Towards Sustainable Low Carbon Transport in Udaipur

Opportunities for Climate Mitigation & Sustainable Development (OPTIMISM)

Report | 2021

Ahmedabad University

ABOUT

This report is part of the OPTIMISM (Opportunities for Climate Mitigation and Sustainable Development) project. OPTIMISM (Opportunities for Climate Mitigation and Sustainable Development) is an international multi-stakeholder partnership and research network funded by the UK Natural Environment Research Council as part of the research council's "Towards a Sustainable Earth" program. The international team consists of four partners: (i) Imperial College London, UK, (ii) Lund University, Sweden, (iii) Waseda University, Japan; and (iv) Ahmedabad University, India. Dr. Darshini Mahadevia (Principal Investigator- India) and Dr. Minal Pathak (Co-Principal Investigator) lead the project team placed in India that is supported and funded by the Department of Biotechnology (DBT), Government of India. The project team in India consisted of Dr. Chandrima Mukhopadhyay, Saumya Lathia, Amitkumar Dubey, Kanika Gounder, Bandish Patel, and Saleem Yatoo.

Adopting a whole-systems perspective, the OPTIMISM project uses the United Nations Sustainable Development Goals framework to analyze (i) the change in human development and the environment amidst rapid and extensive climate action and (ii) the role of insights from sectoral-SDG interaction in creating policies and practices that enable a transformational change. This report stems from the critical assessment Udaipur's Low-Carbon Mobility Plan and other city-level plans to identify interactions of the city's urban passenger transport sector with UN Sustainable Development Goals (SDGs).

ACKNOWLEDGEMENTS

This research is funded by Department of Biotechnology, Ministry of Science & Technology, Government of India. We would like to thank United Nations Environmental Program (UNEP) for sharing Udaipur's Low-Carbon Mobility Plan and related datasets. We express our deep gratitude to Udaipur Municipal Corporation (UMC) for extending their support in data collection and enthusiasm throughout the study. We thank Core Alliance team for conducting the fieldwork and Bandish Patel (Research Associate, OPTIMISM Project) for coordinating data collection efforts. We also thank Maharana of Mewar Charitable Foundation, IMPETUS, DRONAH Foundation, INTACH and 3R WASTE Foundation for participating in the Focus Group Discussion and Dr. Chandrima Mukhopadhyay for conducting them. All site pictures have been collected by Bandish Patel, Saumya Lathia and Kanika Gounder. All the maps presented in the report have been generated by Kanika Gounder referring to the Low Carbon Comprehensive Mobility Plan. This report is designed by Shaurya Patel (Research Associate, Global Center for Environment and Energy). Bhavya Patodi, Isha Iyer and Kanika Bajaj (interns) assisted in referencing of this report.

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ABBREVIATIONS

ARAI	**Automotive Research Association of India**
ATL	Average Trip Length
ATT	Average Trip Time
BAU	Business as Usual
CAGR	Compound Annual Growth Rate
CMP	Comprehensive Mobility Plan
CPCB	Central Pollution Control Board
CO	Carbon Mono-oxide
CO_2	Carbon Di-oxide
EV	Electric Vehicle
FGD	Focus Group Discussion
FY	Financial Year
GhG	Greenhouse Gas
HH	Household
HIG	High Income Group
IPT	Intermediate Public Transport
LCMP	Low Carbon Comprehensive Mobility Plan
LIG	Low Income Group
LoS	Level of Service
MaaS	Mobility as a Service
MIG	Middle Income Group
MoUD/ MoHUA	Ministry of Urban Development/ Ministry of Housing & Urban Affairs
NH	National Highway
NMT	Non-motorised Transport
NO_x	Nitrogen Oxide
PCU	Passenger Car Unit
PM	Particulate Matter
PPH	Person Per Hectare
PT	Public Transport
PWD	Public Works Department
RSPM	Respirable Suspended Particulate Matter
ROW	Right-of-Way
RTO	Regional Transport Office
SDG	Sustainable Development Goal
SLB	Service Level Benchmark
SPM	Suspended Particulate Matter
Sq. km	Square Kilometres
TOD	Transit Oriented Development
UIT	Urban Improvement Trust
UMC	Udaipur Municipal Corporation
UUCA	Udaipur Urban Control Area
VKT	Vehicle Kilometres Travelled
2W	Two-Wheeler
3W	Three-Wheeler
4W	Four-Wheeler

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INTRODUCTION

With its rich heritage, culture, and natural ecosystem, Udaipur ranks 3rd in the list of Top 15 World's Best cities to visit, and receives the second largest flock of foreign tourists in India. It is the city of lakes and home to Rajput-era palaces. Located at the midpoint of the Delhi-Mumbai National Highway (NH 8) and well connected to the state capital Jaipur, Udaipur is a smaller urban centre with a population of 6 lakhs and a total area of 365 square kilometres (sq. km). The city sits amidst several state and national highways; and is the only city in India to be at the intersection of East-West & North-South Corridors of the Golden Quadrilateral Highway project.

Udaipur Urban Control Area (UUCA) comprises of the Udaipur Municipal Corporation (UMC) spread across 64 sq. km and 62 villages, serving as a major market centre and healthcare hub for the surrounding region. The population in the city has nearly tripled from 1961 to 1991, attributing to economic factors leading to better employment opportunities. However, from 1981-91, Udaipur experienced a decline in growth by 10%. Additionally, the city is an educational hub, with 5 Universities, 14 colleges and more than 160 high schools, inviting students from across the state. Due to its favourable spatial location and regional importance, the city is one of the most popular tourist destination in India, and serves a huge floating population around the year.

Picture 1 Aerial view of Udaipur's built heritage

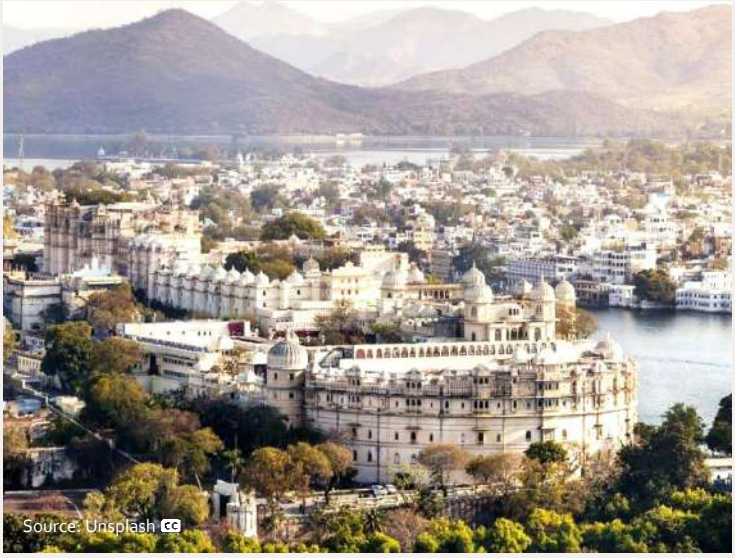
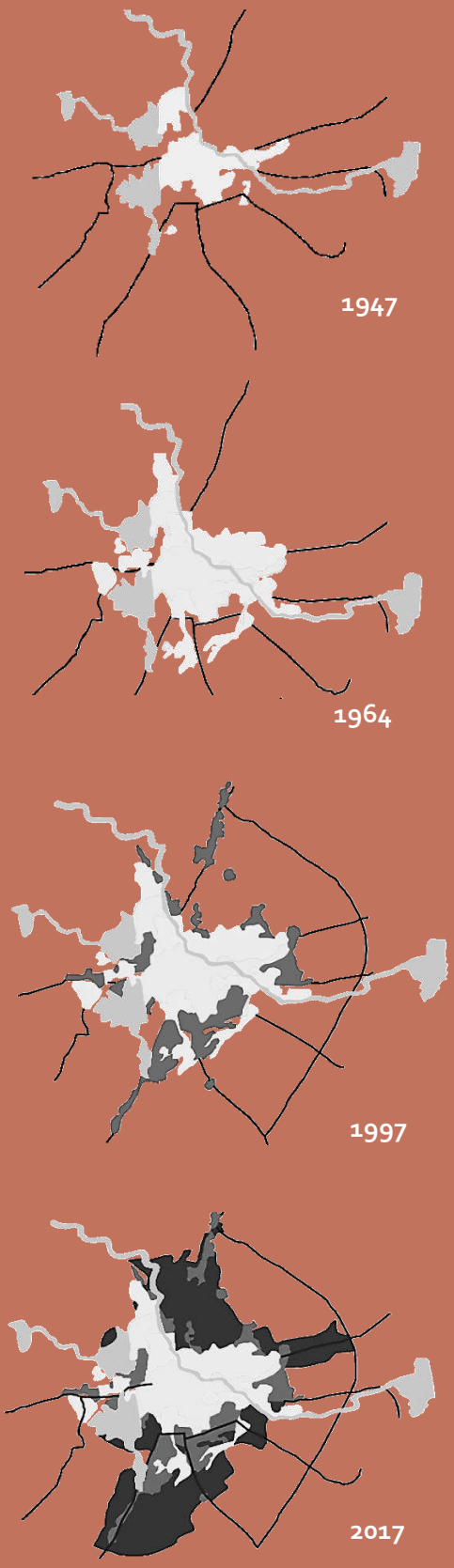


Figure 1 Urban Sprawl in Udaipur



Source: Udaipur LCMP 2013

Picture 2 Boating at Lake Pichola

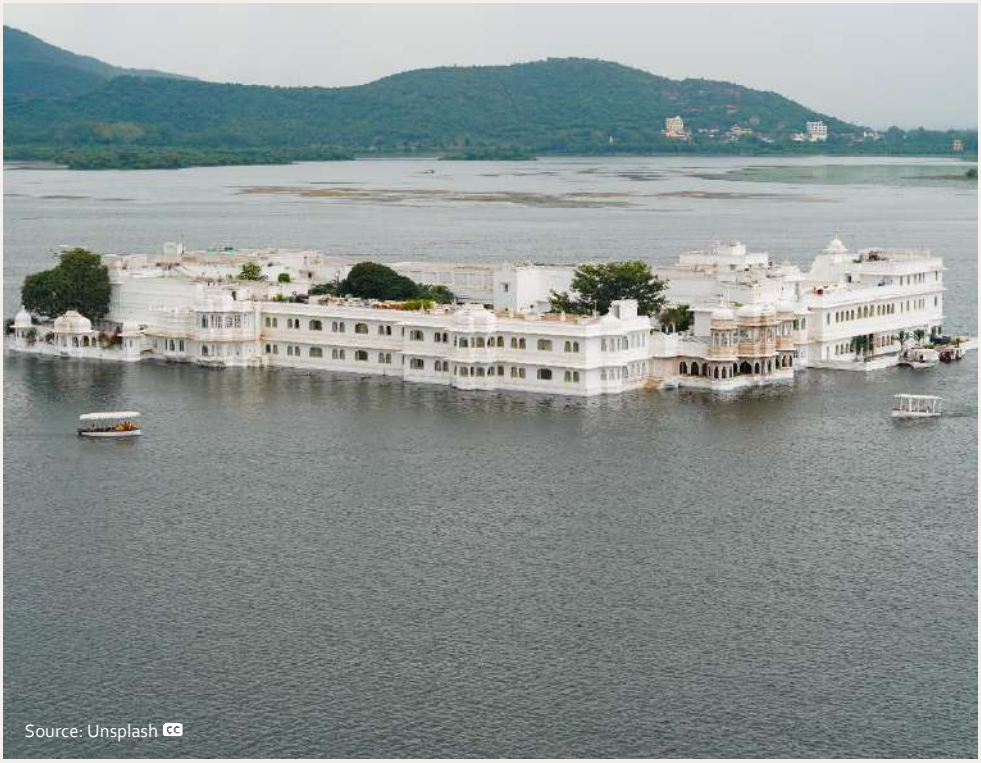
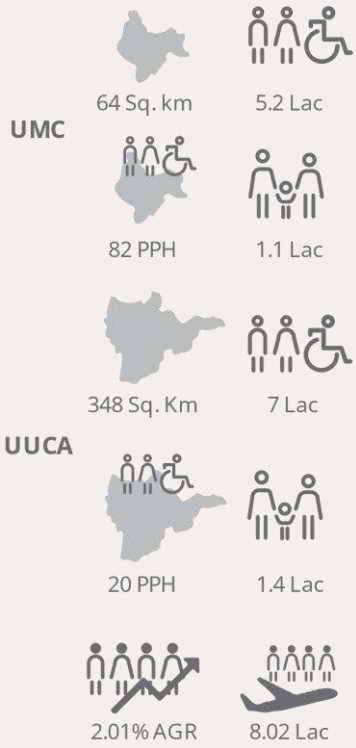
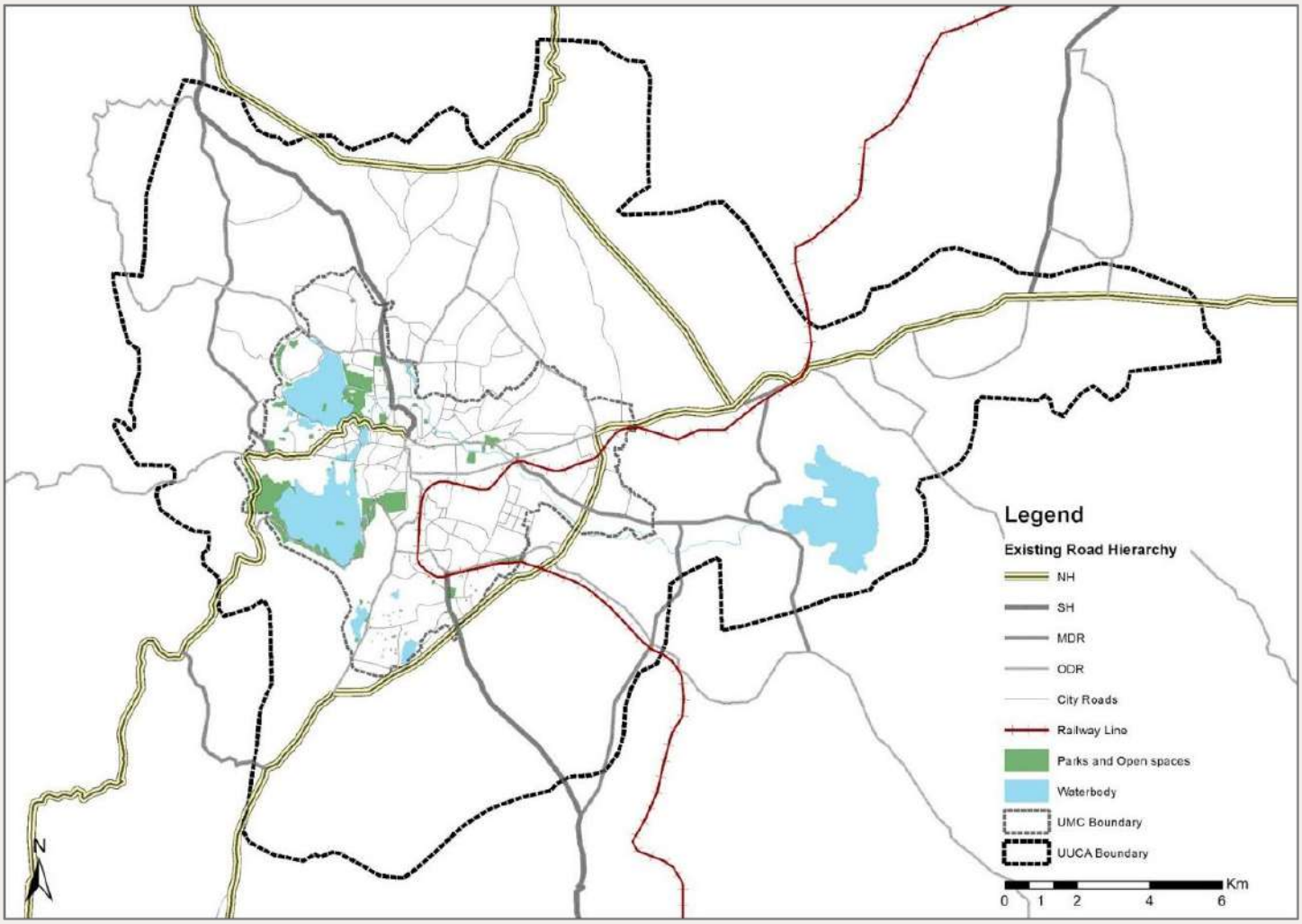


Figure 2 City's Demographic Profile



Source: Udaipur LCMP 2013

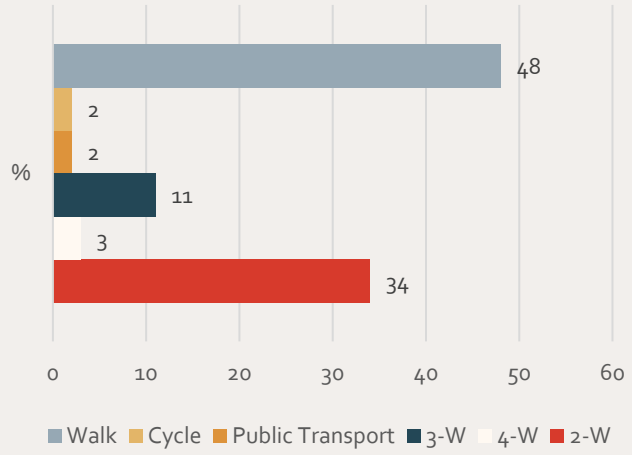
Map 1 Udaipur Urban Control Area Boundary



TRANSPORT SYSTEMS & KEY CHARACTERISTICS

Udaipur is a small-sized 12-minute city known for its history, culture, and institutions, attracting students and high domestic and international tourist footfall. About half the trips in the city are made on non-motorized modes, while more than 37% trips are made on personal motorized vehicles. Public transport operating in the city is mainly shared and personal auto-rickshaws, along with a few city buses. Road space in the city is highly contested with heterogeneous road users: motorized vehicle users, pedestrians, cyclists, street vendors and their clientele, private bus operators and their clientele, pavement dwellers, people engaged in street parking, etc.

Figure 3 Mode share of trips in the UUCA Area

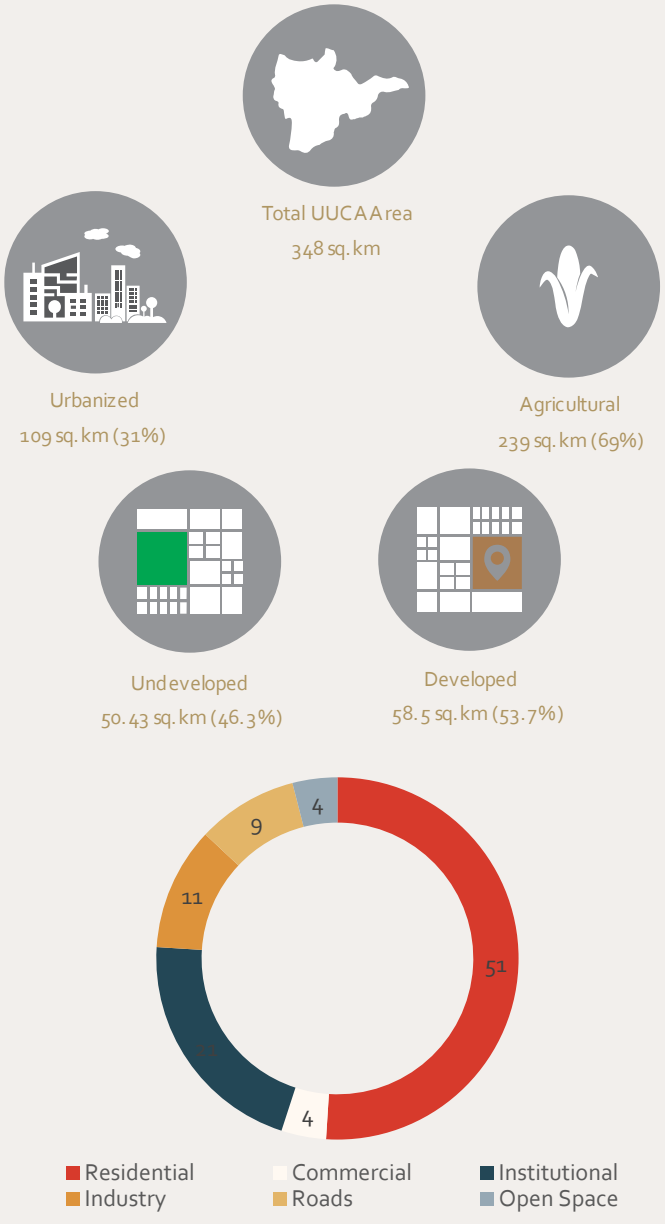


Source: Udaipur LCMP 2013

LAND-USE & DENSITY

As mentioned above, Udaipur, a traditionally compact city, is rapidly expanding along the highways- NH-8, in the southern direction towards Ahmedabad, and NH-76 in the eastern direction towards Chittorgarh. Udaipur is surrounded by hillocks and lakes towards the west, restricting rapid expansion and creating conflicts with heritage and natural preservation whenever expanded. Udaipur's urbanized areas have a high population density of 257 person per hectare (PPH), as 75% population resides within the municipal area (19% of the total UUCA). Within the UMC, the walled city has the highest population density, which gradually drops as one approaches the hinterland. Due to predominance of agricultural land and vacant plots outside the UMC, the population density drops to 61 PPH. Walled city and its immediate surroundings are predominantly mixed use, allowing 56% of the non-work trips to be by walk. The land-use becomes largely residential moving towards the periphery, and industrial towards the eastern ends of UUCA. Hence majority work trips from the city are towards the industrial area, around 15 km from the city centre.

Figure 4 UUCA's Land Profile



Source: Udaipur LCMP 2013

In 2013, 57% of the total area was urbanised. 53% of this area comprises residential and mixed-use areas. Almost 11% and 9% of this urbanised area falls under industries

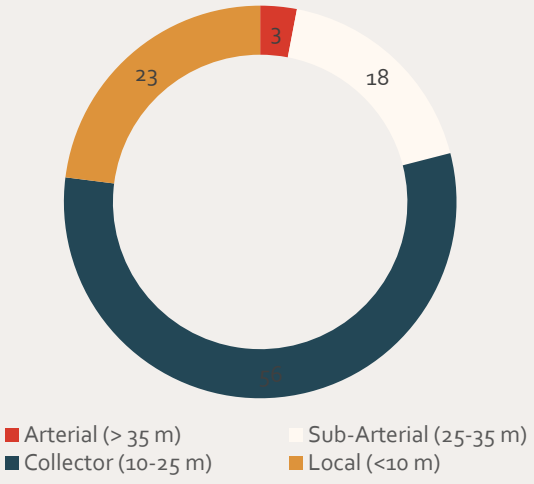
and transport respectively. 4% of the urbanised area is classified as recreational, indicating adequate open/ public spaces, unlike most Indian cities.

MOTORIZATION & ROAD INFRASTRUCTURE

Udaipur's compact built-form is supported by a dense ring-radial road network. However, its rapid expansion along the highways, NH-8 and NH-76, contains predominantly low-density developments. This rapid urbanization in Udaipur has led to a steep increase in motorization. The number of registered vehicles increased by 52% in just a span of 6-7 years, with more than 90% of them being private vehicles. Udaipur has 5,80,271 registered vehicles with a compound annual growth rate (CAGR) of 11.3%. Traffic varies from 2,838 passenger car units (PCUs) to 9,495 PCUs at various mid-blocks in the city. 2Ws make the largest share (78%) of vehicle composition followed by cars (13%), both heavily dependent on non-renewable fuels.

580,271 **11.3% CAGR**

Figure 5 Road Hierarchy

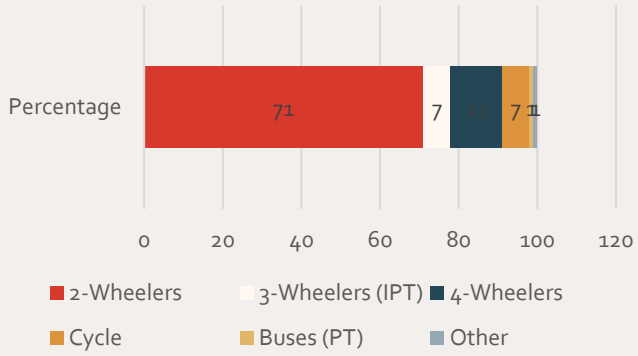


Udaipur sits amidst a dense road network including, 5 State & National Highways that cut through the city fabric. Majority densification is along National Highways NH 8 and NH 76.

Source: Udaipur LCMP 2013

Udaipur has a total of 1011.69 million annual motorized vehicle kilometres travelled (VKT) (1.49% annual growth rate for 2016). Rapid motorisation has resulted in the rise of CO_2 emissions, with higher Respirable Suspended

Figure 6 Traffic Composition

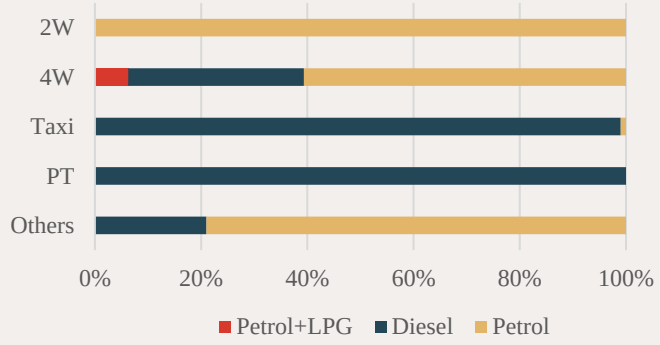


Source: Udaipur LCMP 2013

Private vehicles make 85% of the traffic composition, leading to a higher motorized VKT. Udaipur has a total of 1011.69 million motorized VKT with a 1.49% annual growth rate.

Particulate Matter (RSPM) and Suspended Particulate Matter (SPM) percentages than the norms set by the Central Pollution Control Board (CPCB). In the base year, the city experiences about 4500 tons of PM10 and 17 million tons of carbon di-oxide (CO_2) annually. Increased vehicle motorization adds pressure on the existing road infrastructure; All 7 underpasses in the city are underused due to poor-maintenance and narrow openings. Multiple authorities manage roads and highways in Udaipur; most arterials/ highways are managed by Public Works Department (PWD) and the remaining road network is managed by Urban Improvement Trust (UIT) and Municipal Council.

Figure 7 Fuel Composition by Mode



Source: Udaipur LCMP 2013

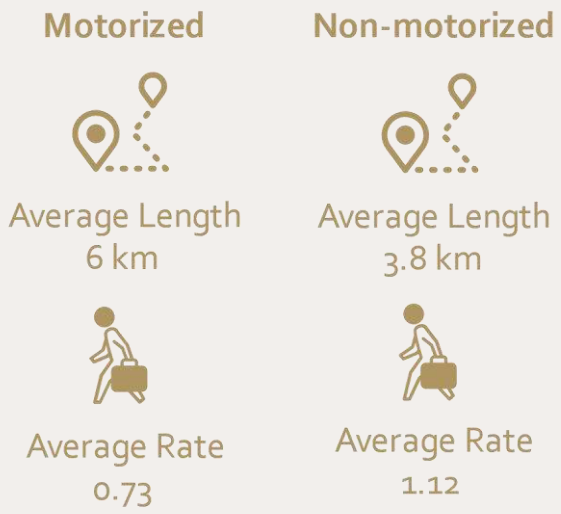
Personal motorized vehicles make about 85% of the vehicle composition, while public transport (PT) and intermediate public transport (IPT) make about 9% of the share. 2-wheelers also contribute to more than 80% of the annual vehicle kilometres travelled (VKT) in the city, followed by four-wheelers (14%) and IPT (three-

wheelers/cabs) (3%) (Figure 6). 39% streets have on-street parking, adding to congestion on already crowded streets. This haphazard street parking in major markets reduces the traffic carrying capacity of roads.

NMT NETWORK & INFRASTRUCTURE

Udaipur has a high pedestrian volume, an average of 2,600 people at mid-blocks and about 18,000 people at intersections daily. At the busiest pedestrian intersection, the pedestrian footfall in the city gets as high as 53,338. 48% of total trips in Udaipur are by walking (**Error! Reference source not found.**). Yet p edestrian/ cycling infrastructure including footpaths, cycle lanes/ tracks, Non-Motorised Transport (NMT) crossings, street lighting is poorly designed, inadequate, or completely absent. Only than 4% of roads have footpaths and less than 1% of the roads have cycling infrastructure in the city (Figure 9). This insufficient and ill-maintained infrastructure along with high conflict between motorized vehicles and NMT users leads to unsafe street environments.

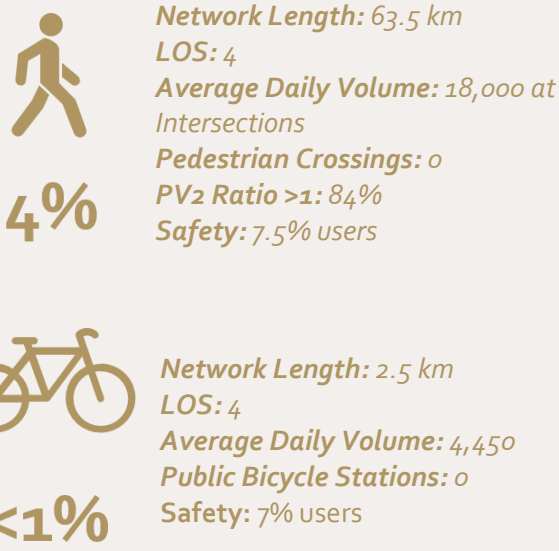
Figure 8 Average Trip Length & Rate by Modes



LIG population is largely dependent on NMT modes to access economic opportunities. Out of all user groups, ***LIG females have the highest dependence on walking****. Walking is also the most used mode for "other" purpose trips, resulting in 80% of all intra-zonal (short trips taken within the zone).*

The Level of Service (LoS) for NMT facilities in Udaipur are rated as 4.0. This indicates that lack of infrastructure demotes the use of cycling in a city that has a huge tourist and student population. Walking is a predominant mode of commute for the low-income group (LIG) with a much higher average trip lengths than that of middle-income group (MIG) and high-income group (HIG). An overwhelming majority of female trips (66%) are by walk as compared to male trips (35%). Data on trip rate indicates that LIG females have the highest dependence on walking than any other group. Walking is also the most preferred mode of commute across all groups for intrazonal trips (80% intrazonal trips are by walk), resulting in an average trip length (ATL) of 2.5 km (the lowest amongst all modes) and the average trip time (ATT) of 28 minutes (the highest amongst all modes).

Figure 9 NMT Infrastructure Highlights



The mode share of cycle is 2%. Out of all the trips on cycle, 72% of them are made by LIG. 56% of the total trips on cycle are to work. Average daily cycle counts are higher for the city core (2,830) than the industrial areas (1,724). The ATL for cycles (5.1 km) is like other motorised modes like 2-wheelers (5.2 km) and higher than IPT (4.5 km), with an ATT of 18.66 minutes/ trip. Although cycling would be the most suitable mode for intrazonal trips (given the trip lengths), only 2% of these trips are made on cycle.

PT/IPT NETWORK AND INFRASTRUCTURE

Udaipur LCMP states that although Autos and Shared Autos are a part of the city's Intermediate Public Transport network, they operate on fixed routes and regulated rates mechanisms, serving as Public Transport (PT). Operating on 27 routes, around 40% of the total IPT fleet is older than 10 years and hence, less fuel efficient. Lately, shared rickshaws haven't been operating on designated routes, causing chaos. As of 2012, the IPT fleet consists of 6,313 auto-rickshaws and 2,637 tempos. Also, 82 auto-rickshaw stands are present

in the city, along with additional 18 E-Rickshaws; both planned to be increased.

Figure 10 PT & IPT Infrastructure Highlights

Network Length: *48.5 km*
UMC Network Coverage: *49.9%*
Fleet: *6,313 auto-rickshaws; 2,637 tempos*
No. of Routes: *24*
10% ***Ridership/ Day:*** *90,420 in Autos; 122,041 in Tempos*
LOS: *N/A*

Network Length: *89 km*
UMC Network Coverage: *37.5%*
Fleet: *13*
No. of Routes: *5*
20% ***Ridership/ Day:*** *4,800*
LOS: *4.0*

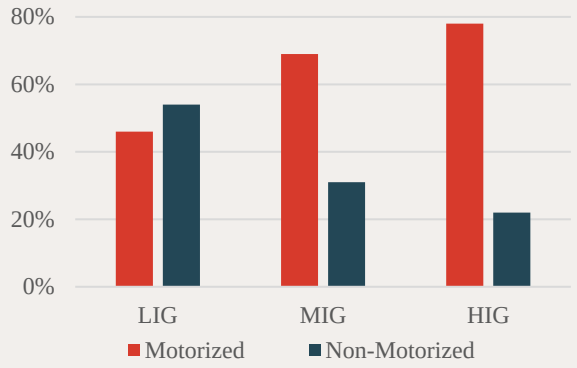
25% of total IPT trips and 33% of total 2-wheeler trips have a trip length of 5 km or more. These trips should ideally be on buses. But due to lack of a robust PT network, ***only 2% of the total trips are taken by Bus.***

11% of the total trips in Udaipur are by IPT, out of which 56% are on Shared Autos/ Tempos and 44% on Autos (Figure 3, calculated using mode share by trip purpose data). Out of the total trips on IPT, 53% are taken to access education opportunities. IPT is the second most preferred mode of commute for LIG (consists of 17% of total the LIG trips) (calculated using data on mode share by social group data). This share declines from LIG to HIG. 14% female trips are by IPT as compared to 10% male trips. Owing to its fixed routes, IPT has the lowest ATL (4.5 km) among motorized vehicles and yet has the highest ATT (14.30 min/trip). It has the lowest travel speed (18 km/hr) among other motorised vehicles.

City Buses operate on 5 routes with 89 km of total route length and an average vehicle occupancy of 38. City buses have a fleet of 13 buses, an average route length of 18 km and on average, 27 bus stops per route (Figure 10). People prefer Autos and Shared Rickshaws over mini-buses, making it less economically viable for mini-bus operators to function within the city. Hence, despite being permitted, the mini-buses don't operate within the city limits. Instead, they connect the city to the surrounding villages within the UUCA.

25% of total IPT trips and 33% of total 2-wheeler trips have a trip length of 5 km or more. These trips should

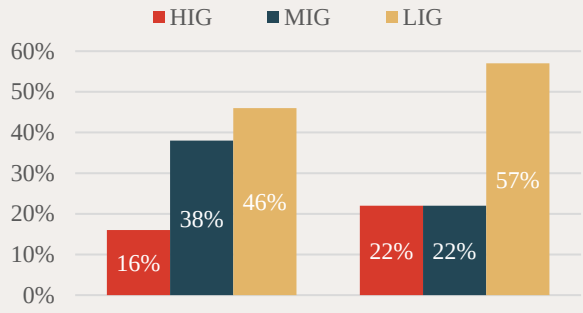
Figure 11 Mode Share by Income Groups



Source: Udaipur LCMP 2013

ideally be on buses. But due to lack of a robust PT network, only 2% of the total trips are by Bus. Buses have the longest ATL (8.47 Km) and a higher ATT (14 min/trip) as compared to other motorized modes (with ATL 5 Km and ATT 9 min/trip). Since the majority of trips on city buses is along the NH-76 (Chittorgarh Road) connecting the city to the industries, educational areas and Udaipur Airport, no intrazonal trips are made on buses. Out of all the trips taken by PT, 57% were taken by LIG. Within the PT services, LIG is largely dependent on mini-buses (10% mode share) than City buses (3% mode share). While MIG and HIG use the City Bus (4% mode share) more than the Mini-Bus (1% mode share). Thus, the poor largely depend on mini buses for connectivity between urban and rural areas. The average cost per trip on PT is Rs. 5. This indicates that the reason for a lower PT ridership use has to do with network and connectivity, instead of affordability.

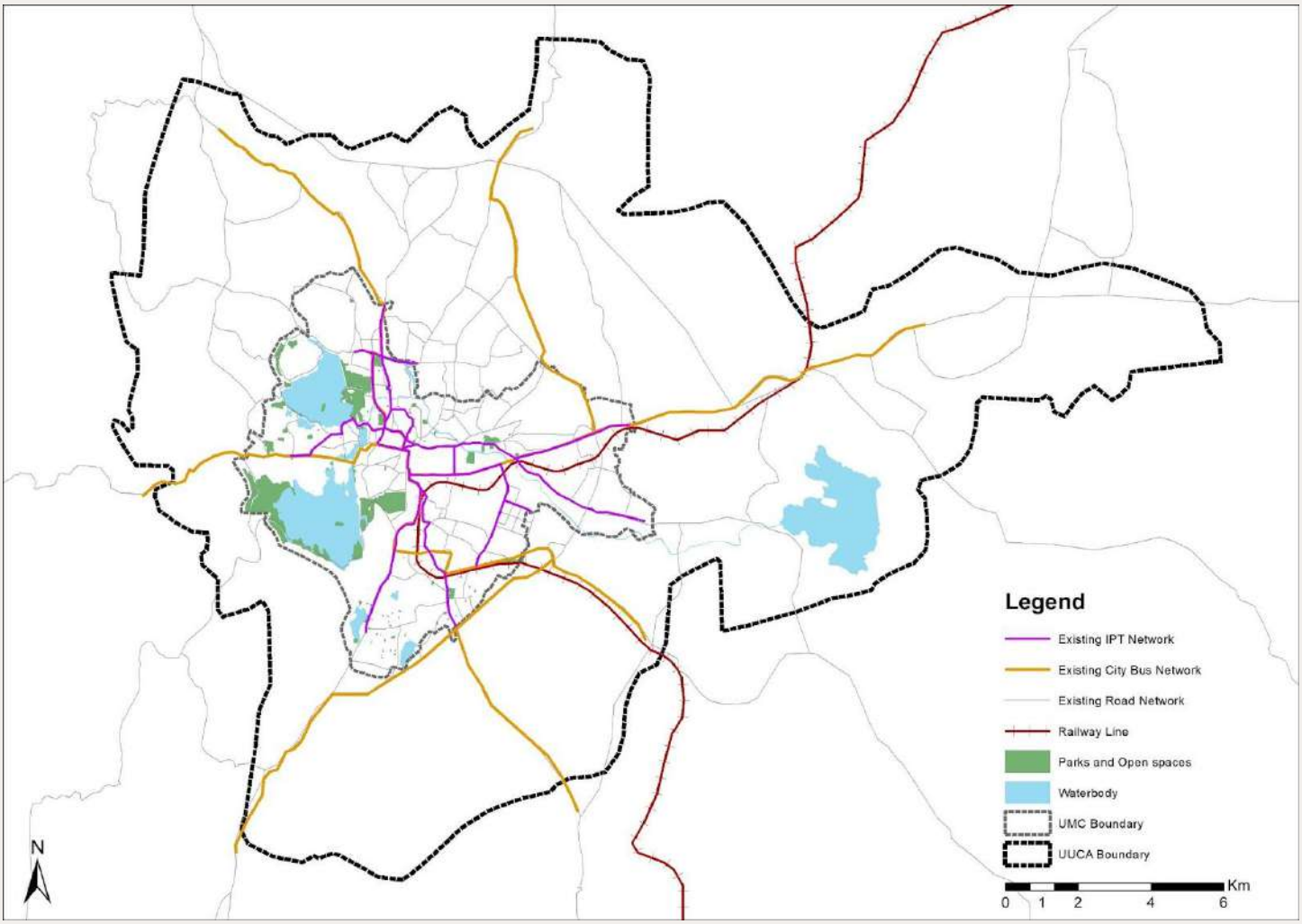
Figure 12 PT & IPT Mode Share by Income Groups



Source: Udaipur LCMP 2013

Udaipur's PT & IPT mode share declines with increase in income, indicating LIG are captive users.

Map 2 IPT and City Bus Network in UUCA Area

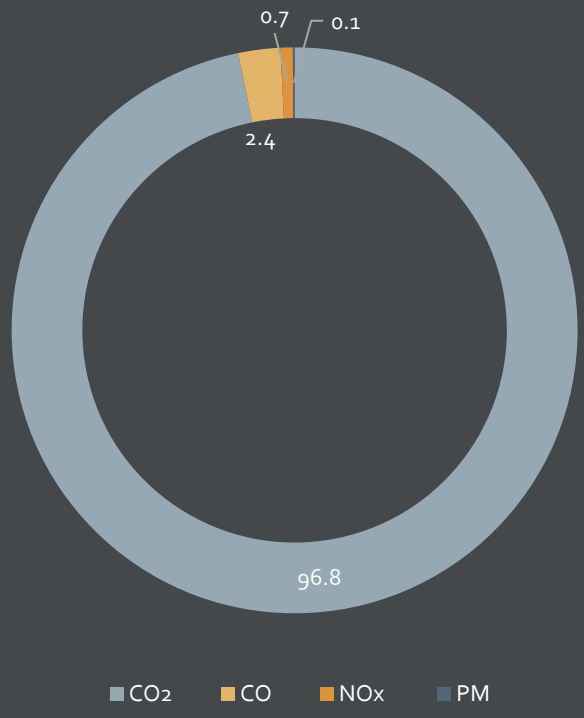


GHG EMISSIONS INVENTORY (2016)

Adopting a bottom-up approach and the ASIF methodology, a Greenhouse Gas (GHG) emission inventory was calculated from the on-road vehicle exhaust emissions in the city for the base year (2016). ASIF refers to the product of activity (A), modal share (S), energy intensity (I) and fuel/ carbon intensity (F). Data was used from the 2013 Udaipur LCMP (projected for 2016), Regional Transport Office (RTO), Emission Factor development for Indian Vehicles, Automotive Research Association of India (ARAI) Pune Report 2008, CPCB and Toolkit for Comprehensive Mobility Plan (CMP) Revised 2014 and Surat CMP (2016). Using this data, the total motorized passenger demand is calculated as the product of the population and the average trip rate, which is then derived for each mode using the mode share. Further, the number of vehicles is calculated by dividing the motorised passenger demand by the average vehicle occupancy of mode. A detailed methodology is mentioned in Annexure 1.

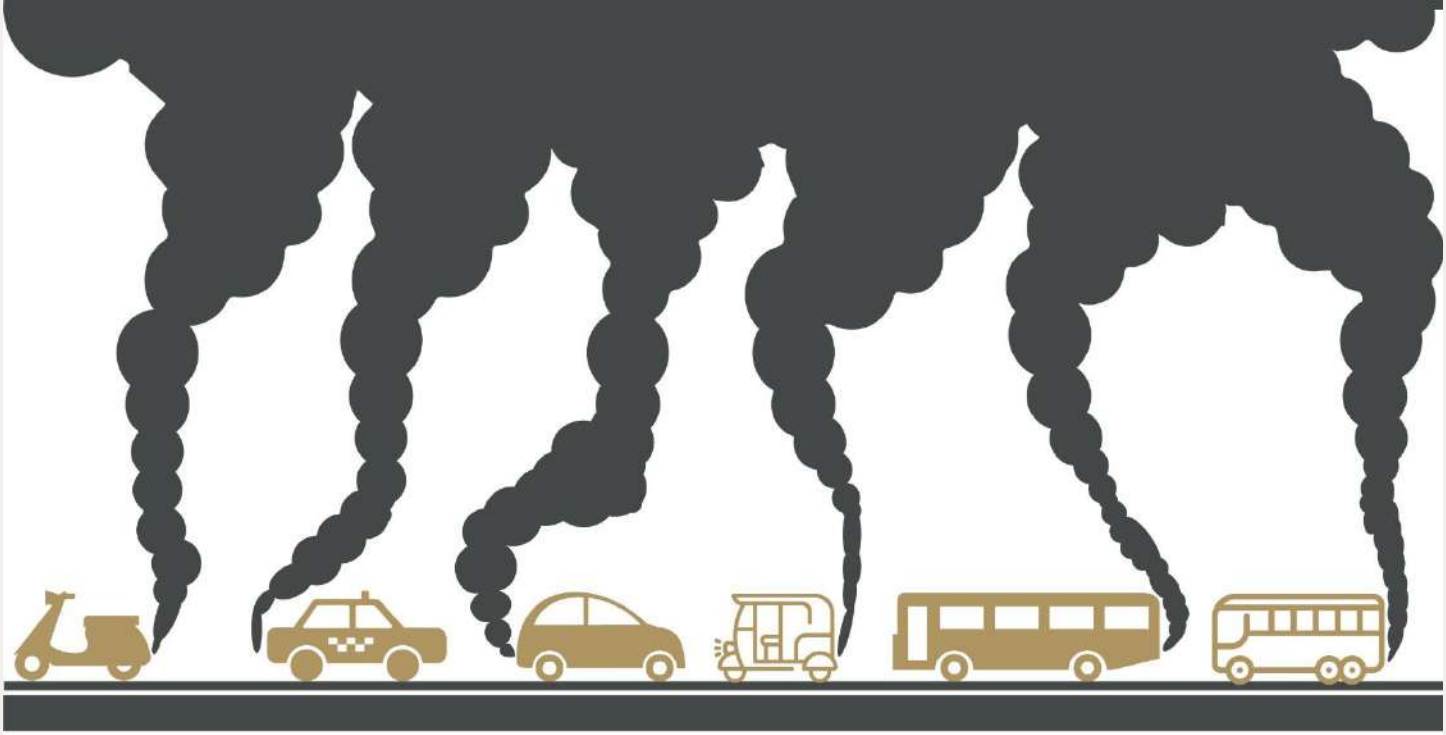
The fundamental equation for calculating these emissions is based on the activity level, which for the transport sector is equivalent of "Emissions = Number of Vehicles * Vehicle kilometres travelled (km) * Emission Factor (gm/km)". The emissions analysis is carried out for the four pollutants – particulate matters (PM), nitrogen oxides (NOx), CO and CO_2. The vehicle types include four-wheelers (4Ws - passenger cars, jeeps, and vans), two-wheelers (2Ws - motorcycles, scooters, and mopeds), three-wheelers (3Ws - scooter rickshaws with 3 to 7 seats), buses (intra- and inter-city operations) and tempos (passenger and goods vehicles). The calculations do not include non-road transport, such as metro rail or long-distance railways. In terms of carbon dioxide emissions, it is observed that two-wheelers contribute to the highest emissions (64.3%), followed by four-wheelers/ taxies that contribute to about 15% emissions (Figure 15).

Emissions from UUCA's Passenger Transport (2016)



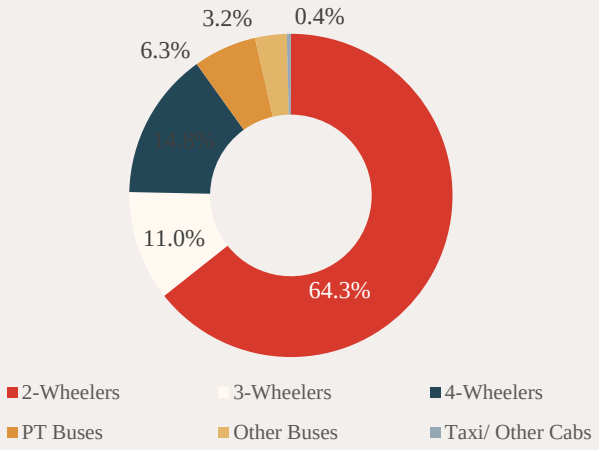
26703 Tons
Total GHG Emissions

34.50 kg
Per Capita GHG Emissions



64.46%	0.40%	14.42%	11.17%	6.40%	3.14%
2-Wheelers	Taxis & Cabs	4-Wheelers	3-Wheelers	Buses (PT)	Other Buses

Figure 13 CO_2 Emissions in Udaipur (tons/ year)

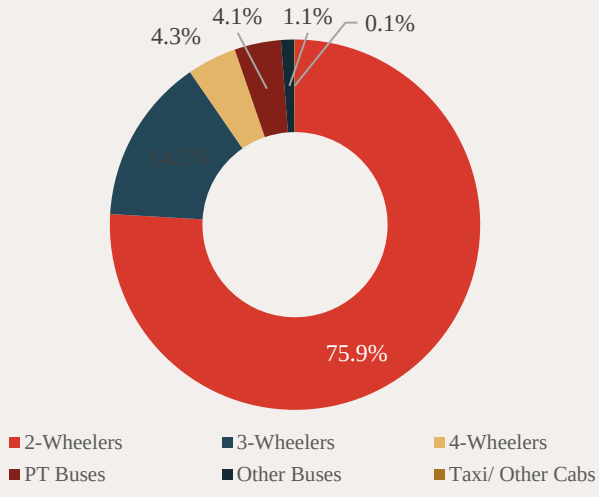


Source: Calculated using data from Udaipur LCMP 2013

In terms of carbon dioxide emissions, it is observed that two-wheelers contribute to the highest emissions (64.3%), followed by four-wheelers/ taxies that contribute to about 15% emissions.

Mini buses travelling from the city to nearby peri-urban settlements and intra-city buses generate about 9.5% CO_2, whereas three-wheelers and tempos contribute to about 11% emissions annually. More than 80% of CO emissions in the city are generated by two-wheelers (76%), four-wheelers and taxis (4.4%). Buses contribute to about 5.6% and auto-rickshaws and tempos generate 14.5% CO emissions annually (Figure 13).

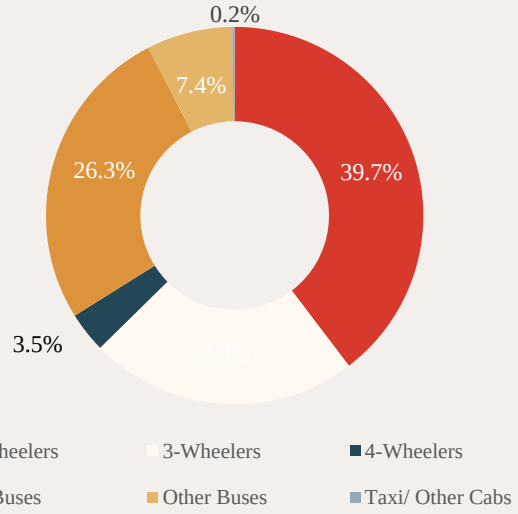
Figure 14: CO Emissions in Udaipur (tons/ year)



Source: Calculated using data from Udaipur LCMP 2013

More than 80% of carbon monoxide emissions in the city are generated by two-wheelers (76%), four-wheelers and taxis (4.4%).

Figure 15: NO_x Emissions in Udaipur (tons/ year)



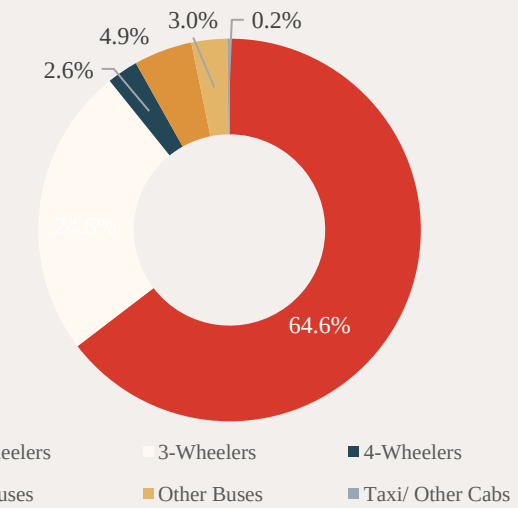
Source: Calculated using data from Udaipur LCMP 2013

40% emissions are generated by two-wheelers and 33.7% emissions are generated by minibuses and city buses.

In terms of nitrous oxides, close to 40% emissions are generated by two-wheelers and 3.5% by four-wheelers/ taxis. 33.7% emissions are generated by minibuses and city buses, followed by auto-rickshaws that contribute to 23% NOx emissions annually (Figure 14).

Whereas, in case of particulate matter, close to two-third of PM emitted by the transportation sector in the city is by two-wheelers (64.6%), followed by three-

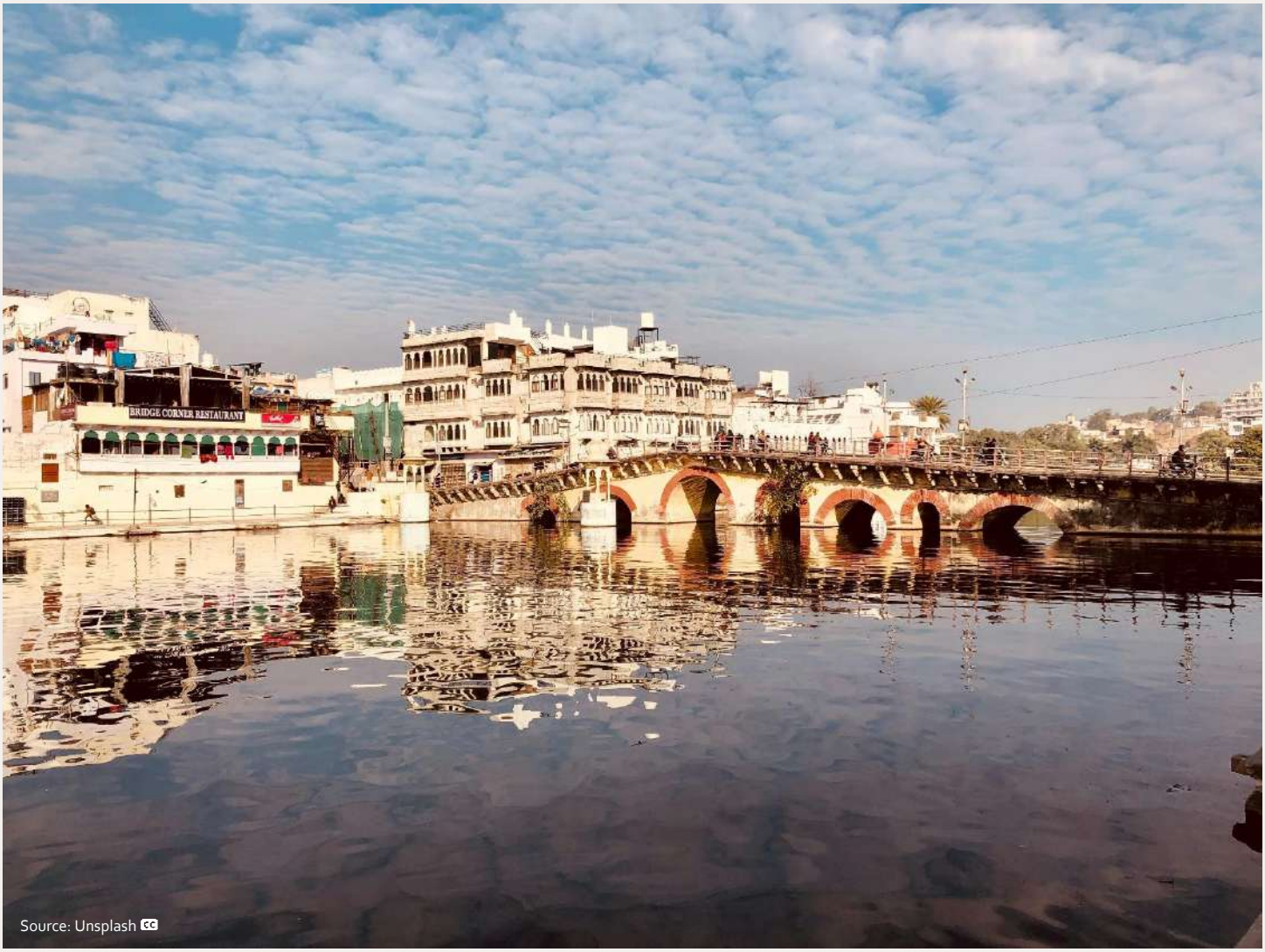
Figure 16: PM Emissions in Udaipur (tons/ year)



Source: Calculated using data from Udaipur LCMP 2013

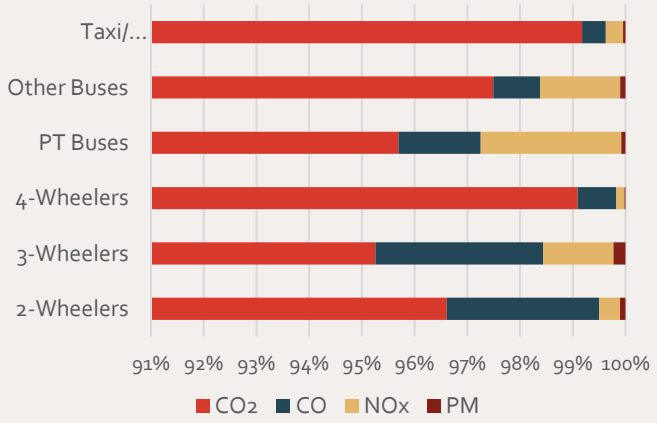
2/3rd of Particulate Matter emitted by the transportation sector in the city is by two-wheelers and a quarter is generated by the three-wheelers.

Picture 3 Pedestrian and 2-Wheeler Bridge in Udaipur



wheelers (24.6%), buses (8%) and four-wheelers/ taxis (2.8%) (Figure 16 & 17). These emissions when disaggregated for each mode, it is also observed that CO2 emissions contribute to an average of 97.2% share annually (Table 1).

Figure 17 GHG Emissions by transportation sector in Udaipur (tons/year)



Source: Calculated using data from Udaipur LCMP 2013

Table 1 GHG Emissions in 2016 by transportation sector in Udaipur (tons/year)

Mode Type	CO_2	CO	NO_x	PM	Total Modal Emissions
2-Wheelers	16629.72	497.26	68.6	17.93	17213.51
3-Wheelers	2842.15	94.92	39.76	6.83	2983.66
4-Wheelers	3816.2	28.27	5.99	0.73	3851.19
PT Buses	1634.23	26.6	45.56	1.37	1707.76
Other Buses	818.62	7.48	12.74	0.84	839.68
Taxi/ Other Cabs	105.97	0.48	0.35	0.05	106.85
Total	**25846.89**	**655.01**	**173.00**	**27.75**	**26702.65**

Source: Calculated in-house referring to vehicle fleet and travel data from Udaipur LCMP, RTO and emission factor data from Emission Factor development for Indian Vehicles, ARAI Pune Report 2008, CPCB and Toolkit for Comprehensive Mobility Plan (CMP) Revised 2014 and Surat CMP (2016)

TRANSPORT-SDG INTERACTIONS: EXISTING SITUATION

The interactions mentioned below are a result of the LCMP's critical assessment and the fieldwork. The primary surveys and semi-structured interviews were conducted in October 2020 for Udaipur city. Apart from the household (HH) surveys and semi structured interviews for tourists, local shop owners and vendors, transport user surveys (across seven transport modes) with a sample size of 405 was conducted. These modes include – non motorized users (pedestrians and cyclists), PT users (City Bus), IPT users (shared & personal auto), private vehicle users (two-wheelers and four-wheelers) and taxi users (Annexure 2: Details of Udaipur fieldwork conducted in October 2020). In this section, each component of Udaipur's urban transport system is tabulated across the six selected Sustainable Development Goals (SDGs – 1, 3, 5, 8, 11 and 13). The interactions are categorized as positive (green), negative (red) and mixed (yellow). SDG1 is No Poverty, SDG3 is Good Health and Well-being, SDG5 is Gender Equality, SDG8 is Economic Growth and Decent Work, SDG11 is Safe, Resilient and Sustainable Cities and SDG13 is Climate Action.

WITH LAND-USE & DENSITY

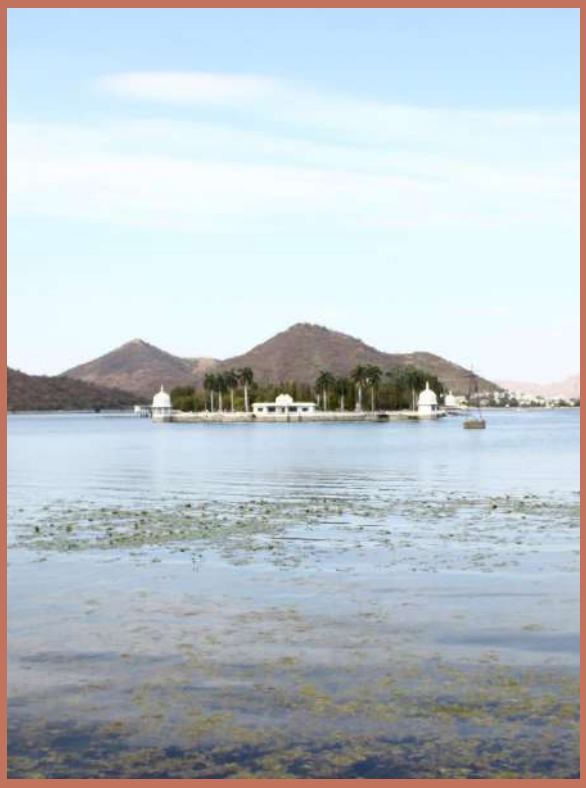
As mentioned in the above section, Udaipur is compact with high densities in the core old city, rapidly expanding along major roads and highways. Conceptually, higher densities are linked with better accessibility to public transport, which in turn improves economic outcomes. But due to the near non-existent city bus services, the vulnerable population in the city does not benefit from this density, causing negative interactions with SDG1 & SDG11.

Due to the presence of national and state highways passing through the core city, local sustainability challenges like (i) increased air and noise pollution (SDG 11 & 13), and (ii) road fatalities/ injuries from high conflict

The land-use and transport system foster a symbiotic relationship between UUCA's urban and peri-urban/ rural areas.

The walled city is Udaipur's commercial and tourist hub. The dense built-up in the walled city, its narrow streets and the high activity generation leads to congestion and restricted mobility. This puts the walled city area in high risk of fire accidents and loss related to it.

Picture 4: Degradation of water bodies around hotels in Udaipur



Source: Kanika Gounder

Intensified development along the lakes over the past two decades contributes to degrading water quality.

Parking lots around parks, gardens and water bodies used as dumping sites for solid waste and vehicles washed on lake banks by locals add to this degradation. Udaipur's increased urbanization and needs conflict with its natural & cultural heritage.

between passenger and freight movement (SDG 3), are faced by the residents. But having listed the negative interactions, it is also important to note that mixed and highly dense land-use results in several positive interactions like increased personal and road safety (SDG3), increased use of NMT and reduced congestion/ emissions (SDG13) due to short trips and distributed trip ends, reduced mental stress of driving and increased productivity of all (especially the informal workers) (SDG5, SDG8, & SDG13).

Also, UUCA's land-use and transport system fosters a symbiotic relationship between its urban and the peri-urban/ rural areas, as it benefits from the agriculture in the hinterland and the rural area benefits from the social infrastructure and commercial opportunities in the urban core (SDG11).

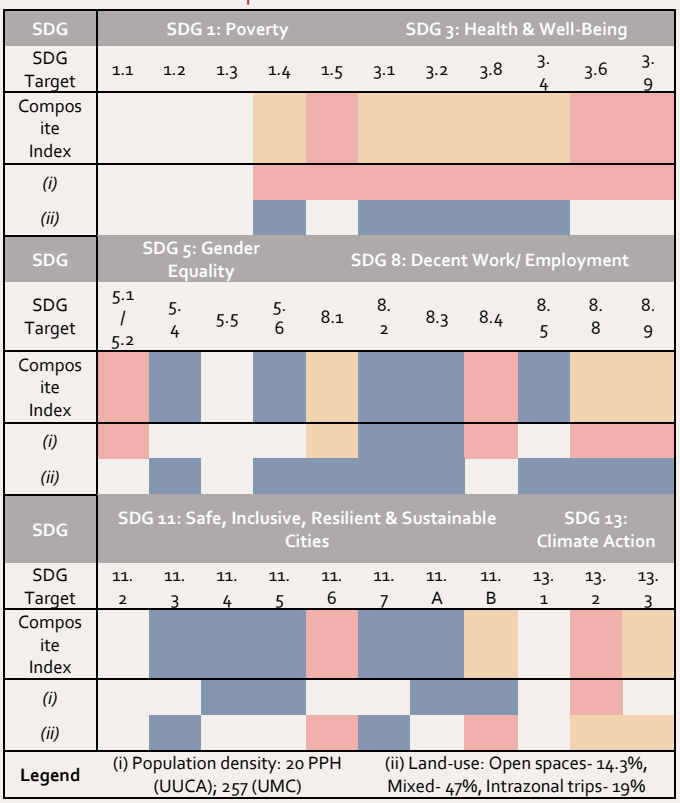
SDG Impacts: This category also generates multiple mixed interactions with the SDGs. Due to the increased congestion, the negative interactions include:

- Longer trip lengths from urban to peri-urban areas resulting in negative externalities like time poverty (SDG1 & SDG5)
- Increased health costs from pollution (air, water and noise), urban heat islands and short life-expectancy (SDG3).

But, mixed-use developments (like Udaipur's walled city area) foster positive interactions:

- Enables commerce enhancing economic growth (SDG 8).
- Allows vulnerable groups (like urban poor and women) to complete their long trips in less time, resulting in reduced time poverty. This also decreases the time they spend in unpaid work, increasing overall productivity, and personal safety (SDG1, SDG5 and SDG8).
- As the proportion of green and open space is linked to self-reported levels of physical health and mental health for all ages and socio-economic groups; Udaipur's wide-network of open and recreational spaces enable these co-benefits for all (SDG3).

Figure 18 Transport Systems with respect to Land Use & Density and SDG Interactions in Udaipur



WITH MOTORIZATION & ROAD INFRASTRUCTURE

Unplanned street networks and inequitable street design opens the way for vehicular traffic. As described in the above section, Udaipur city has grown with rapid motorization in the last decade. This increased motorization is adding pressure on the existing road infrastructure, along with adding to high levels of congestion and emissions (SDG11 & SDG13). The wide carriageway widths result in various negative externalities, especially for the vulnerable groups- (i) the increased congestion also contributes to time poverty for women, affecting their participation in the society (SDG5) (ii) higher risk of developing cardio-vascular/ respiratory diseases due to increased air pollutants exposure (SDG3), (iii) evictions, displacement and deepened poverty, reduced resilience of the among the vulnerable residing around/ on road and road projects (SDG1); (iv) increased congestion and related health issues like stress and anxiety for all from driving in such conditions.

Inadequate street infrastructure and poor design of pavements discourage the use of NMT modes, resulting in increased risk of road crash fatalities and injuries (SDG 3). Additionally, 39% of the roads constitute on-street

parking as encroachments, contributing to higher traffic levels.

Picture 5 Haphazard on-street parking in Udaipur

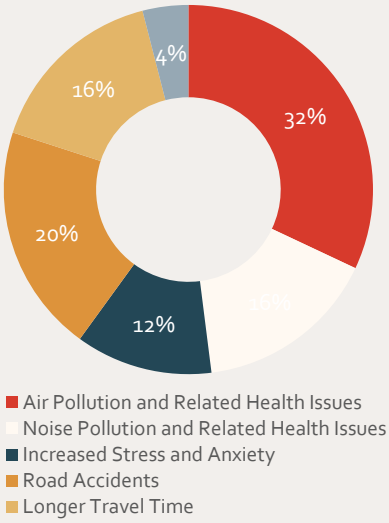
Source: Supporting Sustainable Mobility under Smart Cities Mission (ICLEI)

Table 2 Current and Desirable Household Vehicle Ownership in Udaipur

Currently	No. of	Would	No. of
Cycle	13 (9%)	Cycle	5 (6%)
Two-	53 (38%)	Two-	15 (18%)
Three-	11 (8%)	Three-	3 (4%)
Four-	59 (41%)	Four-	30 (36%)
Other	6 (4%)	E-vehicles	30 (36%)
Total	142	Total	83

Source: Primary Survey (October 2020)

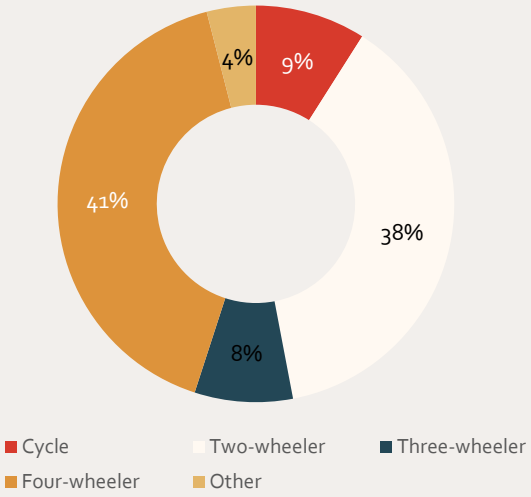
Figure 19: Households with exposure to negative externalities



Source: Primary Data, October 2020

Considering the tourist character for the city, it is filled with informal hawking and vending activities, especially in the core city area. These street vendors may conflict with vehicular and freight movement, and hence work in a risky and unregulated environment, which affects their mental and physical health. Also, due to these unregulated activities and traffic flow mismanagement issues, the productivity of workers is affected, violating their notion of a 'decent work environment' (SDG3 & SDG8).

Figure 20: Household Vehicle Ownership in Udaipur



Source: Primary Data, October 2020

Road space in Udaipur is highly contested with heterogeneous road users: motorized vehicle users, pedestrians, cyclists, street vendors and their clientele, private bus operators and their clientele, pavement dwellers, people engaged in street parking, etc. This causes severe congestion and conflict, leading to numerous trade-offs.

SDG Impacts: This category generates trade-offs with most SDGs. Overwhelmingly high share of personal vehicles registrations (more than 90%) and high VKT generates negative interactions with:

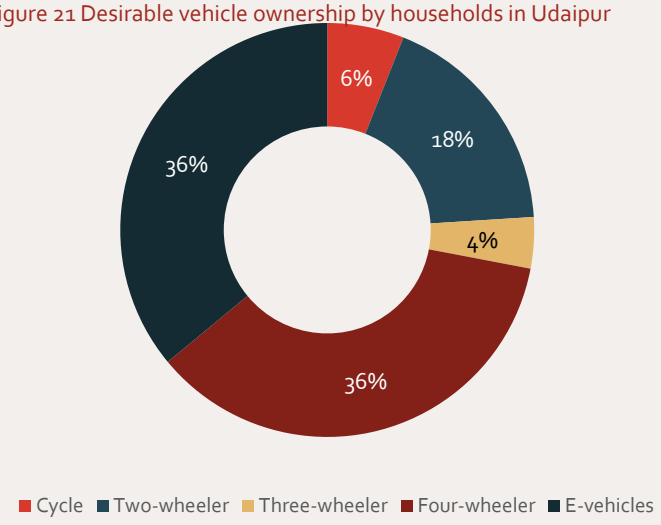
- Sustainable mobility for all (SDG11)
- Environmental conservation & emission reduction (SDG13)
- Safe access to employment opportunities and valued paid work under "decent work environment" (SDG1, SDG5 & SDG8).

Road Density 8.75 (km/km2)

~26% Streets with V/C Ratio > 1

Average speed at bottlenecks is reduced to 10 km/hr

Figure 21 Desirable vehicle ownership by households in Udaipur



Source: Primary Data, October 2020

"The roads in Udaipur are narrow, especially in the old city. With heavy traffic and no proper enforcement on breaking of traffic rules, the streets are quite congested." -FGD participant

Figure 22 Transport Systems with respect to Motorization/ Road Infrastructure and SDG Interactions in Udaipur

SDG	SDG 1: Poverty					SDG 3: Health & Well-Being					
SDG Target	1.1	1.2	1.3	1.4	1.5	3.1	3.2	3.8	3.4	3.6	3.9
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
(v)											
(vi)											

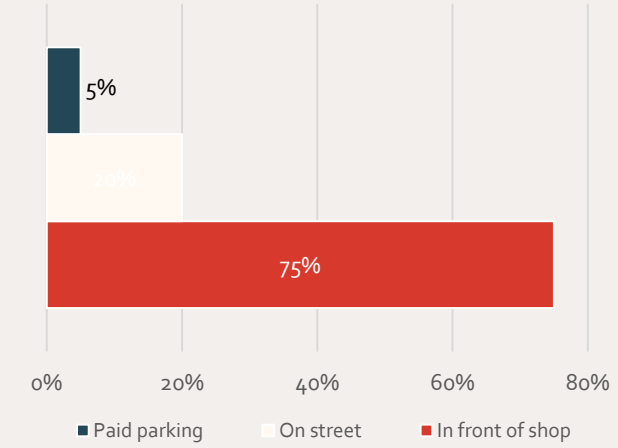
SDG	SDG 5: Gender Equality				SDG 8: Decent Work/ Employment						
SDG Target	5.1 / 5.2	5.4	5.5	5.6	8.1	8.2	8.3	8.4	8.5	8.8	8.9
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
(v)											
(vi)											

SDG	SDG 11: Safe, Inclusive, Resilient & Sustainable Cities								SDG 13: Climate Action		
SDG Target	11.2	11.3	11.4	11.5	11.6	11.7	11.A	11.B	13.1	13.2	13.3
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
(v)											
(vi)											

Legend

(i) Motorization Rate: 11.31%; VKT: 1011.69 million
(ii) 2-Wheelers mode share: 34%
(iii) 4-Wheelers mode share: 3%
(iv) 1 State and 3 National highway pass through Udaipur
(v) Congestion: 26% of roads have V/C Ratio >1
(vi) Illegal and unorganized parking: 39% streets have onstreet parking

Figure 23 Commercial parking by type in Udaipur



Source: Primary Data, October 2020

"Traffic management around Chaurahas (cross-roads) needs attention to minimize conflicting traffic."

WITH NMT NETWORK & INFRASTRUCTURE

Considering the high floating (tourist and student) population in the city, along with vulnerable groups (like women, poor, elderly, disabled, etc.), convenient and safe non-motorised travel is a necessity.

NMT infrastructure in Udaipur is inadequate or completely absent, which discourages NMT users on the street (Picture 5). The minimal footpaths and non-existent cycle tracks are also often encroached by vending and parking activities. Due to these, users are forced to walk or cycle on the carriageway sharing it with passenger and freight traffic, leading to an increased risk of fatalities and serious injuries due to road crashes (SDG3).

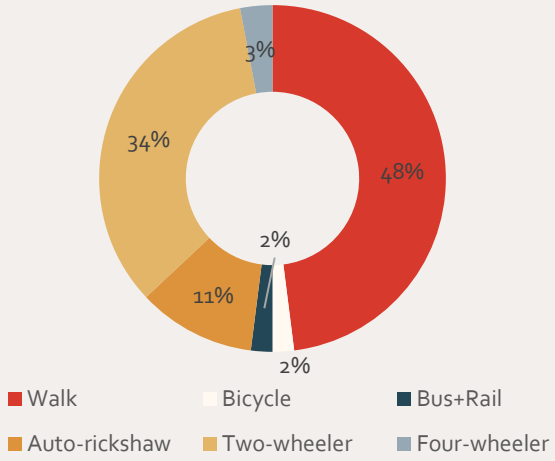
"The roads in the city are too narrow, with too many 2- & 4-wheelers. There are no zebra crossings, proper signalized cross-roads or even traffic sign boards. No one even cares to comply with traffic rules at all. This makes it difficult to move around comfortably" - Focus Group Discussion (FGD) Participant

Picture 6: Absence of NMT Infrastructure in Udaipur

Source: Primary survey, October 2020

Road crashes occur due to unsafe crossings, especially for NMT users. 50% of all fatalities in the city include pedestrians and cyclists. This poorly maintained and absent NMT infrastructure also increases women's fear of violence and curbs their mobility (SDG5). Only 7.5% pedestrians and 7% cyclists in the city ranked the streets as safe. Udaipur has only 2% of its total trips on cycle, versus the national average of 20% for cities with 5-10 lakhs population (as per MoUD 2006 Report). Absence of safe/ integrated transport planning (ex. last-mile connectivity, bicycle parking facilities, unaffordable and inconvenient PT) discourages an easy transition from NMT to PT, creating captive NMT users (SDG 11). Additionally, the ATL for cycles in Udaipur is more than 5 km, a considerably higher trip length on cycle. Considering the vulnerable groups (women, poor, migrants/ laborers, etc.) who are dependent on NMT, they face constrained access to opportunities and greater time poverty (SDG5 & SDG11). Hence, the current infrastructure poses a threat to the 'decent work' clause, as these areas lack quality footpaths, street lighting, signalized junctions, traffic monitoring, etc. (SDG8). The fieldwork also suggests that 27% pedestrians and 21% cyclists surveyed miss out on work or education opportunities due to lack of transportation options.

Figure 24: Share of road users involved in accidents/ road crashes in Udaipur



Source: Primary survey, October 2020

"There is a great need to promote NMT in Udaipur. Currently the city has no sidewalks... maybe, in few parts of the city... but those too are quite narrow. Hence, there's a crucial need to provide safe pedestrian infrastructure, especially to promote and preserve the cultural heritage of Udaipur." - FGD

SDG Impacts: The NMT infrastructure conditions create inaccessible streets for most users (other than personal vehicle users), leading to negative interactions:

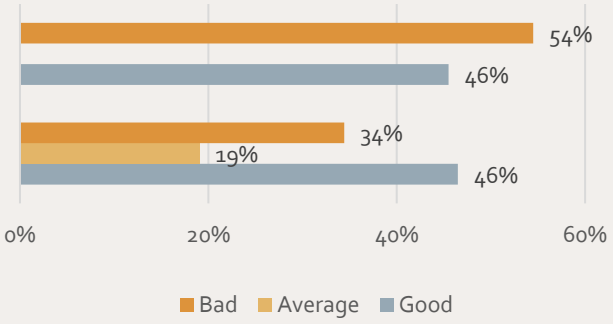
- Curbed access to employment or devaluation of paid work (SDG 8)

- Compromised personal and sexual safety (SDG 3 & 5)
- A distorted mode mix and unequal distribution of road space in Udaipur (SDG 11).
- Also, with an increase in income, the captive NMT users are more likely to shift to motorized transport for first-last mile or whole trips, giving rise to trade-offs like increasing GHG emissions and related negative impacts (SDG 13).

Picture 7: Unsafe roads for pedestrians in Udaipur

Source: Primary survey, October 2020

Figure 25: Users' Satisfaction on using NMT Infrastructure



Source: Primary survey, October 2020

Fieldwork indicates 22% of the pedestrians find the infrastructure discontinuous & disruptive, and 38% reported insufficient and uncomfortable footpaths, needing drastic improvements. In terms of cyclists, 98% users mentioned that they cycle on the carriageway, 44% reported that cycling is uncomfortable, and infrastructure is insufficient.

The NMT mode share (half the trips) in the city (Figure 3) also fosters a positive interaction:

- As it leads to higher levels of physical activity, often linked to health benefits like reduced risk of diabetes, premature death from obesity and other non-communicable diseases (SDG3).

Figure 26 Transport Systems with respect to NMT Network & Infrastructure and SDG Interactions in Udaipur (2016)

SDG	SDG 1: Poverty								SDG 3: Health & Well-Being		
SDG Target	1.1	1.2	1.3	1.4	1.5	3.1	3.2	3.8	3.4	3.6	3.9
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
SDG	**SDG 5: Gender Equality**				**SDG 8: Decent Work/ Employment**						
SDG Target	5.1 / 5.2	5.4	5.5	5.6	8.1	8.2	8.3	8.4	8.5	8.8	8.9
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
SDG	**SDG 11: Safe, Inclusive, Resilient & Sustainable Cities**								**SDG 13: Climate Action**		
SDG Target	11.2	11.3	11.4	11.5	11.6	11.7	11.A	11.B	13.1	13.2	13.3
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											

Legend

(i) Inadequate pedestrian infra (96% streets have no footpath)

(ii) No cycling infrastructure

(iii) NMT mode share: 48% walking; 2% cycling)

(iv) Safety: Average speed of 38 km/ hr; only 7% pedestrians/cyclists feel safe

WITH PARA TRANSIT & PUBLIC TRANSPORT

IPT NETWORK & INFRASTRUCTURE

According to MoUD, the average mode share on IPT for cities with population lying between 5-10 lakhs is 3%. For Udaipur, this share is much higher (11%) than the Indian standard showing dependence on IPT for personal and shared mobility, which acts as the main public transport system in the city. But, due to the lack of fare structure revision, route fixation and fair implementation, mode shares in the city have shifted to personal motorised vehicle use (SDG11). Assuming a single driver per fleet, IPT roughly provides employment to about 9,000 people in Udaipur. But most IPT drivers are untrained and engage in rash driving (SDG8 & SDG3).

Figure 27 Average Mode Share Comparison

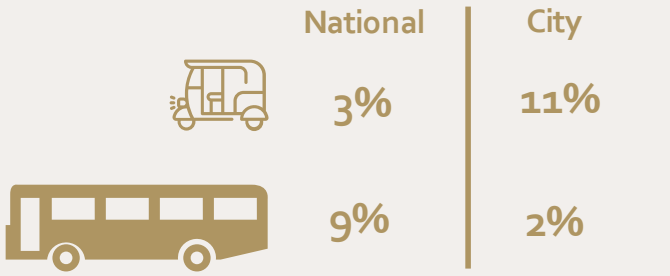
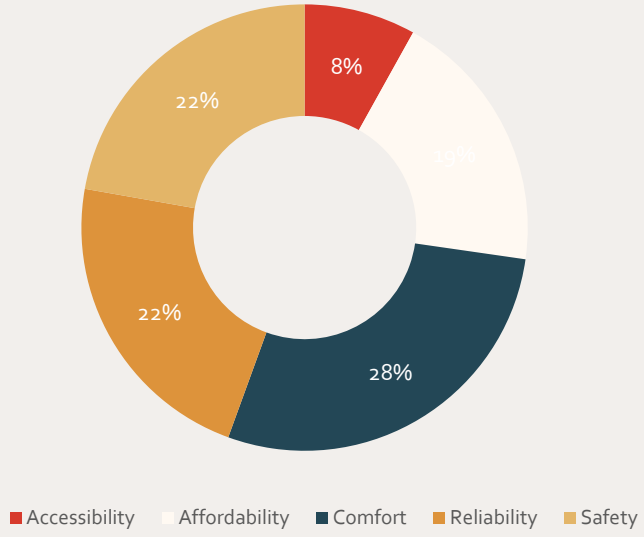


Figure 28 Reasons for choosing IPT



Source: Primary survey, October 2020

"The state of public transport in Udaipur is very weak! The bus fleet and frequency are low... there are only 15-16 buses, largely run by private operators. The municipality hardly runs 3-4 buses" - FGD Participant

Women are at higher risk of being victims of crime and violence, and are also known to forgo an opportunity to work outside their neighbourhoods if they perceive transport fares and services to be expensive and unreliable. They also tend to chain their trips to markets, schools, etc. to complete household responsibilities. Hence, it is essential that they are easily accessible (SDG5).

Picture 8: Types of IPT with old fleets in Udaipur

Source: Low Carbon IPT Action Plan, CapaCITIES

SDG Impacts: The above-mentioned situations generate many negative interactions with SDGs:

- The lack of fair revision, management, and gender bias in among drivers, leads to users over-paying for the trip and feeling unsafe (SDG 1, SDG5 & SDG11).
- Auto-rickshaws operate with old fleets, generating higher levels of emission and air pollution (SDG11 & SDG13).
- Occupational hazard for many IPT drivers involves negative externalities of air and noise pollution and other health concerns; they also face headache and stress, back pain, allergic problems, and general stiffness as a result of continuously sitting on the driving seat. 11% of

all accidents consisted of IPT users in the city; (SDG3 & SDG8).

The positive interactions include:

- Employment generation in the IPT sector (SDG 1 & SDG8)
- Introduction of electric rickshaws in the existing fleet contributes to lower air pollution and GHG emissions (SDG3 and SDG13).

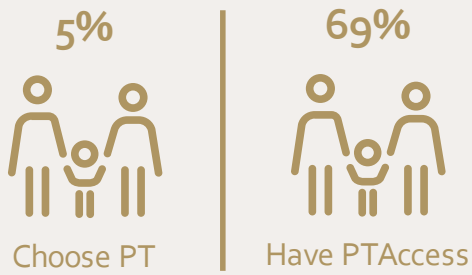
PT NETWORK & INFRASTRUCTURE

According to MoUD, the average mode share on PT for cities with population lying between 5-10 lakhs is 9%. In Udaipur, the PT mode share is negligible with only 2% of the total trips on buses. 80% area in the UUCA lacks access to the bus network currently. Use of city buses for intra city trips is not preferred by the urban poor of the city. On an average, bus trips are longer, covering about 9 km. This suggests that users prefer buses for longer distances as compared to other modes, consequently emitting less carbon and GHG emissions (SDG3 & SDG13). But the poor have a higher preference for mini-buses that connect the core areas to the peri-urban and rural areas (SDG1 & SDG11).

Picture 9 City buses in the UUCA area

Source: Udaipur times (September 2016)

Figure 29 HH choosing PT vs. HH within 10-minute walking distance of PT



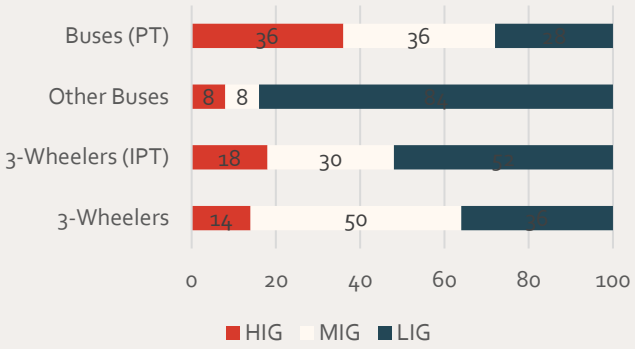
The fieldwork data indicates that all PT users fall under the LIG or poorer income brackets, as 27% households make less than Rs. 60,000 annually and the remaining 73% make between Rs. 60,000- 3,00,000, indicating captive users (SDG1). Majority of the PT users are Mini-Bus users (60%), and 80% respondents use PT to access economic opportunities, followed by groceries and daily essentials (13%) and healthcare (1%). When inquired about why they prefer PT, 28% users responded because PT is comfortable, 22% responded it is both safe and reliable, followed by 19% responded it to be affordable. Although, only 8% of the total respondents found it accessible.

Table 3 Reason for mode preference of modes other than city bus/ mini bus

Reasons for Mode Preference	Walk (1st Rank)	Personal Auto (2nd Rank)	Shared Auto (3rd Rank)
Affordable	2	2	3
Accessible	5	6	4
Comfortable	12	10	6
Safe	4	3	9
Reliable	7	10	9
Total	**29**	**28**	**27**

Source: Primary Survey (October 2020)

Figure 30 IPT/ PT Users by income groups



Source: Udaipur LCMP 2013

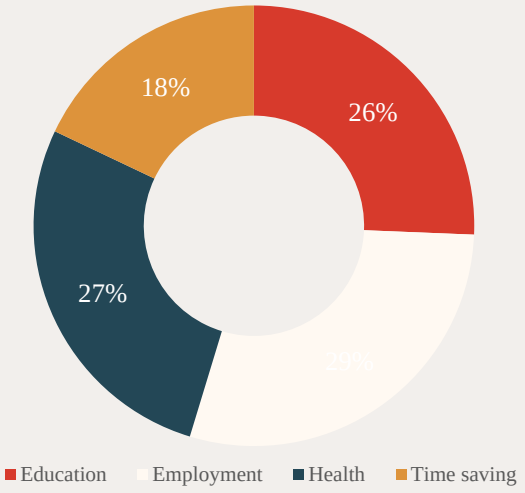
"The current public transport system in Udaipur is mostly around public (shared) rickshaw.... the urban poor usually travel in those. These shared rickshaws are like Mini Private Buses... they stop at designated points to let people in, along a fixed route" - FGD Participant

Picture 10: E-rickshaw in Udaipur

Source: Supporting Sustainable Mobility under Smart Cities Mission (ICLEI)

In terms of alternate mode choices, 53% respondents voted Personal Auto-rickshaws as the most preferred mode as they felt it is comfortable and reliable, followed by 67% respondents rating Shared-Auto as the second most preferred mode due to reasons of safety and 73% respondents rating 2-wheelers as the third-most preferred mode due to its reliable nature (SDG11) (as shown in above Table 3). In Udaipur, buses are the least involved mode in terms of accidents (2%) mainly due to its low fleet and low intra-city coverage (SDG3).

Figure 31: Access to opportunities if households owned their desirable vehicles



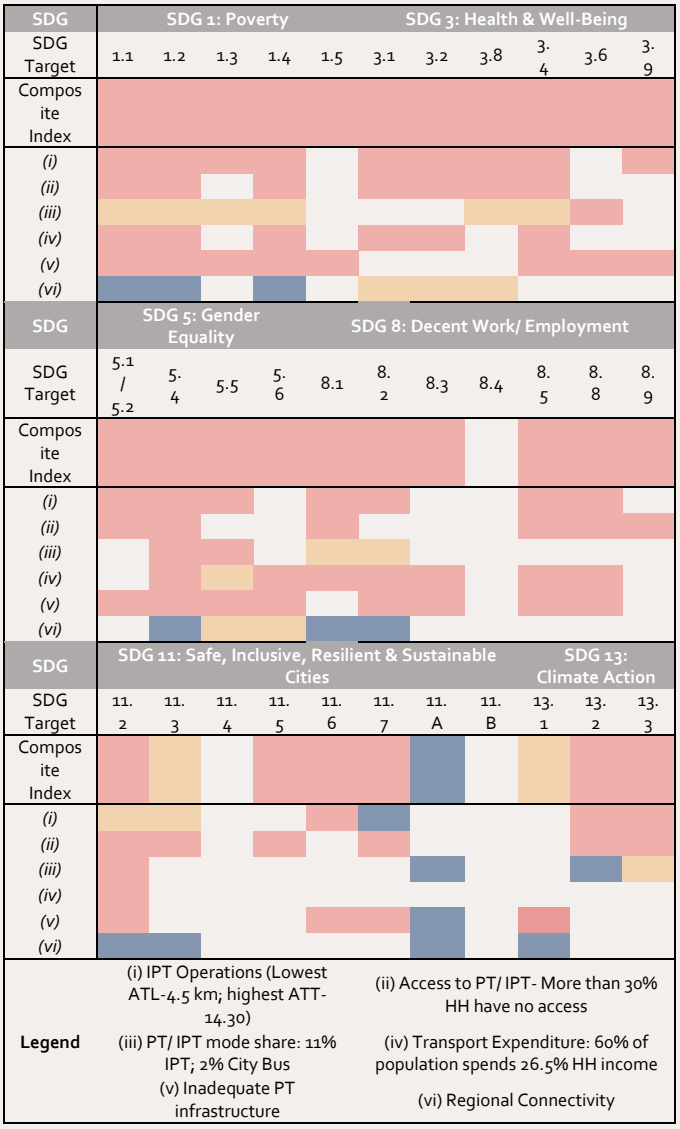
Source: Primary survey, October 2020

"In terms of mobility challenges for women in Udaipur, the public transportation system is poor.... the auto-rickshaws and buses run on limited routes. So, if women need to access destinations that fall outside the fixed routes, they spend more time as they would need to use a mix of different transport modes. Also, we do not have proper streetlights, that adds to unsafe environment" - FGD Participant

SDG Impacts: The negative interactions include:

- The lack of first and last mile connectivity and preference of other public modes in the city has resulted in increased immobility (SDG1 & SDG11).
- The unsafe infrastructure brings immobility and time poverty to women since their dependence on PT is far more than that of men (SDG5).
- Even though buses cause the lowest number of accidents as compared to other modes, regional bus services bypassing the core city add to the high-speed traffic, leading to a higher risk of fatalities caused by road accidents (SDG3); increased air pollution (SDG3 & SDG13); and road accidents and anxiety/ stress while travelling in the city.

Figure 32 Transport Systems with respect to PT/IPT Network & Infrastructure and SDG Interactions in Udaipur



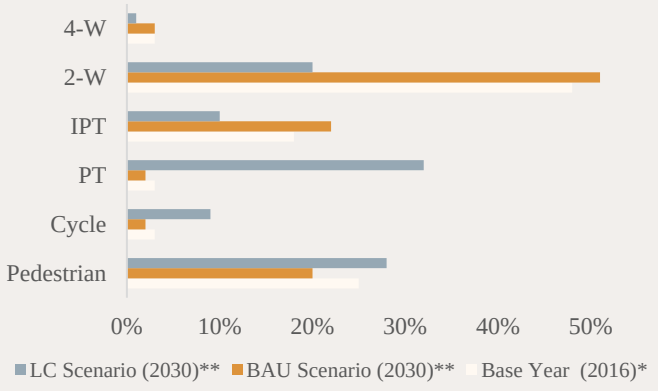
Picture 11: A woman bearing goods boarding a shared auto-rickshaw near the median in Udaipur

Source: Primary survey, October 2020

TRANSPORT-SDG INTERACTIONS: LOW CARBON PROPOSALS BY THE CITY

Without any interventions, meaning in the Business as Usual (BAU) scenario, dependence on private vehicles will exponentially increase, adding immense pressure on transport infrastructure. NMT and public transport users would continue to face severe challenges, as neither the Master Plan nor any other city development documents state NMT or PT improvement as a priority. Hence, this results in higher emission levels and a chaotic mobility scenario.

Figure 33 Mode Shares for trips in the UUCA area as per 3 scenarios



Source: Udaipur LCMP 2013

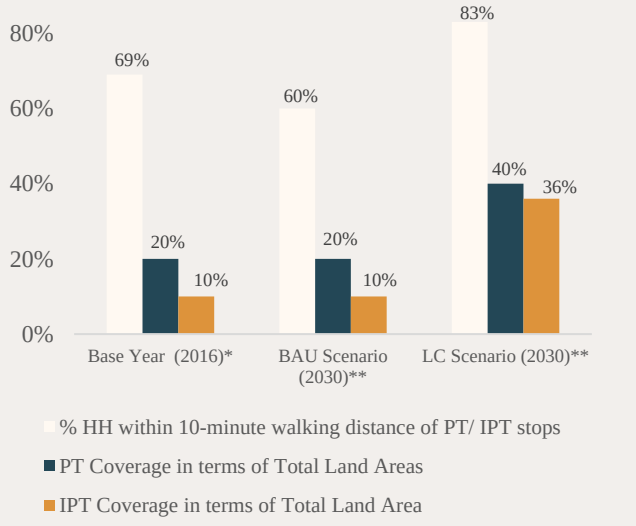
3 scenarios namely base (2016), BAU (2030) and low carbon (2030) scenario are compared in terms of transport systems & level of service.

To mitigate above mentioned outcomes and enhance mobility and accessibility in Udaipur, four alternative scenarios are presented as potential pathways; 1) Land-use scenario- higher density and mixed-use reduce trip lengths and dependence on private vehicles, 2) PT scenario- with emphasis on building a robust, safe, reliable, accessible and affordable public transport system to reduce dependence on private vehicles, 3) NMT scenario- with emphasis on building wide and barrier-free footpaths, cycle tracks, safe crossing facilities at intersections, etc. to reduce VKT, and 4) Technology scenario- with emphasis on energy efficient fuels and engine types, to reduce GHG emissions. The final Low-Carbon Mobility scenario consists of prominent features from each of these scenarios to ensure sustainable and accessible mobility for all. This section contains analysis of proposed low-carbon interventions in 4 categories as discussed.

Table 4 Scenario Comparison by Mode Share

	Base Year (2016) *	BAU Scenario (2030) **	LC Scenario (2030) **
Transport Systems Parameters			
Annual Motorized Vehicle Kilometres Travelled (VKT) (in million km)	1069.7	1,683.20	1,133.73
Congestion (% road length with v/c ratio value >1 or 1)	~26%	26%	5%
Land-use Mix Intensity (% of Intra-zonal trips)	19%	16%	68%
Perception of Safety while using NMT modes			
Walking	7.5%	7.5%	83%
Cycling	7%	7%	80%
Level of Service (LOS) of NMT as per MoUD's SLB	4	4	2
Level of Service (LOS) of PT as per MoUD's SLB	4	4	2

Figure 34 Accessibility to PT/ IPT in the UUCA area as per 3 scenarios



Source: Udaipur LCMP 2013
* Due to data gaps, data for base year 2016 is the same as LCMP report's 2013 calculations. This assumes that for a small-sized city like Udaipur, the transport characteristics would stay consistent for a short span of 2-3 years.
** The LCMP proposal aims at a 20-year span, making 2041 the final year. To align with the project's intended timeline, the final year is capped at 2030. Hence majority data is projected for 2030 using the 2041 trend.

Like the previous section, each aspect of the LCMP transport interventions/ proposals is tabulated across the 6 selected SDGs – 1, 3, 5, 8, 11 and 13, and their interactions are analyzed to understand the positive (green), negative (red) and both positive and negative (yellow) relationships.

WITH LAND-USE & DENSITY

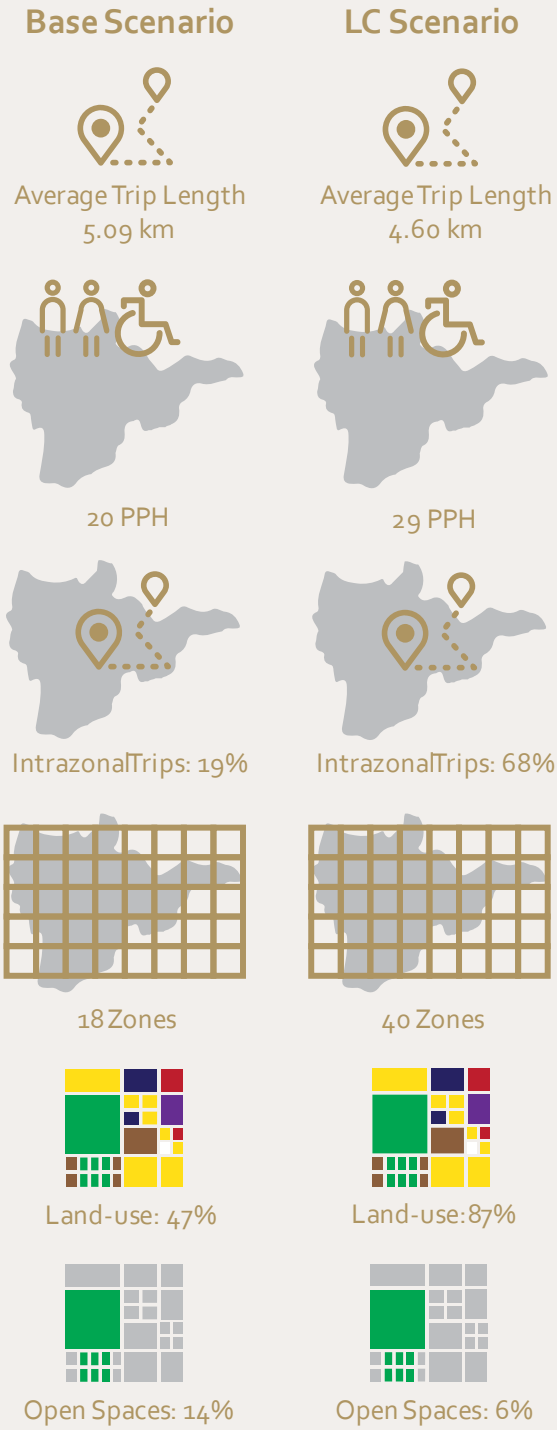
Interventions: As seen in the previous section, Udaipur is rapidly expanding along the highways, causing local sustainability issues. To promote a more compact and uniform growth in Udaipur, the low-carbon mobility plan focuses on two main strategies- increasing the intensity of mixed land-use in the city and increasing the density along PT corridors through infill and redevelopment of the vacant lands and encouragement of new developments along the proposed PT corridors/existing IPT. Currently, 24 out of 80 zones have more than 50 percent of the total land area vacant, and another 55 zones have up to 50% total land area vacant, contributing to sprawled and fragmented land-use. Under the BAU scenario, complete residential land use in most parts of the city 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.

Additionally, the revised Master Plan 2031 for Udaipur recommends a land use structure that increases the average trip length and promotes sprawl. To mitigate this, the low-carbon mobility plan strategy includes- change in land use pattern conducive for smaller trips and shorter travel distances, reversing the current travel demand, increment in intrazonal trips by increasing intensity of mixed land use (commercial, education and recreational) by 40%, ensuring better connectivity between retail jobs and housing, and using serviced land efficiently to create a more compact urban form. Additionally, to decrease automobile-dependency and provide travel options for those not owning cars, a self-contained neighbourhood is provided along the PT corridors. Accordingly, a proposal to increase the gross residential density three-fold, in zones falling within 500 meters' walking distance of the proposed trunk PT corridors with NMT-friendly neighbourhood design follows.

SDG Impacts: Many trade-offs mentioned in the previous section, are either mitigated, or transformed to synergies through land-use and density interventions like rezoning. Some intended outcomes include intra-

Two main mitigation strategies-

1. *Increasing the intensity of mixed land-use in the city*
2. *Increasing the density along PT corridors*
   a) *infill and redevelopment of the vacant land*
   b) *promote new developments along the proposed IPT/ PT corridors.*



The percentage of intra-zonal trips of 40 zones became more than 50 per cent as compared to 18 zones in the BAU scenario.

zonal trips increase from 16 per cent in the BAU scenario to 68 per cent in the low-carbon mobility scenario, gross population density in the UUCA increase to 29 PPH, average trip length for all modes reduced by 7.4%, VKT is reduced by 22% due to the high-density compact development and the overall emissions are reduced by 35%.

- The interventions in this category generate positive interactions with SGD11 & SDG13 through improved access to PT, promotion of NMT modes for most trips and decreased VKT and emissions.
- The implementation of these interventions has the potential to generate some negative interactions, mainly with SDG1. Studies in the Global South indicate that creating Transit-Oriented Development (TOD) zones or high-value capture zones pose threats of gentrification and eviction/ displacement of urban poor, deepening their poverty. If PT fails to attract projected ridership and modal shift, the increased density will exponentially increase traffic congestion, leading to loss of time, fuel, productivity and exposure to air/ noise pollution (SDG 13, SDG 8 & SDG 3).

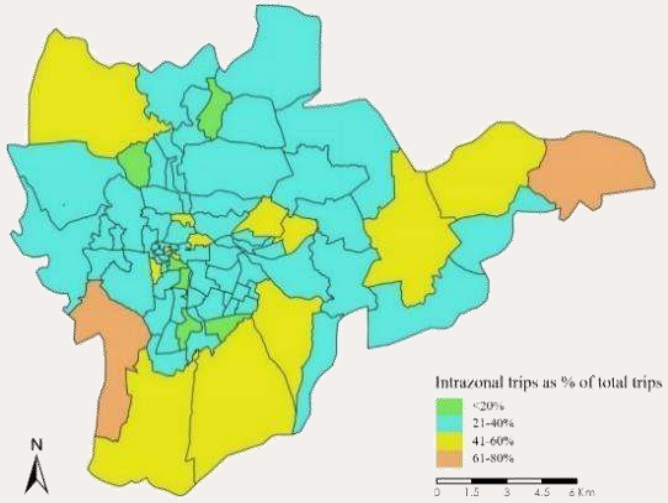
Figure 35 Transport Interventions with respect to Land Use & Density and SDG Interactions in Udaipur (2030)

SDG	SDG 1: Poverty					SDG 3: Health & Well-Being					
SDG Target	1.1	1.2	1.3	1.4	1.5	3.1	3.2	3.8	3.4	3.6	3.9
Composite Index											
(i)											
(ii)											
SDG	**SDG 5: Gender Equality**					**SDG 8: Decent Work/ Employment**					
SDG Target	5.1 / 5.2	5.4	5.5	5.6	8.1	8.2	8.3	8.4	8.5	8.8	8.9
Composite Index											
(i)											
(ii)											
SDG	**SDG 11: Safe, Inclusive, Resilient & Sustainable Cities**								**SDG 13: Climate Action**		
SDG Target	11.2	11.3	11.4	11.5	11.6	11.7	11.A	11.B	13.1	13.2	13.3
Composite Index											
(i)											
(ii)											
Legend	(i) Population Density: 29 PPH (UUCA)					(ii) Landuse- Intrazonal trips- 68%, Open spaces- 6.3%					

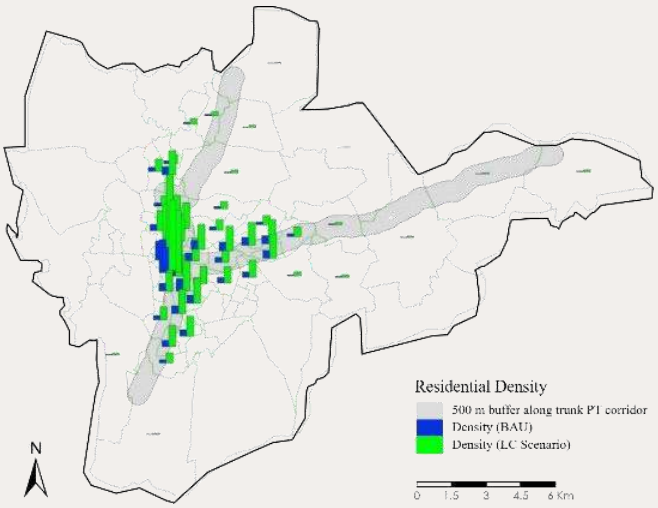
Picture 12 Mixed land-use with shops and residences in Udaipur

Source: Saumya Lathia

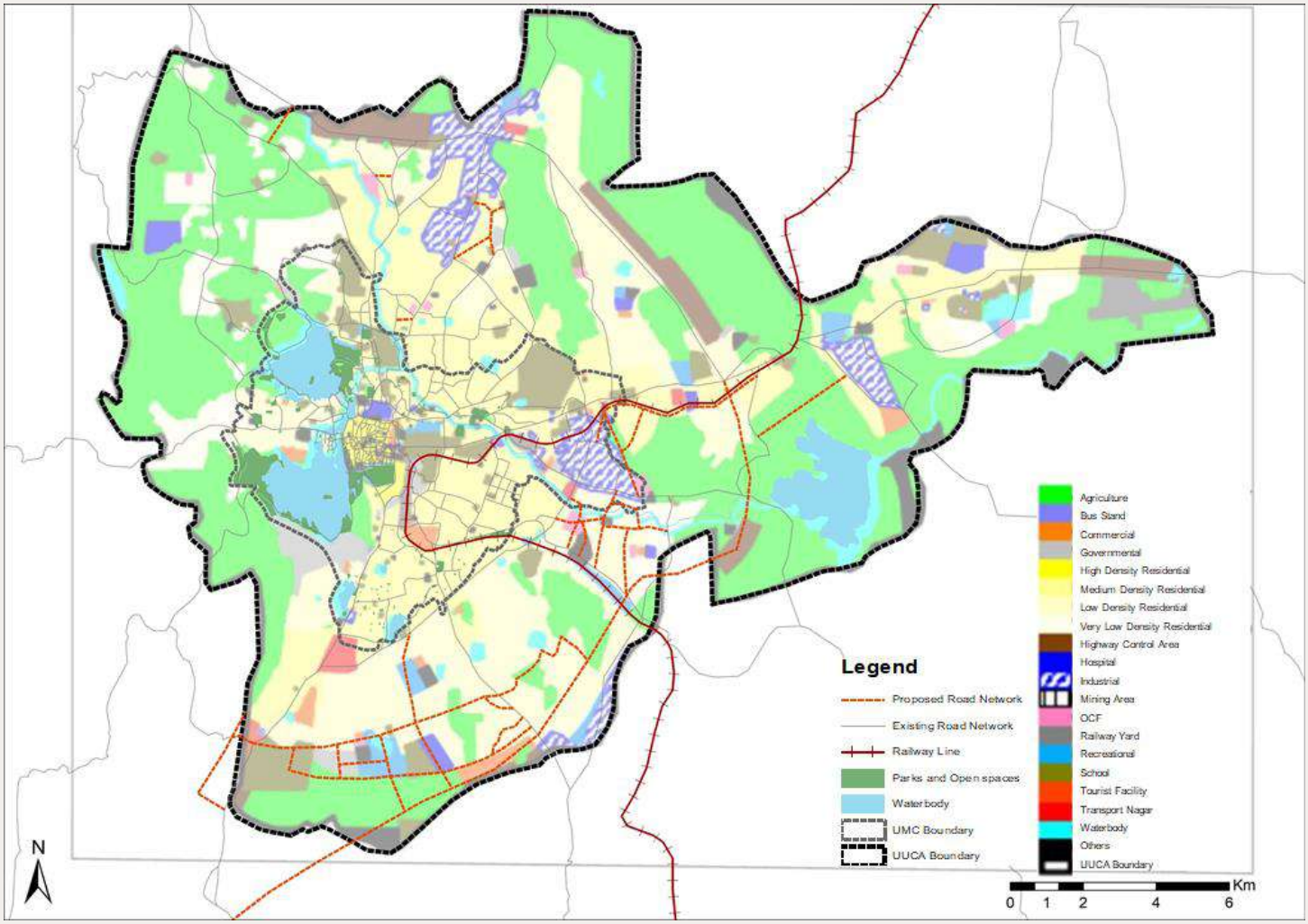
Map 3 Proposed Share of Intrazonal trips in the UUCA Area



Map 4 Proposed residential Density along the trunk PT corridor in the UUCA Area



Map 5 Proposed Land-Use in UUCA Area (2031)



Base Scenario

Road Network	VKT in million km	Mode Share	Mode Share	39% Street with illegal, unpaid parking	~26% % Streets with V/C Ratio > 1
1585 km	1011.69	3%	34%		

LC Scenario

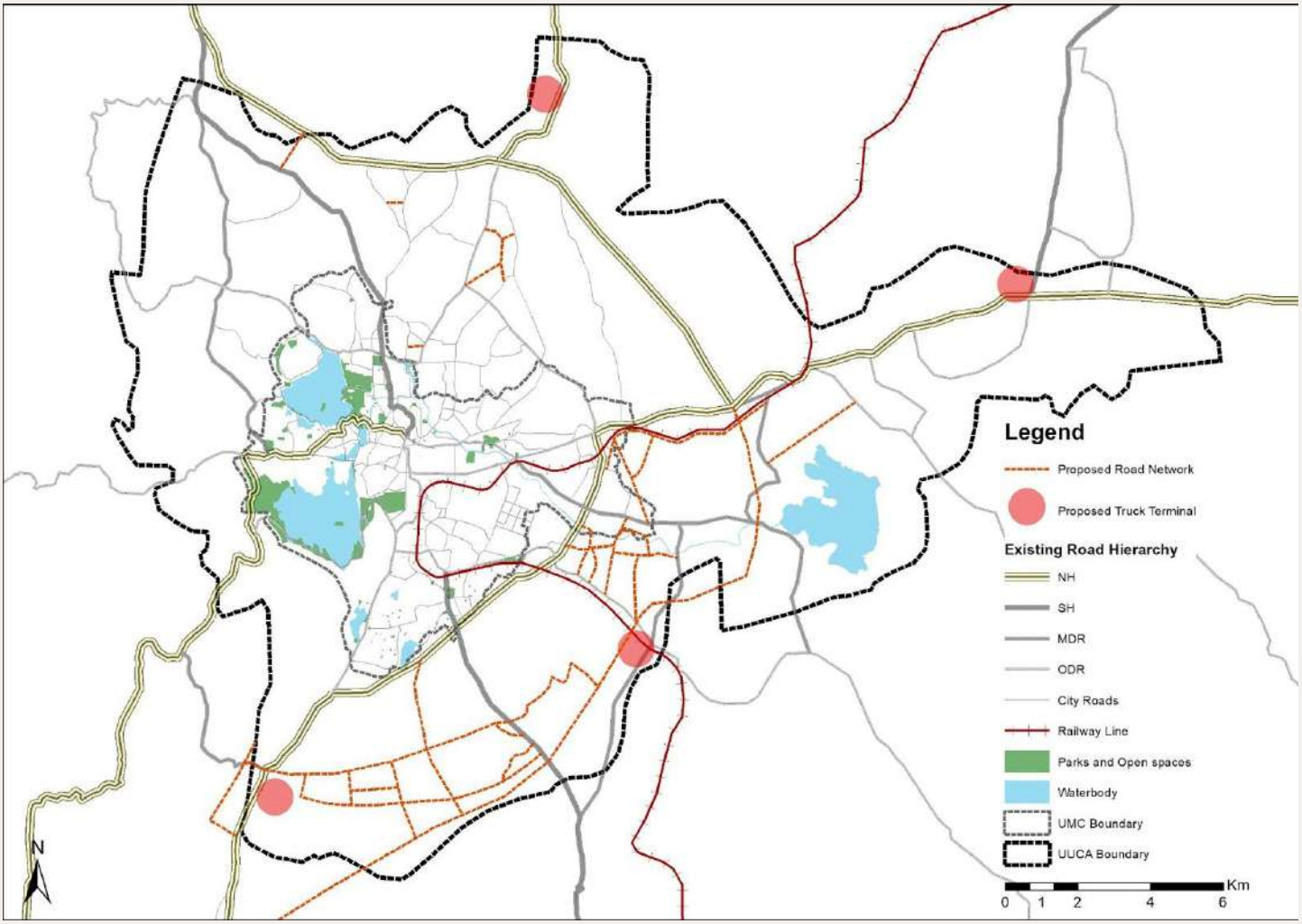
Road Network	VKT in million km	Mode Share	Mode Share	~5% Street with illegal, unpaid parking	5% % Streets with V/C Ratio > 1
1669 km	1133.70	1%	20%		

WITH MOTORIZATION & ROAD INFRASTRUCTURE

Interventions: To mitigate some of the air pollution and emission related impacts, the low-carbon mobility plan proposes a reduction in the personal vehicle mode share from 37% to 21% in 2030. The plan also aims to cap the annual vehicle kilometre travelled at 1335 million (significantly lower growth rate than 2016). 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 the mixing of incompatible functions has led to problems.

To achieve an efficient road system, where appropriate interaction with roadways and adjacent land-use is permitted, but conflicts between them are minimized, the following interventions are suggested: (a) A new bypass road with right-of-way (ROW) of 60 m is proposed connecting the highways, b) A new 11 km with ROW of 36 m is proposed perpendicular to the by-pass road, connecting Ahmedabad Road, for smooth movement of traffic and segregating intercity traffic from city traffic, c) The revised Master Plan 2031 suggests a large network of new roads, while the low-carbon mobility plan disputes that proposed road network and suggests a 48 km of new road network with ROW 24 m, d) 1 new flyover near dense areas to reduce bottlenecks, e) New Parking Policy, Smart Parking Management System, increase effective ROW and decrease traffic congestion f) 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. As a result of all the interventions, the plan projects a 20% decrease in traffic congestion.

Map 6 Proposed Road Network and Truck Terminals in UUCA Area



Picture 13 Interventions for Junction Improvement in Udaipur

Source: Supporting Sustainable Mobility under Smart Cities Mission (ICLEI)

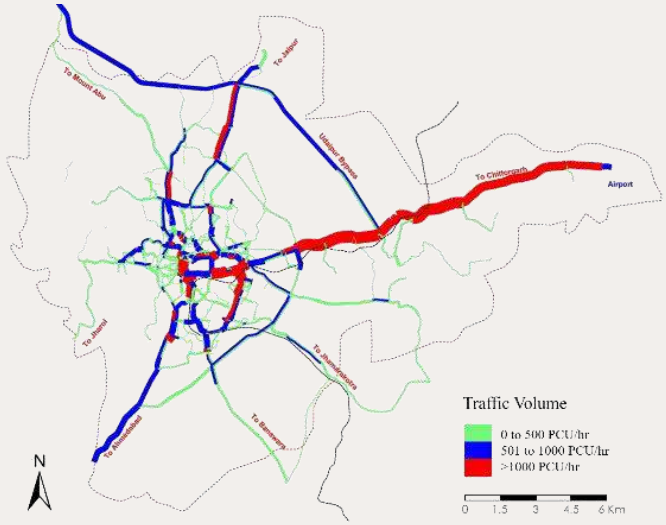
SDG Impacts: The interventions in this category pose the greatest number of negative interactions than any other category. Among the interventions, Parking Management and VKT generate positive interactions, as both discourage the use of personal vehicles. While, building new road infrastructure and road widening largely generate negative interactions:

- Displacement, eviction, loss of employment and property for adjoining residents (SDG1 & SDG8)
- Encourage the use of personal vehicles (SDG11)
- Contribute to air/ noise pollution, mental stress and anxiety (SDG 3) and increased emissions (SDG13).

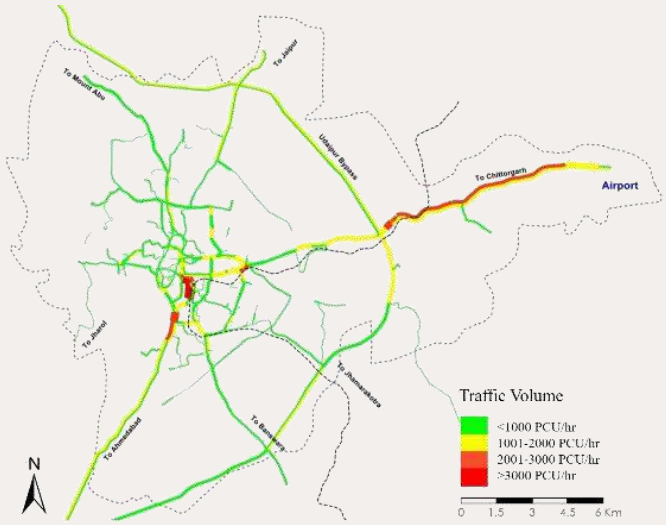
The interventions regarding personal vehicle use (2- & 4-Wheelers) generates many "mixed" interactions:

- While personal vehicles improve access to employment opportunity, the vulnerable groups are not usually a beneficiary of this interaction, as they either can't afford personal vehicles or can't drive them (SDG 1, SDG11 & SDG5).
- Although the personal vehicle mode share reduced in 2030, it still is considerably high for a smaller Indian city, leading to higher traffic congestion and related physical & mental health concerns (SDG3).
- The plan also discusses phasing out older, non-renewable fuel vehicles to more sustainable fleets like Electric Vehicles (EVs) and upgrading to energy efficient engine type (BS IV vehicles), resulting in decreased emissions (SDG13).

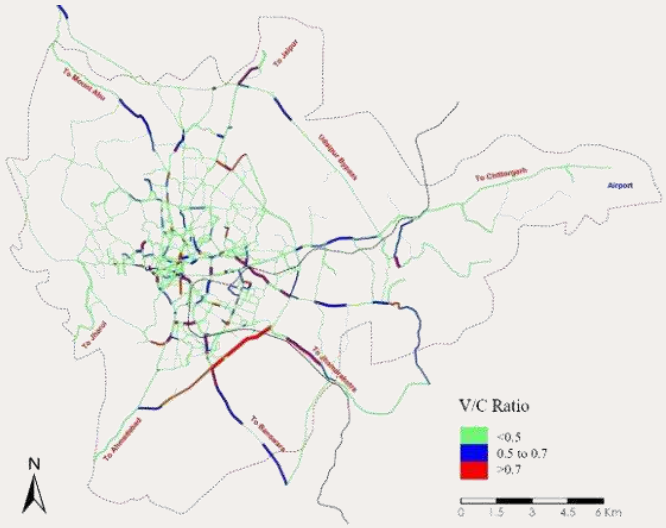
Map 7 Traffic Volume in the UUCA Area during the Base Year



Map 8 Proposed Traffic Volume in the UUCA Area



Map 9 V/C Ratio in the UUCA Area during the Base Year



Map 10 Proposed V/C Ratio in the UUCA Area

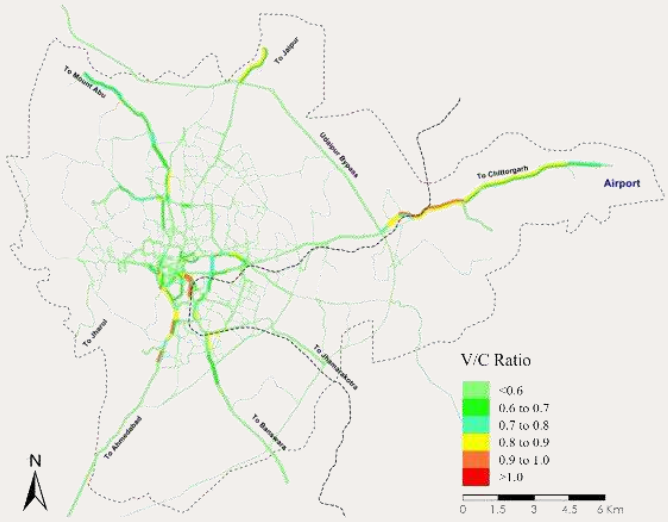


Figure 36 Transport Interventions with respect to Motorization & Road Infrastructure and SDG Interactions in Udaipur (2030)

SDG	SDG 1: Poverty					SDG 3: Health & Well-Being					
SDG Target	1.1	1.2	1.3	1.4	1.5	3.1	3.2	3.8	3.4	3.6	3.9
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
(v)											
(vi)											
(vii)											

SDG	SDG 5: Gender Equality				SDG 8: Decent Work/ Employment						
SDG Target	5.1/ 5.2	5.4	5.5	5.6	8.1	8.2	8.3	8.4	8.5	8.8	8.9
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
(v)											
(vi)											
(vii)											

SDG	SDG 11: Safe, Inclusive, Resilient & Sustainable Cities								SDG 13: Climate Action		
SDG Target	11.2	11.3	11.4	11.5	11.6	11.7	11.A	11.B	13.1	13.2	13.3
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
(v)											
(vi)											
(vii)											

Legend

(i) VKT: 1133.7 million
(ii) 2-Wheelers mode share: 20%
(iii) 4-Wheelers mode share: 1%
(iv) Road widening, new arterial roads, flyovers and bridges
(v) Congestion: 5% of roads have V/C Ratio >1
(vi) New Parking Policy& Smart Parking Management System
(vii) 4 new Truck Terminals within the UUCA

WITH NMT NETWORK & INFRASTRUCTURE

Interventions: The plan aims to improve access to the PT and IPT through NMT modes. Hence street and junction design, along with NMT network is crucial to achieve the projected modal shifts to PT and IPT. To reduce VKT and dependence on personal motorized modes, the low-carbon mobility plan aims to promote the use of NMT modes for short distance (intra-zonal) trips and as an important last mile option for long-distance trips. Along with favourable land-use, safe, inclusive, and accessible NMT infrastructure is crucial for a successful NMT culture in Udaipur. To ensure this, 133 km of new, "obstruction-free" footpath network with a desirable width of 2m or above is proposed, along with upgrading around 10 km of existing footpaths with a minimum width of 1.5m. Maximum NMT network coverage is residential areas and along the transit corridors will ensure increased dependency on NMT for shorter trips and enhanced access to PT and IPT stops.

Picture 14 On-street parking at a commercial street in Udaipur

Source: Primary survey, October 2020

Provision of signals for pedestrian crossings is proposed at 19 intersections to decrease crossing time and increase safety and night-time semi-mast lights installation at all junctions is proposed to improve safety. Along with this, all signalized intersections will have pedestrian crossings and all busy intersections will have handrails to ensure pedestrians can safely cross at the Zebra crossing. To promote the use of bicycles in Udaipur's slightly challenging terrain, the NMT strategy proposes cycle tracks of around 40 km on a few major roads. The proposal also aims to popularize bike-sharing schemes, especially among students and tourists by introducing bike-share docking points around major tourist attractions and other important areas. To further promote tourism through safe, accessible and inclusive NMT infrastructure, the low-carbon mobility plan

proposes 3 vehicle-free Heritage Walk routes in and around the walled city (Map 11).

Map 11: Proposed Path for Heritage Walk in UUCA Area

Source: Supporting Sustainable Mobility under Smart Cities Mission (ICLEI)

Picture 16: Interventions to increase safety for NMT users in Udaipur

Source: Supporting Sustainable Mobility under Smart Cities Mission (ICLEI)

By making more road length accessible by NMT mode (in addition to the land-use changes), the number of households residing within the 10 minutes' walk of a PT system would increase from 16% in the BAU scenario to 83% in the low-carbon mobility scenario. This would immensely improve mobility and access to opportunities to the otherwise "captive users". Similarly, as seen in the above two sections, poor NMT infrastructure makes NMT users the most vulnerable in terms of road safety.

Hence, the strategies listed here and in section 5a, like development of footpaths, dedicated cycle tracks, and signalized intersections with road markings and signages, conducive land-use, improved lighting, etc., increases the perception of safety to use NMT from 8 per cent in the BAU scenario to 83 per cent in the LCM scenario.

Picture 15: A street section near Fateh Sagar Lake showing footpath

Source: Kanika Gounder

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

Figure 37 NMT Infrastructure Highlights

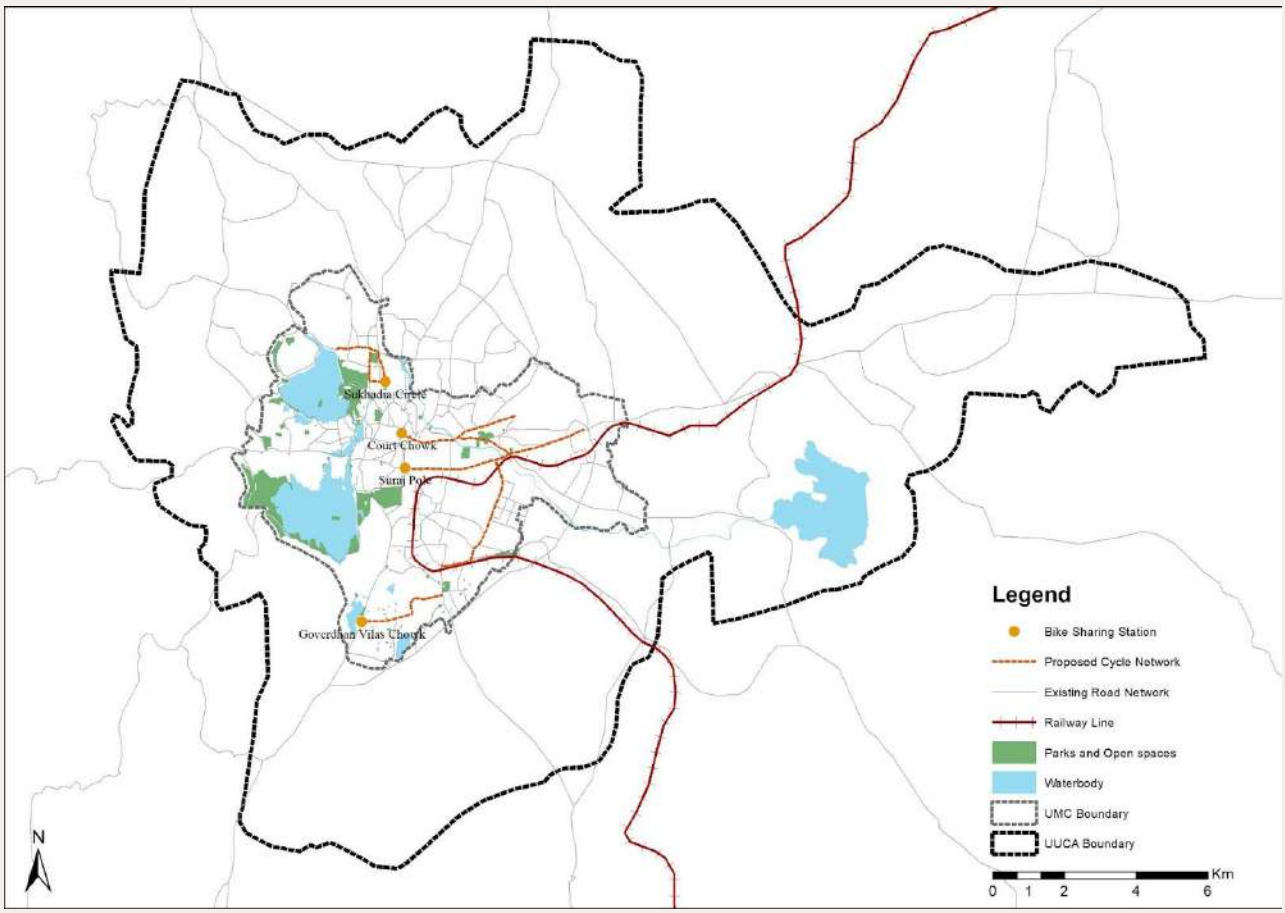
8.6%

Network Length: *143 km*
LOS: *2.0*
Average Daily Volume: *NA*
Pedestrian Crossings: *19*
PV2 Ratio >1: *NA*
Safety: *83% users*

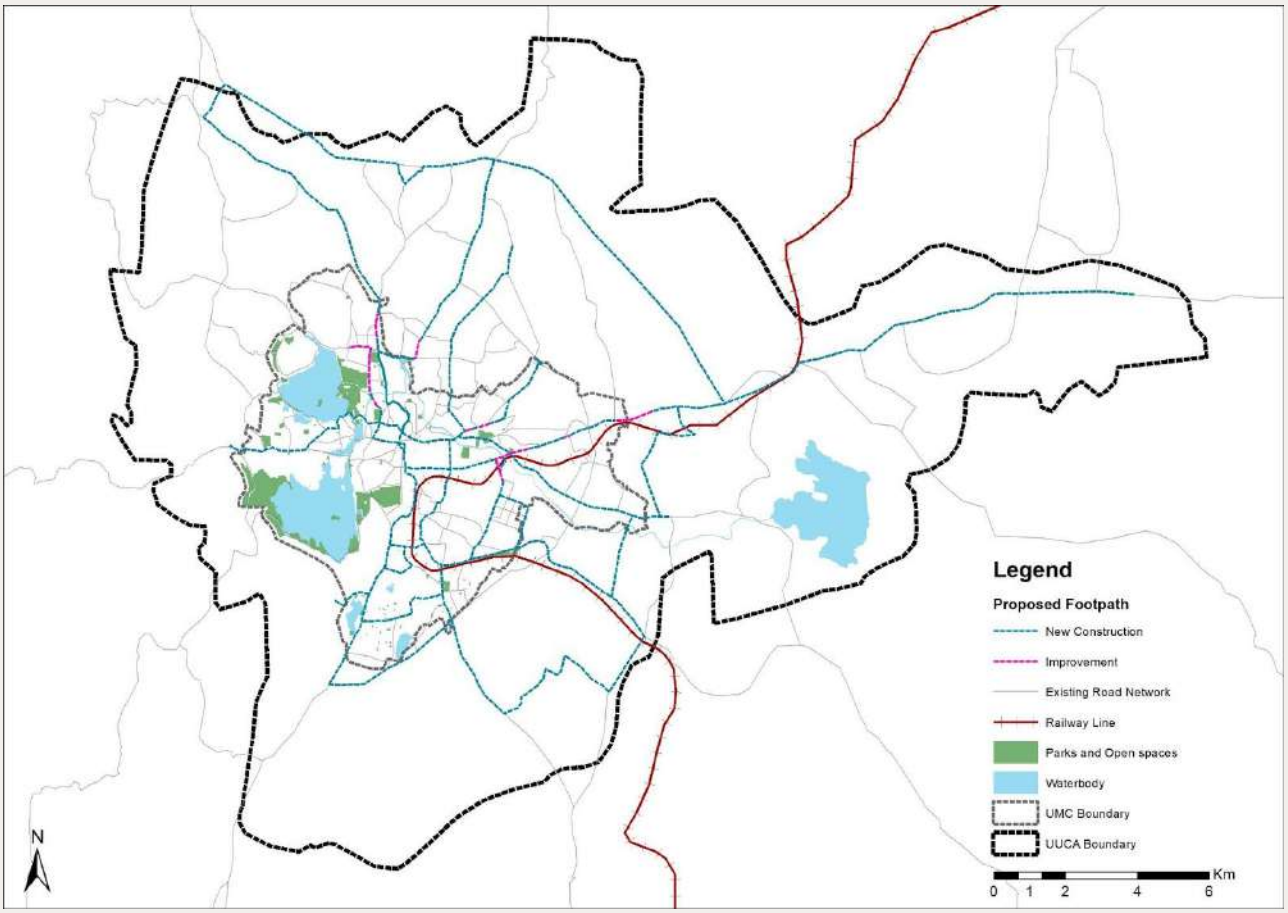
2.4%

Network Length: *40 km*
LOS: *2.0*
Average Daily Volume: *NA*
Bike Racks & Parking*: 4*
Safety*: 80% users*

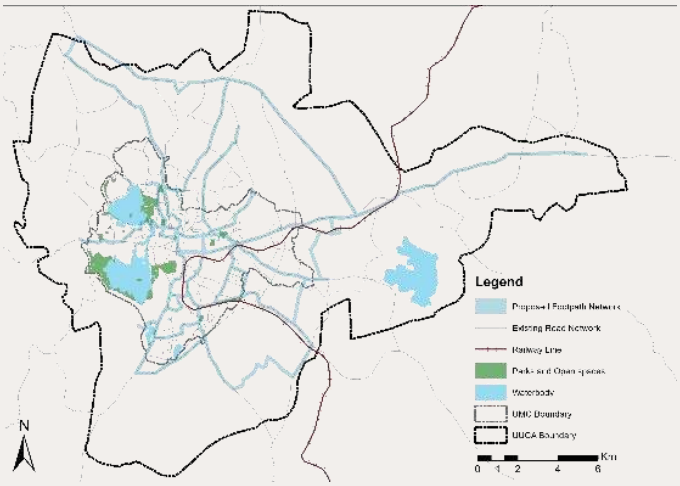
Map 12 Proposed Cycle Network in UUCA Area



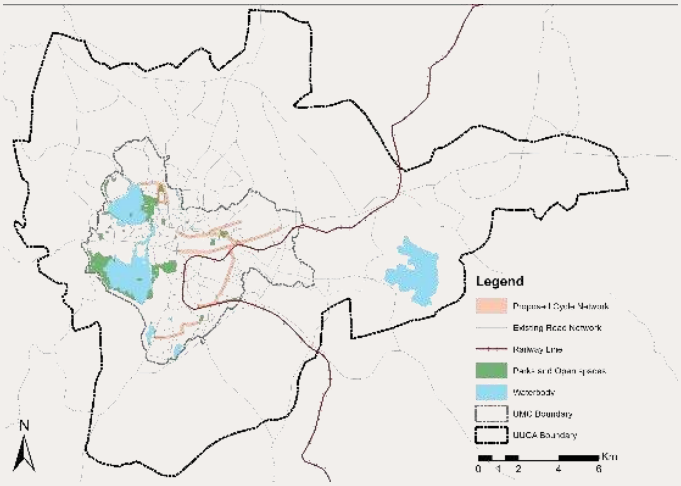
Map 13 Proposed Pedestrian Network in UUCA Area



Map 14 Proposed Footpath Network Coverage in the UUCA Area



Map 15 Proposed Cycle Network Coverage in the UUCA Area



Picture 17 Public Bike Sharing in Udaipur City

Source: Udaipur Smart City Website

SDG Impacts: This category fosters solely. The interventions for improving NMT networks and infrastructure encourage the use of NMT and other low-carbon modes like PT/ IPT by serving as reliable last-mile networks. This in turn:

- Improves access to employment and civic opportunities for all (SDG8 & SDG11)
- Reduces emissions (SDG13)
- Air/ noise pollution and related health hazards and increases physical activity, improving physical and mental well-being (SDG3)
- Also, NMT infrastructure improvements particularly benefit the vulnerable groups, who are often captive users of NMT, by enabling them to reach other affordable, low-carbon modes like PT/ IPT safely (SDG1 & SDG5).

Figure 38 Transport Systems with respect to NMT Network & Infrastructure and SDG Interactions in Udaipur (2030)

SDG	SDG 1: Poverty					SDG 3: Health & Well-Being					
SDG Target	1.1	1.2	1.3	1.4	1.5	3.1	3.2	3.8	3.4	3.6	3.9
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
SDG	**SDG 5: Gender Equality**				**SDG 8: Decent Work/ Employment**						
SDG Target	5.1 / 5.2	5.4	5.5	5.6	8.1	8.2	8.3	8.4	8.5	8.8	8.9
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
SDG	**SDG 11: Safe, Inclusive, Resilient & Sustainable Cities**								**SDG 13: Climate Action**		
SDG Target	11.2	11.3	11.4	11.5	11.6	11.7	11.A	11.B	13.1	13.2	13.3
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
Legend	(i) Pedestrian Infrastructure Improvements (iii) NMT mode share: 28% walking; 9% cycling					(ii) Bicycle Infrastructure Improvements (iv) Safety: 83% pedestrians and 80% bicyclists feel safe					

WITH PT/IPT NETWORK & INFRASTRUCTURE

Interventions: As discussed throughout section 3 & 4, lack of a reliable, robust and accessible PT network in Udaipur is largely responsible for high vehicle ownership rates, motorization rates, VKT and in general, an undesirable transport landscape that compromises people's mobility, curbs access and is highly unsafe. To mitigate these, the low-carbon transport plan proposes an ambitious IPT/ PT improvement strategy that includes: (i) Strengthening the IPT system with improved fixed routes, schedules, and fare structure, (ii) Phase-wise introduction of new bus-based PT system, (iii) Providing accessible and integrated the bus system with other transport modes, (iv) Provide reliable PT system using advanced ITS facilities, and, (v) Providing affordable PT system for all socio-economic groups. Along with this, two key strategies involve developing adequate supporting infrastructure like Bus Shelters, Bus Terminals, and Depots, and running public participation and mass awareness programs to enable a modal switch to PT/ IPT.

Figure 39 PT & IPT Infrastructure Highlights

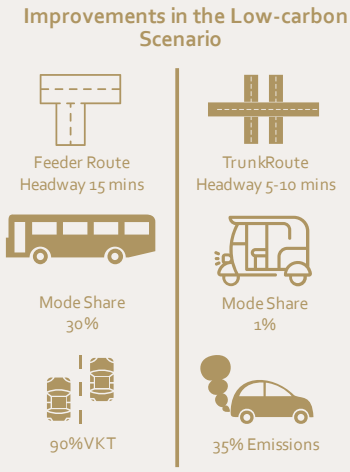
36%

***Network Length**: ~178 km*
***UMC Network Coverage:** 70%*
***New fleet:** 1803 refurbished auto-rickshaws; 18 E-rickshaws*
***Old fleet:** 4,510 auto-rickshaws; 2,637 tempos*
***No. of Routes:** 35*
***LOS:** 2.0*

40%

***Network Length:** 181 km*
***UMC Network Coverage**: 70%*
***Fleet:** 196*
***No. of Routes**: 9*
***LOS:** 2.0*

To increase IPT access and decrease emissions from the old, polluting IPT fleet, the plan proposes IPT operate along notified routes and old shared three-wheeler auto rickshaws be replaced with modern Bharat IV emission norm four-wheeler vehicles; approximately 1,803 vehicles will require replacement on 25 routes covering a total route length of 231.5km. Similarly, for the bus-based PT system, the plan identifies two trunk routes with a total route length of 45 km. To sustain these trunk routes, a robust network of 7 feeder routes with a total length of 133 km are identified. The trunk routes will operate with a headway of 5-10 minutes, while the feeder routes will operate with a 15-minute headway. Around 360 bus shelters will be constructed at a 500-m interval along both sides of the identified routes. With a safe platform for boarding, covered roof, adequate seating space, passenger-oriented information display and other facilities, these Bus Shelters aim to improve safety and comfort of the PT users. The Bus depots will be distributed across the city as per land availability and will serve as parking facilities for buses, house facilities for day-to-day servicing, repair and maintenance of buses, and provide space for administrative/ operations planning, monitoring and control activities. As a result, the low-carbon mobility plan improves PT mode share from 2% in the BAU scenario to 32%, reduces overall VKT by 90%, decreases congestion by 20%, and reduces emissions by 35%.

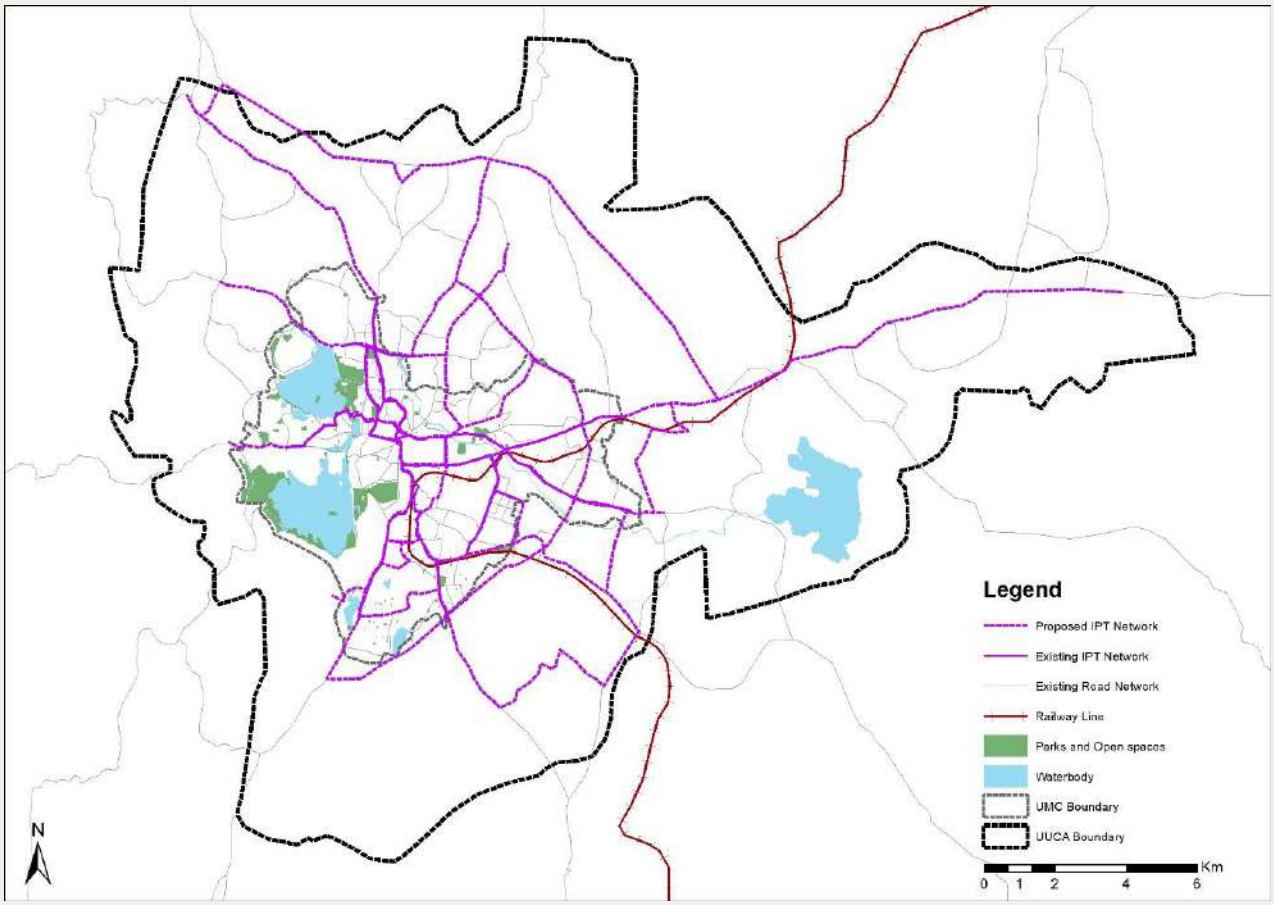


The plan proposes the existing Shared IPT network coverage in the UUCA to increase from 9.94% in the base year to 36% in the future. Similarly, the city bus coverage is proposed to increase from 20.23% in the base year to 40.31% in the future.

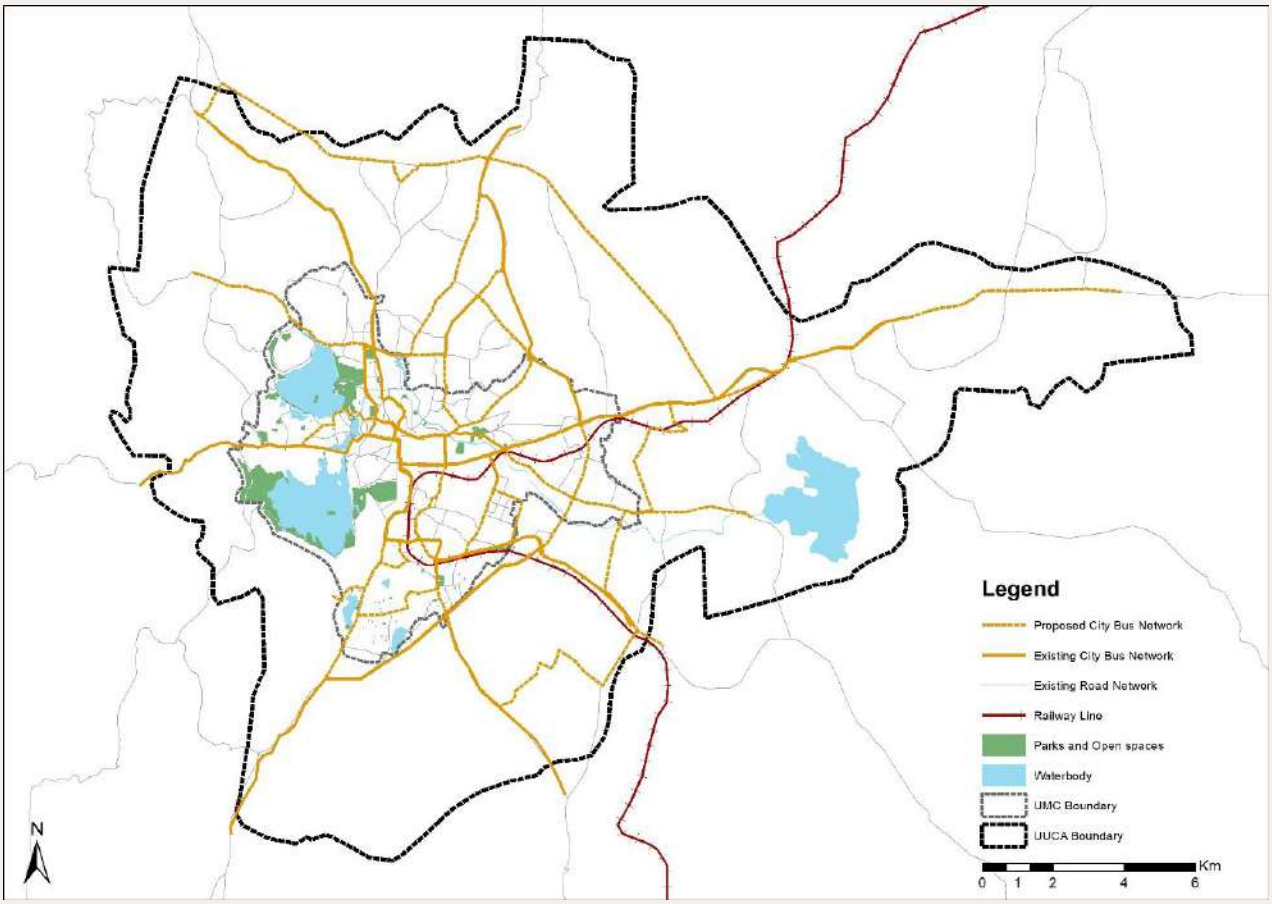
SDG Impacts: This category also largely generates positive interactions with all SDGs:

- Affordable, accessible and robust PT/ IPT services improve access to opportunities and basic services for all (SDG1, SDG8 & SDG11).
- Modal switch to PT reduces VKT, GHG emission, congestion and hence related all health concerns like cardio-vascular diseases, stress and anxiety from driving on congested streets (SDG3 & SDG13.
- Safe infrastructure contributes "decent working environment" for workers, improving their productivity and perception of safety (SDG5 & SDG8).

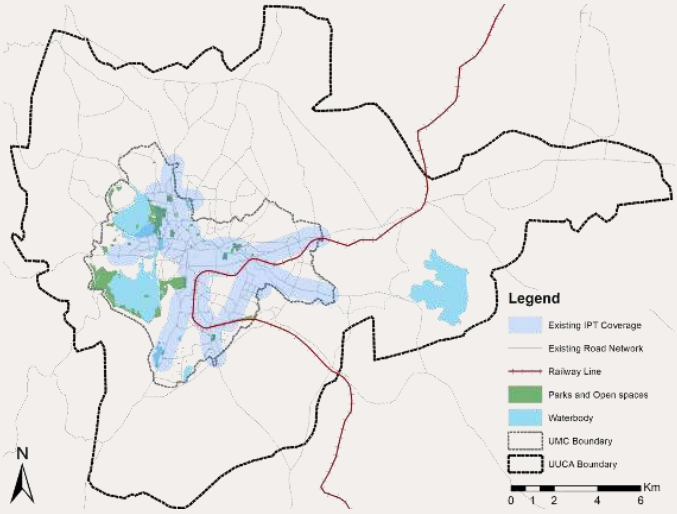
Map 16 Proposed IPT Network in UUCA Area



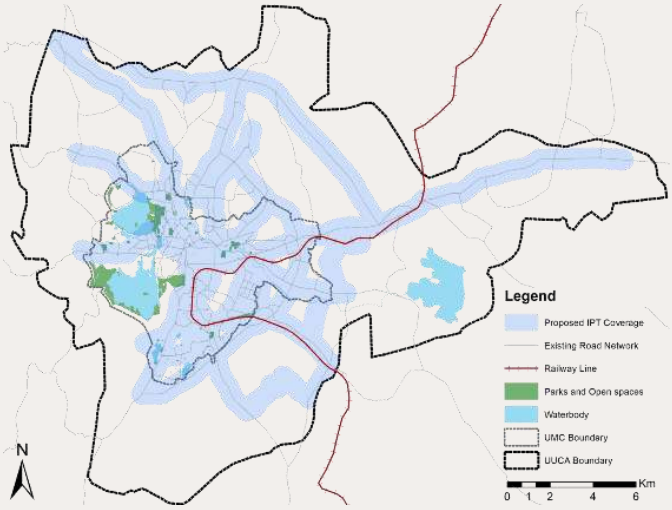
Map 17 Proposed PT Network in UUCA Area



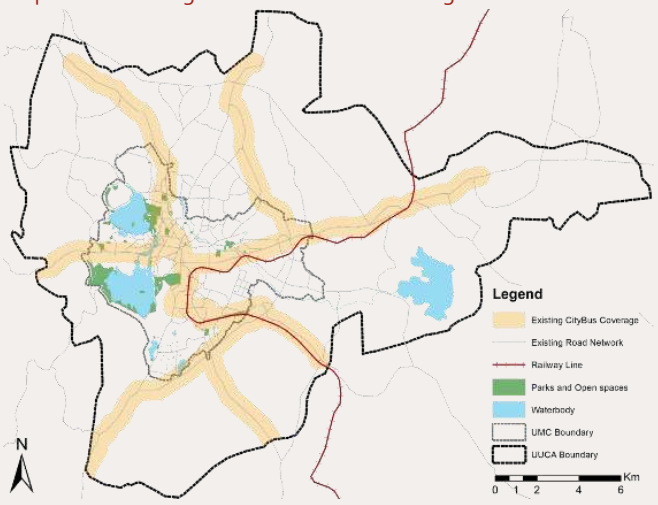
Map 18 Shared IPT Coverage in the UUCA Area during the Base Year



Map 19 Proposed Shared IPT Coverage in the UUCA Area



Map 20 PT Coverage in the UUCA Area during the Base Year



Map 21 Proposed PT Coverage in the UUCA Area

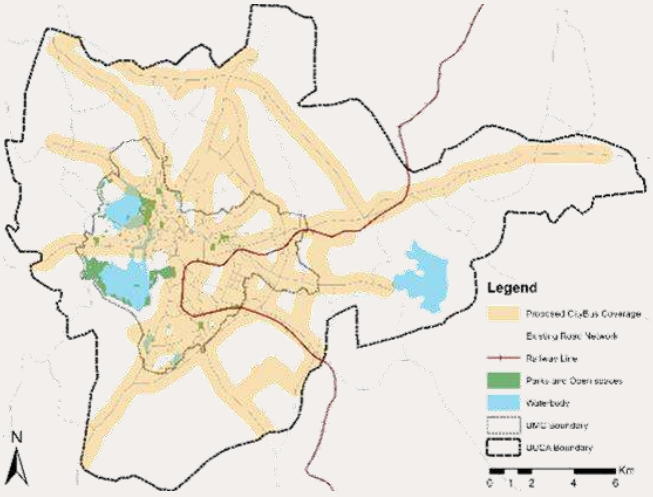


Figure 40 Transport Systems with respect to PT/IPT Network & Infrastructure and SDG Interactions in Udaipur (2030)

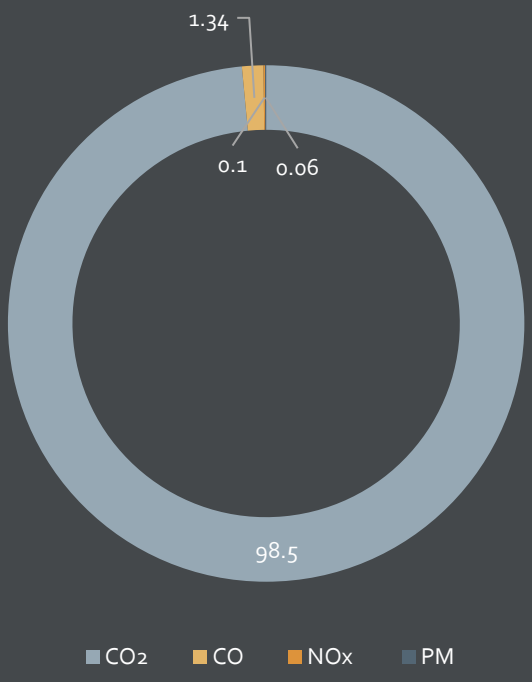
SDG	SDG 1: Poverty					SDG 3: Health & Well-Being					
SDG Target	1.1	1.2	1.3	1.4	1.5	3.1	3.2	3.8	3.4	3.6	3.9
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
(v)											
(vi)											

SDG	SDG 5: Gender Equality				SDG 8: Decent Work/ Employment						
SDG Target	5.1 / 5.2	5.4	5.5	5.6	8.1	8.2	8.3	8.4	8.5	8.8	8.9
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
(v)											
(vi)											

SDG	SDG 11: Safe, Inclusive, Resilient & Sustainable Cities								SDG 13: Climate Action		
SDG Target	11.2	11.3	11.4	11.5	11.6	11.7	11.A	11.B	13.1	13.2	13.3
Composite Index											
(i)											
(ii)											
(iii)											
(iv)											
(v)											
(vi)											

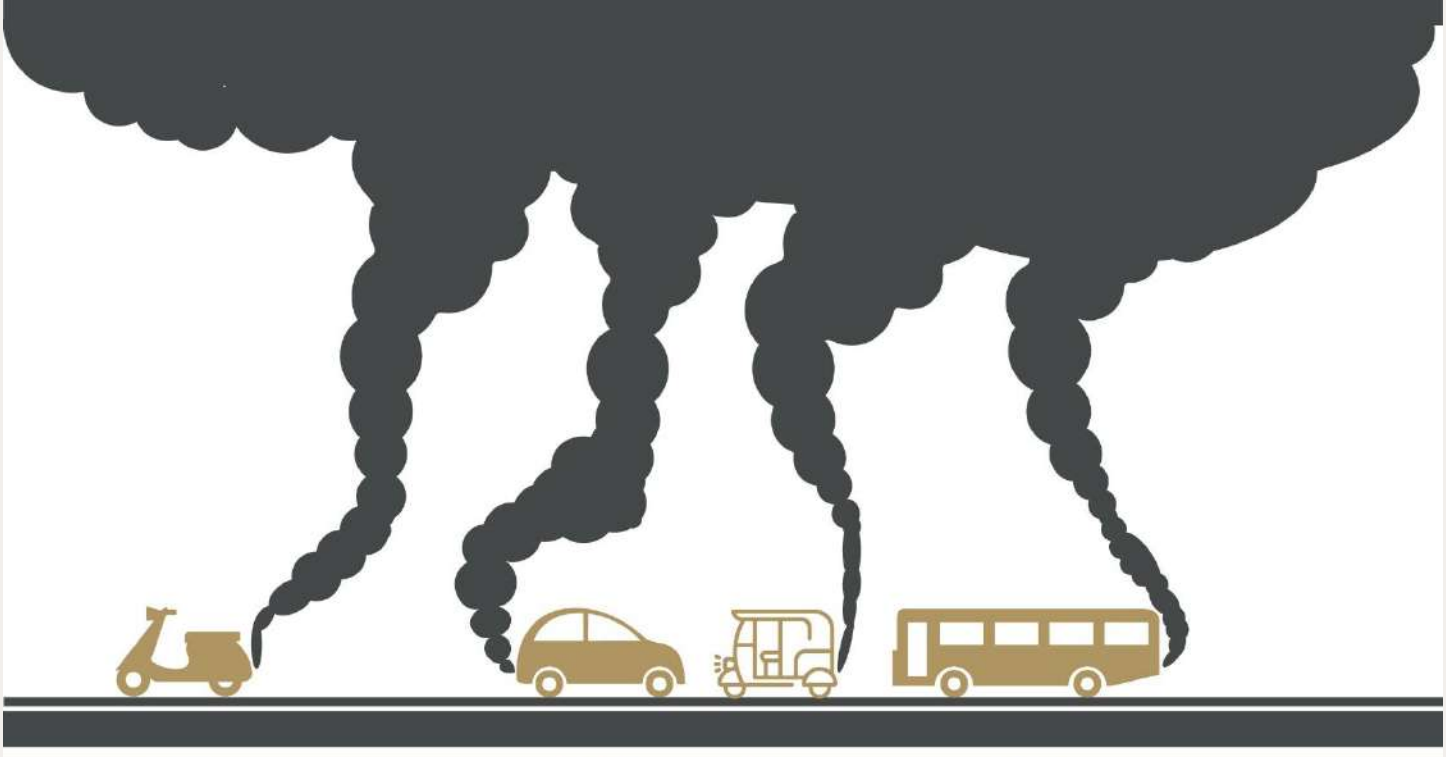
Legend		
	(i) Reorganising IPT	(ii) 83% HH have access (10 min walk) to City Bus and IPT
	(iii) PT/ IPT mode share: 10% IPT; 32% City Bus	(iv) Transport Expenditure: Affordable PT vision
	(v) City Bus Service Improvement	(vi) Regional Bus Service Improvement

Emissions from UUCA's Passenger Transport (2030)



26703 Tons
Total GHG Emissions

22.90 kg
Per Capita GHG Emissions

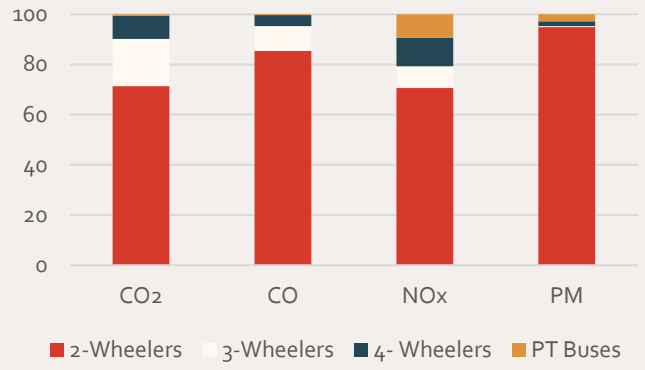


71.64%	9.17%	18.64%	0.55%
2-Wheelers	4-Wheelers	3-Wheelers	Buses (PT)

GHG EMISSION INVENTORY (2030)

For the low-carbon scenario, the proposal aims to reduce the growth rate of motorization and recommends a higher number of NMT and PT trips. However, the GHG emissions still seem high. In terms of carbon dioxide emissions, it is observed that two-wheelers still contribute to the highest emissions (71.4%), followed by three-wheelers/ auto-rickshaws that contribute to about 18.8% emissions (Figure 41). Cars and taxies generate about 9.2% CO_2 emissions, whereas city buses and mini buses contribute to only 0.5% emissions annually. Almost 90% of CO emissions in the city are generated by two-wheelers (85.4%) and four-wheelers and taxis (4.4%). Buses contribute to about 0.3% CO and auto-rickshaws and tempos generate close to 10% CO emissions annually (Figure 41).

Figure 41 Emissions in 2030 in Udaipur (CO_2, CO, NOx, PM)



Source: Calculated using data from Udaipur LCMP 2013

In terms of nitrous oxides, close to 70% emissions are generated by two-wheelers and 11.4% by four-wheelers/ taxis. 9.3% emissions are generated by minibuses and city buses, followed by auto-rickshaws that contribute to 8.7% NOx emissions annually (Figure 41). Whereas, in case of particulate matter, close to 95% of PM emitted by the transportation sector in the city is by two-wheelers (94.9%), followed by three-wheelers (2.8%), four-wheelers/ taxis (1.9%) and public transport (0.3%) (Figure 21). These emissions when disaggregated for each mode, it is also observed that CO_2 emissions still contribute to an average of 98.5% share annually (Table 5).

Table 5 GHG Emissions in 2030 by transportation sector in Udaipur (tons/year)

Mode Type	CO_2	CO	NO_x	PM	Total Emissions
2-Wheelers	17370.23	280.21	16.86	14.26	17681.56
3-Wheelers	4566.66	32.38	2.07	0.42	4601.53
4-Wheelers	2246.51	14.6	2.73	0.29	2264.13
PT Buses	131.74	1.06	2.21	0.05	135.06
Total	24315.14	328.25	23.87	15.02	24682.28

Source: Calculated in-house referring to vehicle fleet and travel data from Udaipur LCMP, RTO, and emission factor data from Emission Factor development for Indian Vehicles, ARAI Pune Report 2008, CPCB and Toolkit for Comprehensive Mobility Plan (CMP) Revised 2014 and Surat CMP (2016).

Picture 18 Lakes are at centre of Udaipur's Economy

STRATEGIES FOR SUSTAINABLE LOW-CARBON SCENARIO

Urban transport improves mobility of all users while improving their access to economic opportunities, leading to socio-economic upliftment, and improving their social acceptance. Udaipur's LCM scenario combines strategies from all four scenarios. Although the LCM scenario includes developing a bus-based PT systems, regulation of the IPT sector, and developing NMT infrastructure, it fails to address other challenges like safety, reliability, affordability and design flaws for transport networks. In this section, we discuss how LCMP's proposal can be more SDG compliant.

This section concludes the study by giving various interventions for each parameter in detail using recommendations from the residents and tourists from Udaipur as well as other urban planning experts working in the city. These interventions are also tabulated with each of the 6 studied SDGs showing their impacts and improvements comparing to the base scenario and the proposed low-carbon scenario from the LCMP.

LAND-USE & DENSITY

Strategies like increasing the intensity of mixed land-use and density along PT corridors through infill and redevelopment of the vacant lands and encouraging new developments along the proposed PT corridors/existing IPT mitigates majority trade-offs discussed in previous sections. Yet, synergies will only be fostered if the strategies are appropriately implemented. Rezoning and redeveloping land around the PT corridors could also lead to gentrification of existing residents and businesses due to increase in property values. Hence, we recommend an equitable (and pro-poor wherever applicable) approach to redevelopment. Some policy recommendations that prevent gentrification involve reducing or capping property tax, introducing rent-control on properties, aggressive promotion of small- and medium-scale, mixed-income development, reserving housing for low-income and below poverty line households. Implementing a combination of these policy recommendations for redevelopment along PT corridors will ensure the trade-offs concerning SDG 1, 8 & 11 are mitigated.

Figure 42: Opinion of local shop owners/ vendors on their business post pedestrianization

Source: Primary Survey, October 2020

"Udaipur is known for its high number of tourists visiting the cultural and natural heritage. Low carbon interventions that support the living environment add to the attractiveness of the city. For example: minimizing motorized vehicles and promoting electric vehicles would solve not only air pollution, but also noise pollution, making the city much more aesthetic as well as sustainable." - FGD Participant

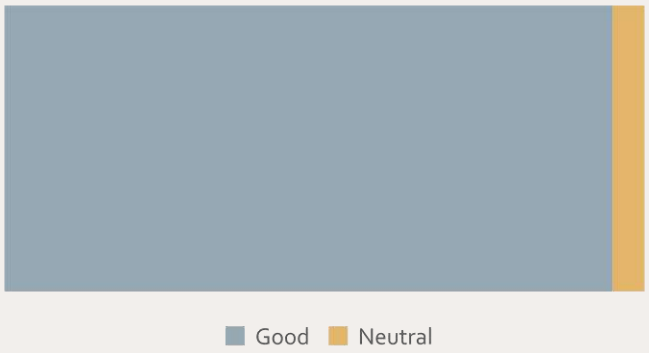
MOTORIZATION & ROAD INFRASTRUCTURE

The LCMP proposes building 84 km of new road infrastructure and road widening, resulting in numerous trade-offs with all SDGs. To triangulate the impacts assessed in section 4 & 5, the semi-structured interview had a specific section dedicated to impacts of transport projects on the local economy and resident's well-being.

90% of the interviewed shop owners & vendors reported transport/ road projects impact their daily revenue to varying degrees- 90% perceived it to affect their revenues, 95% interviewees reported it impacted their health and productivity and 60% reported it impacted their and their customer's safety. 60% of the total interviewees reported facing eviction and displacement in the past due to a road/ transport project in their vicinity. Congestion was reported as a major concern by private vehicle users as 98% two-wheeler users and 35% four-wheeler users experienced getting stuck in frequent traffic congestion in the city. 55% shop owners and vendors also reported traffic congestion as a major work-environment related

challenge. Apart from this, issues like air and noise pollution, increased stress/ anxiety and respiratory issues and longer travel times were highlighted by all stakeholders (private vehicle users, households and vendors/ shop owners). Over 85% households mentioned the issue of road accidents due to the vicinity of a flyover/ bridge or major road in the city. About 22% four-wheelers and 11% two-wheeler users reported being in road accidents within the last three years. These accidents took place at high-speed traffic lanes, with NMT users, at intersections, mixed traffic and parking areas.

Figure 43 Opinion of local shop owners/ vendors on pedestrianization

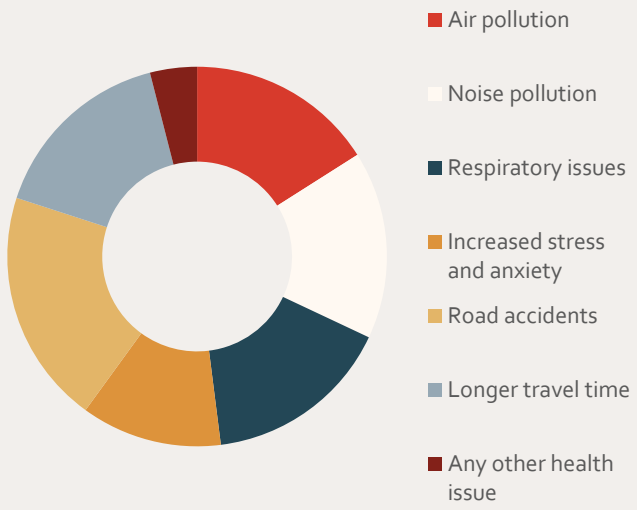


Source: Primary Survey, October 2020

Hence, the fieldwork and assessment presented guide us to modify the strategy proposed in LCMP; 34 km of proposed network for new roads smoothens movement of city traffic by segregating intercity traffic, and hence should be constructed. But we recommend against the remaining 50 km of new road/ flyover construction and all proposed road widening projects, as they are likely to displace or evict residents and businesses (SDG1 & SDG8) in the area, along with encouraging the use of private vehicles (SDG11), leading to increased emissions (SDG13), air/ noise pollution, mental stress and anxiety (SDG3). Instead, we recommend a robust traffic management plan that emphasizes equitable distribution of road space, parking management, freight management and congestion pricing (especially in the walled city). Since 5% streets still have a V/C ratio greater than 1 in the proposed LCMP scenario, we recommend that the city discourage free, on-street parking and promote long-term parking mechanisms to increase effective ROW in commercial and dense areas. Since the UUCA serves a large floating population, we recommend promoting carpooling, car- & motorbike-rentals and Mobility as a Service (MaaS). To avoid chaos, this should also be accommodated in street design through designated drop-off points and curb-side pick-ups for MaaS. Although promoting the switch to cleaner engine & fuel types is often a central or state affair, we recommend the city push for a transition to electric vehicles. The fieldwork indicates that there is strong willingness in private vehicle users to shift to EVs:

48% two-wheeler users are willing to shift to electric bikes, whereas 39% are willing to retrofit to electric two-wheelers. In the case of car users, only 13% four-wheeler users are willing to shift to electric cars, whereas, only 4% may be willing to retrofit to electric cars. The users also recommended various incentives that would make them shift to electric vehicles; 45% car users and 27% two-wheeler users suggested lower maintenance costs followed by around 24% users demanding confidence on mileage. The rest mentioned a demand for upfront investment and EV charging infrastructure.

Figure 44 Issues encountered by households due to proximity to flyover/ bridge/ major road (6 lanes or above)



Source: Primary Survey, October 2020

"Considering the narrow streets of Udaipur, pedestrianization with traffic circulation mechanisms like One-way Streets would be the best fit for the historic core of Udaipur." - FGD Participants

"It (pedestrianization) has been tried in some areas the past, but we need to upscale the effort through more awareness and participation." - FGD Participants

NMT NETWORK & INFRASTRUCTURE

Although the LCMP proposal manages to mitigate most trade-offs discussed in the above section, the fieldwork and the FGDs brought out many additional

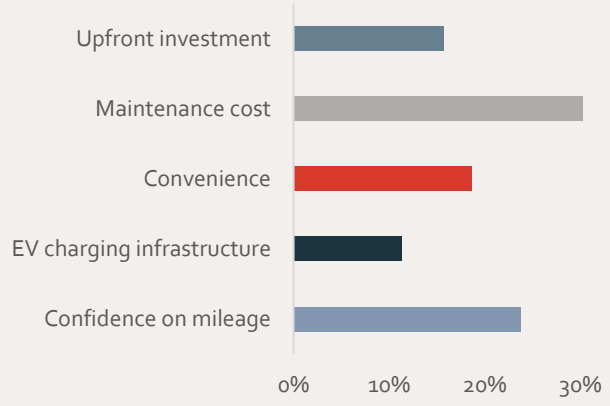
recommendations to amplify the synergies with SDG targets.

Table 6 Recommendations by NMT Users in Udaipur

Recommendations	NMT users
NMT Infrastructure Improvement	64%
Improve Road Quality & Street Lighting	*21%*
Public Amenities: Toilets, Drinking Water, etc.	*13%*
Construct Medians & Speed Breakers	*4%*
Increase Canopy Covers	*3%*
Other NMT Infrastructure Improvements	*23%*
Manage Vending & Parking Zones	5%
Improve Traffic Management	21%
Improve PT & IPT Services	10%

64% NMT users indicated a need for NMT infrastructure: 21% of those recommended improving road quality and street lighting, followed by Public Amenities like toilets and drinking water, 4% recommended median and speed breaker construction and 3% recommended increasing canopy covers. 23% suggested other NMT infrastructure improvements like seating spaces, bike lanes, bike parking, etc. This is consistent with the LCMP assessment where the poor state of NMT infrastructure was hampering tourists' mobility and the tourism economy at large. Another 5% recommended introducing and managing vending and parking zones, 10% recommended improved PT & IPT services and the remaining 21% recommended Traffic Management.

Figure 45 Recommendations from private vehicle users for shifting to electric vehicles

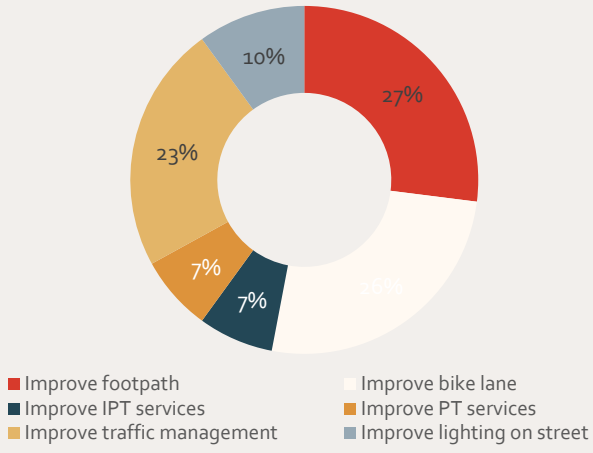


Source: Primary Survey, October 2020

The proposed footpath width of 2m is insufficient for places with heavy foot traffic like tourist and commercial areas. Hence, we recommend increasing the footpath width to 4m around commercial fronts and tourist spots, like lake-fronts. We also recommend interventions like inclusive street design by adopting Universal Design Guidelines. This could be supplemented with Complete Street Design and tactical urbanism measures for effective implementation of vending zones (to enable economic activities along the streets), cycling lanes within mixed traffic, pedestrian and cyclist signals and redesigning high-conflict intersections with refuge islands, smoother/ flattened turning curves and reduced carriageway widths. Udaipur also has a potential for developing a cycle culture, especially around E-bikes and bike-sharing infrastructure. The LCMP fails to create a cycling network across the city. We recommend priority cycle lanes all around the streets of the core city with the concept of "slow streets". Strict implementation of shaded walkways and bike-lanes, through increased canopy cover, would enhance comfort during extreme weather events.

Introducing speed limits would reduce fatalities and other serious injuries due to road crashes. Similarly, intelligent urban public transport system, parking policies discouraging personal vehicle use, along with awareness drives like Accessible Campaign India, and "Cycle 4 Change", will promote sustainable means of transportation along with improving accessibility of the vulnerable, specially the disabled, older adults, women and children. Moreover, fare regulation and subsidies by the state would ensure inclusivity of the urban poor and women in the city. These initiatives would also help a modal switch to more sustainable modes as 98% surveyed private vehicle users agreed to frequently use non-motorized transport modes if the quality of service improved.

Figure 46 Recommendations from Tourists



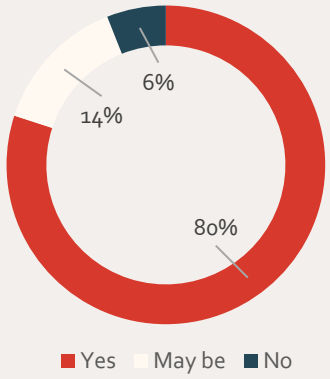
Source: Primary Survey, October 2020

Pedestrianizing the walled city area is another key intervention area brought up in the FGDs as well as fieldwork. Majority local shops owners and vendors believe pedestrianization would improve their businesses and boost their revenues. Majority tourist

and NMT users responded positively to pedestrianizing the walled city or implementing multiple one-way streets for reduced chaos.

95% of all respondents believed pedestrianization of their adjoining streets and walled city streets to be a good measure. 80% of them believed this and other street improvements would positively affect their businesses. 82% respondents also believed they would enjoy Udaipur's heritage and culture more if the old city was pedestrianized. The response for one-way streets was a bit less encouraging, as only 66% respondents were in favour.

Figure 47 Responses from Tourists when asked if they would enjoy pedestrianization in the old city



Source: Primary Survey, October 2020

"Pedestrianization is important for a city like Udaipur, where one can really experience the culture by walking. Tourists and Locals would enjoy it equally." - FGD Participant

"Udaipur can also take inspiration from cities like Pune, which have done some great work in terms of pedestrianization, bike-sharing and other low-carbon mobility measures." - FGD Participant

"Fateh Sagar lake front and adjoining streets have an interesting model: during mornings and evenings, no traffic is allowed there, so people can leisure there. An upscaled version of that model need to be implemented within and around the walled city, especially around major stretches like City Palace Road, Museum Road to Jagdish Chowk and others. UNESCO also recommended the same, but since Udaipur is now a Smart City, they are considering only certain smaller segments. The UMC really must consider pedestrianizing entire walled city." - FGD Participant

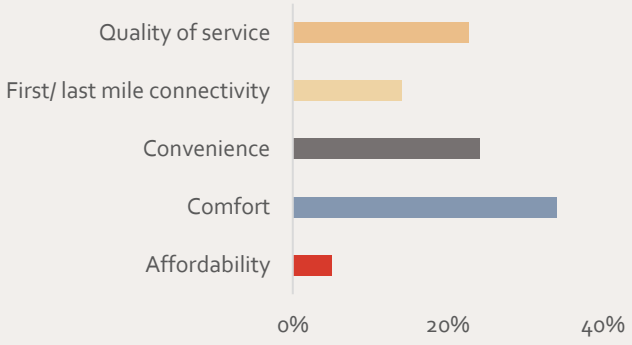
Hence, we recommend largely pedestrianizing in the walled city. As highlighted in the FGDs, all pedestrianized streets should be disable-friendly and age-friendly, to allow access for all. Major circulation streets should allow PT (smaller buses) and IPT so that the walled city is accessible to elderly and people with physical disabilities. All the intermediate streets should enable emergency vehicles (fire-brigade, ambulance, etc.) access to ensure safety for all. The FGDs also suggested to accommodate the residents living within the walled city. Hence, we recommend the pedestrianization to last within a certain operation hour window- like 8 am to 10 pm. The pedestrianization would work effectively only if there was reliable PT/ IPT service or enough parking space outside walled city for people using their personal vehicles.

PT/IPT NETWORK & INFRASTRUCTURE

The LCMP proposes a huge modal shift to PT/ IPT from personal vehicles. This would result in lower 2W and 4W mode shares, in turn decreasing air pollution, GHG emissions and related negative externalities. The fieldwork and FGDs provide insights on pathways that enable the massive modal switch.

The most recommended incentives for two-wheeler users to shift to PT/ IPT are comfort (33%), convenience (26%) and better quality of service (20%). Similarly, those by four-wheeler users are comfort (43%) and better quality of service (39%). 83% two-wheeler users and 28% car users stated that they do not choose to use the bus service due to the low bus coverage, lack of information of route and schedule and lack of last mile connectivity. Users also reflected on the crowded/ unsafe nature of buses.

Figure 48 Recommendations from private vehicle users for shifting to IPT/ PT services



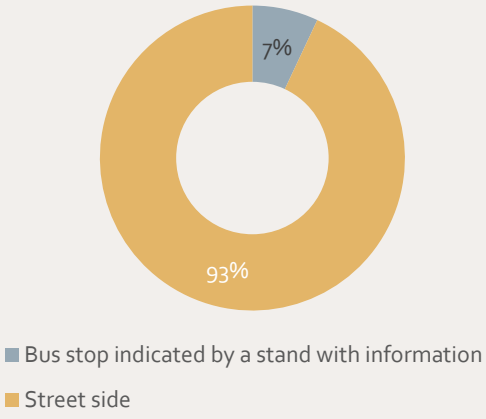
Source: Primary Survey, October 2020

Users in Udaipur feel unsafe to travel in buses due to low frequency, lack of bus infrastructure and lesser number of seats.

Hence, for increased comfort & convenience, we recommend bus stops are provided at a 5-minute walking distance instead of 10 minutes. These bus stops should be shaded, have adequate seating space, route information, signages and raised platforms to enable easy boarding and alighting. Bus stations (larger & more distributed than stops) should also have cycle parking and docking stations. Streets should be designed to accommodate bus bays along all routes and bus-priority lanes along trunk routes.

Over 20% households would still lack access post LCMP proposal implementation; hence we recommend increasing the number of feeder routes to accommodate those households. Additionally, we recommend that the PT system doesn't replace the existing Mini-Bus system, as the Mini-Buses serve a much more vulnerable and sparsely located population. The Mini-Buses could also be integrated with the PT network to work as feeder buses along high-demand routes. Major bus stations in the city should have drinking water and public toilets, along with resting facilities for bus drivers to ensure decent working conditions.

Figure 49 Responses from PT Users when asked where they wait for the bus



Source: Primary Survey, October 2020

"A possible solution to reduce congestion in the walled city area is that there should be a large parking lot in the lower areas, like at Gulab Bagh, beyond which midi buses should not be allowed. We could have smaller high frequency buses that take you into the narrow lanes of the historic core, on one route, enough to carry the tourist influx" - FGD Participant

Being central for both domestic and international tourist attractions, the tangible cultural heritage of Udaipur must be preserved with minimal intervention (i.e., bus-based public transport system, and NMT) to achieve mitigation of trade-offs with SDG1, SDG8 & SDG11. To avoid conflict with built heritage, PT networks must be carefully routed in heritage areas. The authorities could also make ferries a focal point and city-level attraction to enhance the natural and cultural heritage. Since the lakes are well-distributed around tourist spots, the solar ferry fleet has the potential to serve as PT for the floating population, especially to connect the tourists within lake hotels to the walled cities and other attraction spots.

We also recommend UUCA targets aggressive implementation of transition pathways to clean-fuel fleet, including refurbishing or procuring a 100 percent clean-fuel PT fleet, like Electric Buses and subsidizing the transition to EVs for IPT, as the vulnerable groups are largely dependent on these modes for their mobility.

Concluding, preserving the cultural and built heritage with the implementation of pedestrianization/ slow streets across mixed land-uses, efficient freight management, reorganizing IPT and managing an operational city bus service with a trunk and feeder system, promotion of EVs and MaaS in the city, Udaipur can be a safe, sustainable, accessible and equitable tourist city.

Picture 19 Recommended public transport priority lanes (Inspiration from Pune)

Source: ITDP – Urban Street Design Guidelines

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ANNEXURES

ANNEXURE 1: METHODOLOGY CONSIDERED FOR GHG EMISSION INVENTORY CALCULATIONS FOR UDAIPUR

The Udaipur GHG inventory for the base year 2016 is constructed by extrapolating the actual data and trends provided in the Udaipur LCMP (2013). The fundamental equation for calculating these emissions is based on the activity level, which for the transport sector is equivalent of "Emissions = Number of Vehicles * Vehicle kilometres travelled (km) * Emission Factor (gm/km)". This method is followed based on the assumptions listed:

No. of Vehicles

1. Population in the UUCA area was projected from 2013 to 2016 for the base year.
2. Composition of registered vehicles: All newly registered vehicles from 2012-16 were counted as BS-III vehicles; no new BS-I vehicles between 2012-16 were produced, hence the count for BS-I vehicles was the same as 2012; BS-II vehicle count was derived by subtracting the sum of BS-I & BS-III vehicles from the total registered vehicles in 2016.
3. The total motorized passenger demand is calculated as the product of the population and the average trip rate, which is then derived for each mode using the mode share.
4. Further, the number of vehicles is calculated by dividing the motorised passenger demand by the average vehicle occupancy of mode.

Vehicle Kilometer Travelled

1. We assume that the ATL of Taxi/Maxi cabs will be the same as 4-wheelers
2. We assume public buses travel an average of 186 km per day calculated using their speed, time of operation and other route details.

Fuel Standard Mix

1. The fuel standard mix for BS-I is derived from Table 3-6 in the Udaipur LCMP (distribution of old vehicles by type). The share of BS-II and BS-III vehicles is assumed based on no. of registered vehicles in a particular time span; all vehicles sold between financial year (FY) 2004-05 and FY 2009-10 as BS-II vehicles and all vehicles sold between FY 2010-11 and FY 2016-17 as BS-III vehicles.
2. We assume no BS-IV vehicles in Udaipur up to FY 2016-17 as nationwide adoption of BS-IV started from 1st April 2017.
3. In FY 2016-17 there were 23 E-rickshaw in Udaipur. However, the number is quite low and has a negligible impact on the overall emissions level. Hence, we do not account for them in our calculations of emissions inventory. We assume all 3W (rickshaws) to be conventional fuel type (petrol/diesel).
4. Vehicle Fuel Composition - We assume the vehicle fuel composition share to be the same for 2016 as it was in 2011-12 (LCMP).

Emission factor

1. Due to the unavailability of emission factors for diesel 3-wheelers, we assume it to be the same as that for petrol 3-wheelers.

Emission factors for PT Buses and Other Buses are assumed to be the same. Similarly, emission factors for 4-wheelers and Taxi/ Other Cabs are assumed to be the same.

ANNEXURE 2: DETAILS OF UDAIPUR FIELDWORK CONDUCTED IN OCTOBER 2020

Survey type	Survey name	Number of surveys	% of surveys
User surveys	NMT Users	204	50.4%
	PT Users	15	3.7%
	IPT Users survey	30	7.4%
	Private vehicle users	145	35.8%
	Taxi Users survey	11	2.7%
	Total Users	405	100.0%
Operator surveys	E-rickshaw drivers	4	10.0%
	IPT drivers	25	62.5%
	City Bus drivers	1	2.5%
	Taxi drivers	10	25.0%
	Total Operators	40	100.0%
Other Stakeholder surveys	HH surveys	44	38.3%
	Local shop owner/ vendor surveys	20	17.4%
	Tourist surveys	51	44.3%
	Total Stakeholders (other)	115	100.0%

ANNEXURE 3: DEMOGRAPHIC AND LAND-USE DETAILS FOR UDAIPUR

	UUCA (2016)
Demography	
Population	7,02,001
Area (in sq. km)	348
Density (people per sq. km)	2,017
Share of Urbanized Land of Total Area (%)	**57.0**
Land-use Distribution (%)	Residential - 53 Commercial - 4 Industrial - 11 Recreational/ Open - 4 Public/ Semi-public - 21 Transport/ Communication - 9

ANNEXURE 4: TRANSPORT CHARACTERISTICS IN UDAIPUR (2016)

	UUCA (2016)
Transport Characteristics	
Registered Vehicles	5,80,271
Annual Vehicular Growth	11.3%
Traffic Composition	Cycle – 7% 2-wheelers – 72% 4-wheelers – 13% IPT – 7% Public transport – <1% Goods vehicles – 1%
Average Trip Rate	1.12
Average Trip Length (in km)	All modes - 5.09 Walk - 2.54 Cycle - 5.08 Two-wheeler - 5.22 Car – 5.98 PT - 8.47 IPT - 4.47
Mode Share (as per 2016)	Walk- 48% Cycle- 2% Two-wheeler - 34% Car – 3% PT - 2% IPT- 11%
NMT Infrastructure	
Footpath Coverage	1%
Cycle-Track Coverage	<1%
Level of Service ***(Where 1.0 is considered the best and 4.0 the poorest)***	Pedestrian Infrastructure - 4.0 Cycling Infrastructure - 4.0
PT/ IPT Infrastructure	

City Bus Fleet	13
City Bus Network (in km)	89
City Bus Network Coverage	20.23% (37.57% of UMC)
IPT Fleet	6,313 auto-rickshaws; 2,637 tempos
Shared IPT Routes	27
Shared IPT Network Coverage	9.94% (49.95% of UMC)
Level of Service ***(Where 1.0 is considered the best and 4.0 the poorest)***	PT Infrastructure - 4.0 IPT Infrastructure - NA

ANNEXURE 5: SCENARIO COMPARISON BY TRANSPORT PARAMETERS

	Base Year (2016) *	**BAU Scenario (2030) ****	**LC Scenario (2030) ****
Mode Share (Interzonal Trips)			
Pedestrian	25%	20%	28%
Cycle	3%	2%	9%
PT	3%	2%	32%
IPT	18%	22%	10%
2-W	48%	51%	20%
4-W	3%	3%	1%
Transport Systems Parameters			
Annual Motorized Vehicle Kilometres Travelled (VKT) **(in million km)**	1069.7	1,683.2	1,133.73
Congestion (% road length with v/c ratio value >1 or 1)	~26%	26%	5%
Land-use Mix Intensity (% of Intrazonal trips)	19%	16%	68%
Accessibility to PT/ IPT			
% HH within 10-minute walking distance of PT/ IPT stops	*69%*	*60%*	*83%*
PT Coverage in terms of Total Land Areas	*20.23%*	*20.23%*	*40.31%*
IPT Coverage in terms of Total Land Area	*9.95%*	*9.95%*	*36.02%*
Level of Service (LOS) of PT as per MoUD's SLB	*4*	*4*	*2*
Perception of Safety while using NMT modes			
Walking	*7.5%*	*7.5%*	*83%*

Cycling	*7%*	*7%*	*80%*
Level of Service (LOS) of NMT as per MoUD's SLB	*4*	*4*	*2*

Source: Udaipur LCMP 2013

* Due to data gaps, data for base year 2016 is the same as LCMP report's 2013 calculations. This is based on the assumption that for a small-sized city like Udaipur, the transport characteristics would stay consistent for a short span of 2-3 years.

** The LCMP proposal aims at a 20-year span, making 2041 the final year. To align with the project's intended timeline, the final year is capped at 2030. Hence majority data is projected for 2030 using the 2041 trend.

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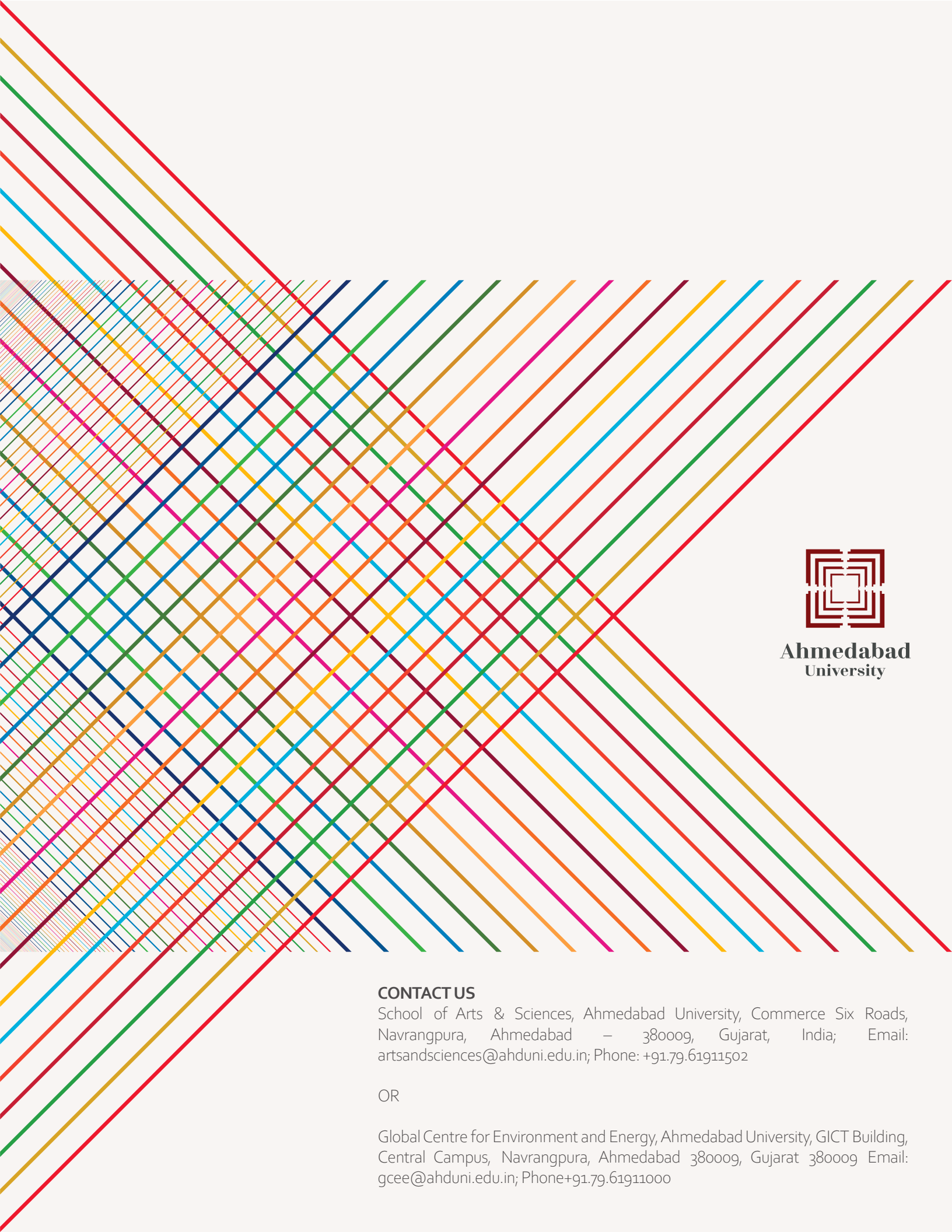

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