cent in the public transport scenario for cars, and that for two-wheelers is from 51 to 21 per cent). This is being fed by an increase in modal share for public transport (from 2 per cent in the BAU scenario to 30 per cent in the public transport scenario). This decline in modal share of private vehicles has resulted in a relative decline in motorized VKT, along with improved mobility for the masses. However, the captive NMT users, such as LIG workers for their daily main (work and other) purpose trips, and the female members of a household for their need-based neighbourhood-level trips, will be left out from the basic paradigm of improved mobility perspective of the city. This would result in a non-inclusive one-gender-favoured scenario in the absence of quality NMT infrastructure.

In order to promote the most environmentally friendly mode of transport and achieve an all-inclusive mobility scenario, the NMT intervention scenario is tested to understand the need of NMT infrastructure for sustainable low-carbon mobility, which has a significant impact on improving all-inclusiveness. However, while the city can achieve a pro-poor, both-genders-friendly transport system by pursuing only NMT interventions, this approach will achieve comparatively less in terms of VKT reduction.

Thus it is apparent that a combined scenario providing the optimum level of public transport and NMT infrastructure, and integrated land use transport planning, can bring about a sea change in the overall mobility pattern of the city, which can provide safe, efficient and an all-inclusive improved mobility situation.

Continuous human endeavour for better technology has resulted in dramatic changes in the automobile sector also. Successively, newer auto-engines generating less and less greenhouse gases are becoming available in both the international and domestic automobile market. The directed emission norms for both fuel and vehicle technology being adopted by the state and the city that comply to the national level goal for reduction of greenhouse gases can significantly reduce emissions from the transport sector.

Considering all the aforementioned aspects, an alternative development scenario is developed by integrating all the strategies together under a combined scenario, which is considered the LCMP scenario. This focuses on achieving the combined positive multiplier effect of all the strategies together towards the sustainable development of Udaipur, catering to the demands of its heterogeneous socio-economic groups. The combined scenario adopts a few additional strategies in addition to the independent strategies of all the scenarios, and these additional strategies are discussed in Section 6.6.2.

6.6.1 Objective

The objective is to integrate NMT, public transport, land use and technology strategies to provide a safe, efficient and environmentally sustainable means of transportation for improved mobility and accessibility of people and goods across gender and heterogeneous socio-economic groups.

6.6.2 Detailed strategies

The detailed strategies have already been discussed in four different stand-alone strategies for achieving low-carbon mobility, namely the land use, public transport, NMT and technology strategies. Under this combined scenario, all the proposed innovations planned to be adopted under each of the standalone scenarios are combined, in addition to adopting the following additional intervention measures.

Urban Mass Transit Company Limited

a. Proposed new road links

The revised Master Plan 2031 has suggested many new road links for Udaipur city. The Low Carbon Mobility Scenario (LCMP) however, after testing different options, has taken only a few roads, and accordingly the LCMP scenario is finalized. This section of transport infrastructure deals with the appropriate proposals made under the LCMP scenario to achieve minimal carbon emissions. Figure 6-37 shows the new road links proposed.

b. Road hierarchy system

The national highways passing through Udaipur serve a variety of functions, including the provision of direct access to properties, pedestrian paths, bus routes, and private vehicles, and catering for through-traffic that is not related to immediate land uses. Apart from the NH, most other roads serve more than one function to varying degrees, but it is clear that the mixing of incompatible functions has been leading to problems.

A road hierarchy is a means of defining each roadway in terms of its function, such that appropriate objectives for that roadway can be set and appropriate design criteria along with functional classification can be implemented. These objectives and design criteria are aimed at achieving an efficient road system, whereby conflicts between the roadway and the adjacent land use are minimized and the appropriate level of interaction between the roadway and land use is permitted. Table 6-20 shows the road hierarchy details proposed.

Table 6-20: Proposed road hierarchy

Sl. No.	Road category	Right-of-way (m)
1	National Highway/State Highway	36-60
2	Arterial roads	36
3	Sub-arterial roads	30
4	Other major roads	24

The proposed road connecting Pratap Nagar Chowk with Ahmedabad Road on the south is the extension of the existing bypass road. This new bypass road will have a right-of-way of 60m, with four lanes in each direction. A new road is proposed perpendicular to this new bypass road connecting Ahmedabad Road for smooth movement of city traffic and segregating intercity traffic with city traffic. This road will be with right-of-way of 36m with three lanes in each direction. All other proposed roads are with right-of-way of 24m. The summary of the roads proposed is given in Table 6-21. A total of 82km of road is considered apart from the flyover near Pratap Nagar Chowk for the LCMP scenario.

Table 6-21: Proposed road network under the LCMP scenario

Sl. No.	Road Category	Right-of-way (m)	Road length (Kms)
1	New Bypass Road	60	23
2	Road connecting new Bypass Road with Ahmedabad Road	36	11
3	Other major roads proposed	30	48
4	Flyover near Pratapnagar Chowk	-	-

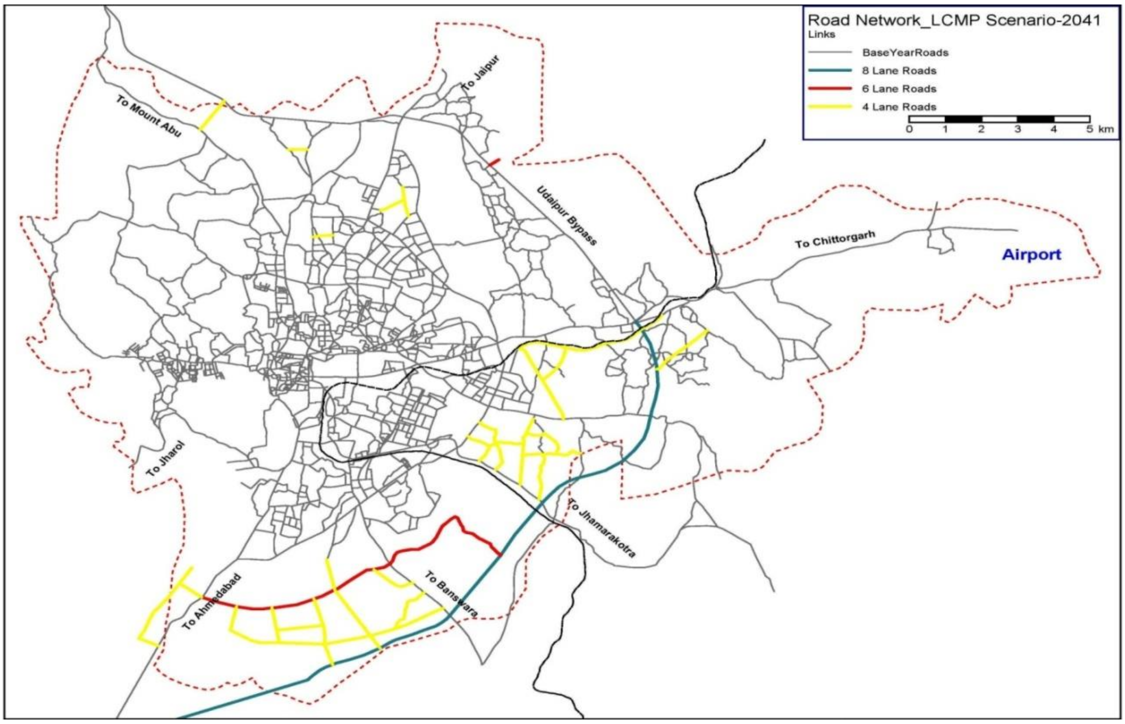

Figure 6-37: Proposed road network for the year 2041, LCMP scenario

c. Proposed public transport infrastructure

A bus-based public transport system will be introduced in Udaipur with trunk and feeder routes based on passenger demand. The routes identified for the PT system are shown in Figure 6-19. The routes are designed in such way that most of the Udaipur residents should have access to the PT system within 10 minutes' walking time. Accordingly, two trunk routes and seven feeder routes are proposed for Udaipur under the LCMP scenario for the year 2041.

The trunk routes (Clock Tower to Moti Khera, Arihant Tiles & Marbles to Shankar filling station) will be operated with 5 minutes headway, while the other feeder routes will be operated with a headway of 15 minutes. The route length of trunk routes is around 45km, while that of feeder routes is 133km, with a total of 181km of PT routes in Udaipur until 2041. The PT infrastructure required is given in Table 6-22.

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Table 6-22: Proposed PT infrastructure for 2041

Sl. No.	Description	Quantity
1	No. of mini/midi buses	100
2	No. of standard buses	96
3	No. of bus shelters	360
4	No. of bus depots	3
5	No. of bus terminals	6
6	Central control centre	1

d. Development of freight infrastructure

In order to reduce the burden of movement of freight vehicles and thereby emissions within the city, four truck terminals have been suggested in the peripheral areas of the city along the corridors that experience heavy freight traffic movement. The location of the proposed truck terminals are as suggested in Figure 6-38.

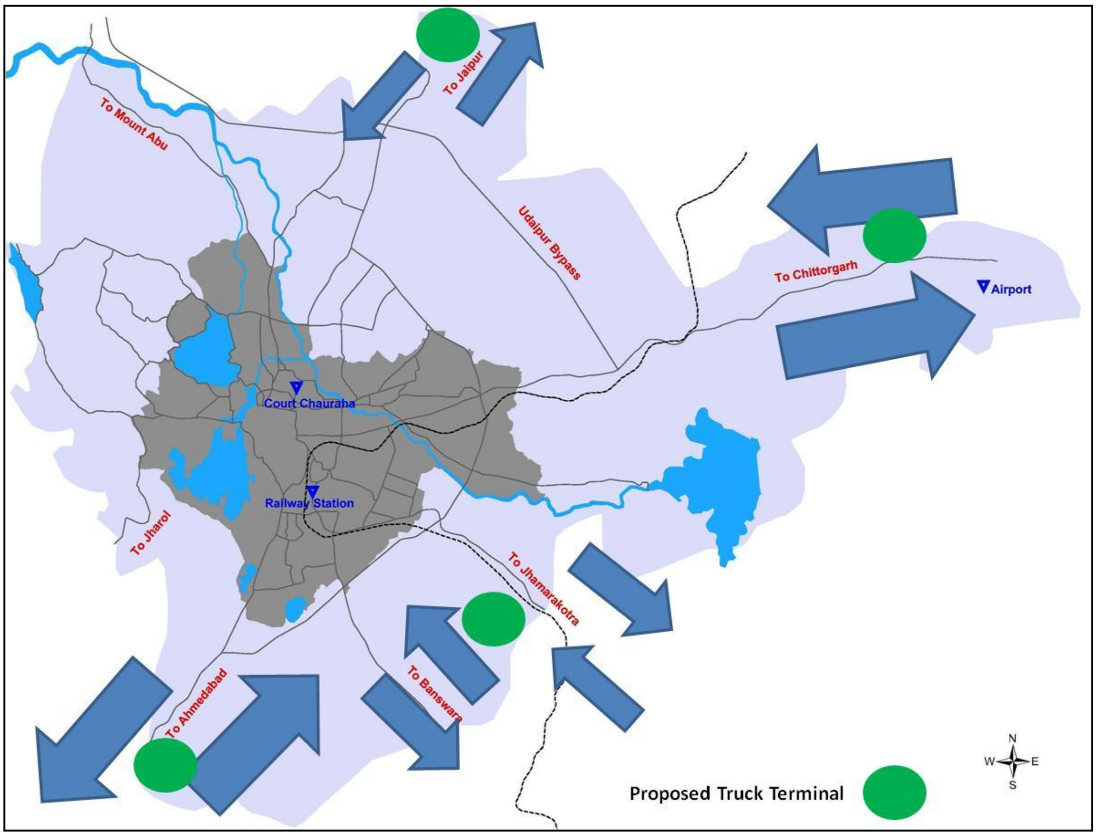

Figure 6-38: Proposed truck terminal locations

6.6.3 Outcomes of the combined scenario

The outcomes of the combined scenario have been classified into two categories: mobility and accessibility results, and emission levels. These results are presented in the subsequent sections as follows.

6.6.3.1 Mobility and accessibility results for the combined scenario

a. Modal shares

Table 6-23 compares the mode shares in the base year, BAU scenario (2041) and combined scenario (2041).

Table 6-23: Modal share comparison of base year, BAU and combined scenarios

Modal share	Base year (2013)	BAU (2041)	Combined scenario (2041)
Walk	25%	20%	28%
Cycle	3%	2%	9%
Two-wheeler	47%	51%	20%
IPT	18%	21%	10%
Car	4%	4%	1%
PT	3%	2%	32%

It can be observed from the table above that the modal share of public transport increases to 32 per cent as against 2 per cent in the BAU scenario, and the modal share of NMT modes increase to 35 per cent as against 22 per cent in the BAU scenario, which means that there is a considerable shift from private vehicles to public transport.

b. Trip lengths

Table 6-24 compares the mode shares in the base year, BAU scenario (2041) and combined scenario (2041).

Table 6-24: Trip length comparison of BAU and combined scenarios

Mode	Base year (2013)	BAU (2041)	Combined scenario (2041)
Walk	1.18	2.06	1.89
Cycle	2.37	3.65	3.09
Two-wheeler	5.54	5.92	5.13
IPT	4.52	5.55	5.32
Car	7.06	7.51	6.56
PT	-	5	5.65
Average	4.13	4.94	4.60

It can be observed from the table above that the ATL of Udaipur city reduces by 8 per cent in the combined scenario as against the BAU scenario for the horizon year 2041. The ATL of walk and cycle modes reduces by 14 percent, whereas the ATL for PT is increased by 12 per cent. This shows that the compact development and environment for incentivising walking and cycling will reduce the dependency on private vehicles except for long distance trips.

c. *V/C ratio and traffic flow pattern:*

As the population grows, under the BAU scenario there will be a huge growth of private vehicles leading to more emission levels. However, in the combined scenario, there will be a reduction in the use of private vehicle as a result of strategies adopted for improvement under the land use, NMT and public transport scenarios. The saturation (V/C ratio) and flow diagrams (flow in PCU/hr), as shown in Figure 6-39 and Figure 6-40, pictorially indicate the level of traffic congestion in Udaipur city under each scenario for the year 2041. The combined scenario gives the best results as compared to the various independent scenarios.

d. *Difference plots*

The difference plot is an easy graphical representation of flow patterns under different scenarios. The user equilibrium assignment is based on Wardrop's first principle, which states that no driver can unilaterally reduce their travel costs by shifting to another route. Hence, under each scenario, the flow-on links are different. The best alternative scenario can be decided by observing the different plots of each alternate scenario and the BAU scenario. Figure 6-41 shows the difference plots comparing each alternate scenario with the BAU scenario. From the figures, it is observed that the combined scenario gives the best results (low VKT).

e. *Kernel density:*

Kernel density is defined as the ratio of the length of the road network in a particular zone versus the area of the zone. The units for kernel density are km/km^2. This kernel density indicates the length of roads available in a particular area. Figure 6-42 shows the kernel density for the combined scenario. The average kernel density value for the combined scenario is $5.73 km/km^2$.

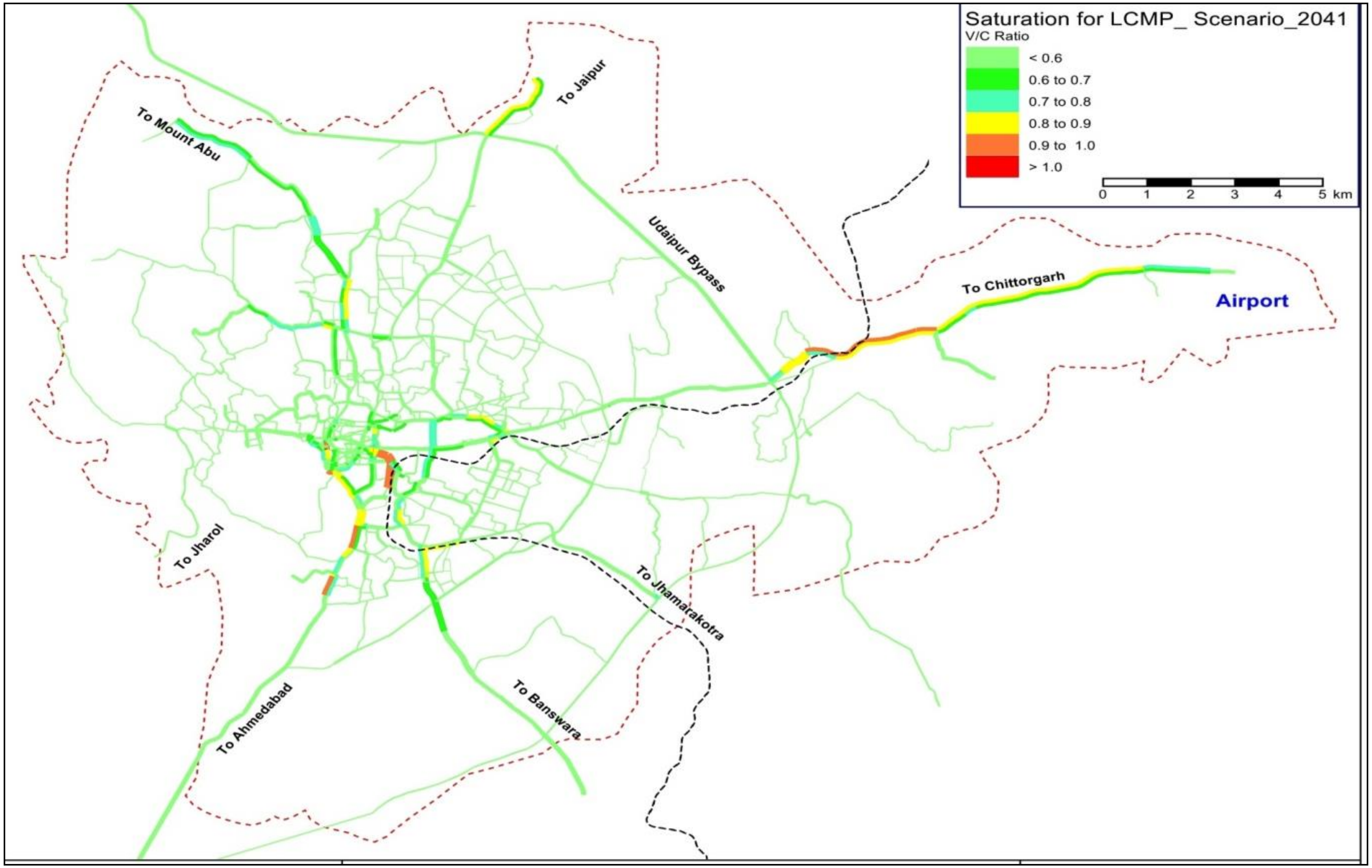

Figure 6-39: V/C ratio under the combined scenario (2041)

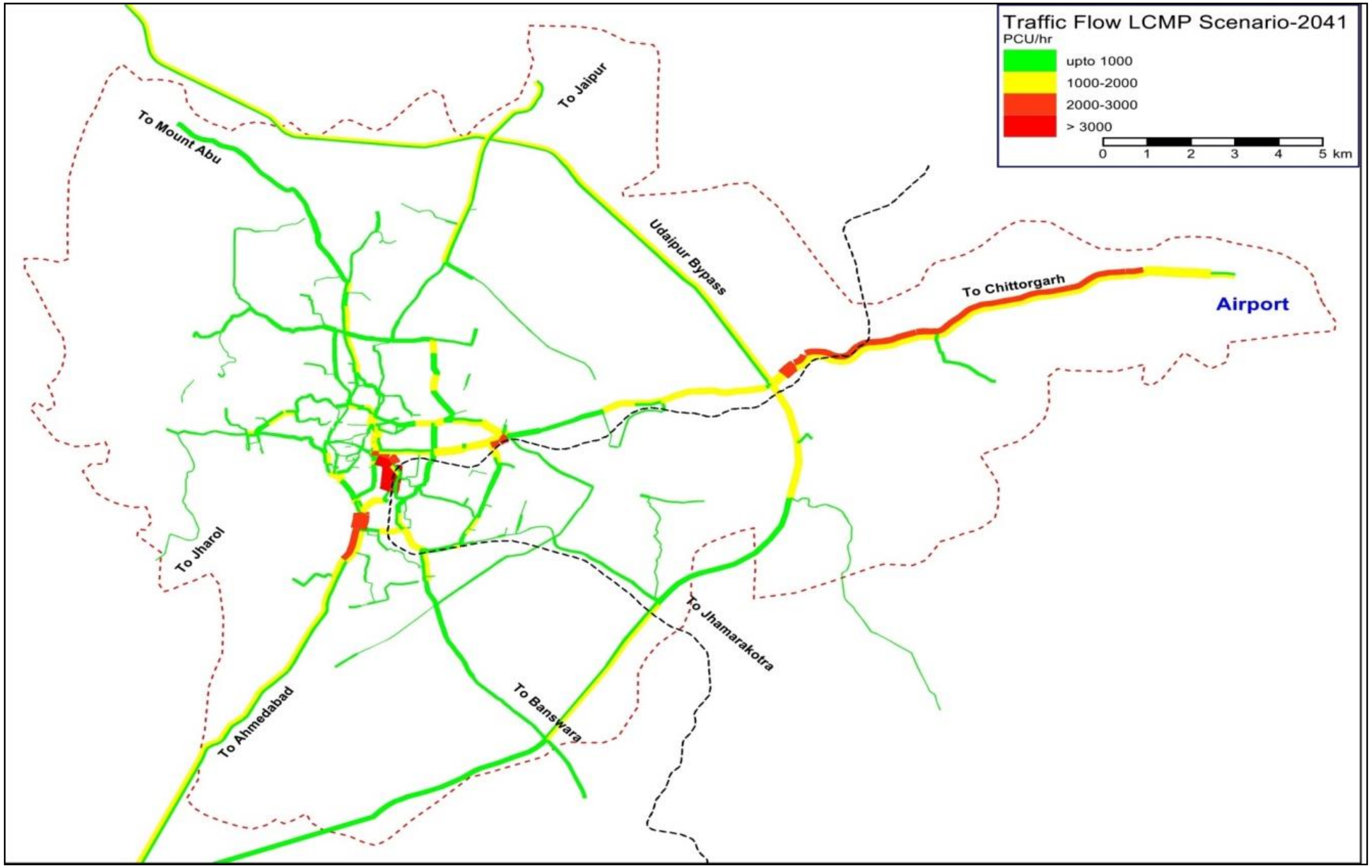

Figure 6-40: Traffic flow (PCU/hr) under the combined scenario (2041)

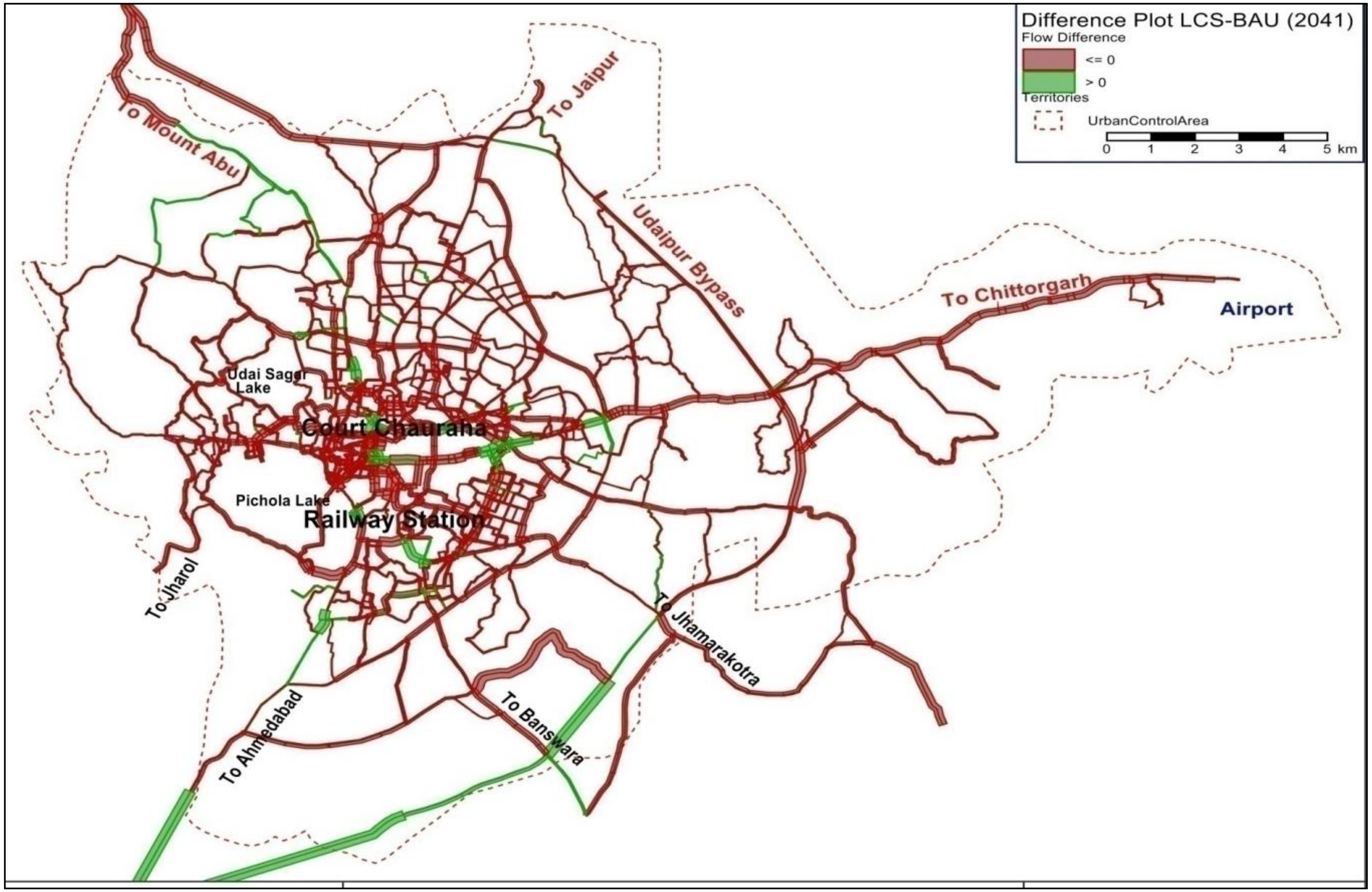

Figure 6-41: Traffic flow difference plot between the combined and BAU scenarios (2041)

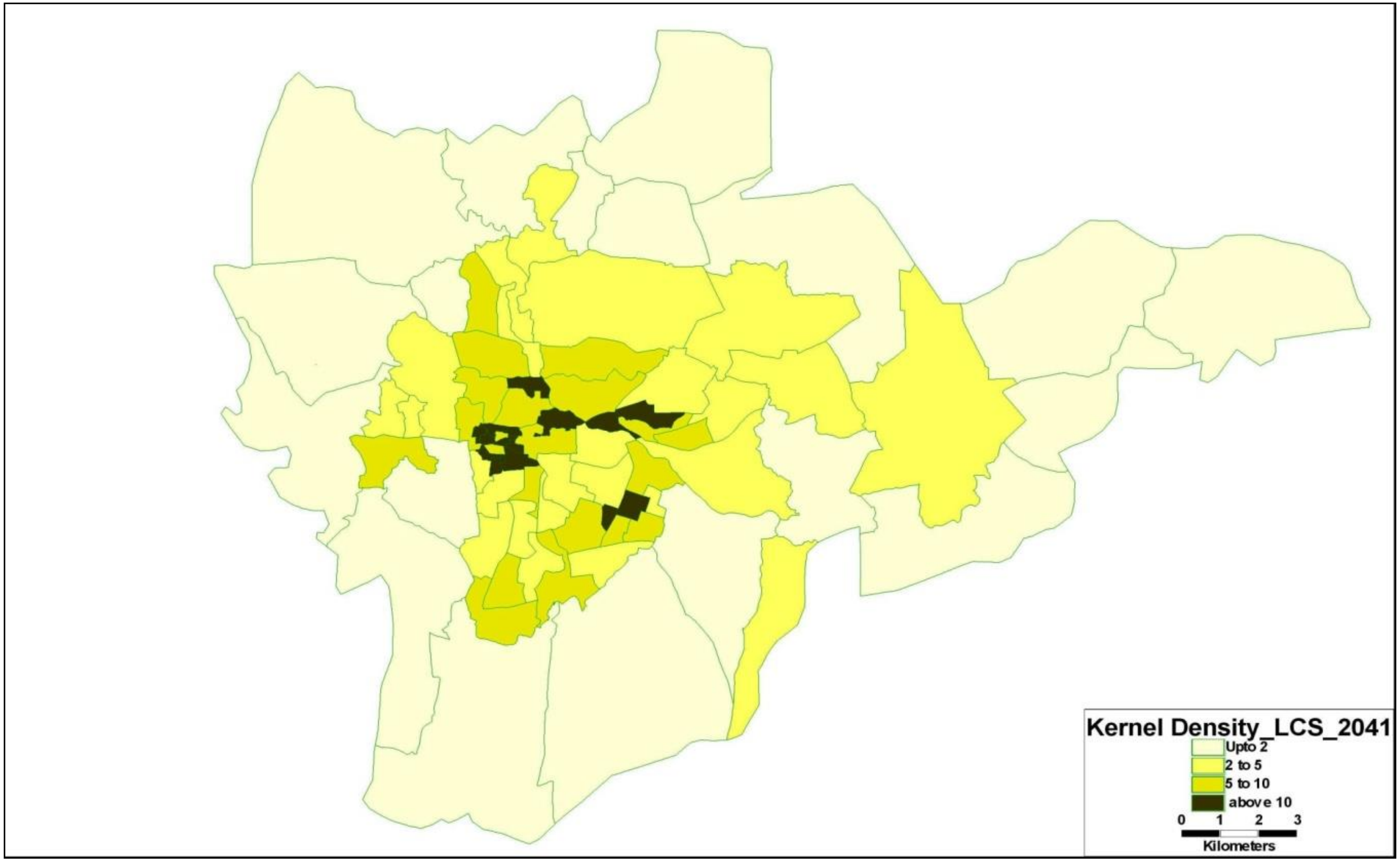

Figure 6-42: Kernel density for the combined scenario (2041)

6.6.3.2 Emission level

Table 6-25 shows the emission levels of the combined scenario.

Table 6-25: Combined scenario emission level

Emission level NO_2 tons annually	Emission level CO_2 million tons annually	Emission level of PM10 tons annually	Emission level of SO_2 tons annually	Emission level of CO tons annually
36,066	24	10,484	591	4,54,591

6.7 Comparative Analysis

6.7.1 Modal share results for all scenarios

A comparison of modal shares for the base year with BAU-2041, land use–2041, PT-2041, NMT-2041, and combined-2041 shows that there is an improvement in the mode shares of sustainable modes like bus, walk and cycle. Table 6-26 gives the comparison of mode shares.

Table 6-26: Modal share comparison of base year and alternate scenarios

Mode	Base year (2013)	BAU scenario (2041)	Land use scenario (2041)	NMT scenario (2041)	PT scenario (2041)	Combined LCMP scenario (2041)
Walk	25%	20%	29%	38%	27%	28%
Cycle	3%	2%	6%	9%	9%	9%
Two-wheeler	47%	51%	41%	31%	21%	20%
IPT	18%	21%	18%	15%	12%	10%
Car	4%	4%	2%	2%	1%	1%
PT	3%	2%	4%	5%	30%	32%
Total	100%	100%	100%	100%	100%	100%

It is observed from the above table that after the introduction of a well-organized and accessible public transport system, the share to PT increases up to 32 per cent. Under the combined scenario, the PT share is the highest, and the better infrastructure facilities for walking and cycling allow for shorter trips by those modes. This supports the access and egress from the PT systems, with an overall reduction in shares of private modes, thus offering the most environmentally sustainable scenario with reduced carbon emissions.

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6.7.2 Average trip length results for all scenarios

The average trip length indicates the average distance travelled by all trip makers of that particular mode. If the average trip length is less for a city, it indicates that the city is compact. Table 6-27 gives the mode-wise average trip lengths under each scenario. Under the BAU scenario, with city growth proposed towards the eastern and southern side (as per revised Master Plan 2031), the trip length increases significantly. However, the trip length decreases in the land use scenario with proposals of more mixed land use intensity. Thus, in developing a sustainable combined scenario, the impact of land use intervention has been taken into account, and accordingly an optimal mixed land use strategy has been proposed in the standalone land use intervention strategy, which forms one of the key strategies in the combined scenario.

Table 6-27: Average trip length (km) comparison for all scenarios

Mode	Base year (2013)	BAU scenario (2041)	Land use scenario (2041)	NMT scenario (2041)	PT scenario (2041)	Combined LCMP scenario (2041)
Walk	1.18	2.06	1.62	3.31	1.78	1.89
Cycle	2.37	3.65	3.13	4.08	3.35	3.09
Two-wheeler	5.54	5.92	5.56	6.30	5.63	5.13
IPT	4.52	5.55	5.24	5.51	4.98	5.32
Car	7.06	7.51	6.98	7.68	7.77	6.56
PT	-	5.00	5.00	5.00	5.75	5.65
Average	4.13	4.94	4.58	5.31	4.87	4.60

6.7.3 Accessibility to PT/IPT – comparison for all scenarios

Accessibility for PT is an important parameter for improving the share of sustainable modes like bus. Table 6-28 shows the comparison of accessibility values measured in terms of percentage under each alternative scenario (100 per cent means completely accessible, and 0 per cent means not accessible). It is observed that, due to the introduction of an organized PT system, the accessibility improved from 60 to 83 per cent. Under the PT scenario, the routes are designed in such a way that 83 per cent of the households are accessible to PT within 10 minutes' walking distance, and the same could be observed in the combined scenario.

Table 6-28: Accessibility to PT/IPT comparison for all scenarios

Description	Base year (2013)	BAU scenario (2041)	Land use scenario (2041)	NMT scenario (2041)	Public transport scenario (2041)	Combined LCMP scenario (2041)
Percentage of HH within 10 minutes' walking distance to access PT (IPT for base year)	69%	60%	80%	78%	83%	83%

6.7.4 Intensity of mixed land use for all scenarios

To arrest the urban sprawl, it was important to encourage different activities such as commercial, educational and recreational activities within the residential areas to increase the intra-zonal trips, which were predominantly performed by NMT modes. Table 6-29 shows the change in the intra-zonal trips as compared to the base year due to the change in the land use mix.

Table 6-29: Intra-zonal trips – comparison for all scenarios

Description	Base year (2013)	BAU scenario (2041)	Land use scenario (2041)	NMT scenario (2041)	Public transport scenario (2041)	Combined LCMP scenario (2041)
Increase in percentage of intra-zonal trips as compared to base year (base year value is 19%)	-	16%	68%	16%	16%	68%

As per the land use scenario, mixed land use with various activities was induced by developing vacant lands within the city, which led to a decrease in the trip lengths and increase in the intra-zonal trips. As a result of this high intensity of mixed land use, the percentage of intra-zonal trips increased in the combined scenario from 16 per cent in the BAU scenario to 68 per cent in the land use scenario, which is represented in Figure 6-9 along with the ratio of residential use with the commercial, educational, and health facilities. The same was represented in the combined scenario; hence the percentage of intra-zonal trips was 68 per cent in the combined scenario.

6.7.5 Safety to use NMT – comparison for all scenarios

Walking and NMT are considered to be the most sustainable transport options. In the case of Udaipur, though the majority of the trips are performed by walking, pedestrian infrastructure in not given priority, as only 4 per cent of the total road network has footpaths. Based on the user survey, where the respondents strongly preferred the development of infrastructure such as footpaths, dedicated cycle tracks, etc., the NMT modes were perceived as safer modes for short distance travel. Accordingly, detailed strategies were drafted out, which are duly discussed in the previous sections. Table 6-30 represents the percentage of respondents who perceived travel by NMT modes to be safer under various scenarios.

Table 6-30: Safety to use NMT – comparison for all scenarios

Description	Base year (2013)	BAU scenario (2041)	Land use scenario (2041)	NMT scenario (2041)	Public transport scenario (2041)	Combined LCMP scenario (2041)
Walk	8%	8%	50%	83%	-	83%
Cycle	7%	7%	55%	80%	-	80%

It can be observed from Table 6-30 that the development of infrastructure like footpaths, dedicated cycle tracks, and signalized intersections with road markings and signages, etc., has increased the perception of safety to use NMT from 8 per cent in the BAU scenario to 83 per cent in the combined scenario.

6.7.6 Annual vehicle kilometres travelled – comparison of all scenarios

Vehicle kilometres travelled is a major indicator for estimating GHG emissions under each scenario. As observed from Table 6-31, the BAU scenario shows the highest VKT due to an increase in the number of private vehicles. The introduction of an organized PT system under the PT scenario resulted in lower VKT as compared to the BAU scenario, and the combined scenario has resulted in the least VKT.

Table 6-31: Annual VKT comparison for all scenarios

Description	Base year (2013)	BAU scenario (2041)	Land use scenario (2041)	NMT scenario (2041)	Public transport scenario (2041)	Combined LCMP scenario (2041)
Total motorized vehicle kilometres (million km)	880.5	2,559.9	2,159.6	2,341.3	1,691.6	1,335.2

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6.7.7 Congestion level – comparison for all scenarios

The V/C ratio is the ratio between the flows (volume) of traffic measured in PCU/hr on a particular road section (link) to the capacity of the road section in PCU/hr. If the V/C ratio is close to 1, it indicates a congested situation and high level of discomfort to the vehicle users. This V/C ratio is the result of a traffic assignment technique of a four step model. As observed from Table 6-32, the BAU scenario has 26 per cent of the road network with a V/C ratio exceeding 1, and due to the introduction of a systematic PT system the value is reduced to 10 per cent and further to 5 per cent in the combined scenario.

Table 6-32: Congestion level comparison for all scenarios

Description	Base year (2013)	BAU scenario (2041)	Land use scenario (2041)	NMT scenario (2041)	Public transport scenario (2041)	Combined LCMP scenario (2041)
Road length (km) with value of V/C ratio equal to 1 or more	-	26%	14%	16%	10%	5%

6.7.8 Emission level – comparison for all scenarios

The main aim of the LCMP study for Udaipur was to provide a safe, efficient and environmentally sustainable means of transportation. To achieve this, it was essential to assess the emission levels of all these scenarios. Table 6-33 shows the comparison of all the scenarios with the combined scenario. Referring to Figure 6-43 and Figure 6-44, the combined scenario has resulted in the reduction of emissions of noxious gases, as well as reduction in CO_2 also by approximately 54 per cent.

Table 6-33: Emission level comparison for all scenarios

Description	Base year (2013)	BAU scenario (2041)	Land use scenario (2041)	NMT scenario (2041)	Public transport scenario (2041)	Combined LCMP scenario (2041)
NO_2 tons annually	10,210	61,261	57,597	60,866	46,947	36,066
CO_2 million tons annually	17	33	32	33	26	24
PM10 tons annually	4,500	18,000	16,696	17,253	13,523	10,484
SO_2 tons annually	201	802	805	792	784	591

Description	Base year (2013)	BAU scenario (2041)	Land use scenario (2041)	NMT scenario (2041)	Public transport scenario (2041)	Combined LCMP scenario (2041)
CO tons annually	397,677	695,935	617,936	681,136	485,139	454,591

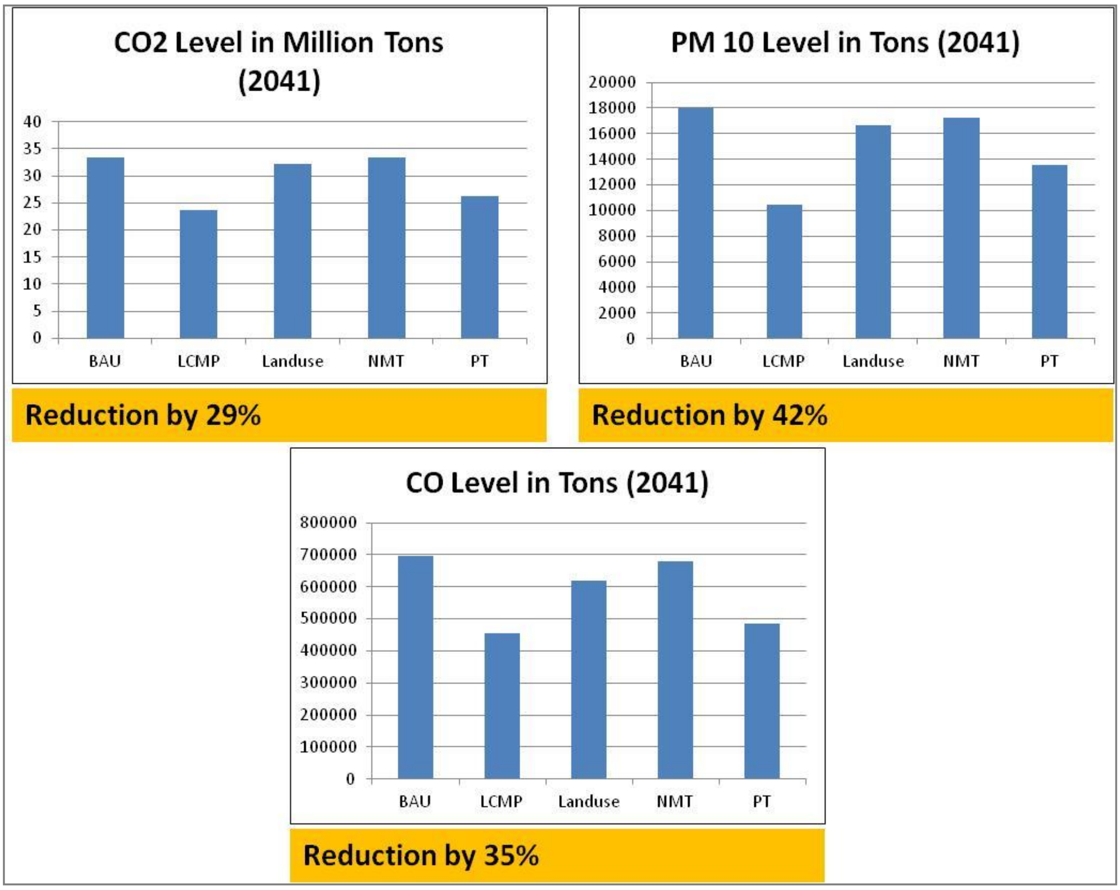

Figure 6-43: Reduction of CO_2, PM10, and CO emissions in the combined scenario (LCMP scenario)

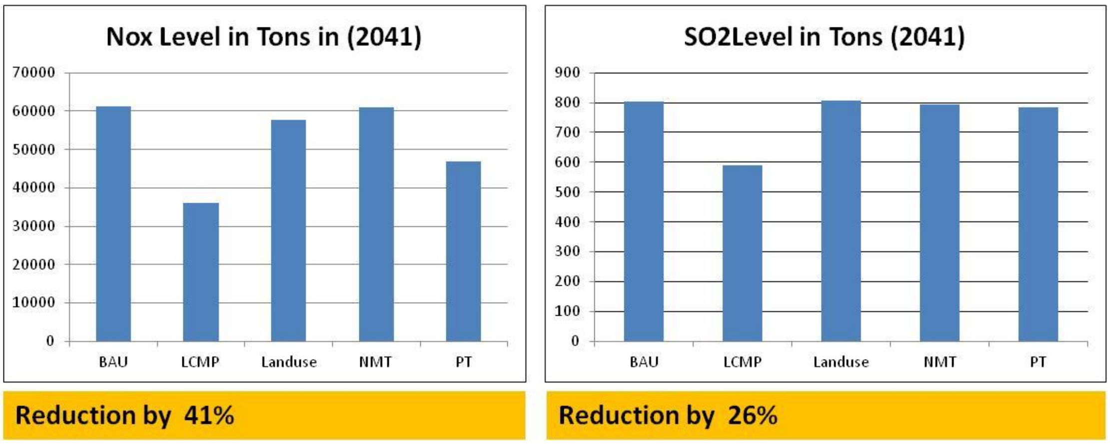

Figure 6-44: Reduction of NOx, SO_2 emissions in the combined scenario (LCMP scenario)

6.7.9 Outcomes of the combined scenario

From the comparative analysis of the previous sections it has emerged that to achieve a comprehensive low-carbon mobility scenario for Udaipur, it is essential to adopt a combination of strategies, namely the land use, PT, NMT and technology scenarios as a pre-requisite condition. The overall outcomes of the combined scenario have been discussed in the previous sections and are shown in Table 6-34.

Table 6-34: Outcomes of combined strategy

Indicator/values	Base year (2013)	BAU scenario (2041)	Land use scenario (2041)	NMT scenario (2041)	Public transport scenario (2041)	Combined LCMP scenario (2041)
Modal Share						
Walk	25%	20%	29%	38%	27%	28%
Cycle	3%	2%	6%	9%	9%	9%
Two-wheeler	48%	51%	41%	31%	21%	20%
IPT	18%	22%	18%	15%	12%	10%
Car	3%	3%	2%	2%	1%	1%
PT	3%	2%	4%	5%	30%	32%
Trip length (km)						
Walk	1.18	2.06	1.62	3.31	1.78	1.89
Cycle	2.37	3.65	3.13	4.08	3.35	3.09
Two-wheeler	5.54	5.92	5.56	6.3	5.63	5.13
IPT	4.52	5.55	5.24	5.51	4.98	5.32
Car	7.06	7.51	6.98	7.68	7.77	6.56
PT	-	5	5	5	5.75	5.65
Accessibility						
Percentage of HH within 10 minutes' walking to access PT (IPT for base year)	69%	60%	80%	78%	83%	83%
LOS of PT facilities	4	4	3	2	2	2

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Indicator/values	Base year (2013)	BAU scenario (2041)	Land use scenario (2041)	NMT scenario (2041)	Public transport scenario (2041)	Combined LCMP scenario (2041)
as per MoUD SLB Handbook						
Land use mix intensity						
Increase in the percentage of intra-zonal trips as compared to base year (base year value is 19%)	-	16%	68%	16%	16%	68%
Safety to use NMT						
Walk	7.5%	7.5%	78%	83%	-	83%
Cycle	7%	7%	70%	80%	-	80%
Total motorized vehicle kilometres (thousand km)	880,489	2,559,907	2,159,624	2,341,289	1,691,624	1,335,210
LOS of NMT facilities as per MoUD SLB Handbook	4	4	3	2	-	2
Congestion level						

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Indicator/values	Base year (2013)	BAU scenario (2041)	Land use scenario (2041)	NMT scenario (2041)	Public transport scenario (2041)	Combined LCMP scenario (2041)
Road length (km) with value of V/C ratio equal to 1 or more	-	26%	14%	16%	10%	5%
Emission levels						
NO_2 tons annually	10,210	61,261	57,597	60,866	46,947	36,066
CO_2 million tons annually	17	33	32	33	26	24
PM10 tons annually	4,500	18,000	16,696	17,253	13,523	10,484
SO_2 tons annually	201	802	805	792	784	591
CO tons annually	397,677	695,935	617,936	681,136	485,139	454,591

The combined scenario tries to address the issues, explicitly spelled out in the land use, PT, NMT and technology scenarios individually, by integrating all the strategy measures mentioned in each of these scenarios along with some additional strategies, which can significantly impact the mobility scenario in Udaipur.

The BAU scenario assumes the development pattern is in line with the proposals of the Master Plan and the proposals being undertaken by the various city authorities. The result of the scenario has been discussed in Chapter 5, and has shown probable pressures on the transport infrastructure of Udaipur city. The emphasis of the spatial spread towards the eastern and southern sides of the city has led to the dispersal of activity centres and increased dependency on private modes of transport, resulting in higher motorized VKT and higher emission levels along with a chaotic motorized scenario.

The land use scenario emphasizes the infill and redevelopment of the vacant lands as well as the encouragement of new developments along the proposed PT corridors/existing IPT corridors in Udaipur, thereby moving towards self-reliant sustainable neighbourhoods. The results of the scenario have been discussed in detail in the previous sections. Given the concentration of mixed use activities along the existing IPT and proposed PT corridors, and improved first mile and last mile connectivity, it was observed that the percentage of intra-zonal trips increase from 16 per cent in the BAU scenario to 68 per cent in the land use scenario, which comparatively reduces the average trip length (ATL). Even though 80 per cent of the households have access to the PT system within 10 minutes' walking distance, it was observed that motorized VKT decreases marginally by 18 per cent as compared to the BAU scenario. This is because the scenario would improve first mile and last mile connectivity only, while the main line haul trips would still be characterized by existing IPT and proposed public transport like in the BAU scenario. Thus in this scenario the emissions reduce only by 6 per cent.

The PT scenario emphasizes fulfilling the mobility needs of the city with an organized public transport system that is safe, reliable and environmentally friendly by re-organizing the existing IPT system and introducing an organized city bus service catering to the anticipated demand in the medium and long term. The results of the scenario have been discussed in detail in the previous sections. It was observed with the introduction of an organized PT system that the modal share of PT increases to 30 per cent from 2 per cent in the BAU scenario, which effectively means a reduced dependency on private modes. It was observed that the total motorized VKT is reduced by 51 per cent as compared to the BAU scenario, resulting in the reduction of emissions by 27 per cent.

The NMT scenario emphasizes the provision of quality NMT infrastructure, such as the development of footpaths, cycle tracks, the introduction of a bicycle sharing scheme, redesigning street furniture, pedestrian crossing facilities at junctions, street lighting facilities, etc., which will significantly impact the mobility scenario in Udaipur, as reflected in the travel demand model results. The result of the NMT scenario has been discussed in detail in the previous sections. It was observed that there is a considerable increase in the modal share of NMT from 2 per cent in the BAU scenario to 9 per cent, while the modal share of walking has increased from 20 per cent in the BAU scenario to 38 per cent in the NMT scenario. The accessibility to the existing IPT or proposed public transport has increased due to improved last mile connectivity via the provision of NMT infrastructure. However, motorized VKT is reduced only by 9 per cent as compared to the BAU scenario, which is due to the fact that there has been improvement in first mile and last mile connectivity only. Conversely, the main line haul trips would be still characterized by existing IPT and proposed public transport like in the BAU scenario only, as there is little or no focus for public transport in the proposed BAU intervention measures. As there has been a marginal change between the BAU and NMT scenarios in terms of VKT, this scenario reduces emissions by 2 per cent only.

It can be observed that each of the above mentioned scenarios emphasize certain developmental strategies. For example, the land use scenario emphasizes compact development, the PT scenario emphasizes an organized PT system, the NMT scenario emphasizes the provision of NMT infrastructure, and the technology scenario emphasizes more energy-efficient vehicle technologies and fuel types, with an overall effort in the reduction of emissions. To achieve an inclusive mobility scenario for Udaipur, a combined scenario was developed, which integrates land use planning with transport and infrastructure development for public transport and NMT, the results of which have been discussed in the previous sections in comparison to the other scenarios.

It was observed that the modal share of the PT and NMT scenarios increased to 32 and 35 per cent respectively as against 2 and 22 per cent in the BAU scenario, as increased road lengths are available to pedestrian and NMT users, which cater to access and egress trips from the PT system. It was observed that the ATL for walk and cycle trips reduces by 14 per cent, whereas the PT is increased by 12 per cent. The integration of high density compact development with an organized PT system and NMT infrastructure encouraged increased intra-zonal trips and ultimately reduced the dependency on private vehicles. This is due to the increased intra-zonal trips, which are combined with the increased road lengths becoming more accessible for NMT and PT users. Given the reduced dependency on private vehicles, the motorized VKT reduced by approximately 90 per cent and the overall reduction in emissions by 35 per cent.

6.8 Conclusions

From the previous sections, by comparing all the alternative development scenarios for the city of Udaipur, it is apparent that the combined LCMP scenario, wherein all the strategy interventions such as land use, PT, NMT and technology are adopted, results in the most improved urban mobility scenario across the heterogeneous socio-economic groups and genders, along with an overall reduction in emission levels.

Chapter 7. Implementation Program and Block Cost Estimation

This chapter defines the phases for implementing the projects identified in the previous chapters, which are sustainable in the long term. This chapter also describes the cost estimates associated with implementing each project. The financing options to implement each of the projects are also described in this chapter.

7.1 Background

The LCMP aims at achieving low-carbon emissions from the transport sector by promoting sustainable modes of transport such as NMT and PT, which emit lower emissions as comapred to private vehicles. The combined LCMP scenario indicates that by 2041, the emissions would be reduced by 35 per cent on account of integrated land use and transport policy along with PT and NMT infrastructure. This scenario also includes the adoption of new fuel and vehicle technologies by 2041 for further reduction of emissions as compared to the BAU scenario. This chapter describes the cost estimates associated with the implementation of each of the strategies as mentioned in the previous sections.

7.2 Phasing Plan

Considering the parameters, such as urgency of implementation, capital investment requirement, ease of implementation, resource availability and environmental considerations, the phasing plan for the various projects identified as part of the LCMP study has been determined. In consultation and agreement with UIT and the District Collectorate, Udaipur, it was envisaged that long-term planning of 30 years would be required to attain the goals of the LCMP. Accordingly, the phasing of the identified projects are categorized into immediate interventions, short term, ,medium term and long term.

- Immediate interventions – envisaged for a period of 1 to 2 years
- Short-term interventions – envisaged for a period of 5 years
- Medium-term interventions – envisaged for a period of 10 years
- Long-term interventions – envisaged for a period of 30 years.

It was discussed and agreed that the projects that do not require high capital investment or resource allocation, and offer a reduction in the overall emissions, are the high priority projects. These are the projects that can instantly relieve the mobility problems of the city. At the same time, the projects requiring high amounts of capital inflow and land requirement that do not cater to the immediate needs of the city have been categorized into medium and long-term projects.

7.3 Block Cost Estimates

A block cost estimation of the projects as part of the strategies has been prepared, which covers NMT infrastructure (footpaths, cycle tracks, etc.), PT infrastructure (fleet requirement, bus depots and terminals, ITS for PT system), street markings, street lightings and other miscellaneous items. The approximate capital cost, excluding land acquisition, for implementing the mobility plan is about Indian Rupee (INR) 22,152.4 million. The phase-wise costing is given in Table 7-1. The item-wise costing and phase-wise implementation framework is given in Table 7-2, and the detailed costing is described in Annexure 6.

Table 7-1: Phase-wise cost details

Phases	Project cost (INR Millions)
Phase I: Immediate projects: 2013-2015	4462.7
Phase II: Short-term projects: 2013-2018	2396.3
Phase III: Medium-term projects: 2019-2022	7032.2
Phase IV: Long-term projects: 2023-2041	8261.1
Total	22152.4

Table 7-2: Item-wise cost details, phase-wise cost details

Sl. No.	Project	Quantity	Units	Total cost (in INR Million)	Phase-wise total cost (in INR Millions)			
					Immediate phase (2013-2015)	Short term (2013 - 2018)	Medium term (2019-2022)	Long term (2023-2041)
	NMT infrastructure							
1	Construction and maintenance of footpaths	143	km	1247.7				
2	Grade-separated pedestrian facilities	19	No	209				
3	Development of cycle tracks							

Sl. No.	Project	Quantity	Units	Total cost (in INR Million)	Phase-wise total cost (in INR Millions)			
					Immediate phase (2013-2015)	Short term (2013 - 2018)	Medium term (2019-2022)	Long term (2023-2041)
	Road resurfacing	100000	m^2	94.5				
	Road markings	100	Sq. m					
4	Introduction of public bike sharing scheme							
	Bicycles	88	No	1.5				
	Infrastructure	8	No	7.4				
	Towing vans	2	No	3.5				
5	Tourism-promoting transport infrastructure (heritage walk)	3.2	Kms	128				
	Cost of NMT infrastructure (A)			**1691.7**				
	PT infrastructure							
6	Modernization of existing IPT	1803	IPT vehicles	991.7				
7	Introduction of city bus services	41	Buses	123				
8	Augmentation of city bus services	360	Buses	1296				
9	Ancillary infrastructure							
	IPT/Bus Q Shelters	372	No	253.2				
	Bus depot/terminal (18 OD terminals and 4 bus depots/terminals)	22	No	880				
	Intelligent Transport Systems							
	ITS on IPT	1803	IPT vehicles	450.8				
	ITS on Bus	41	Buses	25.625				
	ITS of augmented fleet of buses	360	Buses	270				
	ITS on IPT/Bus Q shelters	112	No	73.9				
	Cost for PT infrastructure (B)			**4364.2**				
	Traffic management							
10	Intersection improvement **(C)**	19	No	99.8				

Sl. No.	Project	Quantity	Units	Total cost (in INR Million)	Phase-wise total cost (in INR Millions)			
					Immediate phase (2013-2015)	Short term (2013 - 2018)	Medium term (2019-2022)	Long term (2023-2041)
	Network improvement							
11	Street markings	204	LS	6134				
12	Street lighting	712	km	2018.6				
13	Road network development (60m, 36m and 30m)							
	60 m RoW	23	km	2415				
	36 m RoW	11	km	962.5				
	30 m RoW	48	km	3840				
	Cost of road works (D)			15370.1				
	Freight transport							
14	Development of a freight terminal **(E)**	4	No	400				
	Public awareness programme							
15	Public education and awareness programme **(F)**		Lump sum	226.9				
	Total cost of infrastructure (A+B+C+D+E+F)			**22152.7**				

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7.4 Financing Options for Urban Transport Projects

As per the recommendations of the Working Group on Urban Transport for the 12th Five Year Plan, the financing of urban transport projects in the country has largely been confined to gross budgetary support from the government and user charges. Due to the heavy investment needs of urban transport and conflicting demands on the general exchequer, investment in urban transport in the past has not kept pace with the rapidly increasing requirement of the sector. The current level of user charges on limited urban transport facilities do not make the system self-sustainable. At the same time, providing safe, comfortable, speedy and affordable public urban transport to all has to be a governmental goal. The Municipal Corporation of Udaipur and Urban Improvement Trust, Udaipur are primarily responsible for the governance of the city by providing urban infrastructure and services to its citizens. These organizations are supported by several line departments at the State-level and city-level, such as PWD, RSRTC, Tourism Department, etc., which play an important role in the delivery of services and infrastructure. The institutional setup has been discussed in detail in Chapter 8.

The finances of city administration in a city like Udaipur are limited and are completely dependent on revenue from taxes and government grants. Hence, it is essential to evaluate alternate funding sources besides Government budgetary support and the fare box. Some of the key funding sources can be dedicated levies, land monetization, recovery from non-user beneficiaries, debt and private investments. The paradigm of financing has to clearly move towards the non-user pays principle, and the polluter pays principle. It has been suggested that there is a need for a long-term sustainable dedicated financing mechanism to address the fast-worsening scenario in the field of urban transport, which would mean all the various components in which the investment would be required in the 12th Five Year Plan would need to be funded through a combination of funding from the Government of India, State Government/urban local body, development agencies, property development, loans from domestic and financial institutions, as well as PPP. Thus, it is imperative to identify projects that are amenable to Government funding or PPP. Apart from PPP options, the various sources of finance available for projects from Government sources at various levels are given below:

Table 7-3: Available sources of finance

Funding source	Type	Options	Responsibility
Funding from domestic source at local Level (ULB such as Udaipur Nagar Nigam and UIT)	Public fund domestically Mobilized	– Advertisement/fare box revenue/parking Fee – Creation of city-level UTF – Congestion pricing – Cess on fuel, private vehicle taxation/green cess on existing private vehicles	ULB

Funding source	Type	Options	Responsibility
		– Property development/TOD – Land value capture/ betterment charges/ vacant land tax – Municipal bonds – Pooled financing	
Funding from domestic source at State-level	Public fund domestically mobilized	– General budget funding – Viability gap funding – Loans from financial institutions/banks – Creation of State-level UTF	State Govt.
Funding from domestic Source at national-level	Public fund domestically mobilized	– General budget funding – National-level funding Scheme like JnNURM – Viability gap funding – Climate funding (NAMA financing)	Central Govt.
Funding from international source	Public fund mobilized from international source	– Loans from Multilateral Funding Agency – Carbon finance – Climate funding (NAMA financing)	State Govt. and ULB
Funding from private source	Private fund domestically mobilized	– PPP options (BOOT/BOT/lease/annuity etc.)	State Govt. and ULB

7.4.1 Public Private Partnership (PPP)

Public Private Partnerships are cooperative relationships between a public authority and private companies, created to carry out a specific project. They can take on a number of forms, and can be a useful method of capturing property value gains generated by transport infrastructure. In a PPP for a new transport infrastructure development project, the public authority creates a secure environment for the private sector to carry out the project, and the private partner offers its industry know-how, provides funding and shares in the project's risk.

The objectives of the public and private sector partners appear to be quite different. The public sector aims to best serve the interests of taxpayers. The aim is not to use public money to obtain a return on capital investments. The private sector, on the other hand, aims to ensure a return on investment for its shareholders and to be as profitable as possible. Yet these two contrasting goals can function perfectly well together in the framework of a PPP.

The decision to undertake a Public Private Partnership and the choice of the most suitable form of partnership greatly depends on the context and the types of project to be developed, details of which are given below:

- The project context may influence the type of PPP to be implemented. The public partner must evaluate the total cost of the project, its importance in terms of public need, the time frame, the number of actors involved and the geographic area in question. Does providing this public service require major infrastructure? Will it require high levels of human and financial resources to provide this service? Before a decision can be made, it is necessary to fully understand the context of the proposed project
- The cost of the project is of course a critical factor, which will weigh on the decision. Many PPP projects are for underground systems, LRT and BRT that require significant levels of financing, which the local authorities would have difficulty providing alone
- A well-structured institutional framework and the local authority's experience in developing transport projects are also decisive factors. Urban transport is an industrial and commercial activity, which involves financial risk. Bringing in experienced partners is one way of compensating for a lack of certain skills in this field, though a good PPP should call upon other forms of expertise on the part of the public authority. This can sometimes facilitate obtaining a loan, in particular from international funding agencies
- The tasks entrusted to the private sector (design, construction, development, operation, maintenance) will influence the type of contract
- The sharing of responsibilities and risks will determine the degree of involvement of each partner and the type and clauses of the contract. There are many types of contracts, but it is primarily the sharing of financial risk that will determine the key characteristics. There are two categories of risk: commercial risk, related to trends in revenue; and industrial risk, related to the cost of construction and trends in operating and maintenance expenses. If both types of risk are covered by the public partner, then it would be a management contract in which the private partner is merely performing the work. The private partner must meet the specifications but will not be motivated to improve the service nor propose innovative techniques or management
- If the project is not self-financing, i.e. if at the end of the contract the total revenues and gains do not balance out the total costs, the transit authority may be required to provide compensation, depending on the clauses of the contract.

7.4.2 Government sources of funding

One characteristic of the urban transport sector is that it depends on funding from several sources and involves various partners, public and private, individual and collective.

a. Viability gap funding

In a recent initiative, the Government of India established a special financing facility called 'Viability Gap Funding' under the Department of Economic Affairs, Ministry of Finance, to provide support to PPP infrastructure projects that have at least 40 per cent private equity committed to each project. The Government of India has set certain criteria to provide this facility under formal legal guidelines, issued in August 2004, to support infrastructure under the PPP framework. Viability Gap Funding can take various forms, such as capital grants, subordinated loans, O&M support grants, and interest subsidies. It will be provided in instalments, preferably in the form of annuities. However, the Ministry of Finance guidelines require that the total government support to such a project, including Viability Gap Funding and the financial support of other ministries and agencies of the Government of India, must not exceed 20 per cent of the total project cost as estimated in the preliminary project appraisal, or the actual project cost, whichever is lower.

Projects implemented by the private sector in the following sectors are eligible for funding:

- Roads and bridges, railways, seaports, airports, inland waterways
- Power
- Urban transport, water supply, sewerage, solid waste management and other physical infrastructure in urban areas
- Infrastructure projects in Special Economic Zones
- International convention centres and other tourism infrastructure projects.

b. JnNURM funding

Since cities and towns in India constitute the second largest urban system in the world, and contribute over 50 per cent of the country's GDP, they are central to economic growth. For the cities to realize their full potential and become effective engines of growth, it is necessary that focused attention be given to the improvement of infrastructure in an organized manner. As such, the JnNURM was launched in December 2005 with the aim to encourage reforms and fast track planned development of identified cities. Focus is to be on efficiency in urban infrastructure and service delivery mechanisms, community participation, and accountability of ULBs/Parastatal agencies towards citizens. The period of the Mission was seven years, up to 2014. During this period, funds were provided for proposals that would meet the Mission's requirements. Assistance under JnNURM is additional central assistance, which would be provided as a grant (100 per cent Central Government grant) to the implementing agencies.

The funding from JnNURM is supported by counterpart funding in the form of grants from the State and the ULBs, for which the ratio has been fixed by the Mission for different categories of cities.

c. *Dedicated urban transport fund at city level*

For the projects, which are not admissible under JnNURM, or Viability Gap Funding, the alternative sources of funding that a city could avail by setting up a dedicated urban transport fund at the city level are given below.

A dedicated urban transport fund would need to be created at the city level through other sources, especially land monetization, betterment levy, land value tax, enhanced property tax or grant of development rights, advertisement, tourist tax, congestion, a cess on the sales tax, parking charges reflecting a true value of the land, traffic 'challans', etc.

For example, Pimpri-Chinchwad Municipal Corporation has already set up a dedicated urban transport fund through land monetization and advertisement rights. Similarly, Karnataka has set up a dedicated urban transport fund through an MRTS cess on petrol and diesel sold in Bangalore, which is being used to fund the metro rail projects. The various sources of funding that can be used to set up the urban transport fund are given below.

i. **Anticipated purchase of land**

This method involves public authorities buying land before announcing that an infrastructure will be built or where the route will run. In this way, the purchase can be made at market price without the infrastructure. The strategy then consists in:

- Directly selling the land to private developers, including the estimated added value in the sale price, such as was done in Aguas Claras on the periphery of Brasilia, or in Copenhagen
- Developing the area as part of an urban renewal project and then selling it at market price, as was done in Copenhagen or in Japan, where rail companies were the first to use this method to finance their operations.
- For instance, a city can also levy additional stamp duty on registration of property depending upon absorptive capacity of the city.

ii. Betterment tax

A betterment tax is not the same as a property tax, because the increase in value of property is not due to the action of the owner (such as would be the case with renovations and improvements) but from a community action, thus justifying the public authorities to impose such a tax. However, it is not easy to implement, which no doubt explains why this financing mechanism is still underused. Colombia has implemented this concept through introduction of cost recovery through a betterment charge mechanism (Contribution de Valorización) in 1921.

This tax must be levied on all areas that benefit from the new transport infrastructure. The land is valued each year based on an optimal use of each site, without taking into account the existing facilities. A tax based on the value of the land is then levied in order to generate funds for the public sector. Thus, if the value of the land increases, the tax collected also increases. This means that a vacant plot of land in the city centre, which has been earmarked for building a residential and commercial complex, will pay the same tax as an identical site that has already been developed in a similar manner. Unlike construction taxes, no tax reduction is available to landowners who leave the site empty. Likewise, taxes are not increased if the site is built upon. Landowners will therefore seek to capitalize on the use of their land.

iii. Land value tax

Once an area is well connected by public transport and is accessible to the commercial area, and once the liveability of the area increases, it is possible that the price of the land will increase. Such increases in price can be a source of revenue for the municipality. Similar to parking, the obtained revenue needs to be utilized for improvement of the area and other areas in the vicinity. A substantial amount of revenue could be generated through a cess on turnover, particularly in cities, based on industry, trade and commerce activities. Such cesses have already been levied for the Bangalore MRTS project. Bangalore has also levied a luxury tax and professional tax towards the metro fund.

iv. Advertising

This is another important source of revenue for the city. When properly utilized, this source can be of immense value in supporting sustainable urban transport measures in a city. The revenues from advertising in the city can be used to improve the existing transport system and/or create new schemes in sustainable transport.

Paris, France, has used advertising money in developing a public bike scheme, which is now a well-renowned model. Similarly, Transport for London (TfL) has made a deal with advertising specialist Clear Channel for the regular maintenance and design of street furniture in return for advertising space on bus shelters.

One important aspect that needs to be considered is that the advertising money needs to be utilized for improving the transport system rather than spending it on building more roads. Similarly, the advertising should not be overdone to avoid visual pollution. Further, advertising revenue should ideally not be a reason for building pedestrian overpasses as the greater good for the society from these overpasses is minimal.

v. Tourist fee

The Municipal Corporation of Udaipur can also levy and charge fees on vehicles entering Udaipur bearing registration numbers other than the State of Rajasthan at entry and exit locations within the MC limits as a tourist fee.

The rates/fees for the various classes of vehicles would be valid for a period of only seven days. Although it is proposed that such revenue be utilized for tourism-related activities, a certain percentage of the fees should be transferred to the Urban Transport Fund.

A similar type of pilgrimage tax is currently collected by Ajmer Municipal Corporation from RSRTC (Rajasthan State Road Transport Corporation), wherein Re. 1 per passenger is charged on the passengers coming to Ajmer from a distance exceeding 51km as per the agreement between the Ajmer Municipal Corporation and RSRTC formalized in 1990.

7.4.3 Sources of finance

Based on the above possible sources of funding, and based on broad guidelines as per the Working Group Report for 12th Five Year Plan, the sources of financing for the projects are given in Figure 7-1 and Figure 7-2.

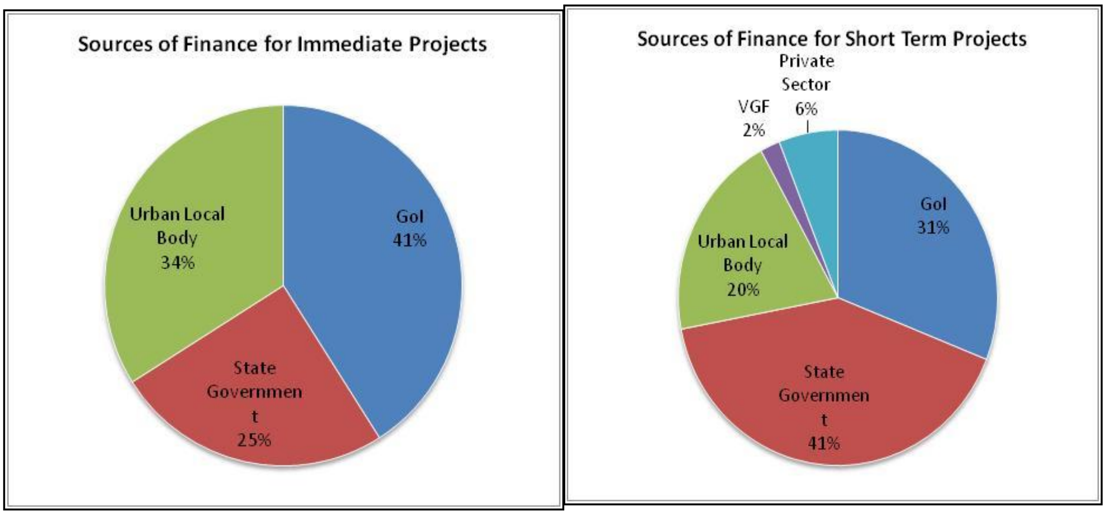
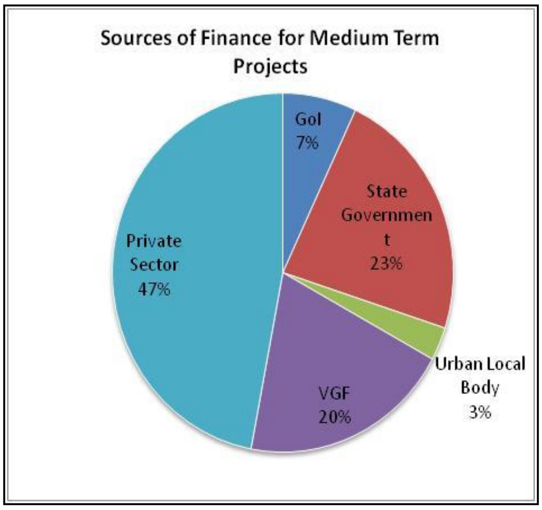


Figure 7-1: Sources of finance for immediate projects and short-term projects



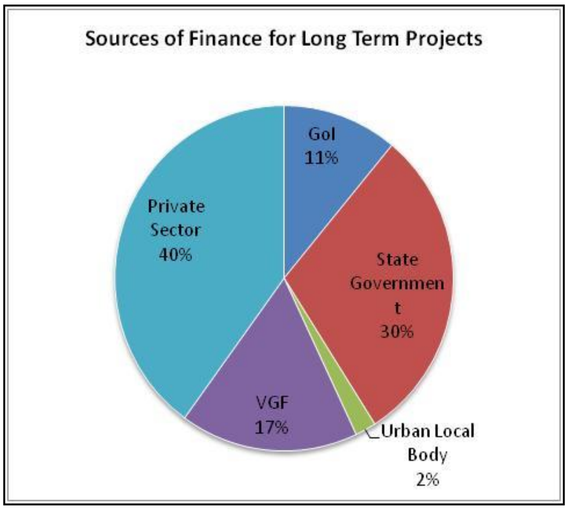


Figure 7-2: Sources of finance for medium-term projects and long-term projects

Referring to Table 7-4, it is evident that the private sector (30.49 per cent) can be one of the major means of financing the urban transport projects in Udaipur.

Table 7-4: Sharing of funding

GoI	State Government	ULB	VGF	Private sector	Total
397.35	619.39	237.28	285.8753	675.34	2,215.23
17.94%	27.96%	10.71%	12.90%	30.49%	100%

7.5 Conclusions

The previous sections defined the phases for implementing the projects, which are sustainable in the long term for Udaipur, and alternate financing options to implement the same have been discussed in detail. It has been observed that the private sector would play a major role in financing urban infrastructure for Udaipur in the long run.

Chapter 8. Institutional Framework

This chapter describes the existing city and State-level institutional structures responsible for managing and monitoring urban transport. This chapter recommends a number of reform measures for improving existing city and State-level institutional structures.

8.1 Introduction

The city transport system generally involves several organizations that look after various forms and aspects of the transport system and network, and have overlapping functions and areas of work. The existing institutional setup in Udaipur includes a variety of institutions sharing their responsibilities in different aspects of governance of Udaipur city. For instance, Udaipur Nagar Nigam and UIT are primarily responsible for the governance of the city and for providing urban infrastructure and services to its citizens. Aside from the local-level institutions, various departments and agencies from the State Government play important roles. Therefore, to delineate areas and to remove any ambiguity of functions, the institutional framework has been proposed.

Some of the departments and organizations involved in Urban Affairs and Urban Transport are as follows:

1. Urban Development Department, Government of Rajasthan
2. Public Works Department
3. National Highway Authority of India (NHAI)
4. Superintendent of Police (Traffic), Udaipur
5. Udaipur Nagar Nigam
6. Urban Improvement Trust, Udaipur.
7. Rajasthan State Road Transport Corporation (RSRTC)
8. Indian Railways
9. State Pollution Control Board, Udaipur
10. Regional Transport Office (RTO)
11. Office of the Divisional Commissioner, Udaipur Division
12. Office of the District Collectorate, Udaipur District.

8.2 Existing City-Level Key Institutions

8.2.1 Udaipur Nagar Nigam

Udaipur Municipal Corporation was formed in December 1922 by the then Mewar State. After the independence and formation of Rajasthan, Udaipur became a Nagar Nigam in 1959. The functional domain of Udaipur Nagar Nigam is derived from the Rajasthan Municipalities Act, 1959, and amendments thereto. Although this Act covers various aspects of municipal governance, it was felt that the comprehensive letter and spirit of the 74th CAA was not captured in its entirety. The Government of Rajasthan has, therefore, recently framed the Rajasthan Municipalities Bill, 2005, in accordance with the Model Municipal Law, which seeks to redress the gaps between existing legislation and the 74th CAA and, in particular, to promote the concept of decentralised and participatory local government.

At the local-level of governance, key institutions are: the primary collection of solid waste; maintenance of the prevention of Food Adulteration Act; O&M of internal sewers and community toilets, and street lighting.

8.2.2 Urban Improvement Trust (UIT), Udaipur

Urban Improvement Trust, Udaipur, was formed in 1960 and is governed by the Rajasthan Urban Improvement Act, 1959, and amendments thereto. The role of the UIT is the development of the urban areas by proper supervision of them and chalking out suitable improvement schemes on modern lines.

UIT, Udaipur, is managed by a board of trustees, consisting of a Chairman and other members, including Superintendent Engineer PWD, Superintendent Engineer PHED, Superintendent Engineer AVVNL and Senior Town Planner, Udaipur. The Chairman, who is currently represented by the District Collector, Udaipur, is the executive head of UIT and Secretary UIT is the administrative head.

8.2.3 Superintendent of Police (Traffic), Udaipur

The Superintendent of Police (Traffic), Udaipur, is a unit of Rajasthan Police responsible for overseeing and enforcing traffic safety compliance on the city roads as well as managing the flow of traffic in the city of Udaipur.

8.3 Existing State-Level Key Institutions

8.3.1 Town Planning Department, Government of Rajasthan

The Town Planning Department is part of the Ministry of Urban Development and Housing of the Government of Rajasthan, with the Chief Town Planner as the head of the Department and having jurisdiction covering the whole of the State of Rajasthan. The objective of the Town Planning Department is to guide physical development of towns through the preparation of master plans, sector plans, schemes along with providing technical advice to various government departments, local bodies and other government agencies. This department helps in giving technical approvals, policies, regulations, etc., to various government heads, and thus acts as a central coordinator between the Local and State Government in the process of urban development.

It also assists the National Capital Region Planning Board in preparation of its Regional Plan and implementation of its policies to give a balanced and harmonious development of the region.

- Preparation of master plans/sector plans/schemes, projects, etc., and their reviews/revision as per requirement
- Preparation of Sub-Regional Plan of Rajasthan, Sub-Region of National Capital Region (NCR). Coordination with line departments for formulation and financing of projects connected with NCR
- Assistance in formulation of legislation/building byelaws/regulations and their modifications
- Technical guidance for approval of layout plan/building plans and current planning matters
- Guidance to municipalities/UITs on city development/coordination with dedicated consultants/subject consultants
- Matters referred by Collector pertaining to development of townships and other projects in rural areas
- Capacity building of the department/ULBs with respect to town planning matters, including the enhancement of skills of prevailing manpower in all the urban bodies of the State
- Assisting Government in formulating urban development policies/review of policies, advising directors of local bodies/Rural Development Department/other Government departments/corporations in all matters referred by them.

8.3.2 Rajasthan Public Works Department.

The Public Works Department is mainly entrusted with the construction and maintenance of roads, bridges and Government buildings. The department also acts as a technical advisor to the State Government in these matters.

The Public Works Department primarily executes the following development works:

- Design, construction, maintenance and repair of Government buildings
- Design, construction, maintenance and repair of roads and bridges
- Undertaking deposit contribution works of various departments, local bodies and other entities.

8.3.3 Rajasthan State Environment Protection and Pollution Control Board

The Rajasthan State Pollution Control Board is a body corporate constituted under Section 4 of the Water (Prevention and Control of Pollution) Act, 1974. It was first constituted on 7th February 1975, with the objectives of the prevention and control of water pollution and maintaining or restoring wholesomeness of water. Later it was also entrusted with the responsibilities of prevention, control and abatement of air pollution under the provisions of Air (Prevention and Control of Pollution) Act, 1981. The Water (Prevention and Control of Pollution) Cess Act, 1977 has been enacted to give the State Board powers to collect a cess on the basis of water consumed by industries, etc.

Enactment of the Environment (Protection) Act, 1986, has further widened the scope of activities of the Board. This Act being umbrella legislation, different rules for addressing the problems of various sectors have been enacted under this Act.

8.3.4 Rajasthan State Road Transport Corporation (RSRTC)

Rajasthan State Road Transport Corporation (RSRTC) came into existence on 1 October 1964 under the Road Transport Corporation Act 1950. RSRTC is responsible for the provision of regional and local transport services, including city bus services in the capital city of the State, Jaipur, along with Jaipur City Transport Services Limited (JCTSL).

8.4 Issues with the Present Institutional Setup

As observed, there are multiple organizations that are involved in urban and rural planning for the city and region. The Nagar Nigam's and UIT's role in urban transport is miniscule, and so is their area of control. The PWD and NHAI are in charge of constructing roads and maintaining them; however, their functioning is independent of the urban/rural planning body of the State. Bus operations, land ownership issues, collection of parking fees and traffic violation fines, NMT planning, pedestrian safety, etc., are several issues that are interconnected, but they fall under the ambit of completely disconnected organisations. Some of these issues are listed below:

- There is no clear segregation between the planning and implementing bodies
- There is a lack of coordination amongst all the departments in the urban transport sector
- All departments related to urban transport do not function in coherence
- Road projects are implemented in isolation with other projects, which should otherwise be an integral part of road development like footpaths, cycle tracks, pedestrian facilities, etc.
- There is no control over the mushrooming growth of IPT modes in the city, which lead to issues of road congestion and also a competitive environment with buses for passengers
- Operation issues in public transport due to poor route and service planning
- There is no dedicated organization that is in charge of long-term urban transport planning for the city.

Thus, the need is felt for setting up an umbrella-level organisation for the overall planning and monitoring of urban transport in the city.

8.5 Proposed Institutional Framework

With a view to coordinate all urban transport activities in the city, it is recommended that a Unified Metropolitan Transport Authority (UMTA) be set up for Udaipur to act as a planning and decision-making body for all matters related to urban transport in the city.

It is recommended that the city-level UMTA be set up on an executive order for the ease of formation; however, it must be given a legal backing so that its functioning falls under an act and commands greater authority.

The overall aim of the UMTA will be to promote public transport in Udaipur through the formulation of policies, programmes, rules and regulations related to urban transport. Its function is to facilitate/coordinate the planning and implementation of urban transport programmes and projects in an integrated management framework. To be effective, the UMTA would need statutory backing.

The National Urban Transport Policy clearly identifies land use and transport as two intricately linked elements of the urban system that have bearing on each other. Hence, the distinctive role of UMTA regarding formation of progressive land use and transportation policy for metropolitan area becomes critical.

8.5.1 Unified Metropolitan Transport Authority (UMTA)

In order to facilitate the integration of transport services holistically and pragmatically, an 'institution' needs to be created to coordinate the activities and functions of multiple organizations dealing with the complex issues of urban transport. With the formation of UMTA, part of the problem would be solved. However, this would have a macroscopic view of resolving policy issues for all urban centres within the State. There would remain a need to set up a localized organization that results in coordinated strategic-level planning at the city level and deals with more day-to-day issues of urban transport.

8.5.1.1 Broad functions

The following functions are proposed to fall under the purview of the city-level UMTA:

- Undertake overall planning for public transport in the city, covering all modes – road, rail, water and air transport systems
- Allocate routes amongst different operators
- Procure public bus services for different routes through contracting, concessions, etc.
- Ensure compliance of terms and conditions of license

- Recommend revocation of license for non-compliance of terms and conditions of the license
- Carry out surveys and manage a database for scientific planning of public transport requirements
- Coordinate fare integration among different operators of public transport and determine the basis for sharing of revenues earned from common tickets or passes
- Operate a scheme of passes for the users of public transport and channel subsidies to operators for any concessions that are offered in accordance with government policy
- Regulate the arrangement amongst operators for the sharing of their revenue derived from the use of passes
- Promote efficiency in public transport operation
- Protect the interests of consumers
- Settle disputes between different operators and between operators and infrastructure providers
- Levy fees and other charges at such rates and in respect of such services as may be determined by regulations.

8.5.1.2 Proposed structure of UMTA

The National Urban Transport Policy, 2006, and GoI recommend setting up a UMTA in all cities with populations exceeding one million, the extract of which is reproduced below:

"The current structure of governance for the transport sector is not equipped to deal with the problems of urban transport. Those structures were put in place well before the problems of urban transport began to surface in India and hence do not provide for the right coordination mechanisms to deal with urban transport. The Central Government will therefore recommend the setting up of Unified Metropolitan Transport Authorities (UMTAs) in all million-plus cities to facilitate more coordinated planning and implementation of urban transport programmes and projects and an integrated management of urban transport systems. Such Metropolitan Transport Authorities would need statutory backing in order to be meaningful.

As per the National Urban Transport Policy (NUTP-2006), the representation of agencies involved in the preparation of the land use and transportation plan is required in UMTA. Given the above guidelines/recommendations, the following structure is proposed for UMTA:

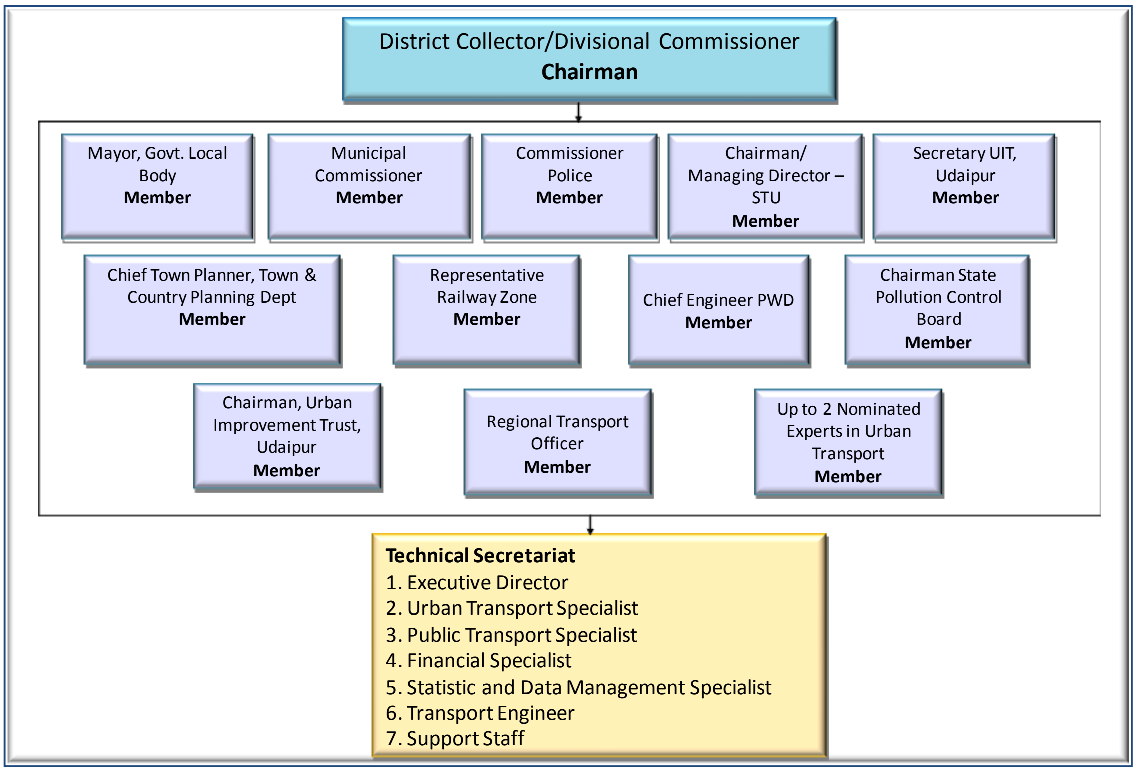


Figure 8-1: Institutional framework

Besides the above members, the Government of Rajasthan could invite representatives from other government departments, bus operation unions, auto rickshaw unions, etc., as considered necessary from time to time.

8.5.1.3 Legal backing of UMTA

In order to give UMTA objectives, functions and operations a legal status, a draft Act has to be prepared by UMTA to be taken up for approval by the State Cabinet after finalization. The draft Act shall cover the following:

1. Objectives and functions of UMTA
2. Operational area of UMTA
3. Powers and delegation of powers of UMTA
4. Authority to have power to acquire land by agreement
5. Power of Government to transfer to the Authority lands belonging to it or to other ULBs, etc.
6. Power of Authority to borrow
7. Laying of annual estimate of income and expenditure
8. Authority to approve or amend such estimate
9. Estimates to be submitted to Government for sanction
10. Supplementary estimates may be prepared and submitted when necessary
11. Provisions regarding expenditure
12. Accounts and audit

13. Schedule of officers and employees to be submitted for sanction of Government
14. Appointments, etc., by whom to be made
15. Powers of entry
16. Directions by the Authority
17. Members and officers to be public servants
18. Power to make rules
19. Power to make regulations.

8.5.1.4 Manpower requirement and staffing plan

UMTA shall have to avail the services of an expert team of traffic and transportation planners, engineers, urban planners and other technical advisers. In order to strengthen its human resources, UMTA shall have to form a schedule of officers and employees whom it shall deem necessary and proper to maintain for the purposes of UMTA Act. In addition to this, various powers related to appointment, promotion, suspension, etc., shall also have to be determined as per the Government's schedule.

8.5.2 Urban Transport Fund (UTF)

As cities and towns are the generators of national wealth, there is a growing recognition that the resources needed for urban development must be generated from within the urban economies by using principles like 'beneficiaries pay', 'users pay' and 'polluters pay'. Provision of public transport/transit facilities act as 'facilitators' and go a long way in triggering the multiplier effect in the city economy. As per the guidelines of the National Urban Transport Policy, an Urban Transport Fund is desired to be set up to sustain and expand the transit operations (city buses) and to develop the transit infrastructure (bus stands, terminals, interchanges, depots, workshops, etc.).

A reasonable quality of service has to be maintained in order to encourage residents to use public transport instead of private vehicles. From domestic and worldwide experience, we know that as the fares are regulated, city bus operations would be a loss-making proposition from the operations' point-of-view. There would be a viability gap and hence, non-operational revenues and state support would be required to bridge the gap.

Public transport sectors in most cities have been running losses, leaving little or no scope for enhanced services to the users. On the physical infrastructure side, vehicle sales generate large revenues through taxation. Most of the proceeds, however, are treated as general taxes and do not trickle down to the urban area level as a ready pool of resources for urban transport projects.

It is thus suggested that a separate collection of funds be generated locally so that the same may be spent locally on development and maintenance of urban transport

Urban Mass Transit Company Limited

infrastructure. This fund can be managed by a professional fund manager appointed by the city level Unified Metropolitan Transport Authority so that the balances in this fund can earn appropriate returns, in accordance with prevailing market potential.
Any local investment proposal that would require funding/part-funding from the Local Government/State Government could be posed to the UTF for financial support. Approval could be given by the UMTA after due appraisal by the Local Administrator/Secretariat. An Urban Transport Fund at State and city level has to be created to support the public transport system. The possible streams for this fund can be as:

1. Cess/tax/additional duty

    a. Cess on fuel: A small cess of 50 paise per litre can be levied, with amendment to the Act.
    b. Higher registration charges on private vehicles
    c. Rationalisation of MV taxes on private vehicles: By increasing taxes on cars, two-wheelers etc. As the diesel cars contribute to the pollution load in greater degree, the MV tax on cars can be increased to a higher degree
    d. Luxury tax and professional taxes, as levied by Bangalore
    e. Additional stamp duty (5 per cent) on registration of property

2. Advertisement rights: Coupled with an appropriate advertisement policy, allowing the SPV (company/ULB/STU responsible for bus operation) rights on the bus stops/terminals and on other infrastructure created especially for bus priority measures would also yield advertisement income to flow into the Urban Transport Fund.

8.5.2.1 Eligibility criteria and approval mechanism from the fund

The fund, in due course of time, due to its intrinsic purpose of set-up, shall be approached for funding by various urban transport projects besides the SPV for the bus operations. A suitable mechanism shall have to be evolved for the concerned secretariat to judge/appraise the claim, put it up for approval from UMTA, and disbursement of the same to the concerned agency for implementation. The detailed guidelines on the type of claims and the appraisal criteria shall be evolved on the lines of the existing MoUD guidelines and procedures.

8.5.3 Implementing agencies

The LCMP for Udaipur has also proposed the agencies responsible for implementation of the LCMP projects based on existing roles, responsibilities and operational capabilities and preparedness of various institutions and as per their corresponding jurisdiction (refer to Table 8-1).

Table 8-1: Project-wise implementing agencies

Sl. No.	Project head	Agencies responsible for implementation	Implementation options	
			Construction	Operation/ maintenance
NMT Infrastructure				
1	Construction and maintenance of footpath	Udaipur Nagar Nigam/UIT under proposed UMTA	PWD/Udaipur Nagar Nigam	PWD/Udaipur Nagar Nigam
2	Grade-separated pedestrian facilities	Udaipur Nagar Nigam/UIT under proposed UMTA	PWD/Udaipur Nagar Nigam	PWD/Udaipur Nagar Nigam
3	Development of cycle tracks	Udaipur Nagar Nigam/UIT under proposed UMTA	PWD/Udaipur Nagar Nigam	PWD/Udaipur Nagar Nigam
4	Introduction of public bike sharing scheme	Udaipur Nagar Nigam/UIT under proposed UMTA	Udaipur Nagar Nigam/UIT	Private
5	Tourism-promoting transport infrastructure (heritage walk)	Udaipur Nagar Nigam/UIT/Tourism Dept. under guidance of proposed UMTA	Udaipur Nagar Nigam/UIT/Tourism Dept.	Tourism Dept./Private
PT infrastructure				
6	Modernization of existing IPT	Proposed UMTA through SPV (as proposed)	Proposed UMTA through SPV (as proposed)/RTO/UIT	Private
7	Introduction of city bus services	Proposed UMTA through SPV (as proposed)	Proposed UMTA through SPV (as proposed)/RTO/UIT	Private
	IPT/Bus Q shelters	Proposed UMTA	Private	Private
	Bus depot/terminal	Proposed UMTA	Private	Private
	Intelligent Transport Systems	Proposed UMTA	Private	Private
	ITS on IPT	Proposed UMTA	Private	Private
	ITS on Bus	Proposed UMTA	Private	Private
	ITS of augmented fleet of buses	Proposed UMTA	Private	Private
	ITS on IPT/Bus Q shelters	Proposed UMTA	Private	Private
Traffic management				
10	Intersection improvement	Udaipur Nagar Nigam/UIT/PWD under proposed UMTA	PWD/Udaipur Nagar Nigam	PWD/Udaipur Nagar Nigam
Network improvement				

Sl. No.	Project head	Agencies responsible for implementation	Implementation options	
			Construction	Operation/ maintenance
11	Street markings	Udaipur Nagar Nigam/PWD under proposed UMTA	PWD/Udaipur Nagar Nigam	PWD/Udaipur Nagar Nigam
12	Street lighting	Udaipur Nagar Nigam/PWD under proposed UMTA	PWD/Udaipur Nagar Nigam	PWD/Udaipur Nagar Nigam
13	Road network development (60m, 36m and 30m)	Udaipur Nagar Nigam/PWD under proposed UMTA	PWD/Udaipur Nagar Nigam	PWD/Udaipur Nagar Nigam
Freight transport				
14	Development of a freight terminal	Proposed UMTA	PWD/Private	Private
Public awareness programme				
15	Public education and awareness programme	Proposed UMTA	Proposed UMTA	Proposed UMTA

Chapter 9. Outcomes and Conclusions

This chapter describes the outcomes of the study, and accordingly justifies the projects suggested in terms of overall sustainable development.

9.1 Outcomes

As part of the LCMP study, the BAU and alternative development scenarios have been assessed in detail for Udaipur based on the assessement of various phase-wise mobility improvement meaures in terms of projects and policy interventions proposed as consistent with reduced emissions and sustainable development. The outcomes of the various scenarios for LCMP have been decribed in detail in Chapter 5 and Chapter 6. Table 9-1 below shows the outcomes of all the scenarios.

Table 9-1: Comparison between various scenarios

Indicator/values	Base year (2013)	BAU scenario (2041)	Land use intervention scenario (2041)	NMT intervention scenario (2041)	Public transport intervention scenario (2041)	Combined LCMP scenario (2041)
Modal share						
Walk	25%	20%	29%	38%	27%	28%
Cycle	3%	2%	6%	9%	9%	9%
Two-wheeler	48%	51%	41%	31%	21%	20%
IPT	18%	22%	18%	15%	12%	10%
Car	3%	3%	2%	2%	1%	1%
PT	3%	2%	4%	5%	30%	32%
Trip length (km)						
Walk	1.18	2.06	1.62	3.31	1.78	1.89
Cycle	2.37	3.65	3.13	4.08	3.35	3.09
Two-wheeler	5.54	5.92	5.56	6.3	5.63	5.13
IPT	4.52	5.55	5.24	5.51	4.98	5.32
Car	7.06	7.51	6.98	7.68	7.77	6.56
PT	-	5	5	5	5.75	5.65
Accessibility						
Percentage of HH within 10 minutes' walking to access PT (IPT for base year)	69%	60%	80%	78%	83%	83%
LOS of PT facilities as per MoUD SLB Handbook	4	4	3	2	2	2
Land use mix intensity						

Indicator/values	Base year (2013)	BAU scenario (2041)	Land use intervention scenario (2041)	NMT intervention scenario (2041)	Public transport intervention scenario (2041)	Combined LCMP scenario (2041)
Increase in the percentage of intra-zonal trips as compared to base year (base year value is 19%)	-	16%	68%	16%	16%	68%
Safety to use NMT						
Walk	7.5%	7.5%	78%	83%	-	83%
Cycle	7%	7%	70%	80%	-	80%
Total motorised VKT (thousand km)	880,489	2,559,907	2,159,624	2,341,289	1,691,624	1,335,210
LOS of NMT facilities as per MoUD SLB Handbook	4	4	3	2	-	2
Congestion level						
Road length (km) with value of V/C ratio equal to 1 or more	-	26%	14%	16%	10%	5%
Emission levels						
NO_2 tons annually	10,210	61,261	57,597	60,866	46,947	36,066
CO_2 million tons annually	17	33	32	33	26	24
PM10 tons annually	4,500	18,000	16,696	17,253	13,523	10,484
SO_2 tons annually	201	802	805	792	784	591
CO tons annually	397,677	695,935	617,936	681,136	485,139	454,591

It is clear from the above table that a combination of all the strategies described in four different scenarios, i.e. land use, public transport, non-motorized transport and technology are needed to be implemented together to have an all-inclusive sustainable mobility development for Udaipur city.

9.2 Conclusions

During the last few decades, urban sprawl in Indian cities has been extending far beyond the existing territorial jurisdiction of the city administrations, resulting in a high use of private modes. Despite substantial efforts, the cities are struggling to cope with the increase in private vehicles along with improving personal mobility and goods distribution. Udaipur has been experiencing high growth in population over the years, which can be attributed to natural growth as well as the migrant population from the adjacent rural areas and towns hoping for better employment and livelihood opportunities.

The rapid pace of urbanization together with the increase in population and private vehicles in Udaipur city will pose an unimaginable load on the city's already struggling transport infrastructure. On the other hand, the share of public transport is also declining, leading to more use of private vehicles for mobility needs and increased demand for parking of private vehicles.

The LCMP for Udaipur lays out a set of measured steps that are designed to improve the transportation infrastructure of the city in a sustainable manner. As explained in previous chapters and sections, sustainable development of Udaipur city, in which sustainable mobility is an important pillar and integral part, can be achieved only through adopting a multi-pronged approach.

The LCMP for Udaipur has thus suggested a comprehensive approach for implementation and adoption of projects and policy initiatives towards land use, public transport, NMT and technology for vehicles and fuel usage. The availability of a wide range of quality and safer public transport and environmentally friendly NMT infrastructure that is accessible and affordable for all, with the use of cleaner motorized modes, will build Udaipur as a compact, sustainable, self-reliant and liveable city.

Survey Photographs

TVC Counts at Ayyad Pul

TVC Counts at Fatehpura Chowk

TVC Counts at Delhi Gate Circle

TVC Counts at Sukhadia Circle

TVC Counts at UIT

Bus Terminal OD

Railway Terminal OD

Railway Terminal OD

Survey Photographs

Parking Survey

OD Survey at Mt. Abu Road

OD Survey at Mt. Abu Road

OD Survey at Amberi Road

OD Surveys at Airport Road

OD Survey at Madri

OD Survey at Eklingpura

OD Survey at Banswara

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ANNEXURES

Annexure 1. – Traffic Survey Methodology and Survey Formats

Introduction

Assessment of the traffic characteristics of the study area is an essential pre-requisite to appreciate the problems with respect to traffic movement and to understand the need for organizing the same in an efficient and economical manner. Traffic characteristics help in appreciating the spatial and temporal features of travel within the area, the relationship of traffic intensity with network capacity, and the prevailing level of service obtained on various corridors of the network in the study area. This appreciation and understanding is essential for identifying the present conditions and constraints for formulating suitable policies and strategies, selecting relevant systems, and designing the individual components of the system.

Traffic Surveys Conducted

Classified traffic volume counts (CTVC) and classified turning movement counts (CTMC)

Classified traffic volume counts and classified turning movement counts were conducted at critical/important links, for one non-incident, non-event working day (weekday) within the city for a period of 16 hours (06:00 to 22:00), covering the morning and evening peak hours. Classified traffic volume count surveys will also be carried out at outer cordons for a period of 24 hours.

The CTVC survey will provide the information like mode-wise volume count and hourly variation of the traffic flow.

The CTMC survey will provide the information regarding the mode-wise and direction-wise movement of traffic.

Origin and destination (OD) survey and occupancy survey

Origin-destination surveys were conducted using the roadside interview method. These will be conducted at the outer cordons, inner cordons and at prominent locations along corridors where important activities are located.

Roadside OD surveys of goods and passenger vehicles: The location and timing of the roadside interviews will coincide with that of traffic counts to facilitate adjustment for sampling.

Similarly, 16 hours surveys were collected by trained enumerators and experienced supervisors. Information recoded will also include type of vehicle, occupancy, type of commodity carried, trip characteristics and user details.

Off-street and on-street parking survey

Work centres, business centres, shopping complexes and tourist places are the major attractors of traffic. The parking demand study would estimate the parking duration (short/long), parking accumulation, and willingness to pay for parking at these locations.

The parking survey was undertaken by manually recording vehicle numbers and their type along the identified stretches over a period of 12 hours.

Road inventory, and speed and delay survey

The road network inventory along the major road network (existing) in the study area was recorded, including arterial, sub-arterial, National Highways, State Highways, etc., will be link lengths, cross-sectional details, type and general condition of the road surface, street furniture, intersections falling therein, control devices, drainage condition, etc.

This survey will identify the journey speed, running speed and delays on road sections across Udaipur. The outputs will assist in identifying the adequacy/deficiency of roads.

Public transport and IPT surveys

The surveys were conducted on different routes operating within the study area and terminal areas. The survey will collect origin, destination, trip purpose, frequency of travel and other details of public transport and intermediate public transport users. The random survey sampling technique will be adopted for this survey.

Commuter survey

Public transport trips, by bus and rail, having one trip end outside Udaipur and one within the city, will be surveyed to assess the floating population in the city. The survey had collected the data using the random sampling method, with surveys conducted at the two railway stations, Airport, etc., and at outer cordon points covering the hours of operation.

Vehicle operator surveys

A sample survey of taxi, auto rickshaw and goods vehicle operators (including slow-moving goods vehicles) was conducted inside the city area with assistance from the vehicle owners' associations.

In the case of slow-moving goods vehicles, operating cost, socio-economic characteristics of operators and routes of operation will be collected for inclusion in the NMT plan.

Terminal area surveys

This survey collected the information on movement patterns of persons/goods at major terminal and market areas, vehicle (goods and passenger) entry/exit, including commodity, occupancy, etc. The survey shall be undertaken at main railway stations, bus terminals, and Airport, etc.

Pedestrian surveys

Pedestrian surveys were carried out to assess the existing pedestrian flows/demand at identified major intersections and important roads. The survey was carried out for 16 hours from 6 am to 10 pm on normal work roads at mid-blocks, and at intersections.

Tourism survey

This survey would estimate the total number of domestic and international tourists by different purpose of travel, identify their contribution to local employment, and assess the transport infrastructure available for tourists.

Household survey

The purpose of the household surveys is to quantify and analyze the travel characteristics of people belonging to various socio-economic groups in the city. The household level survey will also help in modelling the origin-destination of trips, vehicle emissions and stated preferences, etc. This survey mainly captures the existing conditions of the respondents and their preferences or choices as stated by them. Household characteristics, socio-economic characteristics and travel characteristics of 12,831 individuals were collected by conducting the household survey in 2,562 households. The stratified random sampling technique was used to select these 2,562 samples. Stratification was conducted based on the level of income and place of residence, such as HIG, MIG, and LIG. Similarly the whole population was grouped into urban and rural populations.

Survey formats

The survey formats of the aforementioned surveys are as attached in the following section.

Classified traffic volume count and classified turning movement count survey format

<table>
<tr><td colspan="4">Location</td><td colspan="5">Direction from</td><td colspan="5">Date/Month Year</td></tr>
<tr><td colspan="4">Count station no</td><td>Direction</td><td>Right</td><td>Straight</td><td colspan="2">Left turn</td><td colspan="5">Day</td></tr>
<tr><td></td><td colspan="8">Passenger vehicle</td><td colspan="5">Goods vehicle</td></tr>
<tr><td></td><td>Heavy fast</td><td colspan="4">Light fast</td><td colspan="2">Slow</td><td rowspan="2">Other</td><td>Heavy fast</td><td colspan="2">Light fast</td><td colspan="2">Slow</td></tr>
<tr><td></td><td>Bus</td><td>Mini bus</td><td>Car</td><td>MTW</td><td>Auto</td><td>Cycle</td><td>Pedestrian</td><td>Truck</td><td>LCV</td><td>Others</td><td>Cycle rickshaw trolley</td><td>Others</td></tr>
<tr><td>6 – 7 am</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>….</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5 – 6 pm</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>….</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Origin-destination survey for passenger vehicles

Low Carbon Mobility Plan of Udaipur
Passenger Vehicle Origin-Destination Survey

Site No. **Road :**
Location : **Sheet No :**
Direction : **Weather : FINE/CLOUDY/RAINY**

Time	Vehicle Type	ORIGIN	DESTINATION	Trip Length (KM)	PURPOSE	Occupancy
	1. 2 Wheeler 2. Car/Jeep/Van 3. Auto (3 wheeler) 4. Mini Bus 5. Standard Bus 6. Shared Vehicle	Locality/Colony/Village Area District : State :	Locality/Colony/Village Area District : State :		1. Office/Company Work 2. Business 3. Education 4. Social (Marriage,Relationship,etc.) 5. Shopping 6. Religious /Tourism 7. Hospital / Clinic 8.Pass.Shared Vehicle	
	1. 2 Wheeler 2. Car/Jeep/Van 3. Auto (3 wheeler) 4. Mini Bus 5. Standard Bus 6. Shared Vehicle	Locality/Colony/Village Area District : State :	Locality/Colony/Village Area District : State :		1. Office/Company Work 2. Business 3. Education 4. Social (Marriage,Relationship,etc.) 5. Shopping 6. Religious /Tourism 7. Hospital / Clinic 8.Pass.Shared Vehicle	
	1. 2 Wheeler 2. Car/Jeep/Van 3. Auto (3 wheeler) 4. Mini Bus 5. Standard Bus 6. Shared Vehicle	Locality/Colony/Village Area District : State :	Locality/Colony/Village Area District : State :		1. Office/Company Work 2. Business 3. Education 4. Social (Marriage,Relationship,etc.) 5. Shopping 6. Religious /Tourism 7. Hospital / Clinic 8.Pass.Shared Vehicle	
	1. 2 Wheeler 2. Car/Jeep/Van 3. Auto (3 wheeler) 4. Mini Bus 5. Standard Bus 6. Shared Vehicle	Locality/Colony/Village Area District : State :	Locality/Colony/Village Area District : State :		1. Office/Company Work 2. Business 3. Education 4. Social (Marriage,Relationship,etc.) 5. Shopping 6. Religious /Tourism 7. Hospital / Clinic 8.Pass.Shared Vehicle	
	1. 2 Wheeler 2. Car/Jeep/Van 3. Auto (3 wheeler) 4. Mini Bus 5. Standard Bus 6. Shared Vehicle	Locality/Colony/Village Area District : State :	Locality/Colony/Village Area District : State :		1. Office/Company Work 2. Business 3. Education 4. Social (Marriage,Relationship,etc.) 5. Shopping 6. Religious /Tourism 7. Hospital / Clinic 8.Pass.Shared Vehicle	
	1. 2 Wheeler 2. Car/Jeep/Van 3. Auto (3 wheeler) 4. Mini Bus 5. Standard Bus 6. Shared Vehicle	Locality/Colony/Village Area District : State :	Locality/Colony/Village Area District : State :		1. Office/Company Work 2. Business 3. Education 4. Social (Marriage,Relationship,etc.) 5. Shopping 6. Religious /Tourism 7. Hospital / Clinic 8.Pass.Shared Vehicle	
	1. 2 Wheeler 2. Car/Jeep/Van 3. Auto (3 wheeler) 4. Mini Bus 5. Standard Bus 6. Shared Vehicle	Locality/Colony/Village Area District : State :	Locality/Colony/Village Area District : State :		1. Office/Company Work 2. Business 3. Education 4. Social (Marriage,Relationship,etc.) 5. Shopping 6. Religious /Tourism 7. Hospital / Clinic 8.Pass.Shared Vehicle	
	1. 2 Wheeler 2. Car/Jeep/Van 3. Auto (3 wheeler) 4. Mini Bus 5. Standard Bus 6. Shared Vehicle	Locality/Colony/Village Area District : State :	Locality/Colony/Village Area District : State :		1. Office/Company Work 2. Business 3. Education 4. Social (Marriage,Relationship,etc.) 5. Shopping 6. Religious /Tourism 7. Hospital / Clinic 8.Pass.Shared Vehicle	

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Origin-destination survey for goods vehicles

Low Carbon Mobility Plan of Udaipur
Goods Vehicle Origin-Destination Survey

Site No. **Road :** **Name of Enumerator :**
Location : **Shift No :** **Sheet No :** **Date :**
Direction : **Weather : FINE/CLOUDY/RAINY**

Time	Vehicle Type	ORIGIN	DESTINATION	Trip Length (KM)	Commodity Type		Weight (Tonn)
	1. LCV - 3 Wheeler 2. LCV - 4 Wheeler 3. 2 Axle Truck 4. 3 Axle Truck 5. Multi Axle Truck 6. Tractor Trailer	Village/Town/City District : State :	Village/Town/City District : State :		1. Empty 2. Agricultural Products 3. Forest Product 4. Fuel, Oil & Gas 5. Construction Materials 6. Milk	7. Chemicals &Fertilizers 8. Machinery 9. Cloth 10.Glass 11. General Merchandise 12. Iron & Steel 13. Others	
	1. LCV - 3 Wheeler 2. LCV - 4 Wheeler 3. 2 Axle Truck 4. 3 Axle Truck 5. Multi Axle Truck 6. Tractor Trailer	Village/Town/City District : State :	Village/Town/City District : State :		1. Empty 2. Agricultural Products 3. Forest Product 4. Fuel, Oil & Gas 5. Construction Materials 6. Milk	7. Chemicals &Fertilizers 8. Machinery 9. Cloth 10.Glass 11. General Merchandise 12. Iron & Steel 13. Others	
	1. LCV - 3 Wheeler 2. LCV - 4 Wheeler 3. 2 Axle Truck 4. 3 Axle Truck 5. Multi Axle Truck 6. Tractor Trailer	Village/Town/City District : State :	Village/Town/City District : State :		1. Empty 2. Agricultural Products 3. Forest Product 4. Fuel, Oil & Gas 5. Construction Materials 6. Milk	7. Chemicals &Fertilizers 8. Machinery 9. Cloth 10.Glass 11. General Merchandise 12. Iron & Steel 13. Others	
	1. LCV - 3 Wheeler 2. LCV - 4 Wheeler 3. 2 Axle Truck 4. 3 Axle Truck 5. Multi Axle Truck 6. Tractor Trailer	Village/Town/City District : State :	Village/Town/City District : State :		1. Empty 2. Agricultural Products 3. Forest Product 4. Fuel, Oil & Gas 5. Construction Materials 6. Milk	7. Chemicals &Fertilizers 8. Machinery 9. Cloth 10.Glass 11. General Merchandise 12. Iron & Steel 13. Others	
	1. LCV - 3 Wheeler 2. LCV - 4 Wheeler 3. 2 Axle Truck 4. 3 Axle Truck 5. Multi Axle Truck 6. Tractor Trailer	Village/Town/City District : State :	Village/Town/City District : State :		1. Empty 2. Agricultural Products 3. Forest Product 4. Fuel, Oil & Gas 5. Construction Materials 6. Milk	7. Chemicals &Fertilizers 8. Machinery 9. Cloth 10.Glass 11. General Merchandise 12. Iron & Steel 13. Others	

On-street and off-street parking survey format

On-Street and Off-Street Parking Survey (Registration Plate Method)

Location :
Name of Road :
Time Period **From :** **To :**
Ownership of Parking Lot:

On-Street	Off Street Entry	Off Street Exit

Date :
Surveyor Name :
Sheet :
Climate: Sunny/ Cloudy/ Rainy

2-wheeler			Car			Auto Rickshaw	Bus	LCV	Truck (2A/ 3A)	MAV

Cycle		Cycle Rickshaw		Hand Cart	

Road inventory survey format

Road Inventory Survey

Road :		**Sheet :**
Section From :	**To:**	**Date :**
Chainage From :	**To:**	**Name of Surveyor :**

1. Road and Roadside Features

Road Classification [ ] *(Arterial : 1, Sub-Arterial : 2, Collector : 3, Local : 4, Others : 5)*

Landuse Type — Left [ ] Right [ ] *(Residential - 1, Commercial - 2, Residential & Commercial -- 3, Public & Semi Public - 4, Industrial - 5, Agriculture -6, Open - 7)*

Main Carriageway

Carriageway Type [ ] *(Divided - 1, Undivided - 2)*

Carriageway Width — Left [ ] Right [ ] m

Median Width [ ] m

Shoulder Width — Left [ ] Right [ ] m

Available Right of Way [ ] m *(Clear distance between building lines)*

Service Road and Footpath Details

	Left	Right		Left	Right			Left	Right	
Service Road			Width			m	Length			m
Footpath			Width			m	Length			m

(Existing - 1, Not Existing - 2)

Drainage Details

Drainage Channel — Left [ ] Right [ ] *(Existing - 1, Not Existing - 2)*

Type — Left [ ] Right [ ] *(Open - 1, Lined - 2, Underground - 3)*

Condition — Left [ ] Right [ ] *(Good -1, Fair -2, Bad -3)*

On-street Parking

Parking — Left [ ] Right [ ] *(Existing - 1, Not Existing - 2)*

Type — Left [ ] Right [ ] *(Perpendicular - 1, Angular - 2)*

2. Pavement Details

Type [ ] *(Bituminous : 1, Water Bound Macadam : 2, Concrete : 3, Others (Specify): 4)*

Condition [ ] *(Very Good : 1, Good : 2, Fair : 3, Poor: 4)*

3. Street Furniture

Street Light Facility

	Left	Center	Right	
Road Light				*(Existing - 1, Not Existing - 2)*
Type				*(Sodium Vapour - 1, Mercury Lamp - 2, Fluorescent - 3, Tungsten Filement - 4)*

Road Markings

Center Line [ ]
Lane Marking [ ]
Edge Line Marking [ ]
Pedestrian Marking [ ]
(Present - 1, Not Present - 2)

Traffic Signage

Informatory [ ]
Prohibitary [ ]
Mandatory [ ]
Others [ ]
(Present - 1, Not Present - 2)

4. Traffic Management Measures

One way restriction [ ] *(Yes - 1, No - 2)*

Restriction for Freight Vehicles [ ] *(Yes - 1, No - 2)*

Restriction for On-street Parking — Left [ ] Right [ ] *(Yes - 1, No - 2)*

Note : Cross Section to be drawn on the reverse side ***Checked By :***

Speed and delay survey format

Name of Road : Date:

From : To : Day:

Survey Starting Time : Peak : Morning/Evening/Afternoon

S.No.	Section		Start (Km)	End (Km)	Total Distance (Km)	Starting Time	Ending Time	Total Time	Mid block delay	Reasons for Delay
	From	To								

Reasons for Delay : Congestion - 1 Signalised Intersection - 2 Level Crossing - 3 Stray Animals - 4 Others - 5

Terminal area survey format (goods)

Name of the Interviewer :	Zone :
Date of Interview :	Sheet :

A) Identification of Location:

1. Name & Address: ____

2. Type

National Permit	State Permit	Local

3. Abutting Land Use

Residential	Commercial	Public/Semi-pub	Industrial	Institutional	Parks & Open Spaces

Others (Specify)

4. Number of Entries & Exits to the Site

Vehicles Type	Entries	Exits
Goods Autos		
LCV		
2-Axle		
3-Axle		
MAV		
Others		

B) Physical Details

1. Site Area ____ Sq. m
2. Built up Area (Floor Area) ____ Sq. m
3. Hard Standing ____ Sq. m
4. Number of Bays ____

5. Land Use (Sq.m)
   - i) Loading & Unloading Area ____
   - ii) Repair and Servicing ____
   - iii) Idle Parking ____
   - iv) Utilities & Services ____
   - v) Circulation ____
   - vi) Others (Specify) ____

6. Use Details of Built up Area (Sq.m.)
   - i) Godown/Stage ____
   - ii) Total Built up Area ____
   - iii) Commercial ____
   - iv) Offices ____
   - v) Others (Specify) ____

7. Driver Facilities

Wash Rooms	Drinking Water	Shops	Canteen	Fire Fighting Equipments	Security Arrangement

Lighting System	Crew Facilities	Others

C) Operational Details

1. Potential for Commercial exploitation

Offices	Shops	Commercial Establishment	Hotels	Others

2. Details of daily truck movement into the Terminal
(To be collected from records of Terminal or by conducting Primary survey at entry/exit points)

Time	IN	OUT
	Number	Number

Time	IN	OUT
	Number	Number

3. Terminal Entry fee (Rs.)

LCV ______ HCV ______ Others (specify) ______

4. Parking fee

Vehicle Type	DAY TIME		NIGHT TIME	
	Rupees	Duration (hrs.)	Rupees	Duration (hrs.)
Goods Autos				
LCV				
2-Axle				
3-Axle				
MAV				
Others				

5.Capacity of Terminal

No. of Trucks per Day	No. of Truck Bays

6. Time of Vehicles

Dwell Time						
Goods Autos	LCV	2-Axle	3-Axle	MAV	Others	
Idle Parking awaiting Time						
Night Time Parking						

D) Financial Details

1. Captal Cost of Terminal (Lakh Rupees) ______
2. Maintenance Cost (Lakh Rupees) ______
3. Monthly Revenues (Rupees)

Rental ______ Entry Fee ______ Other (Specity) ______

Advertisement ______ Parking Fee ______

E) Management Details

1. Ownership ______
2. Management Structure ______
3. No. of Employees ______

Terminal area survey format (passenger)

Name of the Interviewer :	Zone :
Date of Interview :	Sheet :

A) Identification of Location:

1. Name & Address: ____

2. Type

Inter-City	Intra-city	Inter-State	Intra -State

3. Abutting Land U

Residential	Commercial	Public/Semi-pub	Industrial	Institutional	Parks & Open Spaces

Others (Specify)

4. Number of Entries & Exits to the Site

Vehicles Type	Entries	Exits
Buses		
2-Wheeler		
Car / Jeeps		
Cycles		
Auto		
Others		

B) Physical Details

1. Site Area		Sq. m	2. Built up Area (Floor Area)		Sq. m
3. Hard Standing		Sq. m	4. BQS		Sq. m

5. Land Use (Sq.m)

i) Loading & Unloading Area		ii) Repair and Servicing	
iii) Idle Parking		iv) Utilities & Services	
v) Circulation		vi) Others (Specify)	

6. Use Details of Built up Area (Sq.m.)

i) Godown/Stage		ii) Total Built up Area	
iii) Commercial		iv) Offices	
v) Others (Specify)			

7. Passenger Facilities

Wash Rooms (Gents)	Wash Rooms (Ladies)	Drinking Water	Shops	Canteen	Waiting Rooms	Enquiry Office

Ticketing Advance Booking	Ticketing Booths	Time Table Boards	Fire Fighting Equipments	Police Control Office	Lost and Found Offices	Security Arrangement

Public Address System	Estate Manager Office	Traffic Control System	Lighting System	Clock Room	Crew Facilities	Others

C) Operational Details

1. Passengers handled every day at the terminal

Incoming	Outgoing

2. Potential for Commercial exploitation

Offices	Shops	Commercial Establishment	Hotels	Others

3. Details of daily bus movement into the Terminal
(To be collected from records of Terminal or by conducting Primary survey at entry/exit points)

Time	IN	OUT
	Number	Number

Time	IN	OUT
	Number	Number

4. Terminal Entry fee (Rs.)

LCV ______ HCV ______ Others (specify) ______

5. Parking fee

Vehicle Type	DAY TIME		NIGHT TIME	
	Rupees	Duration (hrs.)	Rupees	Duration (hrs.)
Car/Jeep				
2-Wheeler				
Cycle				
Others (specify)				

6.Capicty of Terminal

No. of Buses per Day	No. of Bus Bay	No. of Places for Idle Parking of Buses	Passenger Alighting	Passenger Boarding

7. Time of Vehicles

Dwell Time						
Buses	Taxis	2-Wheeler	Car / Jeeps	Cycles Rickshaws	Auto	Others
Idle Parking awaiting Time						
Night Time Parking						

D) Financial Details

1. Captal Cost of Terminal (Lakh Rupees) ______
2. Maintenance Cost (Lakh Rupees) ______
3. Monthly Revenues (Rupees)

Rental ______ Entry Fee ______ Other (Specity) ______

Advertisement ______ Parking Fee ______

E) Management Details

1. Ownership ______
2. Management Structure ______
3. No. of Employees ______

______

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Pedestrian survey format

Pedestrian Survey

Location :
Name of the Road :
Direction from : to :

Name of Surveyor:
Date:
Sheet :

Junction Digram

Location Code

Time Period	Movement 1	Movement 2	Movement 3	Movement 4	Movement 5	Movement 6	Movement 7	Movement 8

Tourist destination questionnaire

Dear Sir or Madam!

Good morning/afternoon and welcome to our tourist destination. We are pleased that you decided to stay here. If you have spent at least one night at our destination we kindly ask you to participate in a survey which will help us make your future stay here even more pleasant. The interview will take about 10-15 minutes and is conducted anonymously.

1. How did you arrive to Udaipur? (mark the appropriate answer)
    a. By car.
    b. By bus.
    c. With low-cost airline.
    d. With major airline.
    e. By train.
    f. Other, what: _______

2. How are you travelling within Udaipur? (mark the appropriate answer)
    a. By car.
    b. By bus.
    c. NMV.
    d. Mostly walking.
    e. Other, what: ___________________________

3. Where did you hear about this tourist destination? (mark the appropriate answer, more answers possible)
    a. I already knew of it.
    b. The Internet.
    c. Friends and relatives.
    d. Media.
    e. Books and guides.
    f. Travel agency.
    g. Fairs and/or exhibitions.
    h. It was part of the travel package.
    i. Other, what: ____________________________

4. Is this your first visit to this tourist destination? (mark the appropriate answer)
    a. 1. No. → How many times have you visited this tourist destination in the past? ____________________
    b. 2. Yes.
5. How many nights are you planning to stay at this tourist destination: _________
6. What are the main reasons for your visit to this tourist destination? (mark the appropriate answer)

a. Rest and relaxation.
b. Culture.
c. Religious reasons.
d. Visiting relatives and friends.
e. Business reasons.
f. Attending a conference, congress, seminar, and other forms of educations.
g. Fun.
h. Sports and recreation.
i. Health.
j. Other, what: ________________________ ______________

Household survey format

1. Reference

Form No.	Date:	Surveyor name:
Area:	Settlement Code:	Settlement name:
Traffic zone:	Contact number of respondent (Landline and mobile):	

2. Household information (socio-economic)

S.No.	Name	Relation with head	Sex (M/F)	Age	Education	Main activity	Subsidiary activity
	1	2	3	4	5	6	7
1	Head	1					
2							
3							
4							
5							
6							
7							
8							
9							

Code (Relation with head of the household) (2)	Education (5)	Activities (6-7)
1. Self	1. Illiterate	1. Salaried employment (regular waged)
2. Wife / Husband	2. Literate	2. Daily wages employment (casual labour)

3. Household assets

Household assets owned	Y/N	Number
Mobile phone		
Fridge		
LPG stove/cylinder		
Cooler		
A.C.		
T.V.		
Desktop/laptop computer		
Cycle		
Scooter (M2W)		

3. Son / Daughter	3. Primary education (up to 8th)	3. Self-employed (work in HH enterprise)
4. Grandson / Grand Daughter	4. Matriculation/up to 12th	4. Domestic worker at fixed rate
5. Mother / Father	5. Graduate	5. Honorary worker
6. Mother-in-law / Father–in-law	6. Certificate course	6. Home-based paid work
7. Daughter-in-law	7. Others (specify)	7. Home-based unpaid work (house manager)
8. Uncle/ Aunt		8. Attending educational institute
9. Others		9. Pensioners/remittance recipient
10. Brother / Sister / Nephew / Niece		10. Unemployed – due to disability
		11. Unemployed – seeking work
		12. Others – specify

4. Housing and living conditions

1	What is the type of the house?	Kutcha	Semi-Pucca	Pucca
3	What is the tenure arrangement of the house you live in? Tick the right option	Owned	Rented	Shared
4	If it is rented, what is the rent you pay for it?	Rs. ___________________ /Month		
5	Tick and write the appropriate spaces in the house	Rooms _________ (no.)	Separate kitchen Y/N	Floors_____ (no.)
6	What is the area of the house?	Area________________	_______________(unit)	

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7	Do you pay property tax? (Tick and write the appropriate value)				Yes		No		Rs.____________
8	How long have you been staying in this house?				___________ Years				
9	Where were you living before?								
	Household tap	(Y/N)	Piped sewerage	(Y/N)	HH toilets	(Y/N)	No.		

5. Vehicle ownership in the household

	Present				Before 2 year			
	Type	Make (Year)	Mileage	Fuel	Type	Make (Year)	Mileage	Fuel
1								
2								
3								
4								
5								
Type: Car, MTW, Bicycle, Auto rickshaw, Cycle rickshaw, Bus								

6. Accessibility to important destination

	Distance (km)	Walking minutes	
Daily need shop			
School			
Doctor			
Others (specify)			

7. Choices and opinions

How far is the nearest public transport/shared transport station from your house?														
No.	**Mode**	**Nearest stop (distance)**	**Time taken to reach**	**Avg. waiting time**	**How often do you use it in a week?** (no. of times per week)	**Is it a reliable service?**			**Is it safe?**			**Is it too expensive?**		
1	Public bus					Good	Ok	Bad	Good	Ok	Bad	Good	Ok	Bad
2	BRTS (if any)					Good	Ok	Bad	Good	Ok	Bad	Good	Ok	Bad
3	Shared auto					Good	Ok	Bad	Good	Ok	Bad	Good	Ok	Bad
4	Do you think it is safe and convenient to walk on roads of ……………… city?					Good			Ok			Bad		

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5	Are you satisfied with the way you travel in the city?	Yes	No
6	If no, what do you think needs to be improved?		

Instruction for travel diary: In the survey, one trip is the round trip made by the respondent. Here a trip is divided into six segments, where each segment of the trip presents the additional activity taken within a trip that can be either changing mode of transport, doing interchange or additional trip purpose like buying vegetables or dropping off kids. The primary trip purpose is the main trip being made by the respondent. For example, a main trip is going to work, while dropping off a child or buying vegetables on the way is the secondary trip. If the number of segments in the round trip is more for a respondent, then he/she can use the other table for filling in the details.

1. **Travel diary (a similar format will be filled for each member of the household travelling on the previous day)**

HH member no						Day of trip		Mon/Tue/Wed/Thu/Fri		
Origin						Start time				
Primary trip purpose[3]										
Mode used										
Seg	Mode	Sec trip purpose[4]	Start Location	Start time	Waiting time	Arrival time	Distance (km)	Arrival location	Fare / parking cost	No. of HH member
1										
2										
3										
4										
5										
6										
HH member no						Day of trip		Mon/Tue/Wed/Thu/Fri		

[3] Primary trip purpose: pick up or drop off, work (office, factory, field, and shop), school/education, shopping, access social services (religious, etc.), leisure, go home, buy vegetables and others (please specify).

[4] Secondary trip purpose: pick up or drop off, shopping, access social services, leisure, buy vegetables and others.

Origin					Start time					
Primary trip purpose										
Mode used										
Seg	Mode	Sec trip purpose	Start location	Start time	Waiting time	Arrival time	Distance (km)	Arrival location	Fare / parking cost	No. of HH member
1										
2										
3										
4										
5										
6										
HH member no					Day of trip			Mon/Tue/Wed/Thu/Fri		
Origin					Start time					
Primary trip purpose										
Mode used										
Seg	Mode	Sec trip purpose	Start location	Start time	Waiting time	Arrival time	Distance (km)	Arrival location	Fare / parking cost	No. of HH member
1										
2										
3										
4										
5										
6										
HH member no					Day of trip			Mon/Tue/Wed/Thu/Fri		
Origin					Start time					
Primary trip purpose										

Mode used										
Seg	Mode	Sec trip purpose	Start location	Start time	Waiting time	Arrival time	Distance (km)	Arrival location	Fare / parking cost	No. of HH member
1										
2										
3										
4										
5										
6										

2. Surveyor's remarks

Modes: walk, bicycle, cycle rickshaw, auto rickshaw, taxi, bus, shared auto, two-wheeler, car, other.

Annexure 2. – Traffic Survey Analysis

The assessment of traffic characteristics within an urban area is an essential pre-requisite to appreciate the problems of traffic movement and to understand the need for organizing the same in an efficient and economical manner. Traffic characteristics help in appreciating the spatial and temporal features of travel within the area, relationship of traffic intensity with network capacity, and the prevailing level of service obtained on various corridors of the network in the study area. This appreciation and understanding is essential for identifying the present conditions and constraints for formulating suitable policies and strategies, selecting relevant systems, and designing individual components of the system.

Apart from collection, compilation and analysis of secondary data, in order to appreciate an in-depth and comprehensive traffic and transport system and to understand the mobility pattern of Udaipur, a number of primary surveys were conducted within the study area as mentioned in Chapter 1 and Annexure 1. This section describes the detailed traffic survey analysis and their inferences of the existing transportation scenario in Udaipur.

Existing traffic and transportation characteristics in Udaipur

Regional Connectivity

- Air transport: The airport is located 21km away from city centre on Chittorgarh Road, near Dabok. The airport provides no direct international connections. Though the city is connected to Jaipur, Delhi and Mumbai, the frequency of flights is low. Currently, Air India and Jet Airways are serving as domestic air travel service providers. A lack of facilities at the aerodrome area, low frequency of flights and lack of international connectivity are the main issues of air transport in Udaipur city.
- Rail transport: Udaipur has two main railway stations, namely Udaipur City Railway Station and Rana Pratap Railway Station. With the exception of a few lines between Udaipur-Chithorgarh and Udaipur-Jaipur, most of the railway lines are meter gauge.
- Road transport: Udaipur is well connected by roads with the rest of the country. It is located along NH8 (Delhi-Mumbai) and NH76 along Chittorgarh, Dungerpur, and Banswada State Highways. Regional bus services are being operated by Rajasthan State Road Transport Corporation (RSRTC) and private operators to most of the neighbouring cities.

Area under circulation

As per the Master Plan 1997, prepared by the Urban Improvement Trust, Udaipur, the area under circulation was 11.19 per cent and 10.78 per cent as proposed in the Master Plan for the horizon year of 2022.

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Road network characteristics

Udaipur has a ring radial road network pattern, which is expanding along its radials. A recent trend of rapid urbanization has led to an increase in vehicles, thus exceeding the capacity of the city's road network. The total road network in Udaipur is approximately 822km.

Road hierarchy

The roads in Udaipur can be classified as under:

- Arterial roads: Udaipur has 11 arterial roads covering 84.17km. Most arterials form regional linkages to neighbouring major cities and towns
- Sub-arterial roads: The 26 sub-arterial roads connect the major residential areas to commercial and other areas of the city. Most sub-arterials are undivided, except a few that connect major junctions.

There are three main agencies in Udaipur who are responsible for the design, implementation and supervision of roads, bridges and other traffic engineering works. Currently, of the 822km of road network in Udaipur, 116.60km is maintained and managed by PWD, whereas the remaining 700km (approx.) is maintained and managed by UIT and the Municipal Council.

Rotary intersections

The major rotary intersections of Udaipur are as follows:

1. Nimachmata
2. Sewa Mandir
3. Fatehpura
4. Syphon
5. Bhuwana Bypass
6. Sukhadia Circle
7. Chetak Circle
8. Lokkala Mandal
9. Panchavati
10. UIT
11. Meera Girls College
12. Bhatt Ji ki Baadi
13. Court Junction
14. Shastri Circle
15. Delhi Gate
16. Hatipol
17. Surajpol
18. Udiyapol
19. Sikh Colony Junction
20. Ayurved Junction
21. Thokar Junction
22. Sukhadia Samadhi Junction
23. Anand Plaza Junction
24. Pratap Nagar
25. Bohara Ganeshji
26. Sector 4 and 5
27. Madri Purohitan Bypass Junction
28. Eklingpura Bypass Junction
29. Sub city Centre Junction
30. Transport Nagar Bypass (Near Panchayat Samiti)
31. Patel Circle
32. Rampura Junction
33. Community Hall, Sector 14
34. Sector 8 (Jhamarkotda)

Signalized intersections

The following is a list of signalised junctions:

1. Surajpol Junction
2. Delhi Gate Junction
3. Udiyapol Junction
4. Chetak Circle
5. Court Junction
6. Paras Cinema Junction
7. Pratapnagar Junction

Underpasses

The city has seven underpasses at the following locations:

1. Udaipol
2. RCA Hostel
3. Sikh Colony
4. Sewashram Juntion
5. Hiran Magri Sector-11
6. Eklingpura
7. Debari

Primary data analysis

Classified traffic volume counts at mid-block locations (inner-city entrance points)

Classified traffic volume count surveys were conducted at four mid-block locations for a 16-hour period (0600 hrs to 2200 hrs). These locations act as entrance points to the walled city on a typical fair-weather working day. The quantum and temporal variation of total daily traffic, peak hour traffic, intensity and directional distribution of traffic, and composition of vehicles and passenger trips are presented in the following sections.

Traffic volume (average daily traffic – 16 hrs)

The traffic counts, both in terms of vehicle numbers and passenger car units (PCUs) have been computed for the total daily (16 hour) traffic at various mid-block locations and presented in the table below. It is observed that the traffic at different locations varies from 2,838 PCUs at Ambapole to 9,495 PCUs at Chandpole.

Table 1: Daily traffic volume (16 hrs) at mid-block locations

Location no.	Name of location	Total PCUs
1	Ambapole	2838
2	Naya Puliya	5866
3	Chandpole	9495
4	Bombayya market	3932

Source: Primary Surveys, 2013

Peak hour traffic at mid-block locations

The peak hour traffic at the mid-block locations is presented in the table below. The morning peak hour volume varies from 296 PCUs at Bombayya Market to 1,063 PCUs at Chandpole, and evening peak hour volume varies from 284 PCUs at Ambapole to 995 PCUs at Chandpole.

Table 2: Peak hour traffic at mid-blocks

Locations	Total PCUs	Morning peak		Evening peak	
		PCUs	Per cent of total traffic	PCUs	Per cent of total traffic
Ambapole	2838	325	11	284	10
Naya Puliya	5866	569	10	552	9
Chandpole	9495	1063	11	995	10
Bombayia Market	3932	296	8	640	16

Source: Primary Surveys, 2013

Traffic composition at mid-block locations

Seventy-two per cent of the traffic observed at mid-block locations is composed of two-wheelers. Thirteen per cent of traffic constitutes four-wheelers, including cars, jeeps and taxis. The traffic composition at mid-blocks is shown in Figure 1.

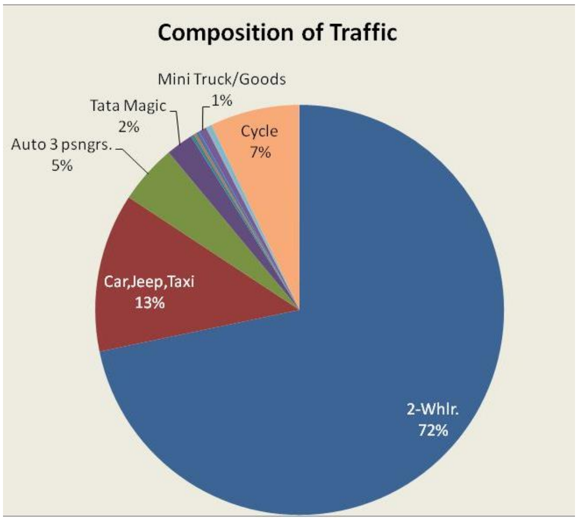

Figure 1: Traffic composition at mid-blocks

Classified turning volume counts at intersection locations

Turning traffic volume count surveys have been conducted at 19 major intersection points for a 16-hour period (0700 Hrs to 2300 Hrs) on a typical fair weather working day.

Traffic volume (average daily traffic – 16 hrs)

The traffic counts, both in terms of the numbers of vehicles and passenger car units (PCUs) have been computed for the total daily (16 hour) traffic at various intersection locations, and are presented in Table 3. It is observed that the traffic at different locations varies from 21,501 PCUs at Syphon Circle to 90,528 PCUs at Surajpol.

Table 3: Traffic volume at the intersection locations

Code	Name	Total traffic		Morning peak		Evening peak	
		Vehicles	PCUs	PCUs	% of total Traffic	PCUs	% of total Traffic
1	Fatehpura Chowk	46,094	39,788	3,588	9.0%	3,551	8.9%
2	Syphon Circle	26,610	21,501	2,187	10.2%	2,080	9.7%
3	Bhuwana Circle	31,467	36,853	2,642	7.2%	4,191	11.4%
4	Sukhadia Circle	24,106	22,263	1,834	8.2%	1,942	8.7%
5	Chetak Circle	71,109	59,229	4,567	7.7%	4,900	8.3%
6	Panchwati Circle	34,510	29,029	2,327	8.0%	2,294	7.9%
7	Court Circle	63,721	53,444	4,223	7.9%	4,346	8.1%
8	Shastri Circle	62,157	49,217	4,025	8.2%	4,169	8.5%
9	Delhi Gate	79,025	63,495	5,067	8.0%	5,367	8.5%
10	Hathipol	46,678	32,461	2,784	8.6%	2,775	8.5%
11	Udiapol	60,075	49,230	3,909	7.9%	4,109	8.3%
12	Pratap Nagar Chowk	48,414	64,260	5,019	7.8%	5,447	8.5%
13	Surajpol	100,578	90,528	8,352	9.2%	7,577	8.4%
14	UIT Circle	27,734	21,909	1,673	7.6%	2,137	9.8%
15	Ayyad Puliya	52,456	40,159	3,542	8.8%	3,383	8.4%
16	Sewashram Circle	68,889	54,322	5,436	10.0%	4,916	9.0%
17	Malla Talai Chowk	35,060	26,455	2,227	8.4%	2,426	9.2%
18	Patel Circle	41,395	36,387	2,651	7.3%	3,304	9.1%
19	Subji Mandi	33,488	30,512	2,827	9.3%	2,601	8.5%

Source: Primary Survey 2013

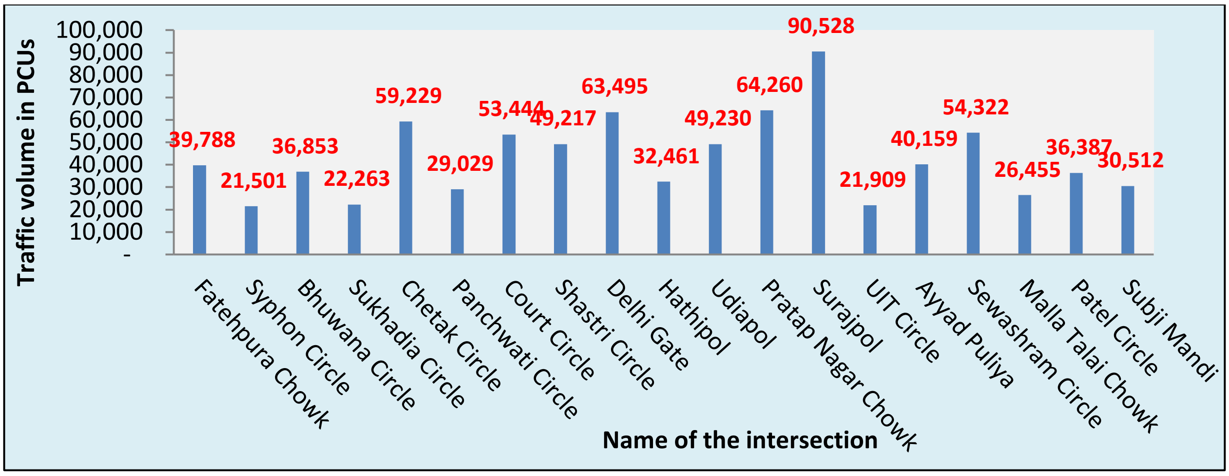

Figure 2: Traffic volume at the intersection locations

Peak hour traffic at intersections

The peak hour traffic at the various intersection locations is presented in Table 4. The morning peak hour volume varies from a minimum of 1,673 PCUs at UIT Circle to a maximum of 8,352 PCUs at Surajpol intersection. The evening peak hour volume varies from as low as 1,942 PCUs at Sukhadia Circle to a maximum of 7,577 PCUs at Surajpol.

Classified traffic volume counts at outer cordon locations

The survey has been conducted at nine cordon locations, which are primarily the major entry and exit points of the study area. The traffic volume counts, both in terms of numbers of vehicles and passenger car units (PCUs), have been computed for the total daily (24 hour) traffic at the outer cordon locations, and are presented in Table 5. It was observed that the traffic at different locations varies from as low as 259 PCUs at Badi Lake to 44,932 PCUs along NH-8 at Balicha.

Peak hour traffic at outer cordon locations

The details of traffic at the outer cordon locations are presented in Table 6. The morning peak hour volume varies from 27 PCUs at Badi Lake to maximum of 3,269 PCUs along NH-76 at Debari. The evening peak hour volume varies from 19 PCUs at Badi Lake to 3,274 PCUs along NH-76 at Debari. Figures 4 through 11 represent the hourly variation on traffic at outer cordon points

Table 4: Details of traffic characteristics at outer cordon

Code	Name of the intersection	Total traffic		Morning peak		Evening peak	
		Vehicles	PCUs	PCUs	% of total traffic	PCUs	% of total traffic
1	Abu Road	6,873	8,804	696	7.9%	705	8.0%
2	Amberi Bypass	9,696	15,139	903	6.0%	1,053	7.0%
3	Debari Bypass	27,306	44,932	3,269	7.3%	3,274	7.3%

4	Madri	13,089	10,749	978	9.1%	838	7.8%
5	Eklingpura	10,225	11,411	892	7.8%	1,158	10.1%
6	Banswara Road	11,230	11,745	1,027	8.7%	1,100	9.4%
7	Balicha Bypass	19,022	42,587	3,119	7.3%	2,657	6.2%
8	Rampura Chuaraha	5,466	4,834	444	9.2%	376	7.8%
9	Badi Lake	358	259	27	10.4%	19	7.4%

Source: Primary Survey 2013

Composition of traffic

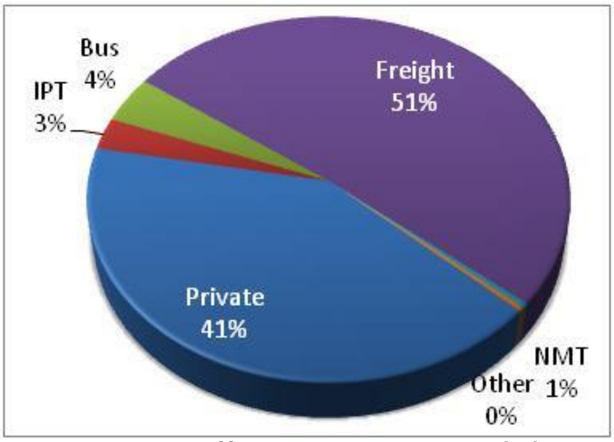

Figure 3: Traffic composition at Balicha

The daily traffic composition at the outer cordon locations exhibits a predominance of fast-moving passenger traffic, consisting of two-wheelers, cars, jeeps/vans, etc., at all locations. Significant freight traffic is observed along NH-8 (towards Ahmedabad) and NH-76 (towards Chittorgarh). The share of bus traffic is as low as 1 per cent at Badi Lake, and as high as 7 per cent at Amberi, along NH-8. The share of freight traffic varies from 3 per cent at Badi Lake to 51 per cent at Balicha, along NH-8. Composition of traffic at outer cordon locations is presented in Figure 3. Figures 12 through 20 exhibit the location-wise traffic composition.

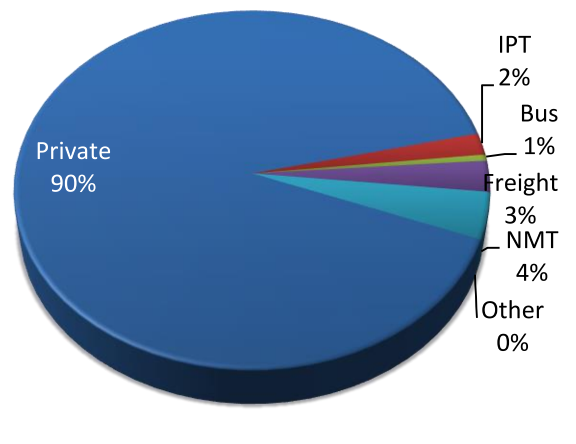

Figure 4: Traffic composition at Baari lake

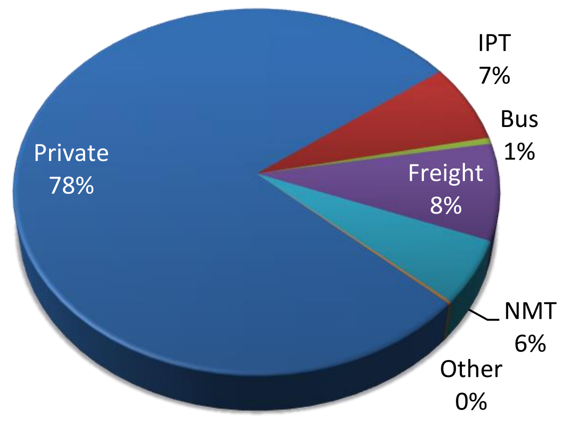

Figure 5: Traffic composition at Madri

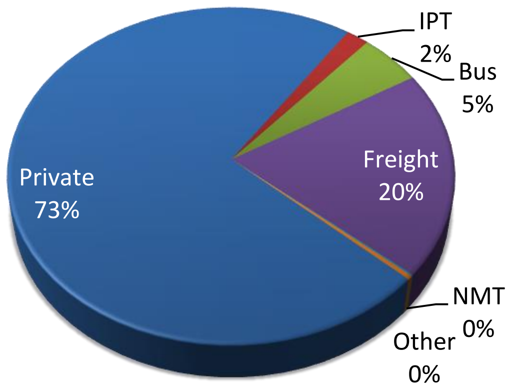

Figure 6: Traffic composition at NH-76 Abu Road

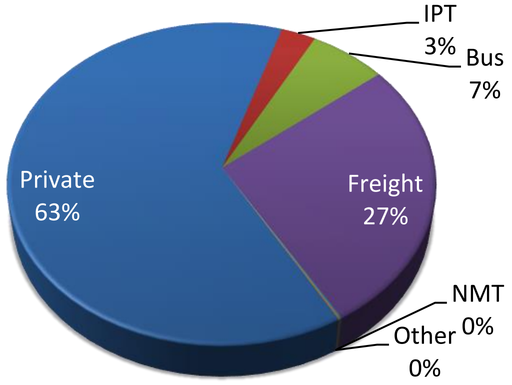

Figure 7: Traffic composition along NH-8, Amberi Bypass

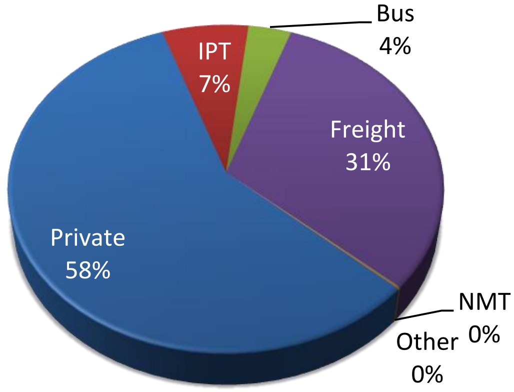

Figure 8: Traffic composition along NH-76, Debari

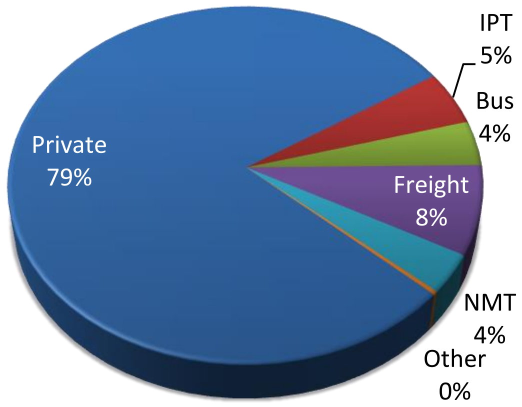

Figure 9: Traffic composition along SH-50 at Rampura

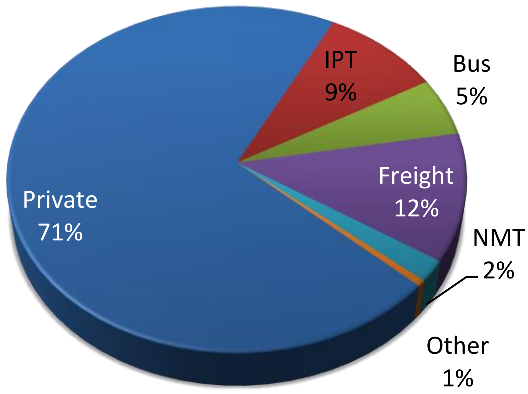

Figure 10: Traffic composition along VR-58 at Eklingpura

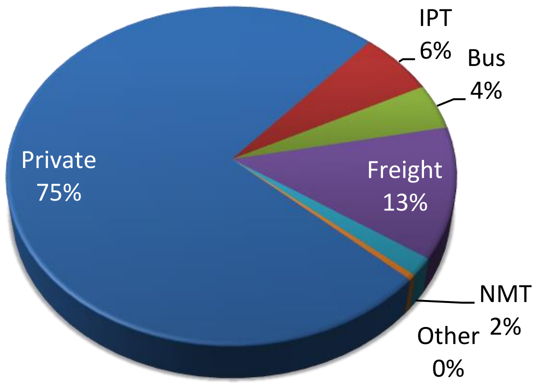

Figure 11: Traffic composition along Banswara Road

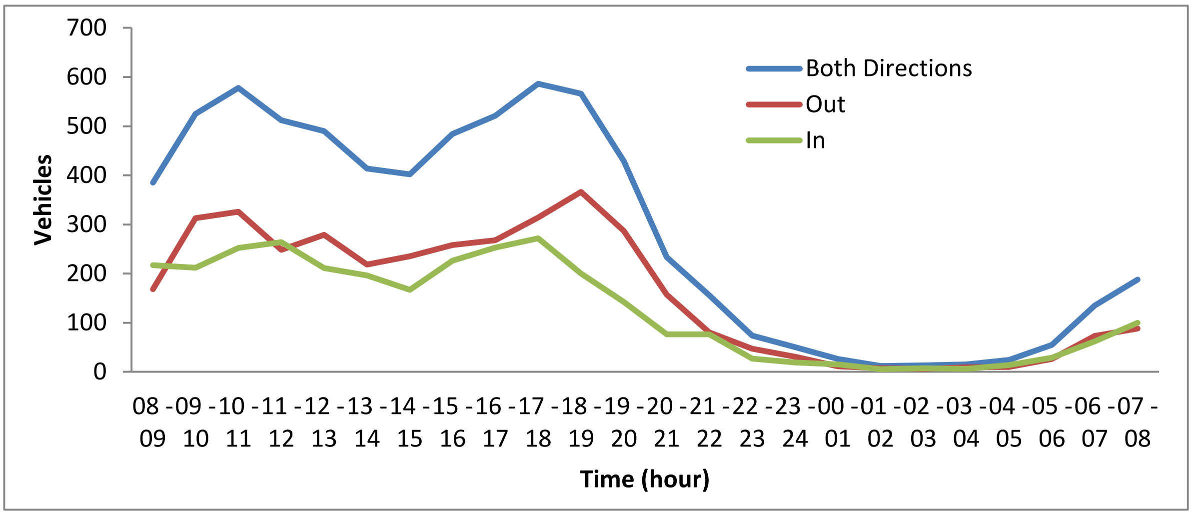

Figure 12: Hourly traffic variation at Abu Road

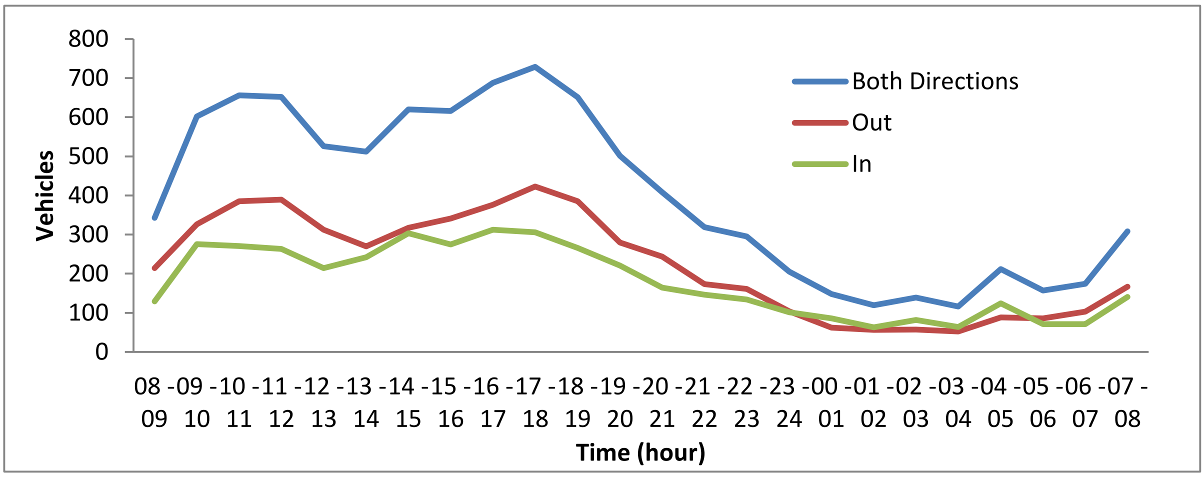

Figure 13: Hourly traffic variation at Amberi along NH-8

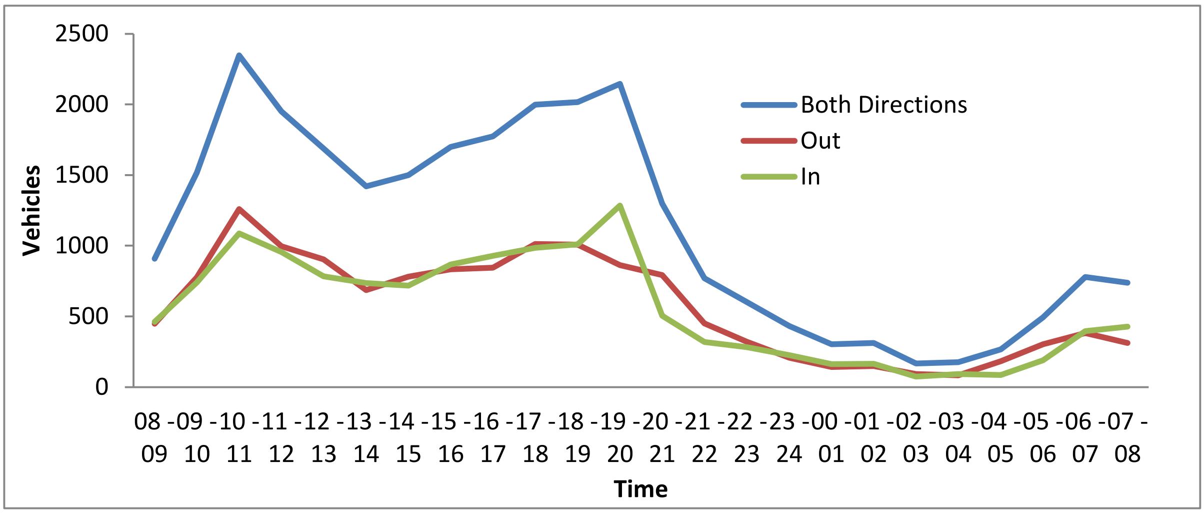

Figure 14: Hourly traffic variation at Debari along NH-76, Chittorgarh Road

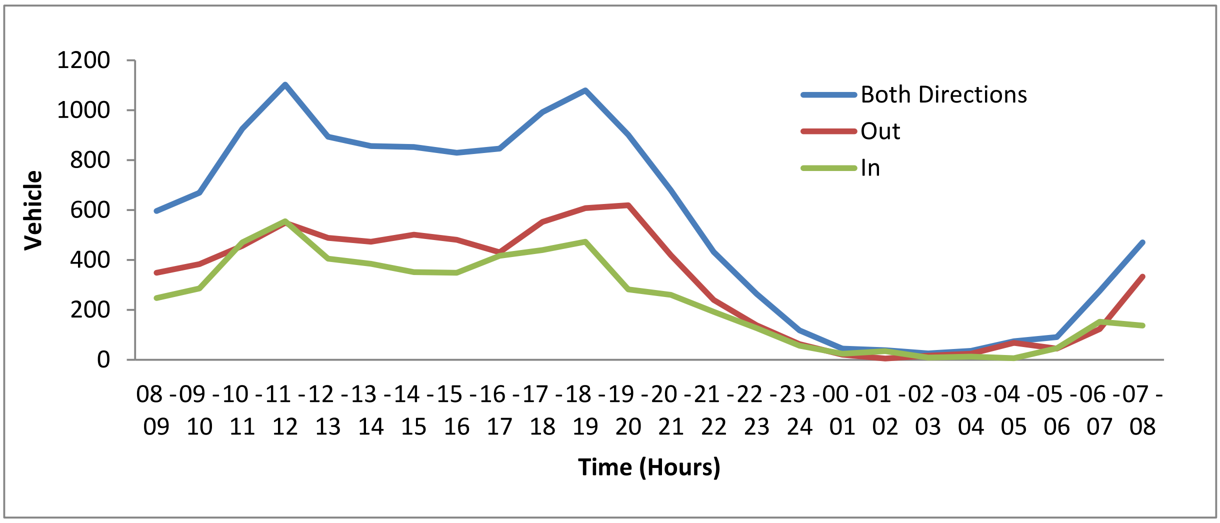

Figure 15: Hourly traffic variation at Madri

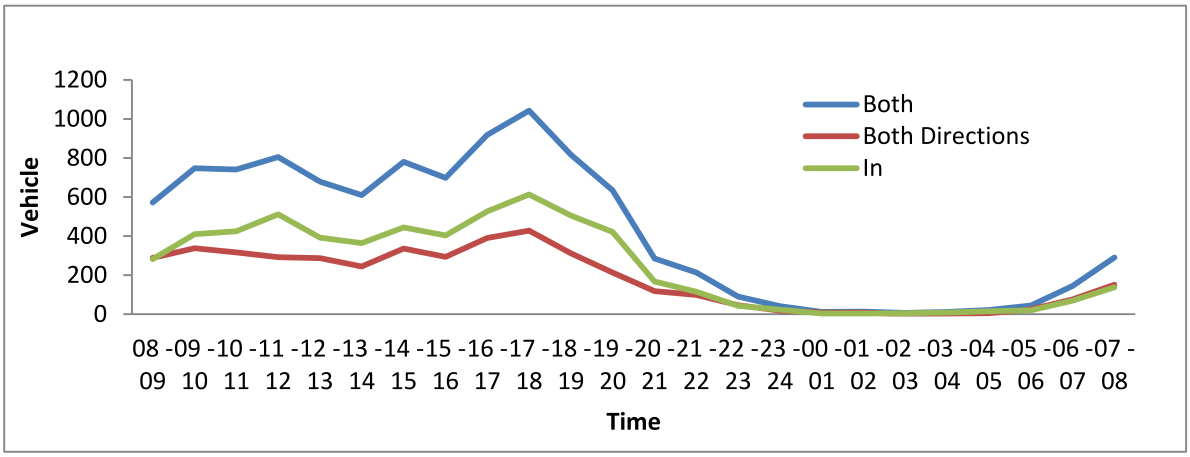

Figure 16: Hourly traffic variation at Eklingpura on Jhamarkotra Road

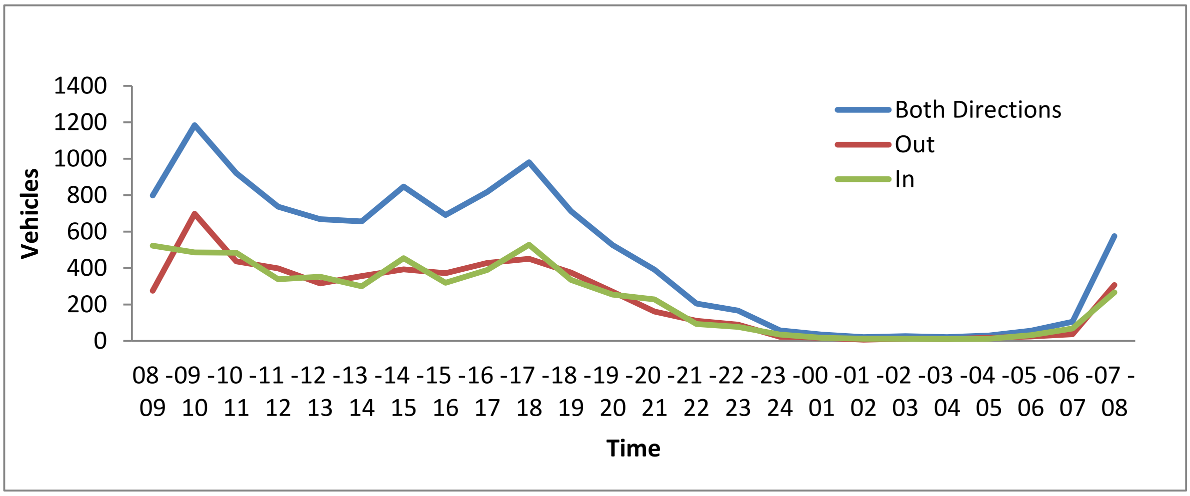

Figure 17: Hourly traffic variation on Banswara Road

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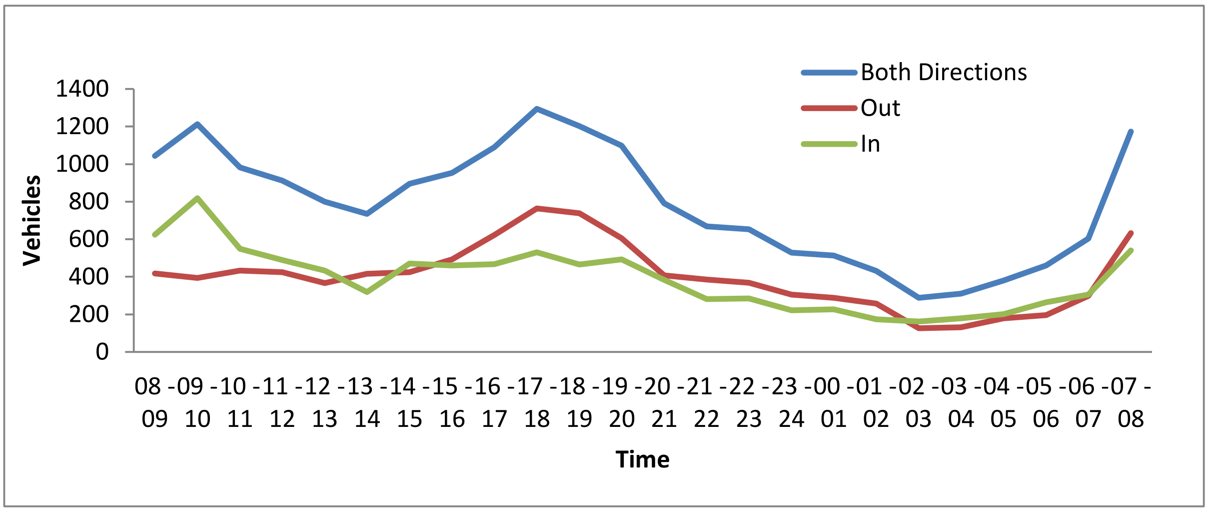

Figure 18: Hourly traffic variation at Balicha on NH-8, Ahmedabad Road

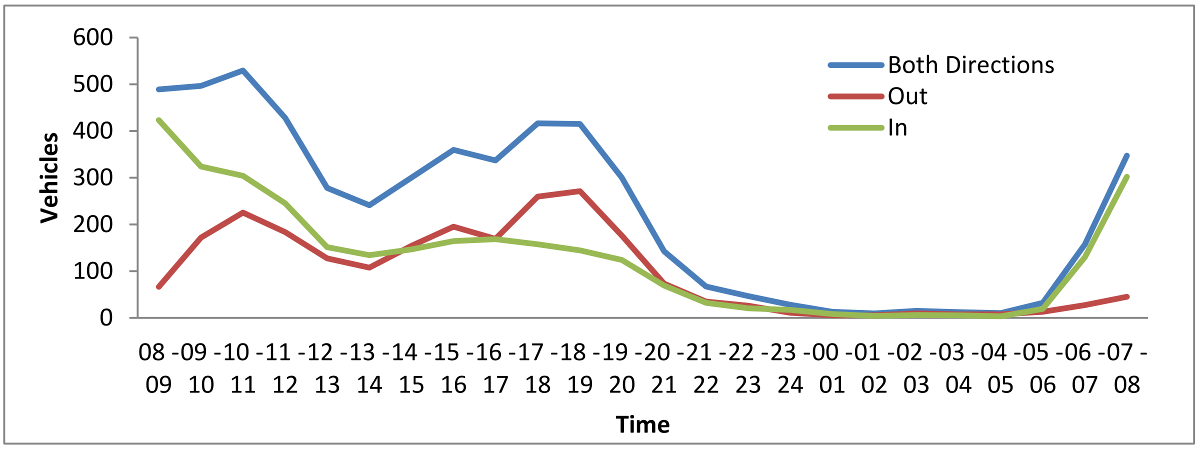

Figure 19: Hourly traffic variation at Rampura Chuaraha along SH-50

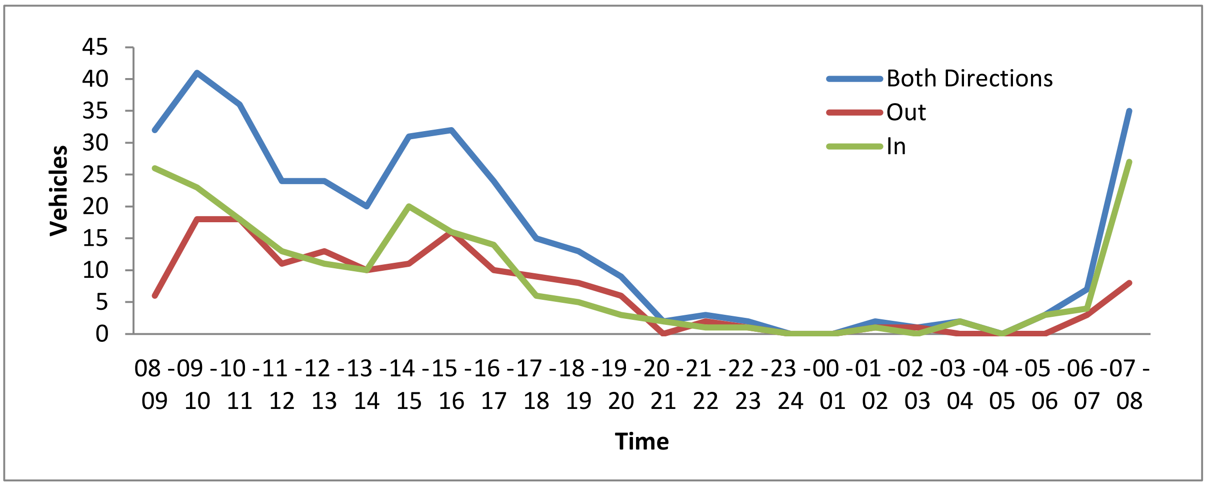

Figure 20: Hourly traffic variation at Badi Lake

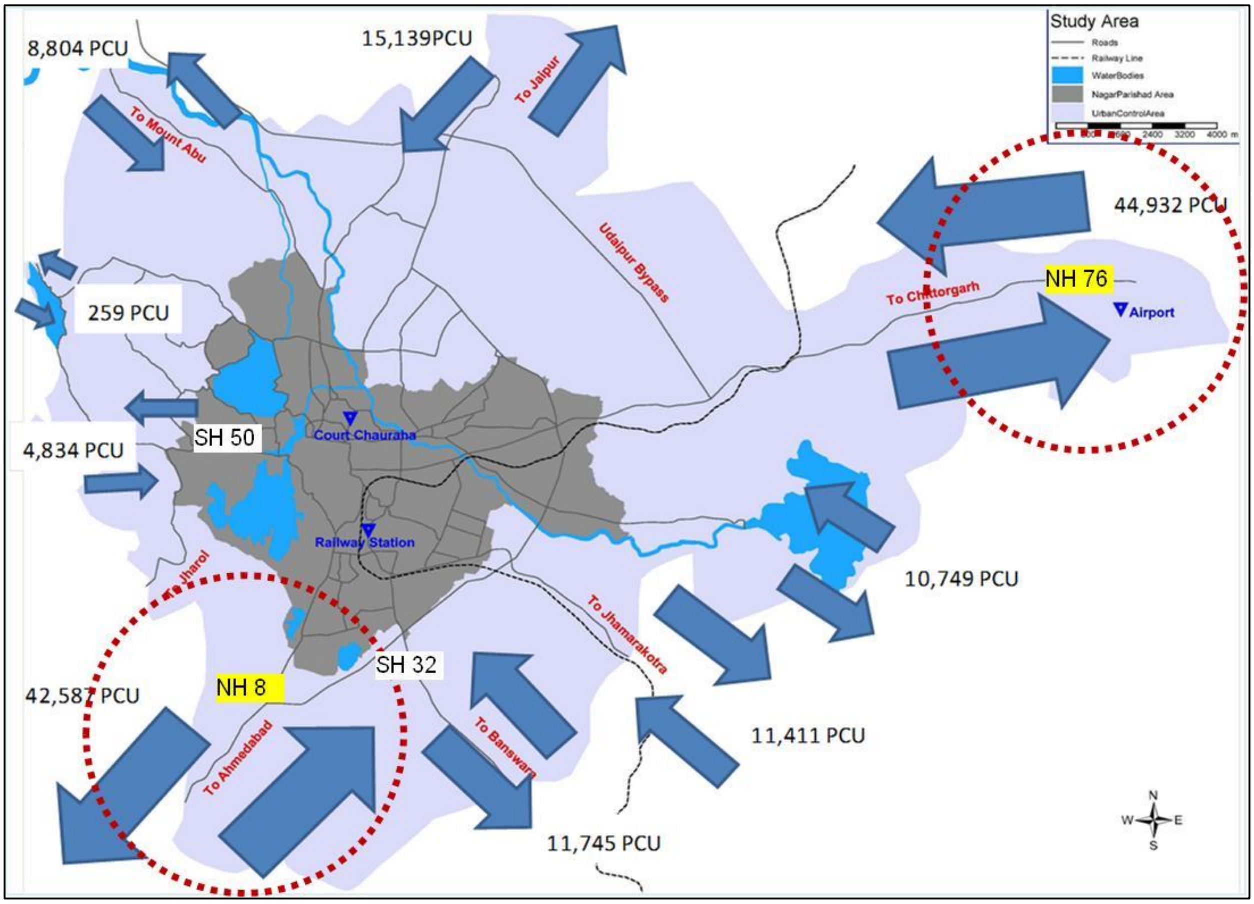

Figure 21: Traffic movement at Outer Cordon

Pedestrian characteristics

Pedestrian volume surveys were conducted at 19 major intersections and four mid-block locations to assess the pedestrian volume and their vulnerability in terms of conflict with vehicular traffic at intersections/mid-blocks.

Pedestrian flow characteristics (intersection locations)

The findings from the pedestrian flow characteristics are presented in the table below.

Table 5: Total pedestrians at intersection locations

Sl. No.	Name of location	Daily pedestrian volume
1	Fatehpura Chauraha	14,077
2	Syphon Chauraha	5,963
3	Bhuwana	9,615
4	Sukhadia Circle	3,772
5	Chetak Circle	22,776
6	Panchawati Circle	7,609
7	Court Chauraha	16,003
8	Shastri Circle	18,530
9	Delhi Gate Chauraha	41,173
10	Hathipol Chauraha	18,035
11	Udiapol Chauraha	40,202
12	Pratap Nagar Chauraha	24,494
13	Surajpol Chauraha	53,338
14	UIT Circle	4,601
15	Ayad Puliya	8,855
16	Shewasram Chauraha	17,188
17	Mallah Talai Chauraha	18,576
18	Patel Circle	7,783
19	Subji Mandi Chauraha	10,915

Source: Primary Survey 2013

It is observed that the total pedestrian traffic at the major intersections varies from a minimum of 4,601 at UIT circle to a maximum of 53,338 at Surajpol Chauraha, followed by Delhi Gate Chauraha and Udiapol Chauraha.

Pedestrian flow characteristics (mid-block locations)

An average of 2,600 pedestrians is observed at the surveyed locations, with a maximum at Nayapulia.

Table 6: Total pedestrians at mid-block locations

Sl. No.	Name of location	Daily pedestrian volume
1	Ambapol	2,696

Sl. No.	Name of location	Daily pedestrian volume
2	Nayapulia	2,774
3	Chandpol	2,630
4	Bombiya Market	2,582

Source: Primary Survey 2013

Pedestrian and vehicular traffic conflict measured by PV^2

The table below shows the calculations for PV^2/(2*10^8) at Fatehpura Chauraha, Syphon Chauraha, Bhuwana, Chetak Circle, Court Chauraha, Shastri Circle, Delhi Gate Chauraha, Hathipol Chauraha, Udiapol Chauraha, Pratap Nagar Chauraha, Surajpol Chauraha, Ayad Puliya, Shewsram Chauraha, Mallah Talai Chauraha, Patel Circle, Subji Mandi Chauraha. Locations where the value is higher than 1 necessitate improvements in pedestrian crossing facilities.

Table 7: PV^2 values at some of the important intersections

Sl. No.	Name of location	PV^2/ (2*10^8)
1	Fatehpura Chauraha	9
2	Syphon Chauraha	4.7
3	Bhuwana	1.87
4	Sukhadia Circle	0.4
5	Chetak Circle	6.5
6	Panchawati Circle	0.77
7	Court Chauraha	3.1
8	Shastri Circle	9
9	Delhi Gate Chauraha	12
10	Hathipol Chauraha	3.8
11	Udiapol Chauraha	12.2
12	Pratap Nagar Chauraha	13.5
13	Surajpol Chauraha	37.1
14	UIT Circle	0.54
15	Ayad Puliya	3.8
16	Shewsram Chauraha	19.4
17	Mallah Talai Chauraha	2.4
18	Patel Circle	2.6
19	Subji Mandi Chauraha	1.4

Source: Primary Survey 2013

Cyclist characteristics

A cyclist volume count survey was conducted at four major mid-block locations in and around the walled city, and at three major industrial areas.

Cyclist characteristics (mid-block locations)

A maximum of 4,450 cyclists were observed at Nayapuliya, followed by 4,295 at Chandpol. The hourly variation data shows that on average, 6 per cent is the peak hour share. Nayapulia and Chandpol have distinctive morning and evening peaks, while Ambapol and Bombiya market have morning peaks only.

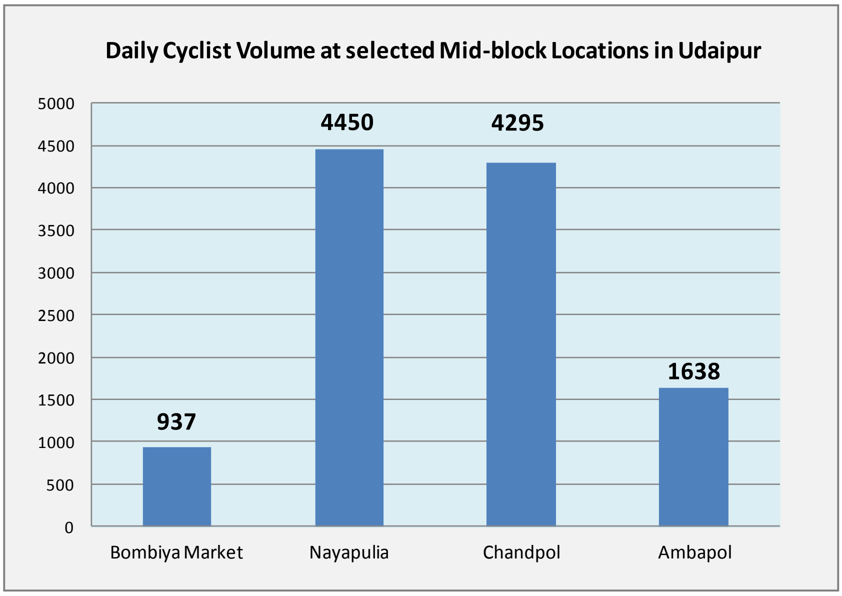

Figure 22: Daily cyclist volume at mid block locations in Udaipur

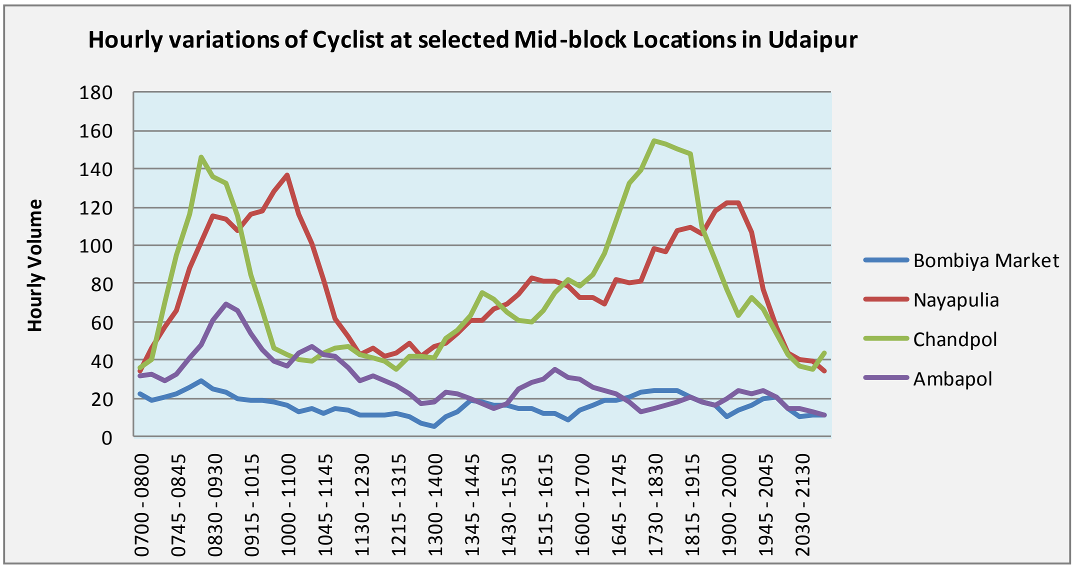

Figure 23: Hourly variation in cyclist volume at mid block locations in Udaipur

Cyclist characteristics (industrial area)

A maximum of 2,704 cyclists were observed at Madri Industrial Area, and the fewest cyclists were observed at RIICO Industrial Area.

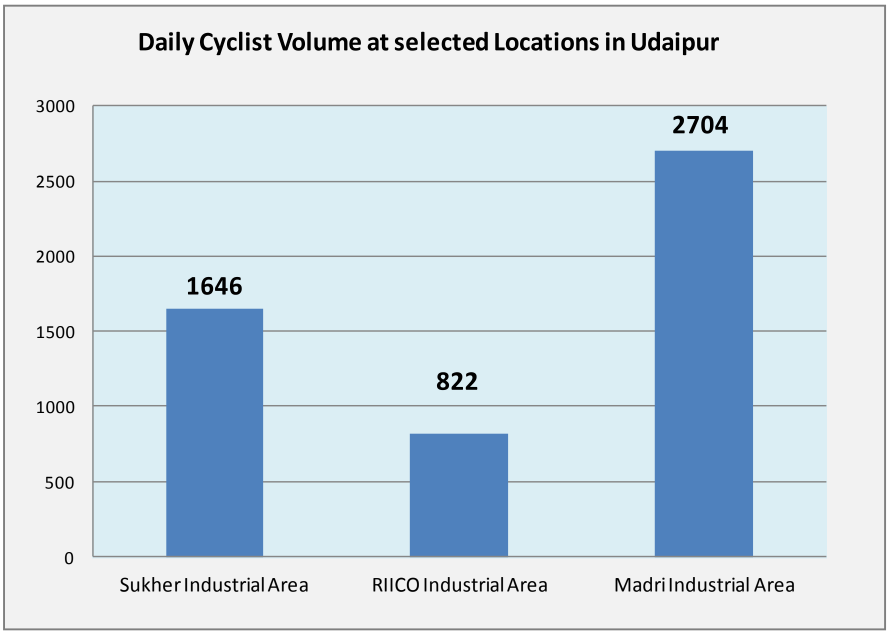

Figure 24: Daily cyclist volume at mid-block locations in Udaipur

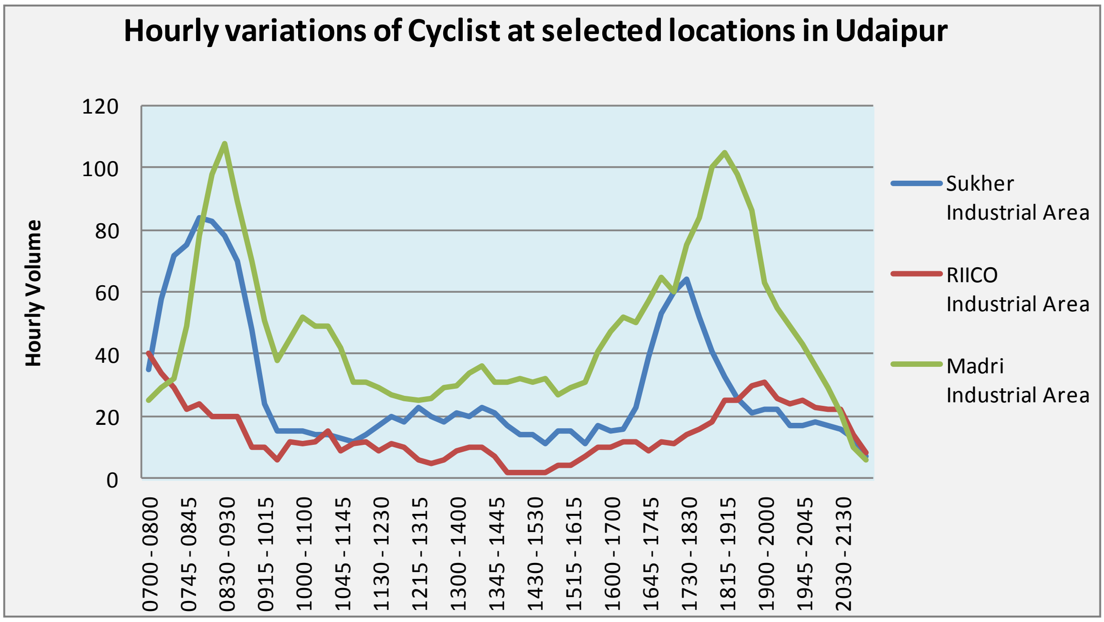

Figure 25: Hourly variation in cyclist volume at intersection locations in Udaipur

Terminals and stands

i. **Truck terminals:** The city has three truck terminals, however, they are not completely developed.

   a) **Goverdhan Vilas Transport Nagar**: Goverdhan Vilas Transport Nagar, located along NH8 to Ahmedabad, is under development. Land allotment and demarcation has already been completed by UIT.

   b) **Chittor Road Octroi Post Transport Nagar**: Currently, a rapid but unplanned development of this Transport Nagar is under progress. All parking and facilities need to be relocated inside the Transport Nagar in order to prevent traffic disruption.

   c) **Automobiles/truck stand:** UIT developed an automobile/truck stand in front of Reti Stand/Agricultural Produce Market. However, an illegal operation of the Reti Stand has caused the loading/unloading of sand-trucks along the main road itself. In addition, adequate parking is not available. Reti Stand is a commercially and economically important centre, and hence it needs to be operated in a planned manner.

ii. **Bus stand and bus stops:** The present Rajasthan Roadways bus stand is located in Udiapol. This is a high-density traffic corridor with inadequate parking.

iii. **Taxi/private bus stands:** An absence of planned taxi and bus stands in Udaipur has resulted in operations of private buses from the main roads. Most private buses operate from Udiapol.

iv. **Auto rickshaw stands:** Udaipur has a capacity to accommodate 558 auto stands, but only 82 have been developed and identified by the Traffic Police.

v. **Shared-auto taxi stands:** The Traffic Police have identified and located stoppages for the shared auto taxi. However, it is observed that these are not properly developed. In addition, these shared taxis randomly stop to pick up/drop off passengers.

Parking characteristics

The existing parking system of Udaipur is decentralized, unmanaged and largely dysfunctional. A large number of small parking lots dominate the scenario. Many of these facilities are generally poorly maintained and lack basic infrastructure. Haphazard street parking in major markets reduces the traffic-carrying capacity of roads. This results in traffic bottlenecks, especially in peak hours, causing economic loss.

In view of improving the parking situation in the walled city area, a number of studies have recommended development of well-organized, off-street parking lots with modern facilities at various locations within and outside the walled city. The parking situation in the rest of the city is better than in the walled city, but could get worse with an increase in the number of vehicles and commercialization along the roads. The tendency in Udaipur is of commercialization along the main roads. Initially, the plots along these roads were residential in nature, but with increasing land values and traffic on these roads, they have become commercialized. The commercialization led to an increase in parking demand along these roads, which in turn reduced the effective carriageway. With a high rate of increase in registered vehicles (two-wheelers and four-wheelers), parking facilities are proving to be inadequate. Most of the commercial areas do not provide for parking, and vehicles are parked along the road, thereby obstructing road traffic.

Ambient air quality

Ambient air quality is an indicator of the impact of urbanisation on air quality. Air Quality testing in Udaipur is conducted at the following three stations:

1. Town Hall
2. Ambamata
3. Regional Office, Madri Industrial area

The following tables show the data on pollution.

Table 8: Air quality parameters at Town Hall

Sl. No.	Pollution parameters	14/01/2005	20/05/2005	30/12/2005	19/05/2005
1	SO_2	13.266	11.033	7.1	6.25

Sl. No.	Pollution parameters	14/01/2005	20/05/2005	30/12/2005	19/05/2005
2	NO_2	45.233	49.933	33.7	29.4
3	SPM	307.666	315.66	349	295
4	RSPM	132.333	90.00	103	54

Source: Rajasthan State Pollution Control Board, 2006.

Table 9: Air quality parameters at Ambamata

Sl. No.	Pollution parameters	13/01/2005	20/05/2005	30/12/2005	18/05/2006
1	SO_2	4.2	6.7	7.133	12.2
2	NO_2	47.133	26.5	73.183	25.533
3	SPM	405	252	273.66	333.00
4	RSPM	N.A.	168	83	70.00

Source: Rajasthan State Pollution Control Board, 2006.

Table 10: Air quality parameters at Regional Office, Madri Industrial Area

Sl. No.	Pollution parameters	15/01/2005	21/05/2005	31/12/2005	18/05/2006
1	SO_2	11.433	9.366	6.2	8.550
2	NO_2	105.3	59.566	58	39.033
3	SPM	561.33	312.333	462	756.33
4	RSPM	167.66	84	149	116.66

Source: Rajasthan State Pollution Control Board, 2006.

Travel Pattern characteristics

Trip rates

The table below suggest that women and people belonging to lower income groups have lower trip rates, indicating a need for pro-poor and gender-friendly transportation infrastructure.

Table 11: Trip rates across different income groups and gender

Income group/gender	Trip rate with walk mode	Trip rate without walk mode
High Income Group (HIG)	1.2	0.96
Female	0.75	0.48
Male	1.57	1.34
Medium Income Group (MIG)	1.17	0.82
Female	0.71	0.34
Male	1.55	1.21
Low Income Group (LIG)	0.96	0.43
Female	0.61	0.19
Male	1.28	0.65
City average	1.12	0.73

Source: Primary Survey, 2013

Table 12: TAZ-wise income level distribution

Zone no.	Income levels		
	High	Medium	Low
1	2.6%	60.5%	36.8%
2	2.5%	55.0%	42.5%
3	6.7%	80.0%	13.3%
4	44.4%	50.0%	5.6%
5	15.0%	70.0%	15.0%
6	16.7%	54.8%	28.6%
7	0.0%	18.6%	81.4%
8	5.6%	80.6%	13.9%
9	11.4%	57.1%	31.4%
10	10.3%	87.2%	2.6%
11	24.3%	75.7%	0.0%
12	2.6%	68.4%	28.9%
13	6.1%	78.8%	15.2%
14	2.6%	76.3%	21.1%
15	5.7%	82.9%	11.4%
16	7.9%	73.7%	18.4%
17	5.3%	89.5%	5.3%
18	8.3%	38.9%	52.8%
19	12.9%	58.1%	29.0%
20	15.4%	69.2%	15.4%
21	5.7%	62.9%	31.4%
22	34.4%	59.4%	6.3%
23	7.9%	68.4%	23.7%
24	44.8%	55.2%	0.0%
25	13.3%	70.0%	16.7%
26	15.4%	56.4%	28.2%
27	12.1%	81.8%	6.1%
28	11.8%	76.5%	11.8%
29	6.1%	60.6%	33.3%
30	8.8%	79.4%	11.8%
31	7.7%	51.3%	41.0%
32	3.0%	84.8%	12.1%
33	10.5%	44.7%	44.7%
34	9.4%	59.4%	31.3%
35	9.7%	87.1%	3.2%
36	36.8%	44.7%	18.4%
37	19.4%	72.2%	8.3%
38	12.1%	72.7%	15.2%
39	21.9%	68.8%	9.4%

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Zone no.	Income levels		
	High	Medium	Low
40	7.1%	38.1%	54.8%
41	32.5%	52.5%	15.0%
42	2.8%	5.6%	91.7%
43	20.6%	67.6%	11.8%
44	7.1%	75.0%	17.9%
45	15.2%	60.6%	24.2%
46	2.6%	92.1%	5.3%
47	7.7%	56.4%	35.9%
48	13.3%	50.0%	36.7%
49	22.6%	54.8%	22.6%
50	26.3%	50.0%	23.7%
51	21.4%	64.3%	14.3%
52	60.0%	32.5%	7.5%
53	48.8%	29.3%	22.0%
54	25.7%	60.0%	14.3%
55	0.0%	58.1%	41.9%
56	21.4%	57.1%	21.4%
57	18.2%	63.6%	18.2%
58	0.0%	70.0%	30.0%
59	2.5%	67.5%	30.0%
60	0.0%	68.2%	31.8%
61	0.0%	71.4%	28.6%
62	12.5%	53.6%	33.9%
63	0.0%	40.0%	60.0%
64	15.0%	55.0%	30.0%
65	8.3%	44.4%	47.2%
66	0.0%	21.9%	78.1%
67	6.0%	36.0%	58.0%
68	13.6%	72.7%	13.6%
69	14.3%	42.9%	42.9%
70	18.2%	40.9%	40.9%
71	5.9%	35.3%	58.8%
72	14.8%	44.4%	40.7%
73	9.1%	43.2%	47.7%
74	12.0%	40.0%	48.0%
75	17.5%	67.5%	15.0%
76	0.0%	100.0%	0.0%
77	0.0%	80.0%	20.0%
78	0.0%	75.0%	25.0%
79	0.0%	82.6%	17.4%

Zone no.	Income levels		
	High	Medium	Low
80	7.3%	60.0%	32.7%
Average	**13%**	**61%**	**27%**

Source: Primary Survey, 2013

Trip length

The average trip length (ATL) for Udaipur is 5.09km. Mode-wise average trip lengths are given in the table below.

Table 13: Mode-wise ATL

Mode	Mode-wise ATL
Walk	2.54
Bicycle	5.08
Two-wheeler	5.22
Car	5.98
IPT	4.47
Bus	8.47
Average	**5.09**

Source: Primary Survey, 2013

Modal share

In the absence of organized public transport, private vehicles consisting of cars and two-wheelers have higher modal share. The share of trips in favour of public transport is as low as 2 per cent, while walking is another predominant mode of transport. Eighty per cent of intra-zonal trips are walk trips.

Table 14: Base year mode shares (all modes)

Mode	Mode shares		
	Total trips	Intra-zonal trips	Inter-zonal trips
Walk	48%	80%	25%
Cycle	2%	2%	3%
Two-wheeler	34%	14%	48%
Car	3%	1%	4%
IPT	11%	3%	18%
Buses	2%	0%	3%

Source: Primary Survey, 2013

Travel time

The average travel time observed in Udaipur is about 12 minutes. Mode-wise travel time is detailed in the table below.

Table 15: Travel time mode-wise

Mode	Travel time (min)
Walk	27.72
Bicycle	18.66
Two-wheeler	9.21
Car	9.51
IPT	14.30
Bus	13.65
Average	**11.87**

Source: Primary Survey, 2013

Travel cost

The average travel cost observed in Udaipur is Rs. 10.5. Mode-wise travel cost is given in the table below.

Table 16: Travel time mode-wise

Mode	Average travel cost (in Rs.)
Walk	0
Bicycle	0
Two-wheeler	7
Car	21.7
IPT	7
Bus	5
Average	**10.5**

Source: Primary Survey, 2013

Annexure 3. – Travel Demand Assessment

Introduction

A transport simulation model has been developed to assess the overall city-level analysis, and model future impacts of the options to be tested, as well as extract the inputs for understanding the air quality analysis. The model broadly consists of two major components:

a. **Demand component**: This includes the process of subdividing the city into homogeneous spatial entities called traffic analysis zones (TAZs), and identifying the movement between these zones.
b. **Supply component:** This includes the transport component, reflecting the availability of roads, rails etc., and their capacities and regulations. These are required to undertake the movements identified in the demand component.

This section of the report will discuss the process of developing these models, the assumptions made, the indicators and relationships estimated, and the validation results of these modelled results, compared against the observed numbers.

Transportation Study Process

The transportation study process consists of developing models for forecasting future travel demand, and assessing alternative strategies for handling this demand. It is not just one model, but a series of interlinked and inter-related models of varying levels of complexity, dealing with travel demand. Through these models, the transportation study process as a whole is checked and calibrated before it is used for future travel predictions. For Udaipur, this has been done by synthesizing the present day movement patterns and adjusting the same until these represent observed conditions. Only when the formulae have been adjusted or calibrated, so that they can adequately predict the present day travel movements, are these used in true predictive mode to determine future conditions.

In the present study, an attempt has been made to develop operational models. The normal and easily available planning variables at zonal levels such as population, employment, number of workers residing, number of students residing, and student enrolment have been used in this transport analysis.

Study area zoning

Before developing the travel demand model, it is necessary to generate the network model representing the road network of Udaipur. It is necessary to divide the city into smaller homogeneous units, referred to as TAZs. This subdivision is based on:

a. Existing ward boundary

b. Road network and natural boundaries

c. Physical features of the city.

The study area has 80 internal zones and four terminal zones. The outside Urban Control Area is grouped into eight external zones. Figure 26 below shows the TAZs with zone number for the study area. The zone parameters such as population, number of households for these TAZs, are given in the following Table.

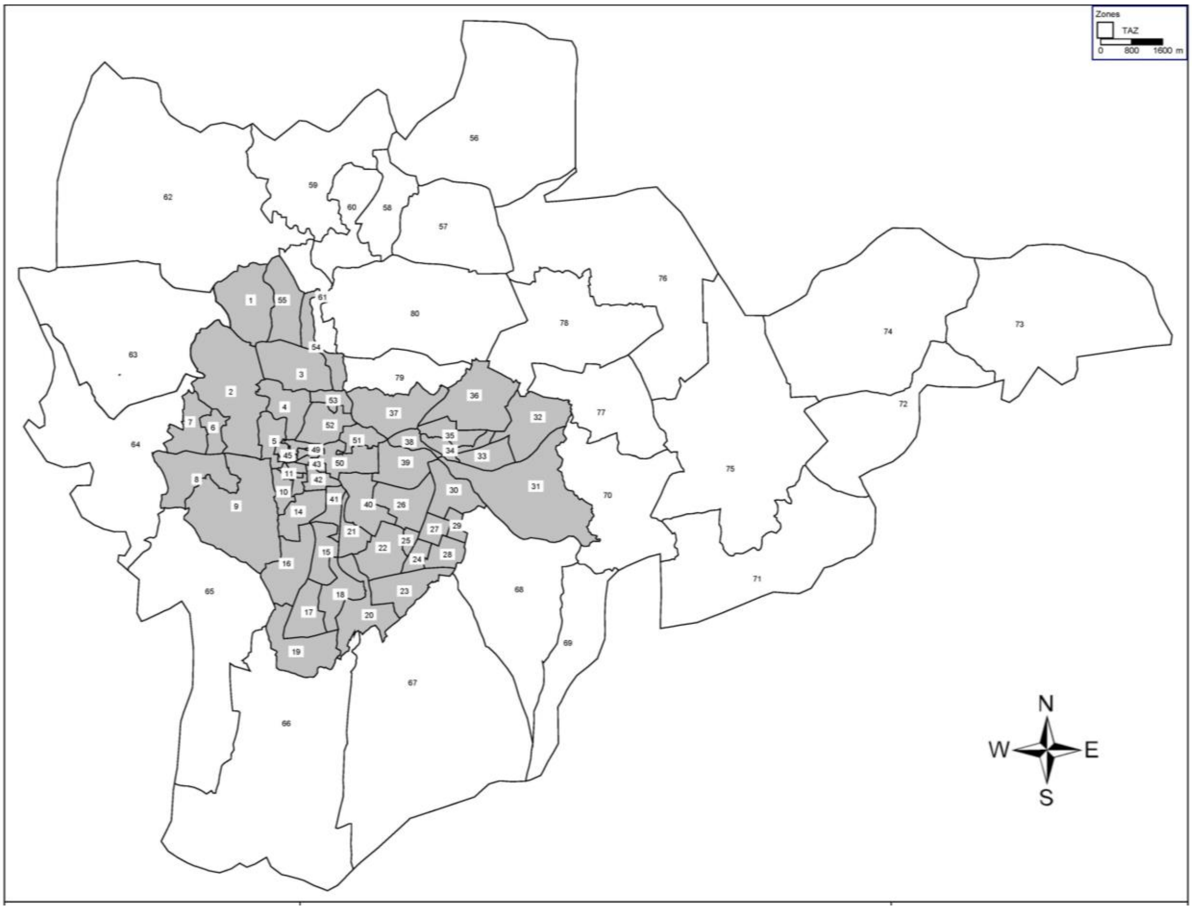

Figure 26: Travel time mode-wise

Table 17: TAZ-wise demographic data

TAZ number	Zone type	Area (ha)	Population (2011)	No. of households
1	Municipal Ward	227.17	9,128	1,822
2	Municipal Ward	447.71	9,711	1,938
3	Municipal Ward	193.65	7,602	1,517
4	Municipal Ward	117.63	9,001	1,797
5	Municipal Ward	72.64	9,714	1,939
6	Municipal Ward	53.07	10,146	2,025
7	Municipal Ward	114.18	9,440	1,884
8	Municipal Ward	192.31	8,544	1,705
9	Municipal Ward	493.28	8,403	1,677
10	Municipal Ward	43.20	9,410	1,878

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TAZ number	Zone type	Area (ha)	Population (2011)	No. of households
11	Municipal Ward	12.61	9,131	1,823
12	Municipal Ward	11.59	9,212	1,839
13	Municipal Ward	15.40	8,431	1,683
14	Municipal Ward	99.47	9,360	1,868
15	Municipal Ward	90.86	8,517	1,700
16	Municipal Ward	172.57	8,841	1,765
17	Municipal Ward	110.51	9,640	1,924
18	Municipal Ward	107.69	8,426	1,682
19	Municipal Ward	192.76	7,676	1,532
20	Municipal Ward	166.67	9,839	1,964
21	Municipal Ward	64.77	7,857	1,568
22	Municipal Ward	135.02	7,826	1,562
23	Municipal Ward	139.36	8,550	1,707
24	Municipal Ward	38.98	7,205	1,438
25	Municipal Ward	20.01	7,411	1,479
26	Municipal Ward	139.46	9,588	1,914
27	Municipal Ward	45.22	8,021	1,601
28	Municipal Ward	64.56	7,975	1,592
29	Municipal Ward	29.88	8,114	1,620
30	Municipal Ward	124.30	8,714	1,739
31	Municipal Ward	542.35	9,367	1,870
32	Municipal Ward	205.27	8,286	1,654
33	Municipal Ward	78.19	9,329	1,862
34	Municipal Ward	54.68	7,879	1,573
35	Municipal Ward	68.82	7,854	1,568
36	Municipal Ward	269.83	9,282	1,853
37	Municipal Ward	214.72	9,074	1,811
38	Municipal Ward	41.53	8,065	1,610
39	Municipal Ward	136.86	7,556	1,508
40	Municipal Ward	132.14	9,567	1,910
41	Municipal Ward	52.61	9,419	1,880
42	Municipal Ward	37.91	9,235	1,843
43	Municipal Ward	10.17	7,451	1,487
44	Municipal Ward	8.60	7,103	1,418
45	Municipal Ward	11.16	8,279	1,653
46	Municipal Ward	9.78	9,758	1,948
47	Municipal Ward	14.25	9,394	1,875
48	Municipal Ward	6.52	7,557	1,508
49	Municipal Ward	9.53	7,763	1,550
50	Municipal Ward	104.90	9,391	1,874
51	Municipal Ward	56.21	10,490	2,094
52	Municipal Ward	107.90	9,744	1,945
53	Municipal Ward	43.71	9,887	1,973
54	Municipal Ward	91.61	8,814	1,759
55	Municipal Ward	156.29	7,679	1,533

TAZ number	Zone type	Area (ha)	Population (2011)	No. of households
56	Municipal Ward	1525.71	3,440	687
57	Villages outside Nagar Parishad Area	558.18	2,676	534
58	Villages outside Nagar Parishad Area	228.51	2,521	503
59	Villages outside Nagar Parishad Area	737.40	10,140	2,024
60	Villages outside Nagar Parishad Area	281.00	5,517	1,101
61	Villages outside Nagar Parishad Area	163.25	5,361	1,070
62	Villages outside Nagar Parishad Area	2333.09	14,091	2,813
63	Villages outside Nagar Parishad Area	1308.82	2,152	430
64	Villages outside Nagar Parishad Area	1087.48	5,104	1,019
65	Villages outside Nagar Parishad Area	1245.95	8,870	1,770
66	Villages outside Nagar Parishad Area	2017.27	7,870	1,571
67	Villages outside Nagar Parishad Area	2296.97	12,258	2,447
68	Villages outside Nagar Parishad Area	943.93	5,141	1,026
69	Villages outside Nagar Parishad Area	489.78	3,545	708
70	Villages outside Nagar Parishad Area	755.65	9,053	1,807
71	Villages outside Nagar Parishad Area	1162.20	3,854	769
72	Villages outside Nagar Parishad Area	730.45	6,606	1,319
73	Villages outside Nagar Parishad Area	1469.49	10,889	2,173
74	Villages outside Nagar Parishad Area	1574.97	6,242	1,246
75	Villages outside Nagar Parishad Area	1739.35	9,884	1,973
76	Villages outside Nagar Parishad Area	1601.35	1,236	247
77	Villages outside Nagar Parishad Area	520.09	3,819	762
78	Villages outside Nagar Parishad Area	782.97	1,961	392

TAZ number	Zone type	Area (ha)	Population (2011)	No. of households
79	Villages outside Nagar Parishad Area	266.86	5,584	1,115
80	Villages outside Nagar Parishad Area	1100.09	14,101	2,815

Source: Census of India

Network development

For the purpose of developing the simulation network of Udaipur, a GIS-based tool has been used (VISUM 12.5). This enables us to represent the detailed network character and behaviour in a geographic manner that is easily understandable by the policy makers. The coded highway network for the study area primarily consists of ***nodes*** (intersections) and ***links*** (roads) connecting the nodes. Connectivity between the network and zones is provided through imaginary ***centroid connectors***. Based on the network inventory, each link has been assigned attributes such as number of lanes, divided or undivided carriageway, one-way/two-way, encroachments, availability of footpaths, etc. Figure 27 below shows the base year road network for the study area. The network attributes, linked with geographic files, have been used to develop the transport model using VISUM 12.5 software.

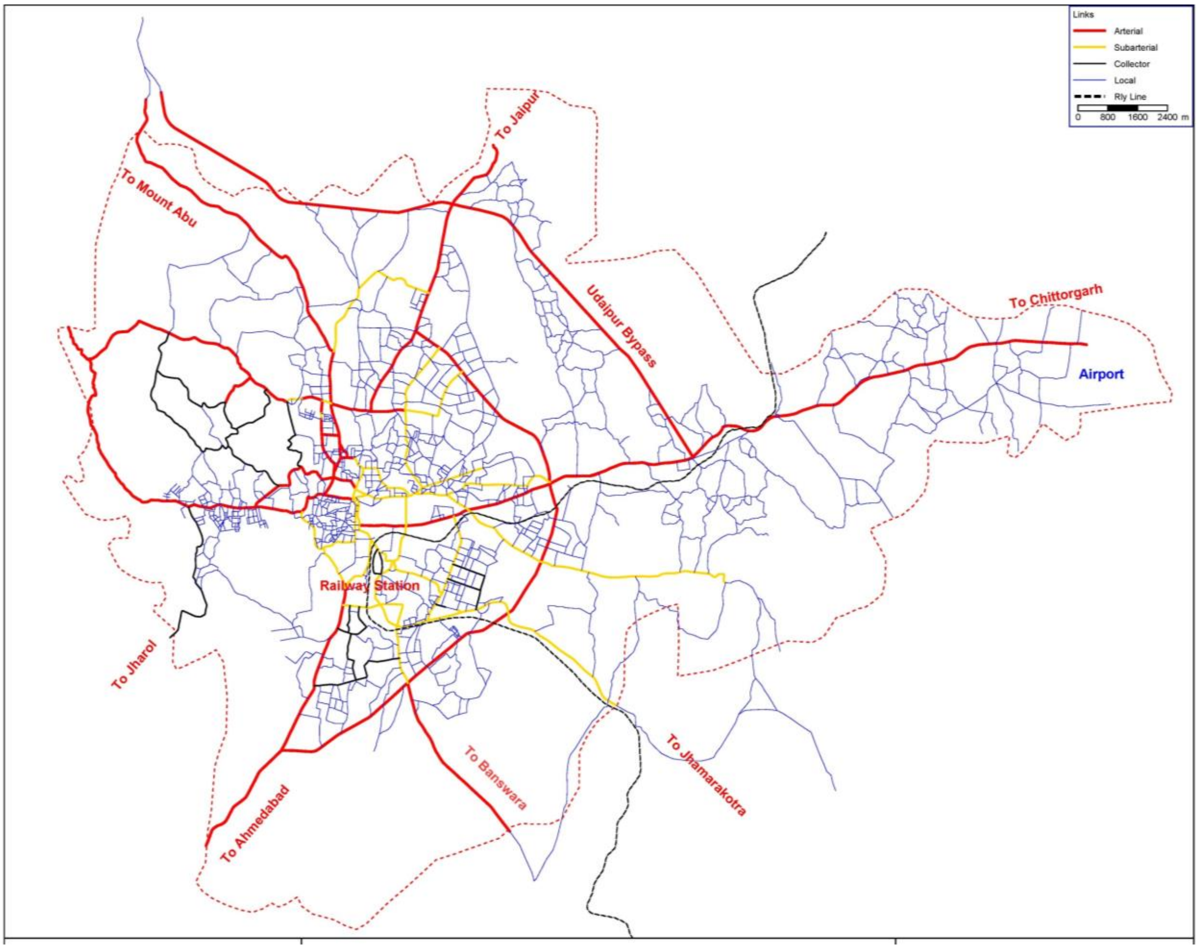

Figure 27: Udaipur road network

Base year travel pattern

The base year trip matrices have been developed using the data compiled from household surveys, terminal surveys and roadside interview surveys. Mode-wise peak hour matrices were extracted and expanded from these surveys. The corresponding mode-wise matrices were added to get a combined matrix that represents the trip movements for the entire Udaipur control area. Each mode-wise matrix consists of movements between internal zones to internal zones (I-I), internal to external zones (E-I and I-E), and external movements (E-E). From the household survey, it is observed that, out of the total one-way trips, 27.39 per cent move in the common peak hour (10:00 to 11:00). These prior matrices thus derived from household, terminal and outer cordon surveys have been calibrated to the counts observed on links and turns using the TFlow Fuzzy process available in VISUM. This process is explained below.

TFlow Fuzzy matrix correction

TFlow Fuzzy is a procedure developed based on fuzzy logic techniques, and made available in VISUM to correct an origin-destination (OD) matrix based on a comparison of counted volumes and assignment volumes.

It is possible to run TFlow Fuzzy with any combination of counts on links, turns and OD traffic for zones. The basic idea behind this procedure is best illustrated in Figure 28 below.

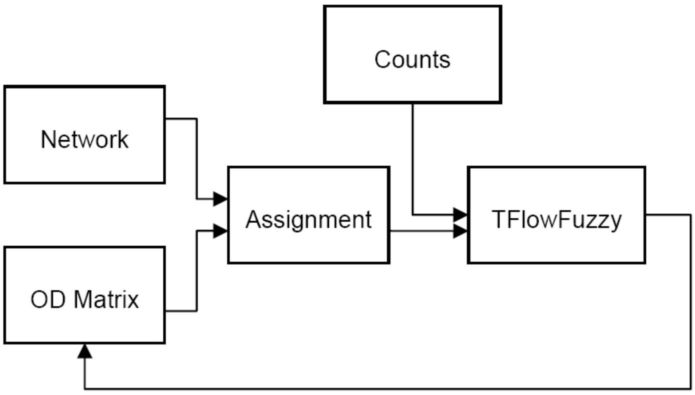

Figure 28: TFlow Fuzzy matrix correction methodology flow chart

TFlow Fuzzy is an iterative exercise where the corrected matrices in the first iteration are assigned again after relevant network corrections until a satisfactory GEH is achieved, i.e. a calibrated-validated model. Generally speaking, the GEH statistic, an empirically derived statistical relationship, is used to compare two sets of traffic volumes. The formula of the GEH statistic is as follows:

$$GEH = \sqrt{\frac{2(M - C)^2}{M + C}}$$

Where,
'M' is the hourly traffic volume from the traffic model and
'C' is the real-world hourly traffic count.

The peak hour calibrated matrices obtained from the TFlow Fuzzy method are assigned on to the road network. The assigned and counted traffic volumes are compared.

The use of GEH as an acceptance criterion is recognized in the UK Highways Agency's Design Manual for Roads and Bridges (DMRB). It is desired that 85 per cent of the volumes in a traffic model should have a GEH of less than 5.0, and 5 per cent of the volumes should have a GEH greater than 10.

The table below gives the GEH statistic value for different modes in Udaipur.

Table 18: GEH statistic for Udaipur

Mode	Comparison	GEH < 5%	GEH > 10%
Cycle	Link volumes	82%	1%
	Turn volumes	81%	2%
	Link volumes	84%	5%

Mode	Comparison	GEH < 5%	GEH > 10%
Two-wheeler	Turn volumes	80%	5%
Other Buses	Link volumes	84%	2%
	Turn volumes	83%	2%
Cars	Link volumes	81%	2%
	Turn volumes	80%	3%
Goods	Link volumes	81%	3%
	Turn volumes	83%	3%
IPT	Boarding	83%	8%
	Alighting	92%	0%

Model structure

Using the components discussed above, as well as the socio-economic data collected from Udaipur, a conventional four-stage transport demand model has been developed. The broad model structure has been shown in Figure 29, and each component of this model has been discussed in the subsequent sections.

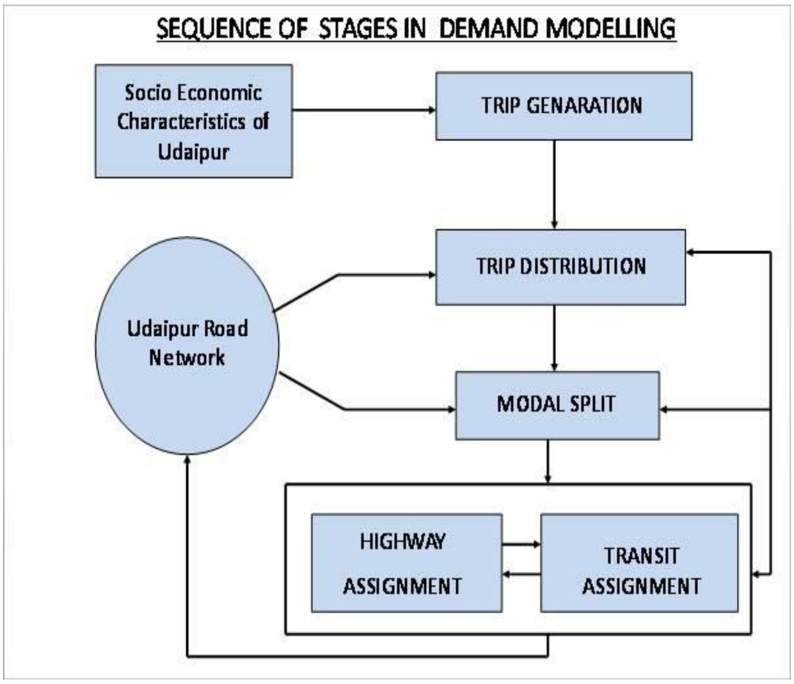

Figure 29: Four-stage transport model structure

- **Trip generation**: calculating the number of productions and attractions for each zone.
- **Trip distribution**: distributing these productions and attractions for each origin-destination (OD) pair.
- **Mode choice**: determining the mode for each trip (two-wheeler, car, cycle, IPT).
- **Trip assignment**: assigning passengers to their respective highway and transit networks.

The values of various constants and parameters estimated for each step of the base year model are explained in this section. These were checked against the observed values of variables, obtained from the surveys of actual travel patterns. Once satisfactory estimates of the parameters for each stage were obtained, the models were checked to ensure that they adequately performed the functions for which they are intended.

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Trip generation calibration and validation

The first of the sub-models in the conventional four-step travel demand modelling process predicts the number of trips starting and finishing in each zone. The techniques developed attempt to utilize the observed relationships between travel characteristics and the urban environment, and are based on the assumption that trip making is a function of three basic factors:

1. The land use pattern and development in the study area
2. The socio-economic characteristics of the trip-making population of the study area
3. The nature, extent and capabilities of the transportation system in the study area.

Mathematically, trip generation can be expressed as:
Trips generated = Function (socio-economic variables etc.)

In most of the studies conducted so far, the least square regression analysis technique has typically been used to develop trip generation models. For the purpose of the present study, the regression analysis technique has been adopted for the development of trip generation sub-models for home-based trips for various purposes. Attempts have been made to develop simple equations using normally available variables, which can be forecasted with a reasonable degree of accuracy.

A typical regression analysis trip generation model might be:
G = a1x1 + a2x2 + ………… + akxk + a0
Where G = Number of trips per zone for a specified purpose.
a0, a1, a2, ….., ak = Coefficients determined by regression analysis.
x0, x1, x2, ….., xk = Zonal planning input factors (Independent variables).

Various trip generation models for one-way trips were developed with the following independent variables:

- Population
- No. of cars
- No. of two-wheelers
- Total vehicles
- Zone-wise number of households
- No. of high income group workers residing in the zone
- No. of medium income group workers residing in the zone
- No. of low income group workers residing in the zone
- No. of high Income group students residing in the zone
- No. of medium income group students residing in the zone
- No. of low income group students residing in the zone

- Employment
- Student enrolment
- Accessibility.

From all the variables tested, it was found that only a few variables were statistically significant. The selected trip end models developed for various purposes are presented in Table 19 below.

Table 19: Calibrated trip end models

Home-based work productions	**R-square**	**t-stat**
Work productions = 18.94 + 1.5039 * No. of high and medium income group workers residing + 1.486* No. of low income workers residing	0.7	10.14 (HIG & MIG workers) 5.98 (LIG workers)
Home-based work attractions	**R-Square**	**t-stat**
Work Attractions = 1207.4 + 0.8869 * Employment	0.76	15.39
Home-based education productions	**R-square**	**t-stat**
Education productions **= 105.06 + 1.1655 * No. of** high and m**edium** income **group** s**tudents residing + 1.5273* No. of** low in**come** group **students** r**esiding**	0.7	10.14 (HIG & MIG students) 5.98 (LIG students)
Home-based education attractions	**R-square**	**t-stat**
Education attractions = -172.91 + 1.5926 * Student enrolment	0.9	26.42
Home-based other productions	**R-square**	**t-stat**
Other productions = -205.56 + 0.364 * No. of workers residing	0.52	8.31
Home-based other attractions	**R-square**	**t-stat**
Other attractions = 244.64 + 0.1505 * Employment	0.5	8.21

It was observed from all the models tested that the variables “No. of high and medium income group workers residing”, and “No. of low income group workers residing” are highly significant in estimating one-way work trips produced from a zone. Similarly, the variables “No. of high and medium income group students residing”, and “No. of low income group students residing” are highly significant in estimating one-way education trips produced from a zone.

A comparison of the modelled production-attraction with the observed production-attraction is shown in Figures 30 through 35. It is observed from the figures that the observed and modelled values are close when the R-square value is greater than or equal to 0.7. The other trips include trips produced and attracted for different purposes like social, health, recreational, shopping, etc. It is difficult to model this complexity in travel behaviour. This is reflected in the case of home-based other productions and attractions where the R-square values are less than and close to 0.5 only.

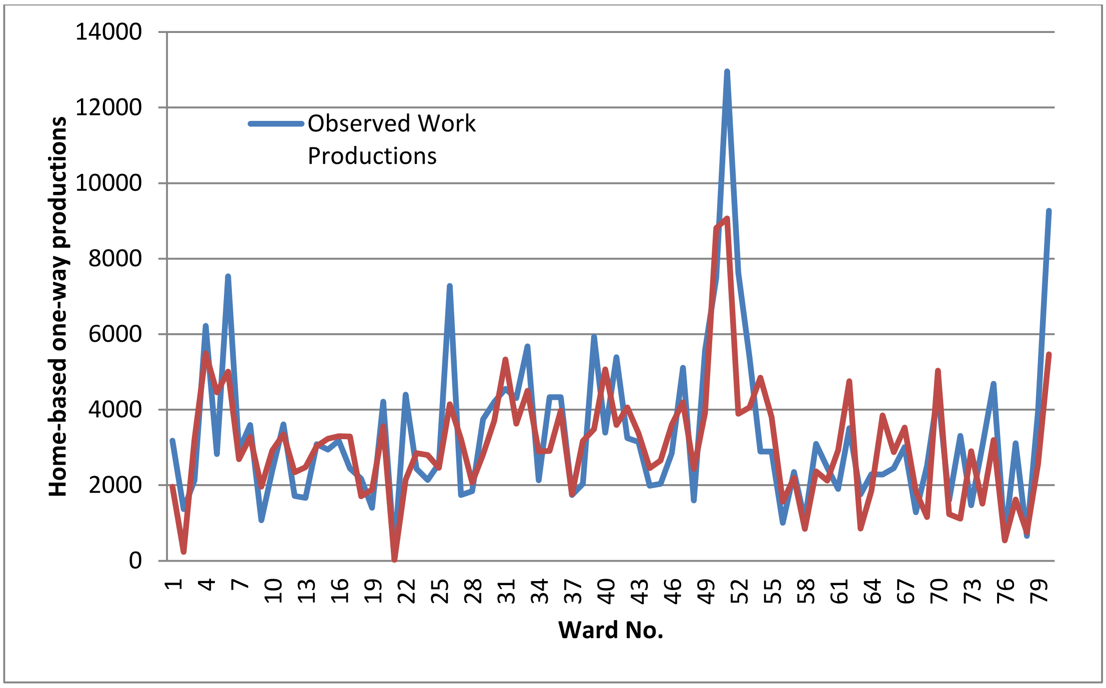

Figure 30: Comparison of observed and estimated home-based one-way work productions

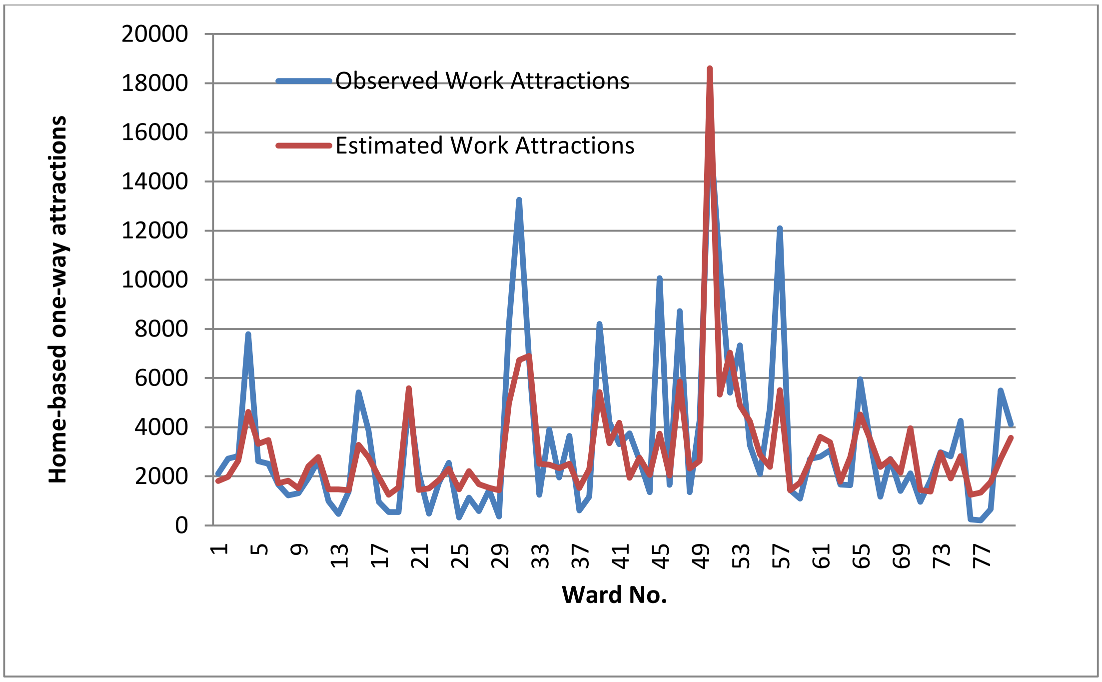

Figure 31: Comparison of observed and estimated home-based one-way work attractions

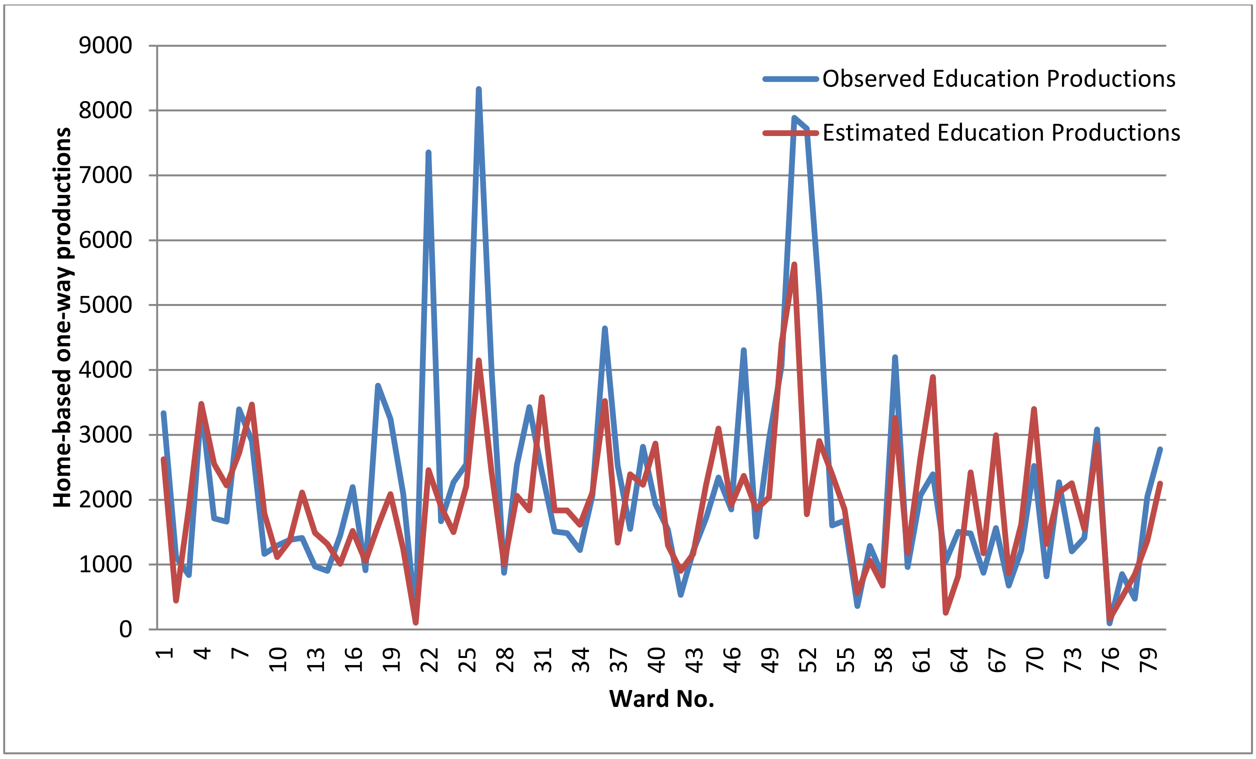

Figure 32: Comparison of observed and estimated home-based one-way education productions

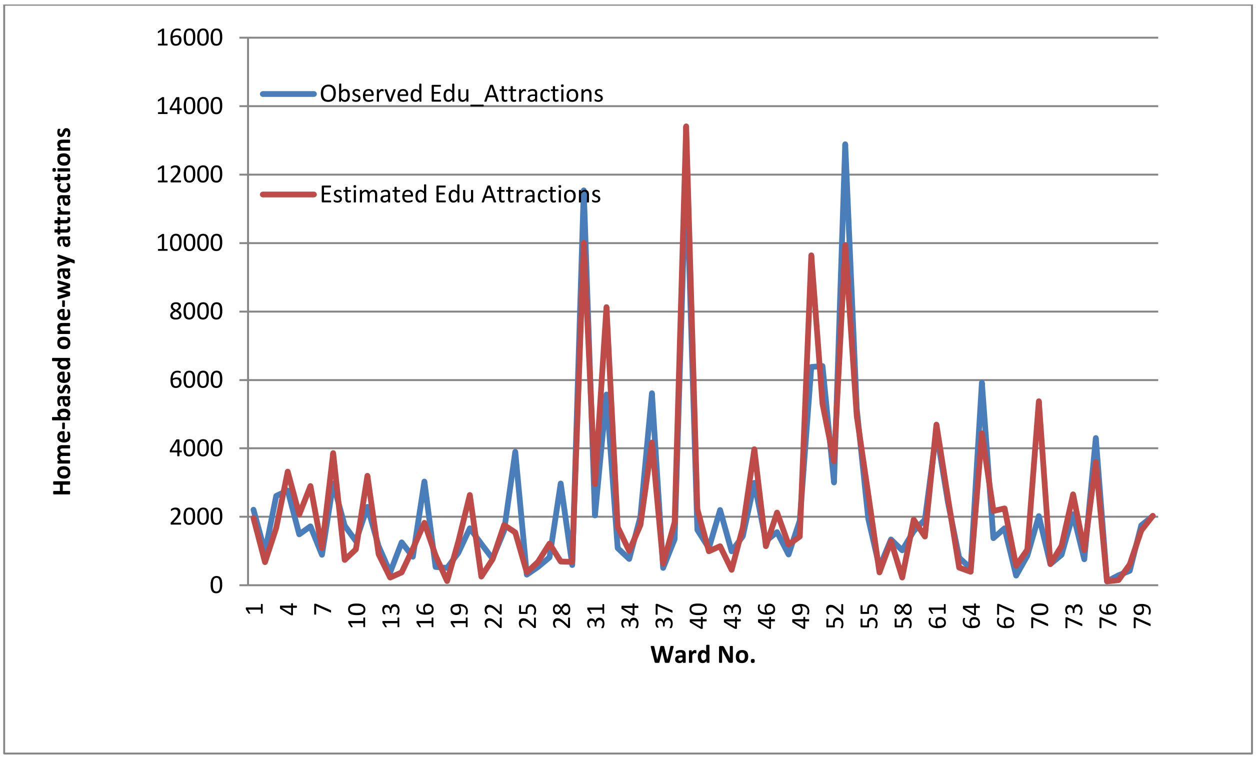

Figure 33: Comparison of observed and estimated home-based one-way education attractions

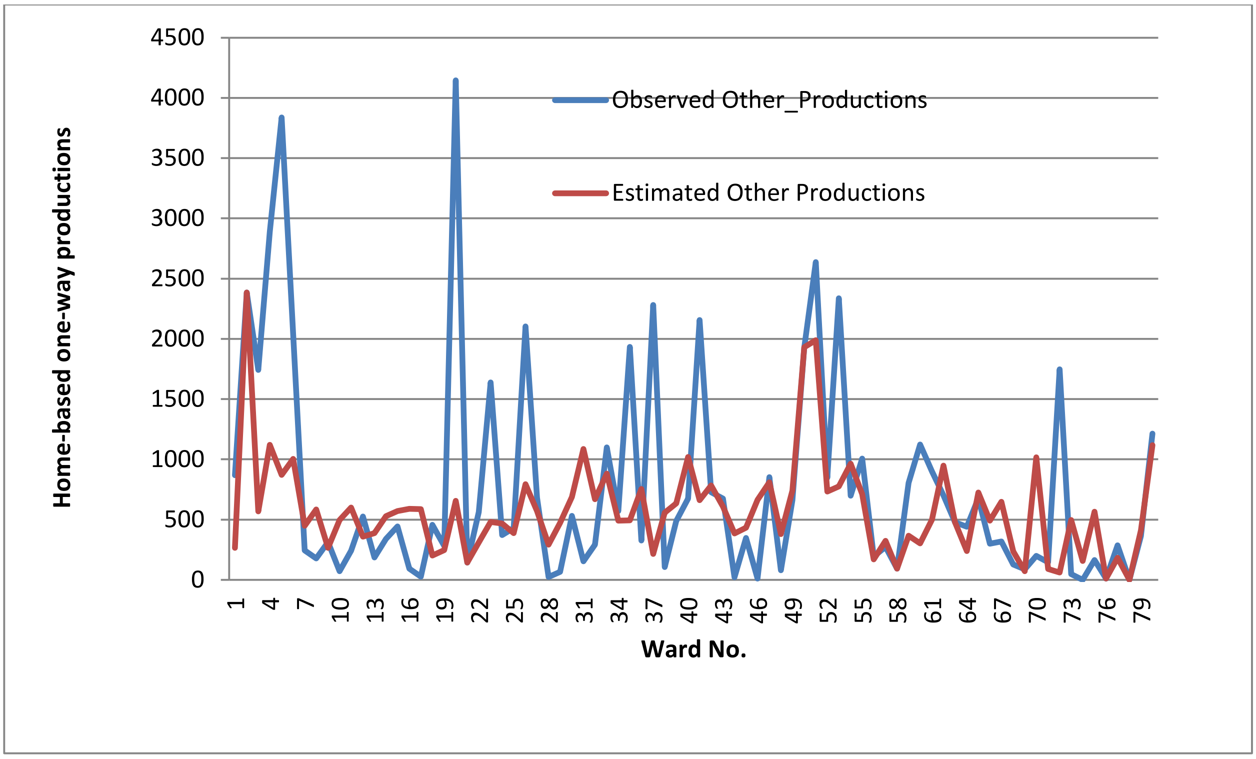

Figure 34: Comparison of observed and estimated home-based one-way other productions

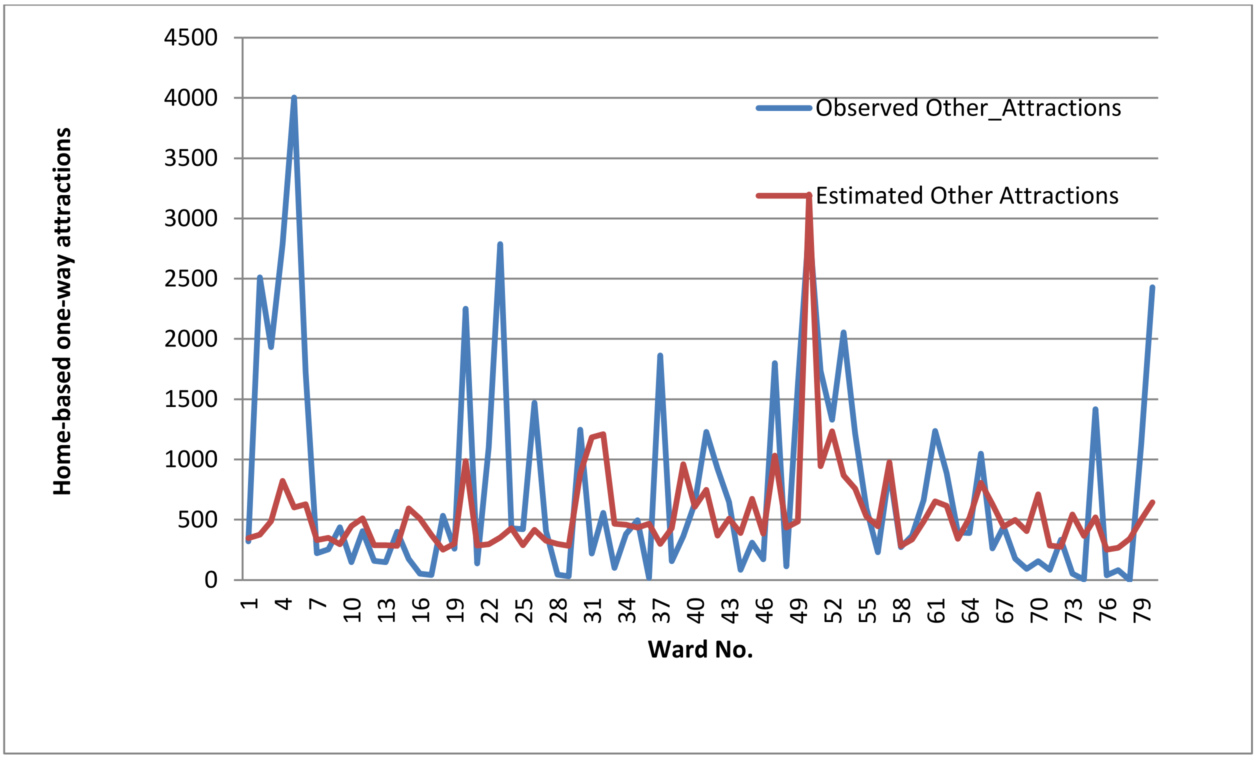

Figure 35: Comparison of observed and estimated home-based one-way other attractions

Trip distribution calibration and validation

The gravity model was used to estimate the trip distribution parameters. To arrive at this, different distribution functions like gamma, inverse and exponential functions were tested to fit the survey data. It was found that the gamma function gave the best fit when compared against the observed data. The gamma function formulation is as below:

$$\mathbf{f(d_{ij}) = a * {d_{ij}}^{b} * e^{c(d_{ij})}}$$

Where,

d_{ij} = distance in shortest path from zone i to j.

a, b, c = calibrated parameters

The calibrated gravity model parameters for each purpose are shown in the table below.

Table 20: Calibrated gravity model parameters

Parameters/purpose	HBW	HBE	HBO	Total trips
a	0	0.318	0	0.284
b	-0.342	0	-0.266	0
c	-0.272	-0.387	-0.464	-0.464

The base year (2013) productions and attractions obtained from the corrected OD matrices, skim matrices from network and the calibrated gamma function parameters were used to generate purpose-wise synthetic matrices in VISUM.

The trip length distributions from observed/corrected and synthetic OD matrices were calculated and the mode-wise comparison graphs are shown in Figures 36 through 39. The average trip lengths obtained from the model are presented in the table below.

Table 21: Modelled average trip lengths

Purpose	Modelled average trip length (km)
Home-based work trips	4.75
Home-based education trips	4.23
Home-based other trips	3.95
Total trips	4.49

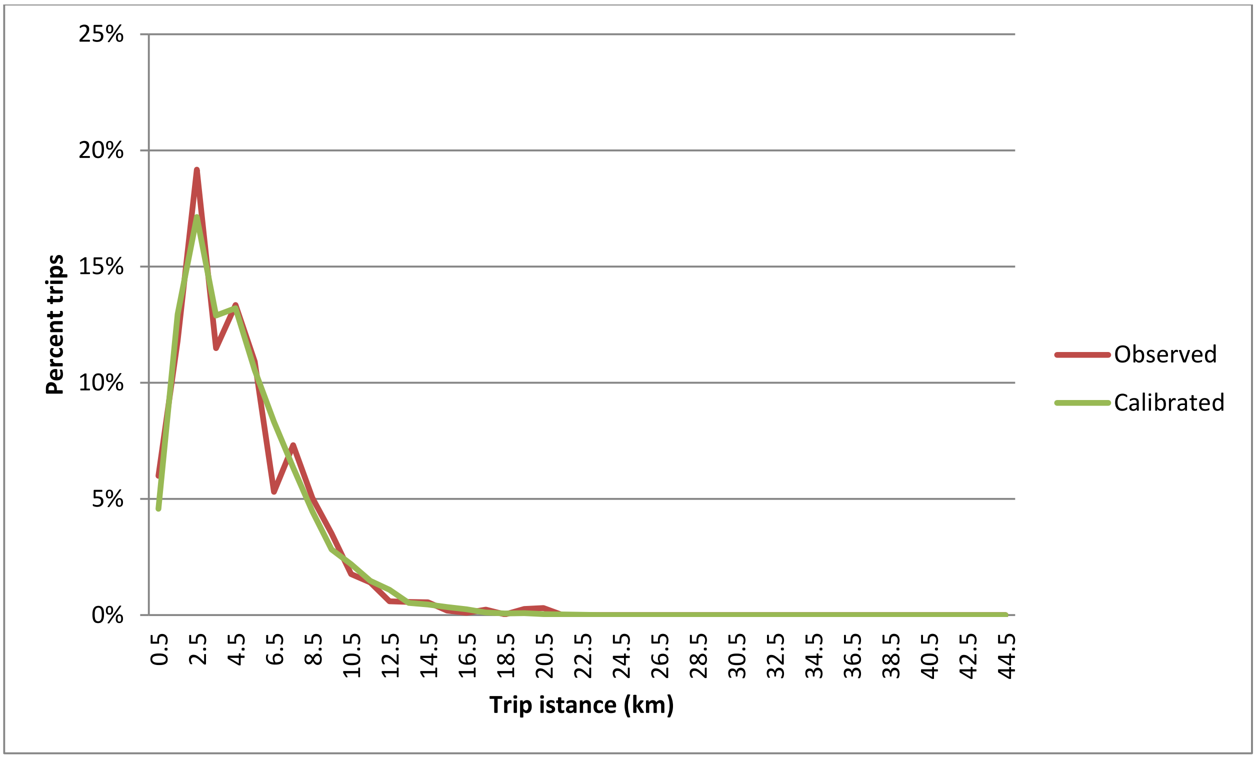

Figure 36: Observed and calibrated trip length distribution for home-based work purpose

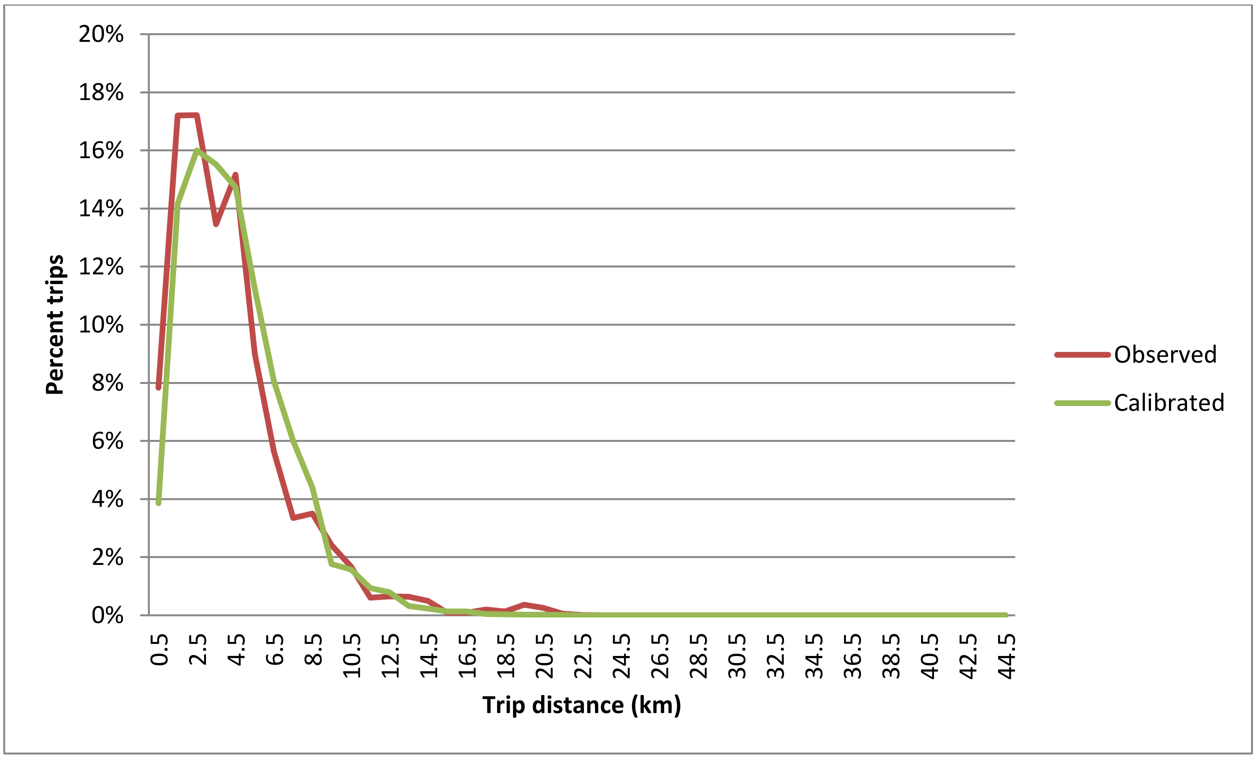

Figure 37: Observed and calibrated trip length distribution for home-based education purpose

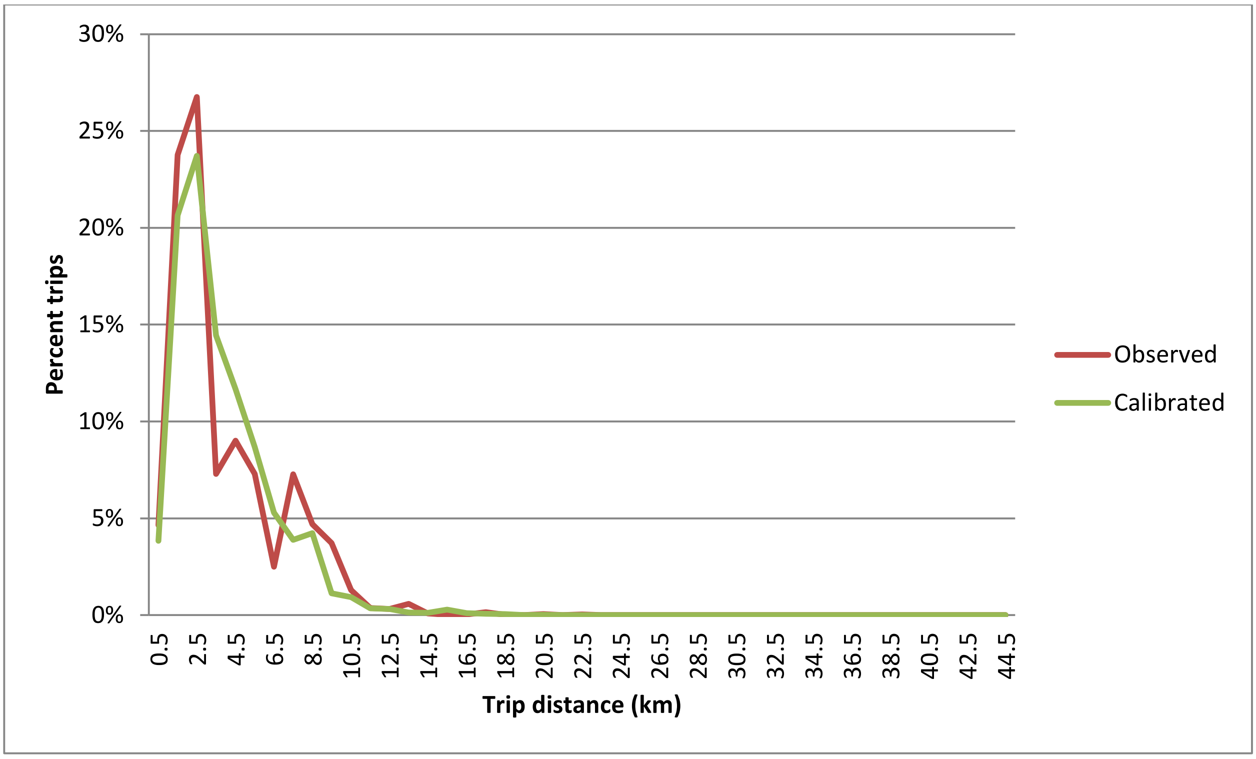

Figure 38: Observed and calibrated trip length distribution for home-based other purpose

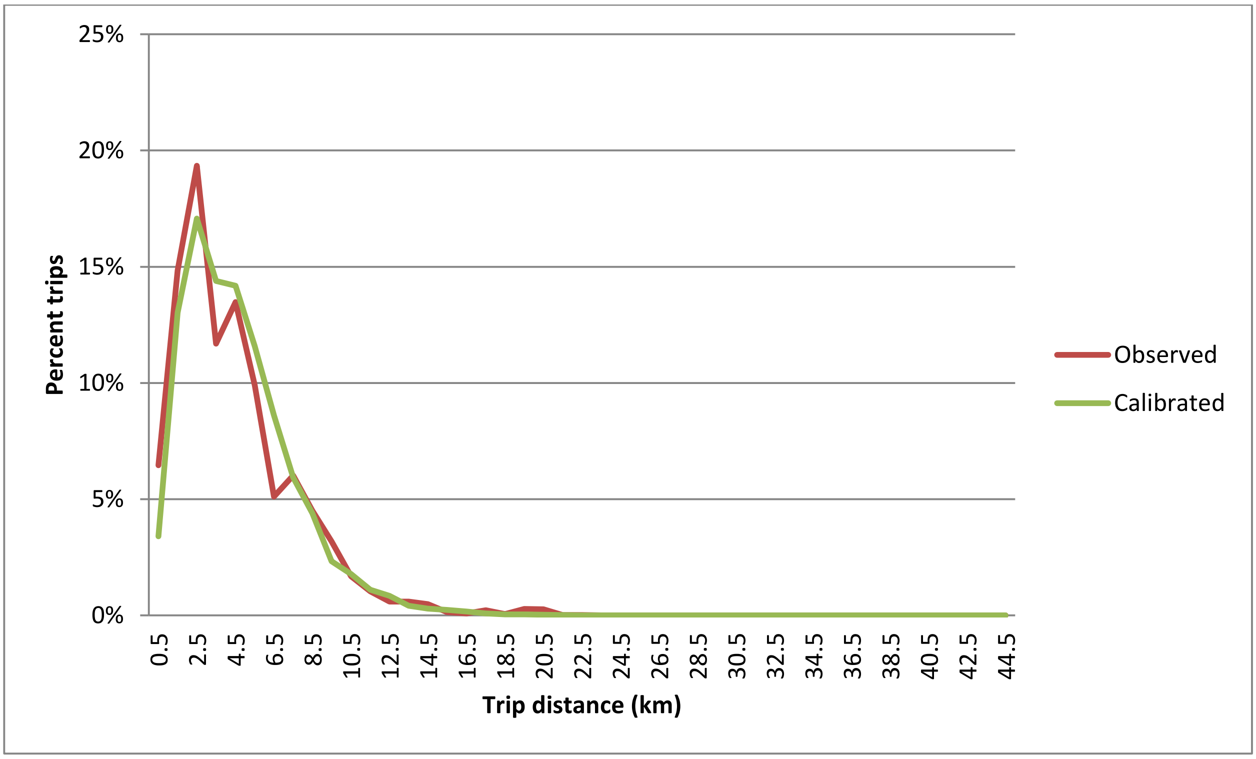

Figure 39: Observed and calibrated trip length distribution for all-purpose trips

Mode choice analysis

The modal split for person trips (all purposes) as observed in the base year (2013) was 50 per cent by non-motorized modes, and 50 per cent by motorized modes. The observed mode split is shown in the tables below. There is no organized public transport system in Udaipur; however, share autos (IPT) operate as an informal public transport system without standard frequencies. The relatively high share of private modes (52 per cent in the case of inter-zonal trips) is not a desirable mode share from an emissions point of view. The absence of organized public transport coupled with consumers' growing purchasing power, is leading to an increase in the number of two-wheeler and car users.

Table 22: Base year mode shares (all modes)

Mode	Mode shares		
	Total trips	Intra-zonal trips	Inter-zonal trips
Walk	48%	80%	25%
Cycle	2%	2%	3%
Two-wheeler	34%	14%	48%
Car	3%	1%	4%
IPT	11%	3%	18%
Other buses	2%	0%	3%

Table 23: Base ear mode shares (motorized modes)

Mode	Mode shares		
	Total trips	Intra-zonal trips	Inter-zonal trips
Two-wheeler	68%	77%	67%
Car	5%	6%	5%
IPT	23%	15%	24%
Other buses	4%	2%	4%

From the above tables, it is observed that 25 per cent of the trips are performed using the walk mode for inter-zonal trips. This share goes to 80 per cent for intra-zonal trips. Hence, NMT infrastructure facilities are required for Udaipur to improve the mode shares of walking and cycling significantly.

a. Utility theory

Virtually all mode choice models for predicting individuals' choices are based on a behavioural principle called 'utility maximization'. This principle and its relation to choice can be stated in words very simply. According to the utility maximization principle, there is a mathematical function U, called a utility function, whose numerical value depends on the attributes of the available options and the individual. The utility function's value for one option exceeds its value for another if and only if the individual prefers the first option to the second. Thus, the

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ranking of the available options according to the individual's preferences and the ranking according to the values of the utility function are the same. The individual chooses the most preferred option, which is the one with the highest utility-function value.

The utility maximization principle can be stated mathematically as follows:

- Let C denote the set of options available to an individual (e.g., car, auto and bus in the case of mode choice). C is called the choice set.
- For each option i in C, let Xi denote the attributes of i for the individual in question. For example, if i corresponds to the car mode, Xi denotes the travel time, travel cost, and other relevant attributes of car mode for the individual in question.
- Let S denote the attributes of the individual that are relevant to preferences among the options in C (e.g. income, etc.).

Then, according to the utility maximization principle, there is a function U (the utility function) of the attributes of options and individuals that describes individuals' preferences. U has the property that for any two options i and j in C

$$\mathbf{U(X_i, S) > U(X_j, S)}$$

Utility is an indicator that an individual decision maker will give to an alternative mode. Utility for an alternative mode is generally derived from the attributes of the alternative mode. It is assumed that the decision maker will choose an alternative whose utility value is greater than the utilities of other alternatives.

The utility of an alternative is a function of its attributes. Suppose in a set of alternatives ‘C’, an individual will only choose the alternative ‘i’, if and only if Ui is greater than the utilities of all other alternatives ‘j’.

$$\mathbf{U (Xi) > U (Xj), \text{ for all } j \in C}$$

Where C is as set of ‘j’ alternatives and Xi , Xj are vectors of attributes describing alternatives i and j respectively.

The utility equation consists of two components:

- The deterministic portion, which is an observable utility portion that can be estimated
- The error portion, which is unknown.

This error portion is the sum of the errors from many sources like imperfect information, measurement errors, omission of modal attributes, and errors in the utility function. The final utility equation is represented as follows:

$$\mathbf{U (Xi) = V (Xi) + E (Xi)}$$

Where U (Xi) = Total utility of the alternative

V (Xi) = Deterministic or observable portion of the utility estimated

E (Xi) = Error portion of the utility function unknown to estimate

Based on the utility theory, the decision maker chooses an alternative mode what suits him or her the best, i.e. where U of the mode selected is greater than other modes.

The following example illustrates the use of the utility maximization principle in mode choice analysis.

Example:

Suppose that an individual can travel to work by car, auto and bus. Assume that the relevant attributes of these modes are travel time and travel cost. Assume that the relevant attribute of the individual is annual income. Let:

- T denote point-to-point travel time in hours
- C denote travel cost in Rupees
- Y denote annual income in thousands of Rupees per year. Let the utility function be U (T, C, Y) = -T - 5C/Y

Suppose the values of travel time and cost for the available modes are:

Mode	Time (T in hours)	Cost (C in Rupees)
Car	0.50	2.00
Bus	0.75	1.00
Auto	1.00	0.75

Then if income is Rs 40,000 per year, for example;

U for car is = -0.50 - 5(2.00)/40 = -0.75

The following table shows the value of U corresponding to each mode for an individual 'A' whose income is Rs 40,000 per year (Y = 40) and an individual 'B' whose income is Rs 10,000 per year (Y = 10):

Mode	Utility of "A"	Utility of "B"
	Y =40	Y =10
Car	-0.75	-1.50
Auto	-0.88	-1.25
Bus	-1.09	-1.38

The high-income individual chooses the car mode (because a car has the highest utility for this individual), and the low-income individual chooses auto. Note that all utilities are negative because U consists of (generalized) costs of travel but excludes the value of reaching the destination. In this case, the highest value of U is the one that is least negative.
Now suppose that the quality of transit service is improved so that the travel time for the bus mode is 0.75 hr. Then the utilities become:

Mode	Utility of "A"	Utility of "B"
	Y =40	Y =10
Car	-0.75	-1.50
Auto	-0.88	-1.25
Bus	-1.09	-1.13

The high-income individual still drives a car, but the low-income individual switches to the bus mode.

Although this example is very simple, it illustrates some important characteristics of choice models based on the utility maximization principle.

- First, it shows how a utility function can be used to describe the dependence of preferences and choices on attributes of individuals and options. Notice, in particular, that the same utility function describes the preferences of more than one individual. It is not necessary to have a separate utility function for each individual if differences among individuals can be accounted for by attribute variables such as income.
- Second, the example illustrates the use of utility theory to predict changes in preferences and choices that occur when an attribute of one of the options changes. Moreover, the utility model is able to capture differences in the responses of different individuals to the same attribute change.
- Finally, the example illustrates some advantages of utility models over many traditional mode choice models. For instance, the model in the example treats choice among three modes and can easily be extended to treat more than three modes. Many traditional models are able to treat only two modes. In addition, since the utility model operates at the level of individuals, it guarantees that the percentages of individuals choosing a mode always are within the range of zero to 100 per cent, and always add up to 100 Per cent. Many traditional mode choice models do not have this obviously desirable property.

b. MNL model for Udaipur

The revealed preference (RP) data captures observed or reported actual behaviour. On the basis of the household surveys, 3,561 choice set data points of inter-zonal trips were collected. Four separate models were run for respondents who indicated that they had no access to any individual vehicle, those who indicated that they had access to cycles, access to two-wheelers, and access to cars. The results of a calibrated multinomial logit model (MNL) are shown in the table below.

Table 24: MNL results from Udaipur household surveys (2013)

MNL results for households with no access to individual vehicles		
Parameter	**Estimate**	**t-stat**
Log (generalized cost)	-2.875635	-8.22

Constant (walk)	-3.167187	8.80
MNL results for households with access to cycles		
Log (generalized cost)	-0.157742	-0.65
Constant (cycle)	-0.117913	-0.27
Constant (walk)	0.185411	0.67
MNL results for households with access to two-wheelers		
Log (generalized cost)	-0.000170	-0.009716
Constant (walk)	0.259138	3.66
Constant (cycle)	-1.918456	-13.22
Constant (two-wheeler)	1.269361	21.45
Constant (other buses)	-1.558235	-13.11
MNL results for households with access to cars		
Log (generalized cost)	-0.049174	-0.82
Constant (walk)	0.520880	2.55
Constant (cycle)	-2.045763	-4.51
Constant (two-wheeler)	1.798944	10.47
Constant (car)	1.115314	6.17
Constant (other buses)	-0.648829	-2.46

The generalized cost for each mode is calculated as follows:

Generalized cost = (Value of time * Travel time) + Travel cost

The following are the assumptions regarding travel cost calculations for each mode.

Table 25: Assumptions for travel cost calculation

Mode	Cost	Remarks
Two-wheeler	Rs. 1.875 per km	Cost of petrol = RS. 75/litre, and mileage = 40km/litre
Car	Rs. 6.25 per km	Cost of petrol = RS. 75/litre, and mileage = 12km/litre
IPT	As per prevailing fare	
Other buses	Rs. 20 per trip flat fare	Based on average school/college fee for buses

Based on the calibrated MNL models, the aggregate modal shares are estimated and the following table gives the comparison of aggregate observed and modelled modals shares.

Table 26: Comparison of aggregate inter-zonal modal shares

Mode	Observed mode shares	Modelled mode shares
Walk	25%	25%
Cycle	3%	2%
2W	47%	49%
IPT	18%	16%
Car	4%	5%
Bus	3%	3%

Traffic Assignment and Analysis

Traffic assignment is the process of allocating a given set of trip interchanges to a specific transportation system, and is generally used to estimate the volume of travel on various links of the system to simulate present conditions.

The process requires as input a complete description of the existing transportation system, and a matrix of inter-zonal trip movements. The output of the process is an estimate of the trips on each link of the transportation system.

The purposes of trip assignment are broadly explained as follows:

- To evaluate the effects of limited improvements and extensions to the existing transportation system by assigning estimated future trips to the network
- To test alternative transportation system proposals by systematic and readily acceptable procedures
- To provide design hour volumes and turning movements.

The corrected peak hour mode-wise demand matrices were assigned on to the supply road network. The volumes to capacity (V/C) ratios for a few selected corridors are shown in the table below. The V/C ratios close to 0.9 indicate that the operating conditions are close to capacity, which is not desirable. V/C ratios between 0.71 and 0.8 indicate that there is less freedom to manoeuvre, and a high density of traffic volume.

Table 27: Average V/C ratios on a few selected corridors for the base year

Sl. No,	Road name	V/C ratio
1	RNT Medical College Road	0.78
2	Road Opposite Udaipur Bus Terminal	0.67
3	Bapu Bazaar Road	0.70
4	Hiran Mangari Police Station Road	0.88
5	ROB near Geetanjali Medical College (NH8)	0.86
6	Bara Baazar Road	0.70
7	Silavat Vari Road	0.76

The saturation (V/C) map of Udaipur is shown in Figure 40, and the traffic volume is shown in Figure 41.

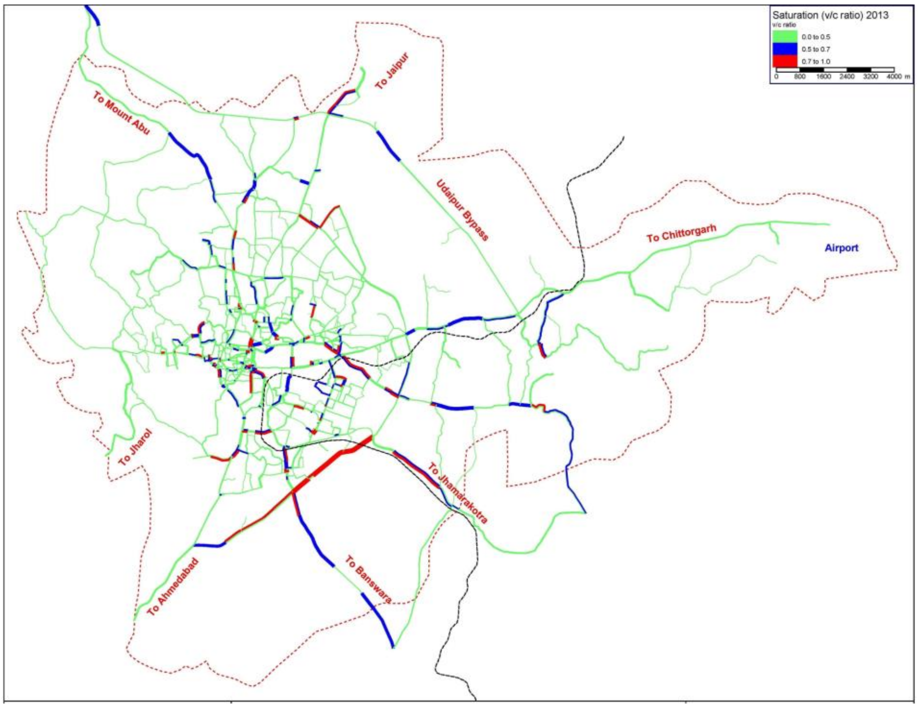

Figure 40: Saturation level (V/C) for Udaipur roads (2013)

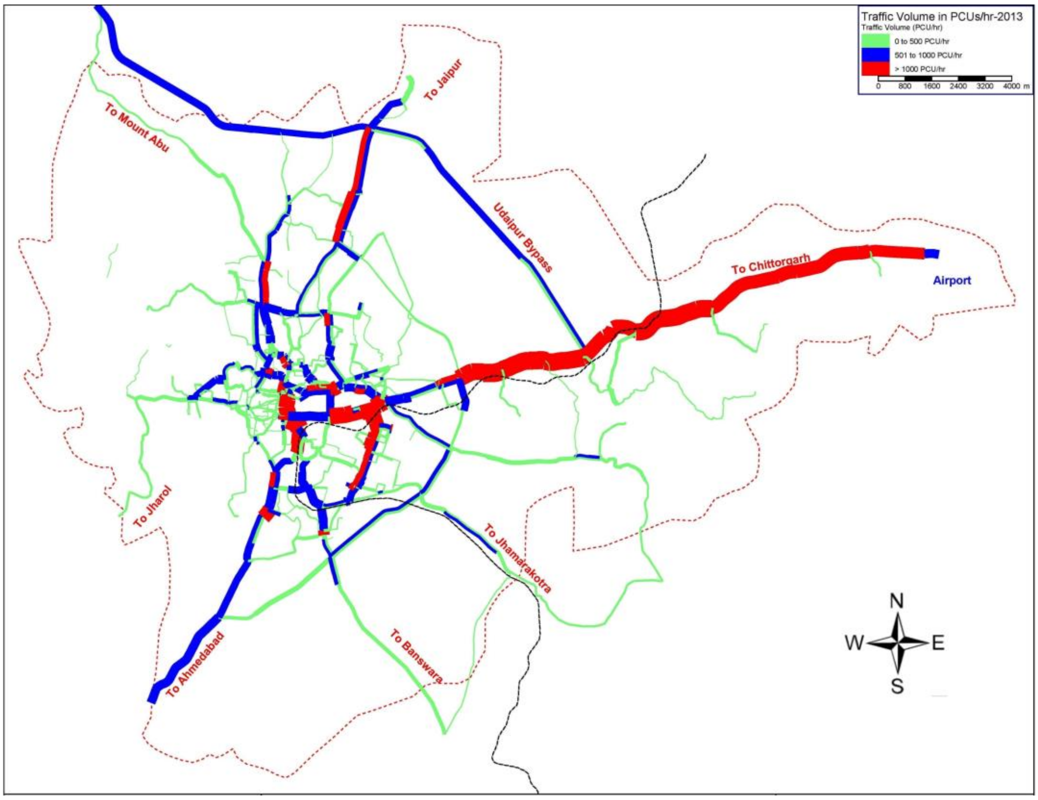

Figure 41: Traffic flow map of Udaipur (2013)

From the traffic flow map above, major traffic flow is observed on NH-76 from Pratap Nagar to Udaipur Airport. The Bapu Bazaar Road, University Road, and Durga Nursery Road are experiencing heavy traffic during peak hours. The Linematic Road (NH-8) from Sukher to Bhrahmanon ka Gurha also observed high traffic volumes.

NMT trips

The non-motorized modes in Udaipur are walk and cycle. The presence of cycle rickshaw is insignificant. Figure 3-17 shows the TAZ map with Daily (one-way) NMT productions for the base year (2013). It is observed that ward numbers 4, 5, 6, 26, 50 and 51 are producing more than 4,000 NMT trips per day. However, ward numbers 2, 21, 28, 58, 76, 77 and 78 are producing few NMT trips (< 500 trips per day).

Similarly, the figure below shows the TAZ map with daily (one-way) NMT attractions for the base year (2013). It is observed that ward numbers 4, 5, 6, 26, 50 and 51 are attracting more than 4,000 NMT trips per day. However, ward numbers 2, 21, 28, 58, 76, 77 and 78 are attracting few NMT trips (< 500 trips per day).

Another key aspect of model development is to understand the key movement corridors and depict this relationship correctly. This shows the major zones which are producing and attracting trips. This will also show how far people are prepared to travel to access certain zones. This is depicted in the form of ‘desire lines’, where the thickness of lines represents the intensity of trips between different zones.

Figure 42 below shows the desire line diagram of inter-zonal NMT trips. From the modal share analysis, it is evident that 11 per cent of the total daily trips are NMT trips. It is observed that most of the NMT trip interchanges are performed from ward number 50 where many educational institutes are located. The zones along Pichola and Fateh Sagar lakes produce and attract many NMT trips. NMT infrastructure along these lakes is desirable to improve the NMT trips share significantly.

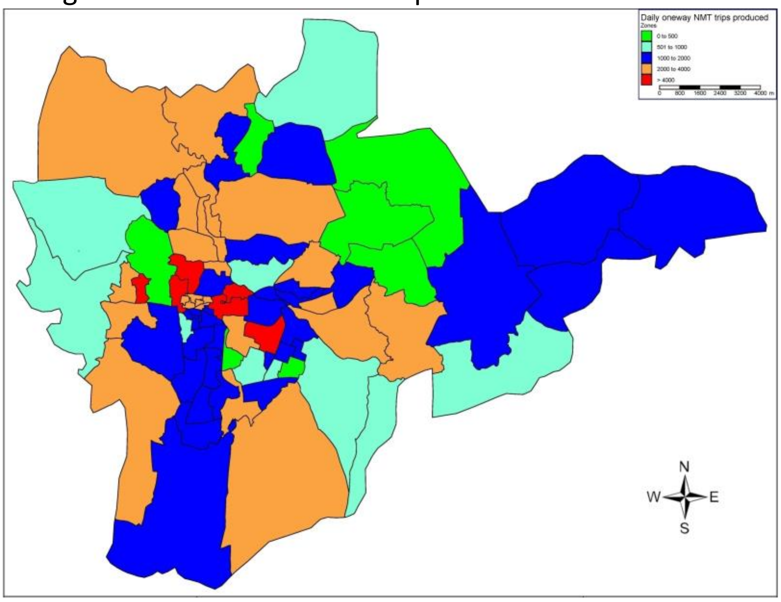

Figure 42: TAZ map showing NMT trips produced

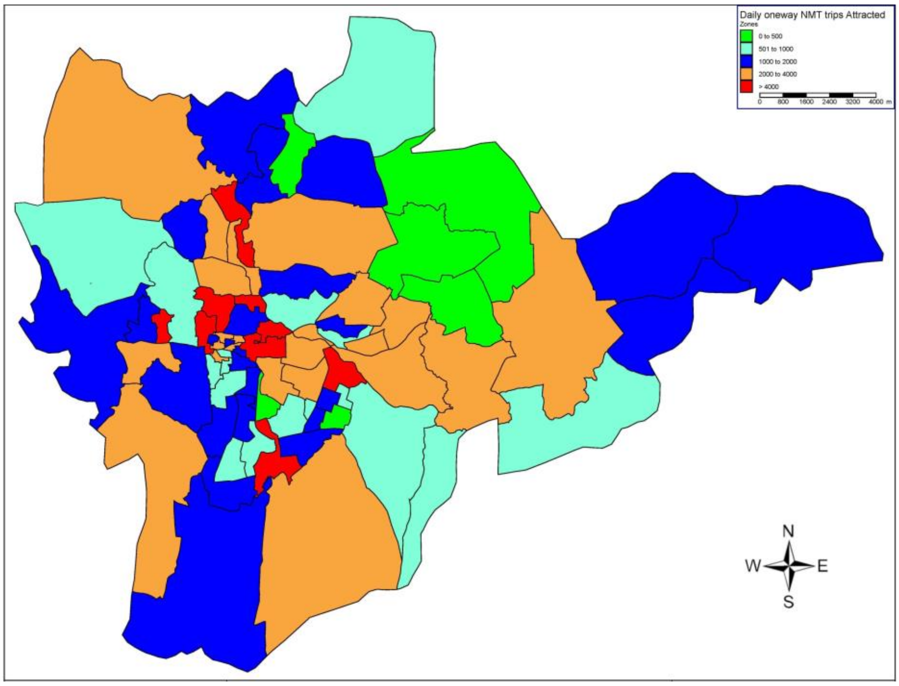

Figure 43: TAZ map showing NMT trips attracted

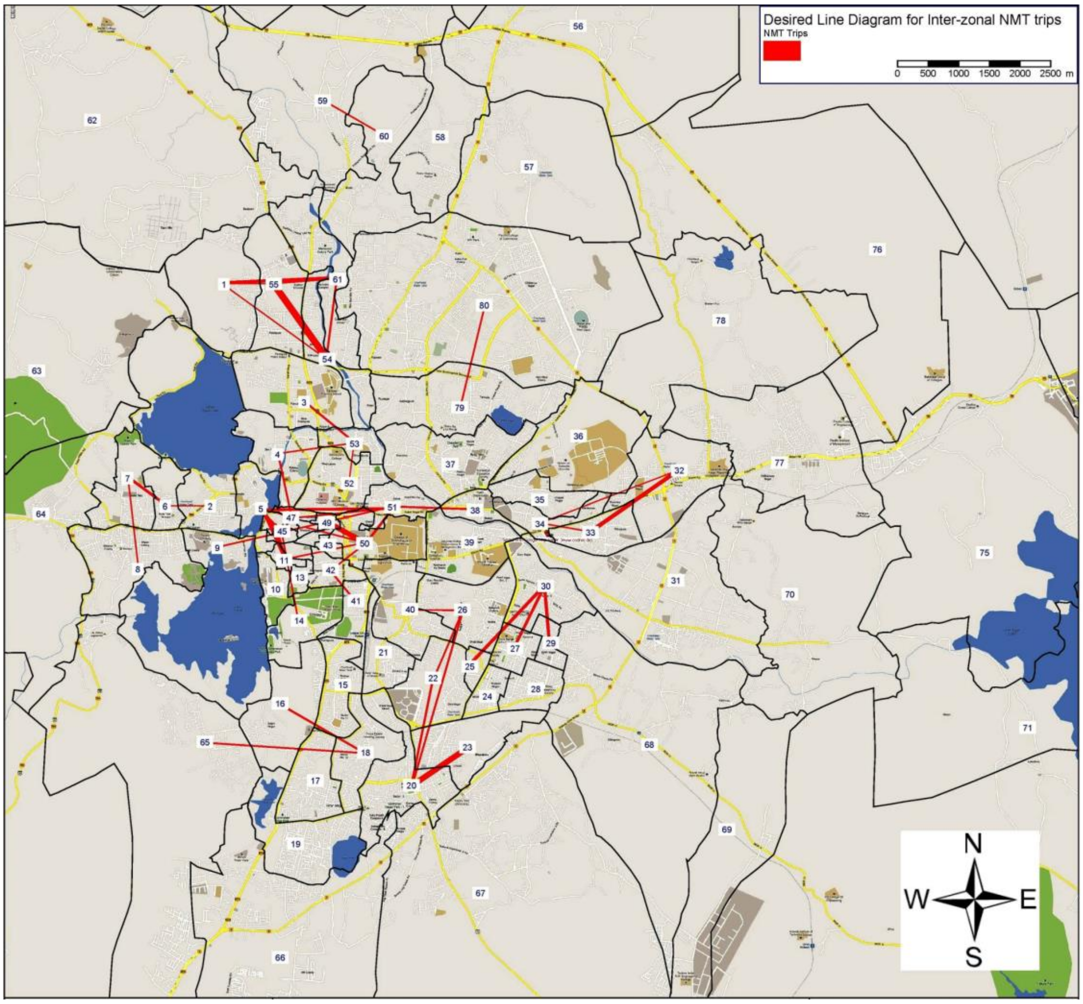

Figure 44: Desire line diagram for inter-zonal NMT trips

Planning Forecast

Demographic Forecast

The revised Master Plan has projected the future population as follows:

Table 28: Forecasted population (Master Plan Udaipur)

Year	Population
2021	759,000
2031	1,002,000
2041	1,580,354

The revised Master Plan has suggested an overall average city density of 285 persons per hectare by the year 2013, and divided the whole city into four different zones based on maximum allowable density.

Referring to Figures 45 and 46, these zones are as:

1. Lower density area with density of 87 persons per hectare consisting of peripheral areas located about 12km away from the city centre
2. Low density area with density of 198 persons per hectare consisting of peripheral areas located about 9km away from the city centre.
3. Medium density area with density of 296 persons per hectare consisting of areas which lie between 3 and 6km from the city centre
4. High density old city area with density of 494 persons per hectare.

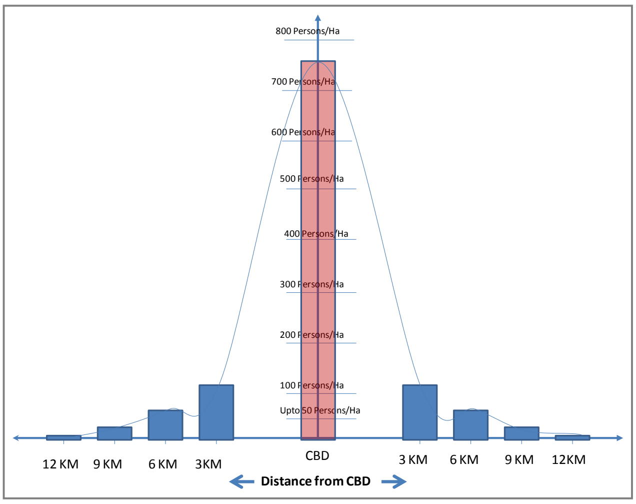

Figure 45: Distance from city center and densitv

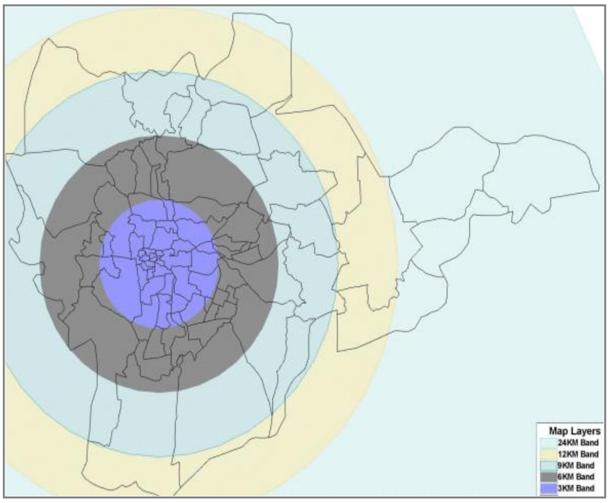

Figure 46: Areas with distance from city center and density

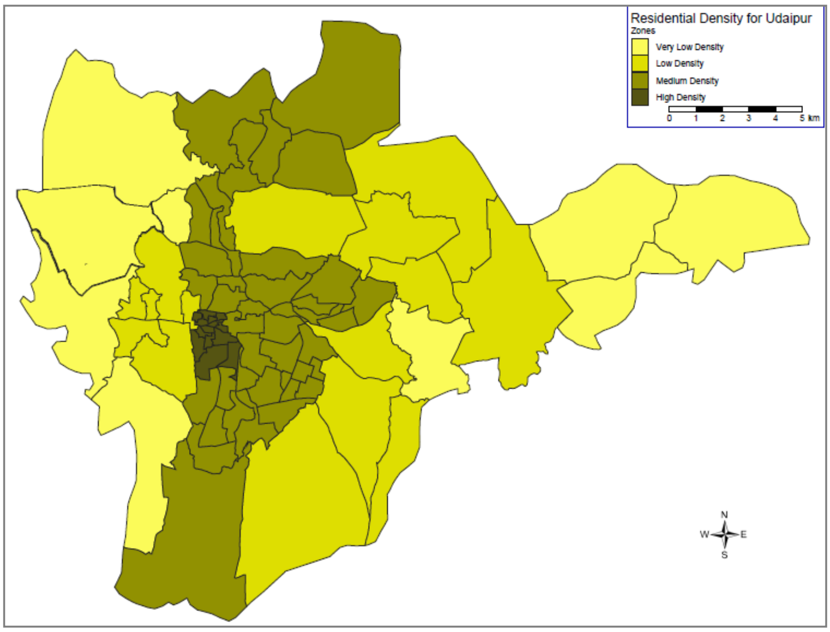

Figure 47: Zone-wise density

Economic Forecast

In economic forecasting, the future employment, work force participation and share of different sectors of the economy of Udaipur, as forecasted by the revised Master Plan, are used in the transport model.

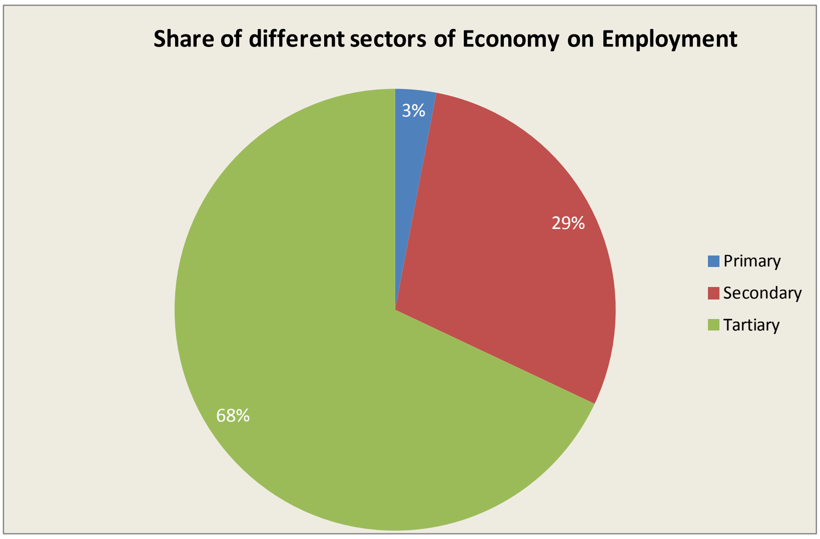

Figure 48: Share of different sectors of the economy on employment

As per the revised Master Plan for Udaipur, the total employment in 2014 was estimated at 517,238, with a work force participation rate of 32.7 per cent. Referring to Figure 48, the tertiary sector will generate the maximum employment opportunity, followed by the secondary sector.

Land use in the horizon year

Udaipur City has been developing on the eastern (Airport side) and southern side (Ahmedabad Road side). The less pronounced growth in other directions could be due to natural terrain constraints. The past growth pattern of Udaipur is shown in Figure 49.

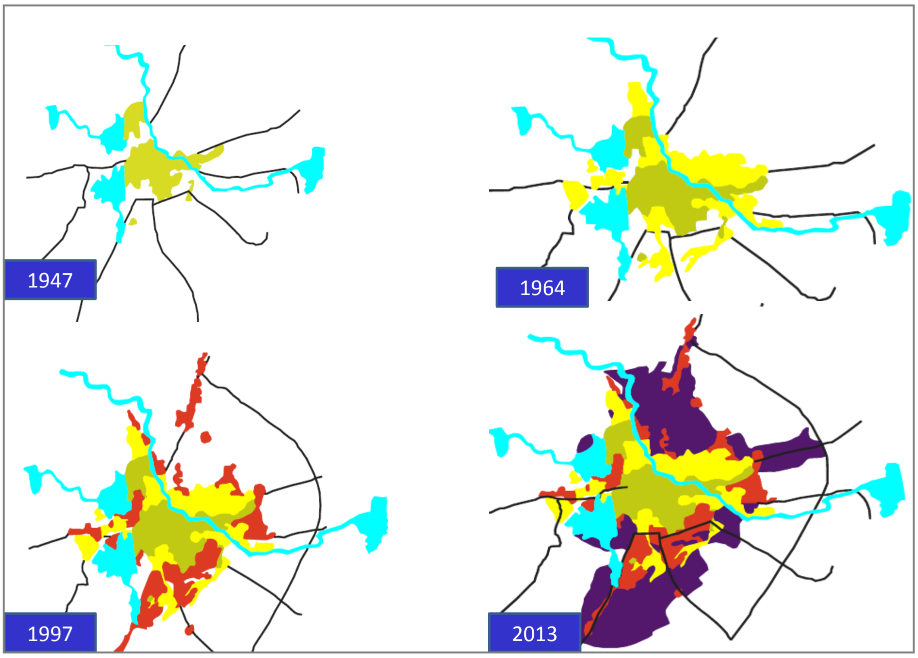

Figure 49: Growth pattern of Udaipur city

The revised Master Plan-2031 has suggested 60 per cent of land will be under residential use, 11 per cent will be under traffic and transportation, 11 per cent under parks and open space, 7 per cent under public and semi-public, and 3 per cent under commercial use. The share of each land use category is graphically shown in the Figure 50.

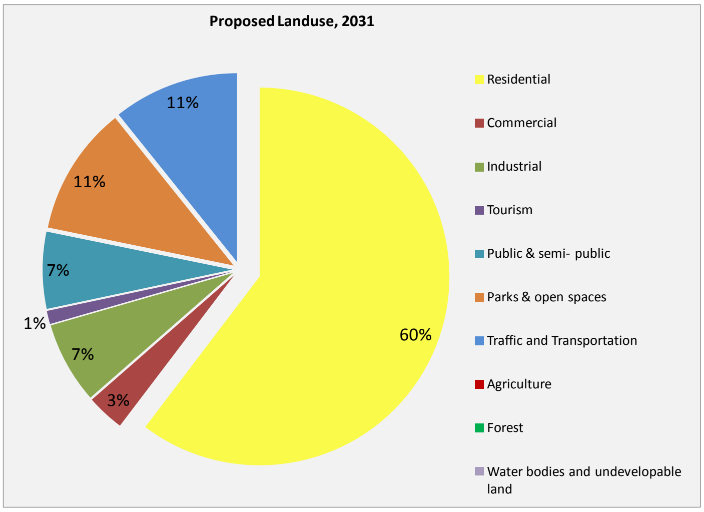

Figure 50: Proposed land use pattern

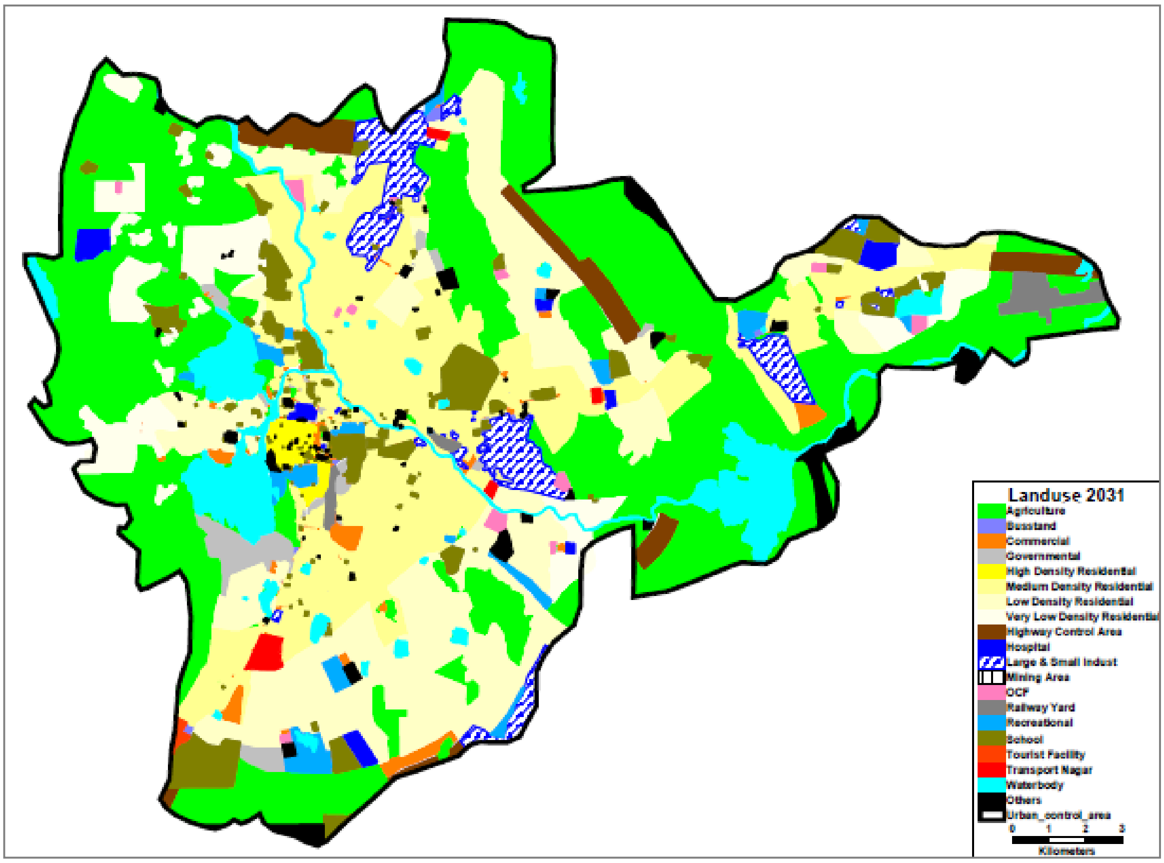

Figure 51: Proposed land use plan

The number of trips produced and attracted from each zone depends on the corresponding zone population, employment, etc. Based on the revised Master Plan, these trip generation variables (population, employment, etc.) were estimated. During the assignment stage of travel demand modelling, these trip productions and attractions were transformed to hourly traffic in terms of PCU/hr on each link, from which the impact of each strategy was tested. The detailed zone-wise trips generated are mentioned in the table below.

Table 29: TAZ-wise forecasted population for Udaipur

TAZ number	Zone type	POP 2021	POP 2031	POP 2041
1	Municipal Ward	11,232	15,476	19,728
2	Municipal Ward	11,961	16,375	28,529
3	Municipal Ward	9,325	13,061	23,302
4	Municipal Ward	11,073	15,259	26,769
5	Municipal Ward	11,965	14,354	14,354
6	Municipal Ward	10,011	10,487	10,487
7	Municipal Ward	11,622	15,949	22,562
8	Municipal Ward	10,502	14,541	25,637
9	Municipal Ward	10,326	14,319	25,287
10	Municipal Ward	11,585	15,902	21,341
11	Municipal Ward	9,131	9,131	9,131

TAZ number	Zone type	POP 2021	POP 2031	POP 2041
12	Municipal Ward	9,212	9,212	9,212
13	Municipal Ward	8,431	8,431	8,431
14	Municipal Ward	11,489	15,823	27,659
15	Municipal Ward	10,468	14,499	25,570
16	Municipal Ward	10,873	15,008	26,373
17	Municipal Ward	11,872	16,263	28,353
18	Municipal Ward	10,355	14,356	25,344
19	Municipal Ward	9,417	13,177	23,486
20	Municipal Ward	12,121	16,576	28,846
21	Municipal Ward	9,643	13,462	19,172
22	Municipal Ward	9,605	13,413	23,857
23	Municipal Ward	10,510	14,550	25,652
24	Municipal Ward	8,828	10,822	11,538
25	Municipal Ward	7,411	7,411	7,411
26	Municipal Ward	11,807	16,181	28,224
27	Municipal Ward	9,848	12,104	13,385
28	Municipal Ward	9,791	13,647	19,110
29	Municipal Ward	8,368	8,844	8,844
30	Municipal Ward	10,715	14,808	26,058
31	Municipal Ward	11,531	15,834	27,676
32	Municipal Ward	10,180	14,136	24,997
33	Municipal Ward	11,483	15,774	22,526
34	Municipal Ward	9,671	13,496	16,185
35	Municipal Ward	9,640	13,457	18,870
36	Municipal Ward	11,425	15,701	27,466
37	Municipal Ward	11,165	15,374	26,950
38	Municipal Ward	9,903	12,293	12,293
39	Municipal Ward	9,267	12,989	23,188
40	Municipal Ward	11,781	16,148	28,172
41	Municipal Ward	11,596	15,916	22,749
42	Municipal Ward	11,366	15,627	18,728
43	Municipal Ward	7,451	7,451	7,451
44	Municipal Ward	7,103	7,103	7,103
45	Municipal Ward	8,279	8,279	8,279
46	Municipal Ward	9,758	9,758	9,758
47	Municipal Ward	9,394	9,394	9,394
48	Municipal Ward	7,557	7,557	7,557
49	Municipal Ward	7,763	7,763	7,763
50	Municipal Ward	11,561	15,872	27,736
51	Municipal Ward	12,935	15,983	16,638
52	Municipal Ward	12,002	16,426	28,610
53	Municipal Ward	12,181	12,938	12,938
54	Municipal Ward	10,840	14,965	26,306
55	Municipal Ward	9,421	13,182	23,493
56	Municipal Ward	4,121	6,521	12,988

TAZ number	Zone type	POP 2021	POP 2031	POP 2041
57	Villages outside Nagar Parishad Area	3,166	5,321	11,095
58	Villages outside Nagar Parishad Area	2,973	5,078	10,711
59	Villages outside Nagar Parishad Area	12,497	17,049	29,592
60	Villages outside Nagar Parishad Area	6,718	9,785	18,135
61	Villages outside Nagar Parishad Area	6,523	9,540	17,749
62	Villages outside Nagar Parishad Area	17,437	23,257	39,383
63	Villages outside Nagar Parishad Area	2,511	4,498	9,796
64	Villages outside Nagar Parishad Area	6,202	9,136	17,112
65	Villages outside Nagar Parishad Area	10,910	15,053	26,445
66	Villages outside Nagar Parishad Area	9,660	13,482	23,966
67	Villages outside Nagar Parishad Area	15,145	20,377	34,841
68	Villages outside Nagar Parishad Area	6,248	9,194	17,204
69	Villages outside Nagar Parishad Area	4,253	6,686	13,248
70	Villages outside Nagar Parishad Area	11,138	15,341	26,898
71	Villages outside Nagar Parishad Area	0	0	0
72	Villages outside Nagar Parishad Area	8,079	11,496	20,834
73	Villages outside Nagar Parishad Area	13,434	18,226	31,448
74	Villages outside Nagar Parishad Area	8,100	10,924	19,932
75	Villages outside Nagar Parishad Area	12,177	16,646	28,957
76	Villages outside Nagar Parishad Area	1,839	3,058	7,526
77	Villages outside Nagar Parishad Area	4,595	7,117	13,927
78	Villages outside Nagar Parishad Area	2,273	4,198	9,323
79	Villages outside Nagar Parishad Area	6,802	9,890	23,357

TAZ number	Zone type	POP 2021	POP 2031	POP 2041
80	Villages outside Nagar Parishad Area	17,449	23,272	39,408
	Total	**759,000**	**1,002,000**	**1,580,354**

Table 30: TAZ-wise forecasted employment for Udaipur

TAZ number	Zone type	Employment (2021)	Employment (2031)	Employment (2041)
1	Municipal Ward	3,482	4,952	6,510
2	Municipal Ward	3,708	5,240	9,414
3	Municipal Ward	2,891	4,179	7,690
4	Municipal Ward	3,433	4,883	8,834
5	Municipal Ward	3,709	4,593	4,737
6	Municipal Ward	3,103	3,356	3,461
7	Municipal Ward	3,603	5,104	7,445
8	Municipal Ward	3,256	4,653	8,460
9	Municipal Ward	3,201	4,582	8,345
10	Municipal Ward	3,591	5,089	7,042
11	Municipal Ward	2,831	2,922	3,013
12	Municipal Ward	2,856	2,948	3,040
13	Municipal Ward	2,614	2,698	2,782
14	Municipal Ward	3,562	5,063	9,127
15	Municipal Ward	3,245	4,640	8,438
16	Municipal Ward	3,371	4,802	8,703
17	Municipal Ward	3,680	5,204	9,356
18	Municipal Ward	3,210	4,594	8,364
19	Municipal Ward	2,919	4,217	7,750
20	Municipal Ward	3,758	5,304	9,519
21	Municipal Ward	2,989	4,308	6,327
22	Municipal Ward	2,977	4,292	7,873
23	Municipal Ward	3,258	4,656	8,465
24	Municipal Ward	2,737	3,463	3,808
25	Municipal Ward	2,297	2,372	2,446
26	Municipal Ward	3,660	5,178	9,314
27	Municipal Ward	3,053	3,873	4,417
28	Municipal Ward	3,035	4,367	6,306
29	Municipal Ward	251	442	884
30	Municipal Ward	3,322	4,739	8,599
31	Municipal Ward	3,575	5,067	9,133
32	Municipal Ward	3,156	4,523	8,249
33	Municipal Ward	3,560	5,048	7,433

TAZ number	Zone type	Employment (2021)	Employment (2031)	Employment (2041)
34	Municipal Ward	2,998	4,319	5,341
35	Municipal Ward	2,988	4,306	6,227
36	Municipal Ward	3,542	5,024	9,064
37	Municipal Ward	3,461	4,920	8,894
38	Municipal Ward	3,070	3,934	4,057
39	Municipal Ward	2,873	4,156	7,652
40	Municipal Ward	3,652	5,167	9,297
41	Municipal Ward	3,595	5,093	7,507
42	Municipal Ward	3,523	5,001	6,180
43	Municipal Ward	2,310	2,384	2,459
44	Municipal Ward	2,202	2,273	2,344
45	Municipal Ward	2,566	2,649	2,732
46	Municipal Ward	293	488	976
47	Municipal Ward	2,912	3,006	3,100
48	Municipal Ward	2,343	2,418	2,494
49	Municipal Ward	2,407	2,484	2,562
50	Municipal Ward	3,584	5,079	9,153
51	Municipal Ward	4,010	5,115	5,491
52	Municipal Ward	3,721	5,256	9,441
53	Municipal Ward	3,776	4,140	4,270
54	Municipal Ward	3,360	4,789	8,681
55	Municipal Ward	2,920	4,218	7,753
56	Municipal Ward	1,278	2,087	4,286
57	Villages outside Nagar Parishad Area	982	1,703	3,661
58	Villages outside Nagar Parishad Area	922	1,625	3,535
59	Villages outside Nagar Parishad Area	3,874	5,456	9,765
60	Villages outside Nagar Parishad Area	2,083	3,131	5,985
61	Villages outside Nagar Parishad Area	2,022	3,053	5,857
62	Villages outside Nagar Parishad Area	5,405	7,442	12,996
63	Villages outside Nagar Parishad Area	778	1,439	3,233
64	Villages outside Nagar Parishad Area	1,923	2,924	5,647
65	Villages outside Nagar Parishad Area	3,382	4,817	8,727
66	Villages outside Nagar Parishad Area	2,994	4,314	7,909

TAZ number	Zone type	Employment (2021)	Employment (2031)	Employment (2041)
67	Villages outside Nagar Parishad Area	4,695	6,521	11,497
68	Villages outside Nagar Parishad Area	1,937	2,942	5,677
69	Villages outside Nagar Parishad Area	1,318	2,140	4,372
70	Villages outside Nagar Parishad Area	3,453	4,909	8,876
71	Villages outside Nagar Parishad Area	0	0	0
72	Villages outside Nagar Parishad Area	2,505	3,679	6,875
73	Villages outside Nagar Parishad Area	4,164	5,832	10,378
74	Villages outside Nagar Parishad Area	2,511	3,496	6,578
75	Villages outside Nagar Parishad Area	3,775	5,327	9,556
76	Villages outside Nagar Parishad Area	570	979	2,484
77	Villages outside Nagar Parishad Area	1,425	2,277	4,596
78	Villages outside Nagar Parishad Area	704	1,343	3,077
79	Villages outside Nagar Parishad Area	2,109	3,165	7,708
80	Villages outside Nagar Parishad Area	5,409	7,447	13,005
	Total	**230,215**	**315,617**	**517,238**

Table 31: TAZ-wise forecasted student population

TAZ number	Zone type	Students enrolment 2021	Students enrolment 2031	Students enrolment 2041
1	Municipal Ward	1,250	1,723	2,196
2	Municipal Ward	1,575	2,157	3,757
3	Municipal Ward	4,343	6,084	10,854
4	Municipal Ward	4,199	5,786	10,150
5	Municipal Ward	1,659	1,990	1,990
6	Municipal Ward	2,119	2,220	2,220
7	Municipal Ward	5,546	7,611	10,767
8	Municipal Ward	4,761	6,591	11,621
9	Municipal Ward	1,246	1,728	3,051
10	Municipal Ward	5,848	8,027	10,772

TAZ number	Zone type	Students enrolment 2021	Students enrolment 2031	Students enrolment 2041
11	Municipal Ward	1,937	1,937	1,937
12	Municipal Ward	1,853	1,853	1,853
13	Municipal Ward	1,307	1,307	1,307
14	Municipal Ward	6,028	8,302	14,512
15	Municipal Ward	1,094	1,515	2,672
16	Municipal Ward	1,286	1,776	3,120
17	Municipal Ward	2,281	3,124	5,447
18	Municipal Ward	1,929	2,675	4,722
19	Municipal Ward	3,768	5,272	9,396
20	Municipal Ward	5,820	7,959	13,850
21	Municipal Ward	0	0	0
22	Municipal Ward	762	1,064	1,893
23	Municipal Ward	2,465	3,412	6,015
24	Municipal Ward	515	631	673
25	Municipal Ward	4,151	4,151	4,151
26	Municipal Ward	3,996	5,476	9,552
27	Municipal Ward	1,667	2,049	2,266
28	Municipal Ward	3,381	4,713	6,599
29	Municipal Ward	1,882	1,989	1,989
30	Municipal Ward	2,977	4,114	7,240
31	Municipal Ward	4,349	5,972	10,439
32	Municipal Ward	1,839	2,554	4,516
33	Municipal Ward	64	88	126
34	Municipal Ward	1,102	1,538	1,845
35	Municipal Ward	930	1,299	1,821
36	Municipal Ward	3,115	4,281	7,489
37	Municipal Ward	262	361	633
38	Municipal Ward	3,356	4,166	4,166
39	Municipal Ward	1,662	2,329	4,158
40	Municipal Ward	1,435	1,966	3,431
41	Municipal Ward	4,043	5,549	7,931
42	Municipal Ward	751	1,032	1,237
43	Municipal Ward	456	456	456
44	Municipal Ward	21	21	21
45	Municipal Ward	231	231	231
46	Municipal Ward	928	928	928
47	Municipal Ward	543	543	543
48	Municipal Ward	1,047	1,047	1,047
49	Municipal Ward	207	207	207

TAZ number	Zone type	Students enrolment 2021	Students enrolment 2031	Students enrolment 2041
50	Municipal Ward	428	588	1,028
51	Municipal Ward	17	21	22
52	Municipal Ward	0	0	0
53	Municipal Ward	99	105	105
54	Municipal Ward	0	0	0
55	Municipal Ward	748	1,047	1,866
56	Municipal Ward	858	1,357	2,703
57	Villages outside Nagar Parishad Area	1,892	3,180	6,630
58	Villages outside Nagar Parishad Area	1,154	1,972	4,159
59	Villages outside Nagar Parishad Area	1,829	2,495	4,331
60	Villages outside Nagar Parishad Area	1,926	2,806	5,200
61	Villages outside Nagar Parishad Area	2,230	3,262	6,069
62	Villages outside Nagar Parishad Area	1,960	2,614	4,427
63	Villages outside Nagar Parishad Area	518	928	2,021
64	Villages outside Nagar Parishad Area	1,053	1,552	2,907
65	Villages outside Nagar Parishad Area	4,819	6,649	11,681
66	Villages outside Nagar Parishad Area	3,313	4,624	8,219
67	Villages outside Nagar Parishad Area	4,235	5,698	9,743
68	Villages outside Nagar Parishad Area	503	740	1,385
69	Villages outside Nagar Parishad Area	583	917	1,816
70	Villages outside Nagar Parishad Area	2,546	3,506	6,147
71	Villages outside Nagar Parishad Area	0	0	0
72	Villages outside Nagar Parishad Area	771	1,096	1,987
73	Villages outside Nagar Parishad Area	2,654	3,600	6,212
74	Villages outside Nagar Parishad Area	1,595	2,151	3,924
75	Villages outside Nagar Parishad Area	2,423	3,313	5,763

TAZ number	Zone type	Students enrolment 2021	Students enrolment 2031	Students enrolment 2041
76	Villages outside Nagar Parishad Area	0	0	0
77	Villages outside Nagar Parishad Area	591	915	1,791
78	Villages outside Nagar Parishad Area	409	756	1,678
79	Villages outside Nagar Parishad Area	0	0	0
80	Villages outside Nagar Parishad Area	3,582	4,778	8,091
	Total	**150,725**	**202,475**	**327,706**

Annexure 4. – Proposals and Strategies

Components of a standard depot

A standard bus depot shall constitute the administrative building, workshop or bus engineering facilities, bus parking area, adequate circulation area and other facilities such as fuel sheds, cleaning sheds, washing sheds, etc., which are explained below.

Administrative building

Administrative building shall consist of a managers room, administration staff room, cash collection office, ticket-issuing office, bank area, canteen or refreshment areas, meeting/discussion room, store room, locker room, rest area and other support facilities.

Workshop/bus engineering building

The workshop or bus engineering building shall consist of major pits, minor pits, general checking area, workshop office room, store room, inspection ramp, engine overhaul section, re-ringing section, spare parts room, tool room, engineering facilities room, parking area and other support facilities. The suggestive typical layout for a depot is shown in the Figure.

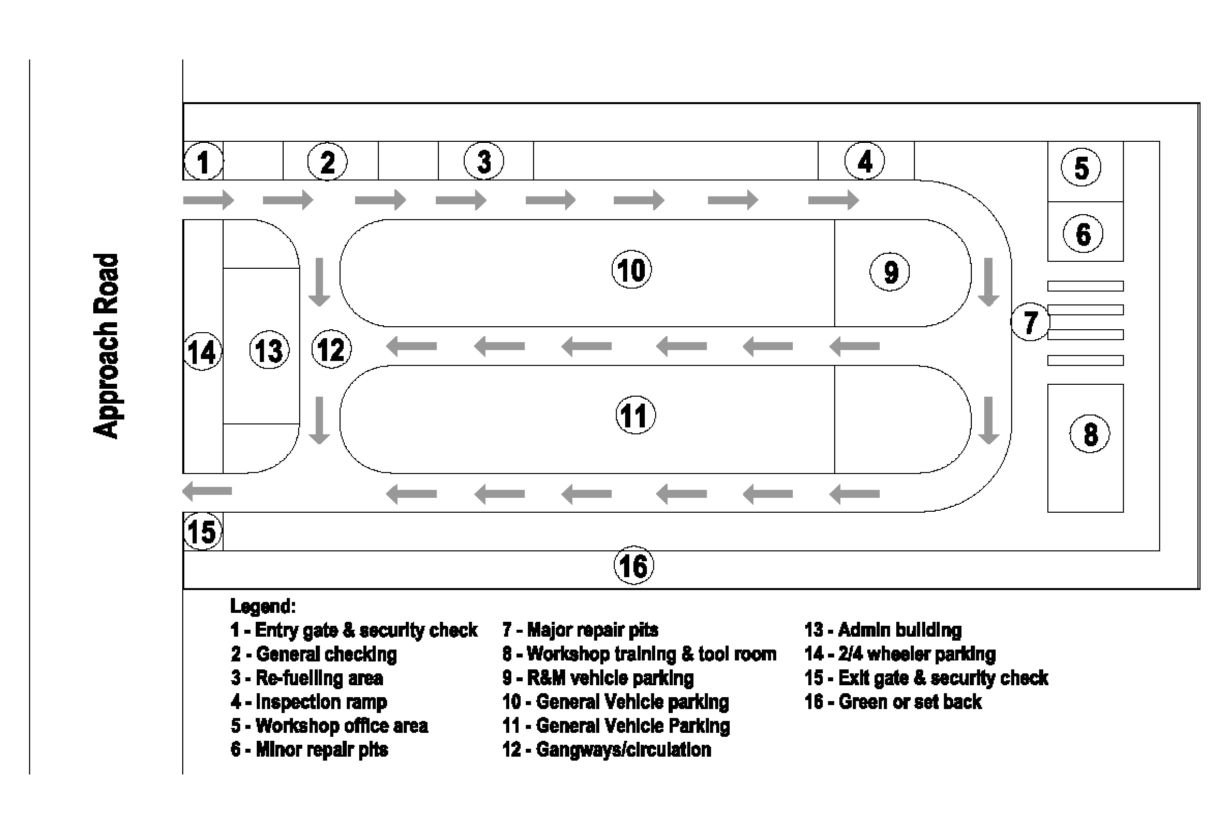

Figure 52: Layout of a standard depot

Implementation of ITS for improving reliability of public transport

Urban Mass Transit Company Limited

Udaipur city lacks a history of an organised public transport system, and has therefore been experiencing a mushrooming growth of IPT and private modes.

To promote public transport in general and the city bus service in particular, an improvement in the quality of service, efficiency, reliability and safety is of utmost importance, as this would lead to a wider acceptance of the service. Installation of ITS will improve the efficiency, reliability, and safety of the city bus service, which will add value to the service and thereby contribute to an increase in ridership. The LCMP for Udaipur has proposed a phase-wise installation of ITS system for improving the quality of the city bus service and to promote public transport.

Passenger information system (PIS) at all bus stops

The PIS displays at bus stops have to be capable of displaying data in a multilingual format, and should have the capability of scrolling between different languages and different character sets, for example between English and Hindi. All the bus stops are proposed to have this PIS display system.

Central control facility

A central control facility should be set up for controlling the services. This acts as a nerve centre for the entire system and associated services, and provides the overall control and coordination of the system. It houses all the necessary computing and communications hardware and software needed to fulfil this function. The control facility shall have: control panels on which the location of all buses can be spotted and tracked; monitors for transmitting visuals of the actual ground position by cameras located at strategic points on the corridor; facilities for voice communication between the drivers and the control room, as well as between terminal/bus stop supervisors; control room facilities to receive and transmit, as needed, all data being collected by the vehicle mounted units, fare collection units, cameras, all other hardware; report and alert operators to errors and faults and collect, process and store data generated by the system.

This central control facility can be provided as a part of the depots proposed.

i. Fare collection system
   Technology for fare collection should be capable of the following:

   - Avoid over-travel possibility on payment of lower tariffs
   - Establish data transfer links between the ticket vending system and control centre
   - Generate a management information system (MIS) for trip-wise/route-wise/ duty-wise revenue collected, passenger flow, trend analysis (both physical and financial trends) and decision-making

- Enable PMC to conduct routine appraisals of drivers' and conductors' performance in terms of earning per kilometre (EPK), revenue collected, etc.
- Analyse frequency/intensity of use of various ticketing instruments for facilitating expansion of ticket issue centres.

The proposed fare collection system for bus operations broadly comprises of sub-systems discussed here under:

ii. On-board ticket vending and verification

Each bus is proposed to be provided with a hand-held electronic ticket vending and verification machine (ETVM). These machines shall be capable of verification of/charging from contact-less cards, magnetic cards/smart cards and other user tariff charging instruments such as seasonal travel passes, prepaid cards, single journey tickets, integrated tickets, etc., issued earlier or off-board or by other mass passenger transport operators. Assuming two shifts per day, the total number of ETVM machines will be twice the number of buses.

Promoting public participation and campaigning for the mass awareness programme

For the successful implementation of any transport project in general, and a public transport project in particular, it is necessary to promote public awareness and create a sense of public ownership of the project. It is necessary to evolve an outreach and education strategy for public transport. The outreach and education goals need to be defined at the planning stage of the public transport project itself to focus the efforts of the project implementation team. To secure the support of the public for the public transport facilities and obtain acceptance thereof, the outreach and education goals are defined as follows:

- Introduce the concept of public transport, its purpose and benefits to the various stakeholders
- Create a profile of public transport as a big impact, incremental step for achieving the long-term vision for mobility in the city
- Enhance understanding that public transport projects positively impact economic health and environmental sustainability of the city
- Introduce the concept of public transport as an important strategy in making the best use of transportation resources
- Establish communication channels for the public to receive information and interact with the project implementation team.

Education and Outreach goals can be addressed by utilizing the following strategies:

- Create a network of allies and provide platforms for them to actively participate as disseminators of project benefits
- Use proactive and creative media relations to promote key public transport messages, particularly trip reliability messages.

Communication media

The selection of the communication media is critical in ensuring that the message is delivered effectively to the target audience. Available media include:

- Print: newsletters, newspapers, magazines
- Broadcast: radio, TV
- New Media: internet, web sites
- Out of home: hoardings, posters, short films, display models
- Direct mail: flyers, inserts, brochures, letters, fact sheets
- Event marketing: special events, workshops/conferences
- Public Relations: media management, general awareness programme
- Mobile phone: through SMS, toll free enquiry system, etc.

The choice of media is predicated on budget, ability to reach the target audience, the desired impact, and the message to be communicated. The messages have to be reiterated at a regular frequency for them to impact the target audience effectively. The development of the message is also critical to the success of the marketing plan, and the message has to be well crafted with both written copy and the visual component. The messages should be focused on the benefits of public transport, supported by facts, and be positive and consistent.

Target audience

- Segment 1: Existing IPT users (such as share autos and other buses)
- Segment 2: Potential users – two-wheeler users, car users
- Segment 3: Local community/special Interest Groups/NGOs.

Marketing strategies are to be designed to cater to the specific needs of each of these segments separately.

Initiating reform measures in urban transport

To effectively promote and implement public transport, a robust institutional arrangement is essential. In line with the Government of India guidelines, it is proposed to set up a single agency that would coordinate public transport services in the city so that there is an integrated service.

Encouraging private sector in promotion of public transport

Traditionally, the responsibility of providing public transport lies with the Government, being financed and operated using resources from taxes and various levies. Over the years, experience has shown that important urban utility services like urban transport is controlled by multiple institutions resulting in fragmentation of functional responsibilities and large scale inefficiencies in service delivery. In order to improve the quality of service delivery of public transport and to effectively infuse and utilise a private fund for the supply of public transport, participation of private players should be encouraged through adopting various Public Private Partnership (PPP) models.

Annexure 5. – Timelines of Emission Regulation in India

1989 - Idle emission regulation

1991 - Mass emission regulation (CO & HC) (Hot Start; Indian Driving Cycle)

1992 - Mass emission regulation for diesel vehicles

1995 - Fitting of CAT converters for cars in four metros

1996 - Tightening of emission limits (CO, HC & NOx), Evaporative Emission & Crank Case Emission

1998 - Norms for CAT-fitted vehicles (50 per cent tighter standards)

1998 - From September, fitting of CAT-converters in 42 major cities for petrol-driven passenger cars

2000 - India 2000 (Euro-I equivalent) norms for all four-wheelers, Bharat Stage II (Euro-II equivalent) norms in NCR for passenger cars and MUVs

- Extended to Mumbai and Kolkata from January

2001 - Extended to Chennai from July 2001

- Tightest norms in the world for two-wheelers

2001 - Bharat Stage II (Euro-II equivalent) norms for commercial vehicles in Delhi and Kolkata (from 24 October 2001)

- Bharat Stage II norms for CVs in Mumbai and Chennai from 1 November 2001

2003 - October 6 – Adoption of National Auto Fuel policy, recommending a phased program for introducing Euro 2-4 emission and fuel regulations by 2010. The implementation schedule of EU emission standards in India is summarized in the following table.

Table 32: Implementation schedule of EU emission standards in India

Standard	Euro norms reference	Timelines	Region
India 2000	Euro 1	2000	Nationwide
Bharat Stage II	Euro 2	2001	National Capital Region, Delhi and three other cities (Mumbai, Kolkata, Chennai)
		2003.04	National Capital Region, Delhi and 13 Cities (Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, Lucknow, Sholapur, Jamshedpur and Agra)
		2005.04	Nationwide

Standard	Euro norms reference	Timelines	Region
Bharat Stage III	Euro 3	2005.04	National Capital Region, Delhi and 13 Cities (Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, Lucknow, Sholapur, Jamshedpur and Agra)
		2010.04	Nationwide
Bharat Stage IV	Euro 4	2010.04	National Capital Region, Delhi and 13 Cities (Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad, Pune, Surat, Kanpur, Lucknow, Sholapur, Jamshedpur and Agra)
Bharat Stage V	Euro 5	2020 (proposed)	Nationwide

The above standards apply to all new four-wheel vehicles sold and registered in the respective regions. For two and three-wheelers, Bharat Stage II applied from 1 April 2005 and Stage-III standards came into force on 1 April 2010.

The Planning Commission has established a Committee in 2013 to draft an updated Auto Fuel Policy. The panel recommended that Bharat Stage IV fuel be required nationwide from April 2017, followed by a further step up to Bharat Stage V in April 2020. Draft recommendations discussed prior to the report’s release included a national Bharat Phase IV+ stage (40 ppm sulfur), starting in 2017 and a national Bharat Stage V fuel standard staring in 2021.

Annexure 6. – Block Cost Estimates

The mobility plan components discussed in the previous sections were considered in the estimation of block costs for implementing the projects in the future. The approximate capital cost, excluding land acquisition, for implementing the mobility plan is about INR 221, 52.4 million. The phase-wise costing is given in the table below:

Table 33: Phase-wise cost details

Phases	Project cost (in INR Millions)
Phase I: Immediate projects: 2013-2015	4462.7
Phase II: Short-term projects: 2013-2018	2396.3
Phase III: Medium-term projects: 2019-2022	7032.2
Phase IV: Long-term projects: 2023-2041	8261.1
Total	**22152.4**

The breakup of the project cost is given in the table below:

Table 34: Project costing of Phase I: Immediate projects: 2013-2015

Sl. No.	Project	Quantity	Unit	Unit rate (INR Millions)	Total cost (in INR Millions)
1	Construction of footpath	143	km	4.7	675.7
2	Grade-separated pedestrian facilities	19	No	11	209
3	Road marking	88	LS	36.8	3234
4	Street lights	88	km	2.8	249.5
5	Development of bike network				
a	*Road resurfacing*	100000	sqm		94.5
b	*Road markings*	100	sqm		0.1
c	*Towing vans*		no	1.6	
	Phase I				**4462.7**

Table 35: Project costing of Phase II: Short-term projects: 2013-2018

Sl. No.	Project	Quantity	Unit	Unit rate (INR Millions)	Total cost (In INR Millions)
1	Modern IPT	1,803	IPT	0.55	991.7
2	IPT/bus stops	112	No	1.1	123.2

3	Street lights	208	km	2.8	589.7
4	Intersection improvement	19	No	5.3	99.8
5	ITS on IPT	1,803	LS	0.25	450.8
6	ITS on stops	112	LS	0.66	73.9
7	Public education and awareness program		LS	55	55
8	Introduction of bicycles at bike parking lots	88	No	0.02	1.5
a	*Infrastructure*	8	No	0.92	7.4
b	*Towing vans*	2	No	1.73	3.5
	Phase II				**2396.3**

Table 36: Project costing of Phase III: Medium-term projects: 2019-2022

Sl. No.	Project	Quantity	Unit	Unit rate (INR Millions)	Total cost (In INR Millions)
1	City bus service	41	Buses	3	123
2	IPT Stops	260	No	0.5	130
3	OD terminal for bus	9	No	30	270
4	Road marking	116	LS	25	2900
5	ITS on buses	41	LS	0.6	25.625
6	Street lights	416	km	2.8	1179.4
7	Network development			0	0
a	*60m RoW*	7	km	105	735
b	*36m RoW*	3	km	87.5	262.5
c	*30m RoW*	12	km	80	960
8	Terminal cum depot	4	No	62.5	250
9	Public education and awareness program		LS	68.8	68.8
10	Tourism-promoting transport infrastructures (heritage walk)	3.2	km	40	128
	Phase III				**7032.2**

Table 37: Project costing of Phase IV: Long-term projects: 2023-2041

Sl. No.	Project	Quantity	Unit	Unit rate (INR Millions)	Total cost (In INR Millions)
1	City bus service (bus augmentation)	360	Buses	3.6	1296
2	Maintenance of footpath	143	km	4	572
3	ITS on buses	360	LS	0.8	270
4	OD bus terminal	9	No	40	360
5	Development of Freight Terminal	4	No	100	400
6	Network development			0	0
a	*60m RoW*	16	km	105	1680
b	*36m RoW*	8	km	87.5	700
c	*30m RoW*	36	km	80	2880
7	Public education and awareness program		LS	103.1	103.1
	Phase IV				**8261.1**

Urban Mass Transit Company Limited

BIBILIOGRAPHY

Bibiliography

Bibliography

1. Master Plan for Udaipur, 2021 (UIT, 2013)
2. City Development Plan
3. Toolkit for preparation of Comprehensive Mobility Plan, published by MoUD, GoI
4. Toolkit for preparation of Low-carbon Comprehensive Mobility Plan, published by UNEP
5. Promoting Low Carbon Transport in India. Low Carbon City: A Guidebook for City Planners and Practitioners, published by UNEP
6. Census of India – 2001 and 2011
7. Transportation 2040: Toward a Sustainable Transportation System, Puget Sound Regional Council, 20 May 2010
8. Green Paper: Towards a New Culture for Urban Mobility, Commission of the European Communities, Brussels, 25 September 2007
9. Action Plan on Urban Mobility, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 30 September 2009
10. The Opportunities for Sustainable Urban Transportation in Medium-Sized Cities in Latin American and the Caribbean, Inter-American Development Bank – Sustainable Development Department, Environment Division, November 2004
11. The Implementation of Brazil Sustainable Urban Mobility Policy, National Secretary of Transportation and Urban Mobility, Ministry of Cities
12. Sustainable Urban Transport in Asia, Making the Vision a Reality – a CAI-Asia Programme
13. Motorising the Developing World, Daniel Sperling and Eileen Claussen
14. Sustainable Urban Mobility Measures that may be Applicable in Hanoi, Peter Midgley, Global Transport Knowledge Partnership – The International Seminar on Sustainable Development of Hanoi Urban Transport, 25 June 2010
15. Changing Course, a New Paradigm for Sustainable Urban Transport, Urban Development Series, Asian Development Bank, 2009
16. Urban Transport Thematic Research Summary, European Commission, DG Energy and Transport: Transport Research Knowledge Centre, 15 September 2009
17. Mobility Plans: The Way Forward for a Sustainable Urban Mobility – European Metropolitan Transport Authorities, 2009
18. Land Use/Transport Interaction Models, Department for Transport Analysis Guidance (TAG), June 2005
19. Bicycle and Pedestrian Mobility Plan, Thornbury Township, Chester County, PA, 20 November 2007

20. Pennsylvania Mobility Plan, Gannett Fleming/Parsons Brinckerhoff Team, September 2006
21. SUTP Development in Europe, State of the Art Review, European Commission, DG Environment, November 2005
22. Texas Urban Mobility Plan: Breaking the Gridlock, Victoria County Urban Transportation Study in Cooperation with the Texas Department of Transportation
23. Managing Travel Demand Applying European Perspectives to U.S. Practice, U.S. Department of Transportation Federal Highway Administration in Cooperation with American Association of State Highway and Transportation Officials National Cooperative Highway Research Programme, May 2006
24. Mitigating Traffic Congestion: The Role of Demand-Side Strategies, Association for Commuter Transportation, October 2004
25. Travel Demand Management: Some Insights, Thomas Guéret, International Energy Agency
26. Greater Dublin Area Travel Demand Management Study, Dublin, October 2004
27. Is Curitiba, Brazil the Model City for Parking Management, Christopher Ziemann, District of Columbia, Department of Transportation, 15 November 2008
28. Victoria Transport Policy Institute, Parking Management Strategies, Evaluation and Planning, Todd Litman Victoria Transport Policy Institute, 5 November 2008
29. Congestion Pricing and Parking Policy in the Netherlands, Karel Martens, Institute for Management Research Radboud Universiteit Nijmegen
30. Parking Pricing Implementation Guidelines: How More Efficient Parking Pricing Can Help Solve Parking and Traffic Problems, Increase Revenue and Achieve Other Planning Objectives, Todd Litman, Victoria Transport Policy Institute, 25 February 2010
31. Parking Management Strategies, Evaluation and Planning, Todd Litman, Victoria Transport Policy Institute, 4 February 2011
32. The Integrated Sustainable Urban Transport Plan Dresden 2025, Polis Conference, Brussels, Gerd-Axel Ahrens Dresden, 10 December 2009
33. Road User Pricing Could Help Ease and Manage International Traffic Congestion: Deloitte Research Highlights Effective Examples of Road User Pricing
34. Intelligent Transport Systems, Results from the Transport Research Pogramme by European Commission
35. Study on Traffic and Transportation Policies and Strategies in Urban Areas in India, Ministry of Urban Development, Government of India, 1998
36. Study on Traffic and Transportation Policies and Strategies in Urban Areas in India, Ministry of Urban Development, Government of India, 2008
37. Land Transport Master Plan, Land Transport Authority, Singapore
38. Sustainable Urban Transport, European Project Trendsetter, Civitas, 2006
39. Streetscaping of Delhi Road for Commonwealth Games, Pradeep Sachdeva Design

Associates, May 2009

40. NUTP guidelines

Websites

1. http://planningcommission.nic.in/
2. http://cpcb.nic.in/
3. http://www.gtkp.com
4. http://psrc.org/transportation/t2040
5. http://www.dft.gov.uk/
6. http://transportblog.co.nz
7. http://sustainablecities.dk/
8. http://ops.fhwa.dot.gov
9. http://ec.europa.eu
10. Online TDM encyclopedia

Information about the project:

UNEP Transport Unit in Kenya, UNEP DTU Partnership in Denmark and partners in India have embarked on a new initiative to support a low-carbon transport pathway in India. The three-year EUR 2.49 million project is funded under the International Climate Initiative of the German Government, and is designed in line with India's National Action Plan on Climate Change (NAPCC). This project aims to address transportation growth, development agenda and climate change issues in an integrated manner by catalyzing the development of a Transport Action Plan at the national level and Low-Carbon Mobility plans at the cities level.

Key local partners include the Indian Institute of Management, Ahmedabad, the Indian Institute of Technology, Delhi and CEPT University, Ahmedabad. The cooperation between the Government of India, Indian institutions, UNEP, and the Government of Germany will assist in the development of a low-carbon transport system and showcase best practices within India, and for other developing countries.

Homepage : www.unep.org/transport/lowcarbon

FOR MORE INFORMATION, CONTACT:

United Nations Environment Programme (UNEP)
Division of Technology, Industry and Economics (DTIE)
Transport Unit
P.O Box 30552
Nairobi, Kenya
Tel : +254 20 762 4184
Email : lowcarbon@unep.org
www.unep.org/transport/lowcarbon

DTU