Sustainable Urban Transport Index

Surat, India

December -2018

Surat Municipal Corporation

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1. INTRODUCTION

Surat is India's eighth most populous city with a population of 4.5 million (Census 2011) and second most populous city in the state of Gujarat. The city has recorded a decadal growth rate more than 60% consistently over the past five decades. Surat is a major industrial and trade centre in the state of Gujarat. The city has a strong and vibrant economic base and is a major destination for employment seekers in the country. Surat is called the diamond capital of the world with 92% of the world's diamond being cut and polished in Surat. Another major economic driver for the city is the textile sector and it is the biggest centre for manmade fibre in India and the largest manufacturer of clothes in the country (SGCCI,2017). Surat has also emerged as the India's highest ranked 'Smart City' with the largest number of projects implemented and completed in the Smart City Mission stating the administrative and determination of the people of Surat. Surat is also one of the cleanest cities in India and held the 4th rank in the 'Swachh Sarvekshan' conducted by the Ministry of Housing and Urban Affairs - MoHUA in 2017.

The study area considered for the SUTI Indicators is the Surat Municipal Corporation (SMC) Area spanning over 326.52 sq.km. It houses for a population of 5.21 million people. The SMC consists of 89 wards in 7 zones with a gross population density of 245 PPH (Persons per Hectare). The study area has a built up of 262 sq.km i.e. 48% of the total SMC area and 88% of population in Surat resides within the SMC. The study area has a built-up density of 305 PPH and an averaged consumed FSI of 1.3. Surat's walled city is a densely populated area, with a huge concentration of commercial activity. The textile market, Agricultural Produce Market Committee (APMC), main railway station and Gujrat State Road Transport Corporation (GSRTC) terminal are present in this area. Surat also being an industrial town, the percentage of urbanized area under industrial use is quite high and covers almost one fourth of the total area. The average household size in Surat in 2011 was 4.60, which has shown a decrease of 5.45% from 2001. It can be seen that the average household size in case of Surat is much lower as compared to India (5.3) and Gujarat (5.2). It was found that the average income per household is Rs. 31,300 per month within the study area. Surat is truly an industrial city with over 50% of the workforce engaged in manufacturing activity. The Surat is ranked highest with 58% of internal migration in India. It also implies that almost 26% of the city's population is comprised of migrants. The majority of

immigrants who come to find work in the city belong to the working age group. Work Force Participation Rate (WPR) is defined as the ratio of total number of workers in an area to the total population of that area. A low ratio indicates high dependency of population on few jobs. WPR for the study area was found out to be 54%.

1.1 SMC as study area

The figure 1 shows the population density over the areas of Surat including Surat Urban Development Area (SUDA) and SMC area. It is found that the population density is greater within the SMC area and thus it becomes the area of concern.
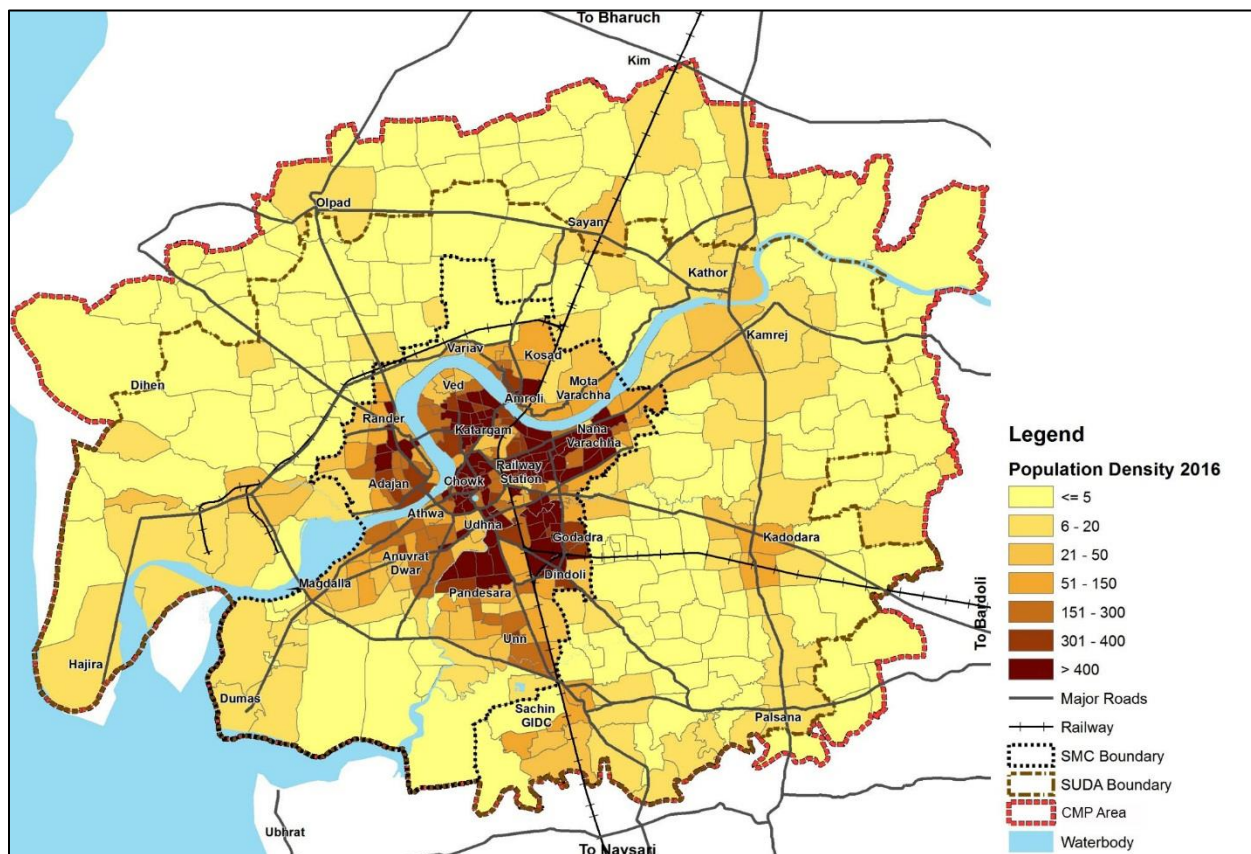
Figure 1 Population density -Surat 2016

Source: CMP, 2018

The study area is subdivided into smaller areas known as Traffic Analysis Zones (TAZs). TAZs are delineated taking into account various factors like administrative boundaries, physical barriers such as water bodies, railway lines, highways and homogenous land uses. In SMC, 89 wards under

7 zones were further split to form TAZs based on the above criteria and around 313 TAZs were identified.

1.2 Objectives of the study

The objective of this study is to develop a Sustainable Urban Transportation Index (SUTI) for Surat, India. This index was developed by United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) to measure, compare and evaluate the performance of sustainable urban transport and related sustainable development goals of Asian cities. Sustainable Urban Transport Index (SUTI) is a framework of indicators for the assessment of urban transport systems and services in a city. The 10 indicators specified in the SUTI will evaluate the transportation system in the Surat Municipal Corporation area and the results will be depicted in the spider diagram. Results will help in identifying the fields of improvement from the existing situation and thereby equipping the civic body to plan for the betterment of city.

2. EXISTING URBAN TRANSPORT SYSTEM AND SERVICE

The urban transport system is highly dependent on the land use character of the city. The city of Surat has developed over the years the transport system with large investment in the development of roads and providing the basic connectivity. The city is well connected by road rail and water. Several National and State highways pass through the city and having a high industrial economic base has resulted in higher volume of traffic entering the city. The city's transportation is predominantly road based. The dependence on individual motorised modes and intermediate public transport is high due to the absence of an adequate public transport system. Even when roads are generally wide, network design and development are not complete. The existing urban transport system will be analysed by the following components such as land use, road network, vehicular growth and public transportation systems.

2.1 Land use

Based on the recent city level plans like Development Pan 2004, the existing the existing land use scenario in 2016 and the Development Plan 2035 reveals that the city has been growing rapidly on the north-eastern, southern and south-western sides since the 1990s owing to the development of many industries in Sachin, Hazira etc. along with residential zones. The urbanised area in Surat city has increased by nearly three-folds between 1978 and 2004, with development mostly occurring within the SMC limits. Surat being an industrial town, the percentage of urbanised area under industrial use is quite high and covers almost one-fourth of the total area. The area under transport is about 17.83%, indicating adequate network. Surat's walled city is a densely populated area, with a huge concentration of commercial activity. The textile market, the APMC, the main railway station and the GSRTC terminal are present in this area. This results in heavy congestion and an increased risk of accidents.

The population within the SMC was 44.7 lakhs in 2011 and has increased to 52.1 lakhs in 2016 as per the estimates provided in the Comprehensive Mobility Plan 2046. The population increase over the last 5 years has occurred with no change in the boundary limits adding to the densification of the city. The built-up area in 2011 within SMC was 101.7 sq.km and has increased to 138.5 sq.km in 2016. The average household size in Surat was 4.60 in 2011, which has shown a decrease of 5.45% from 2001. The total households within the SMC was 5.86 lakhs in 2011 and has increased to 9.75 lakhs in 2016. The migration census has not been released yet and as per a recent study conducted by the UNESCO in 2013 (which used NSSO 2007-08 data) which looked into migration trends in selected million plus cities, it was seen that

Surat ranked highest with 58% of internal migration in India. It also implies that almost 26% of the city's population is comprised of migrants with the highest numbers coming from the states of Uttar Pradesh, Bihar, Odisha, Maharashtra and Rajasthan and getting employed in textile, construction and diamond sectors in the region (Census, 2001).

2.2 Road network

Surat city is well connected with two National Highways (NH-8 and NH-53) and six State Highways (SH-6, SH-167, SH-168, SH-169, SH-170 and SH-602). NH-8 is the busiest highway of the nation and passes towards the eastern periphery of the city and provides connectivity from Delhi to Mumbai. The length of road network within the SMC is 3,859Km. Hierarchy of roads is required to cater to various levels of mobility needs of the city. The hierarchy is predominantly defined by the function that the roads cater to. However, the road network hierarchy defined by the SMC is based purely on road widths, without taking into consideration the functionality of the road network. The hierarchy adopted for the design of Surat's road network is as follows:

Table 1 Road network hierarchy

Road Levels	Length (km)	%Share
Level 1 - Arterial (above 36 m)	370	10%
Level 2 - Sub Arterial (24-36 m)	356	9%
Level 3 - Collector (12-24 m)	953	25%
Level 4 - Local (<12 m)	2180	56%
Total	3859	100%
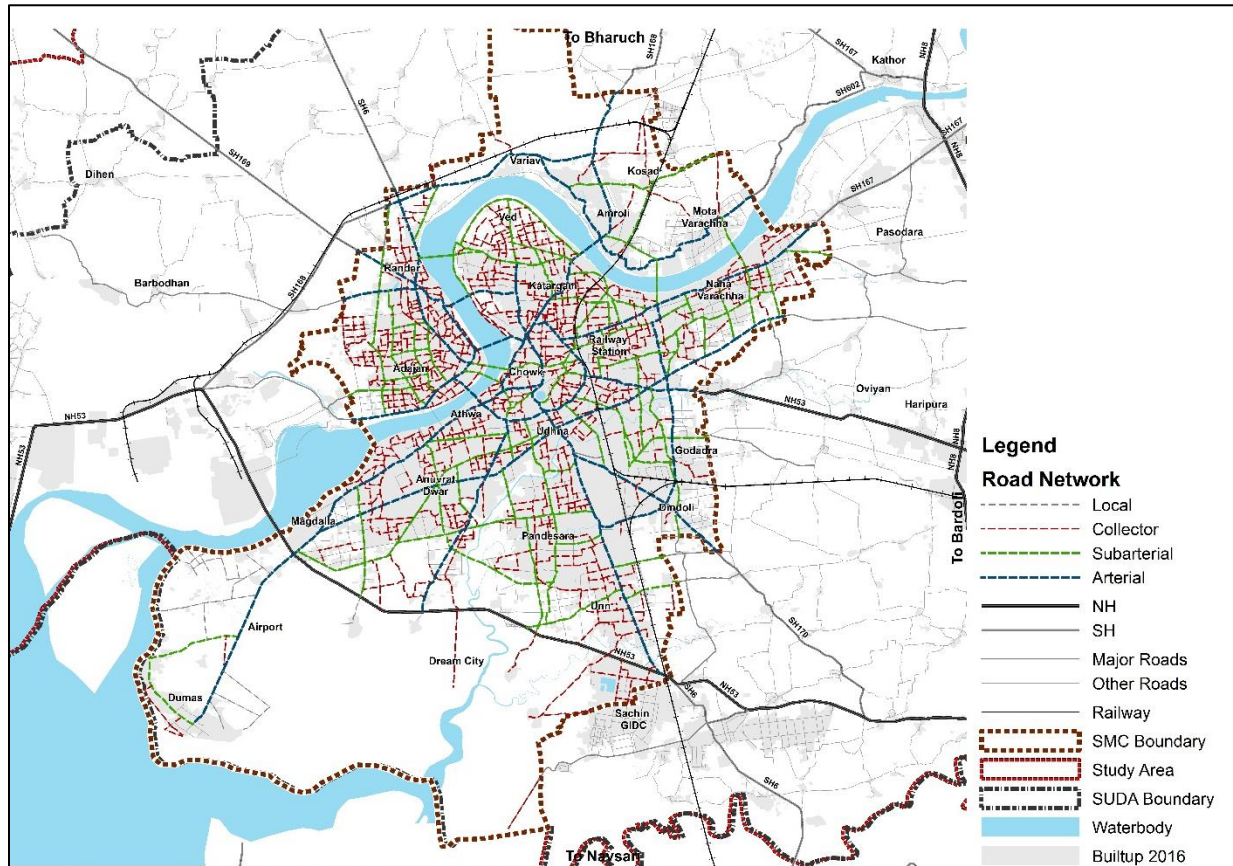
Figure 2 Road network system - Surat

Source: SMC, 2017

2.3 Vehicular growth

The city of Surat has high motorisation rates over the years. The number of vehicles registered with the Surat RTO has risen from 0.62 lakh in 1980 to 30.09 lakh in March 2018. In the last five years alone, the growth in vehicles has been around 9% per year. In terms of the number and type of vehicles being registered, it is seen that 2-wheelers lead the growth followed by cars and 3-wheelers. In respect to 2011, 2-wheelers per 1000 population has increased from 96 to 275 while during the same period, 4-wheeler per 1000 population has increased from 19 to 22. In terms of the share of vehicles in the last 10 years, it is observed that the share of 2-wheelers is almost stable at around 78% while that of 4-wheelers has increased from 10%–18%, which is likely to have major implications in terms of congestion.
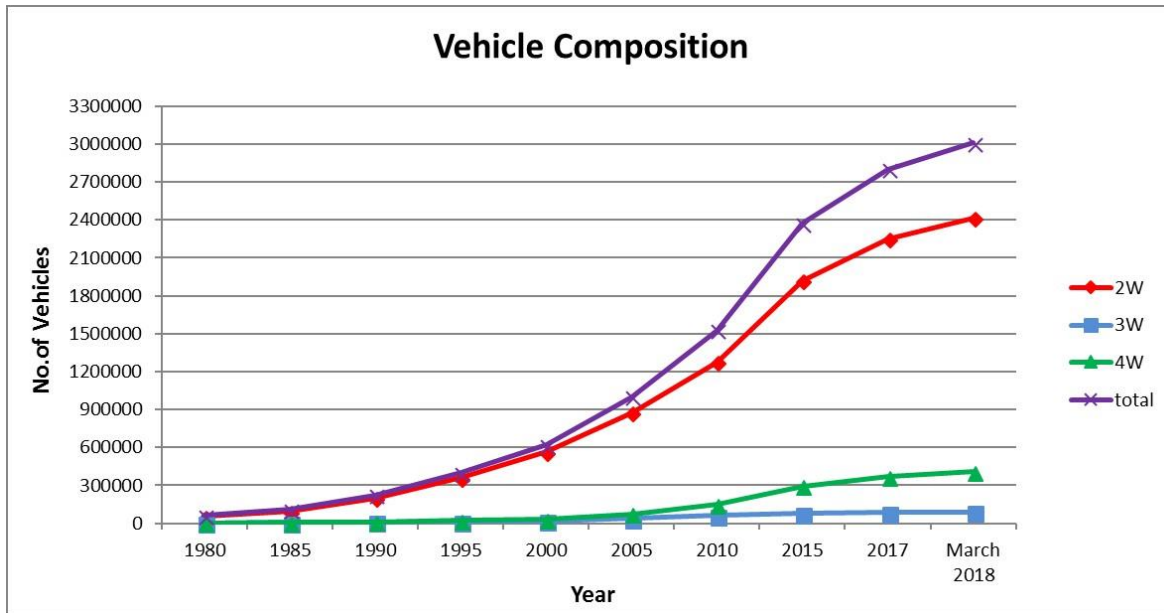
Figure 3 Vehicular growth by mode

2.4 Travel characteristics

Travel characteristics can be defined in terms of trip rate, mode share, trip length etc. Trip rate is defined as the total number of trips made per capita per day. The per capita trip rate (PCTR) for the study area is observed to be 0.95.

Two-wheeler is a predominant transportation mode in Surat, accounting for 63% of the trips (without walk trips). As discussed in the previous section, the share of the public transport mode is quite low at 2% (without walk trips). The share of walk and cycle trips is about 43%, which is quite high because of compact and mixed land use development in the city.
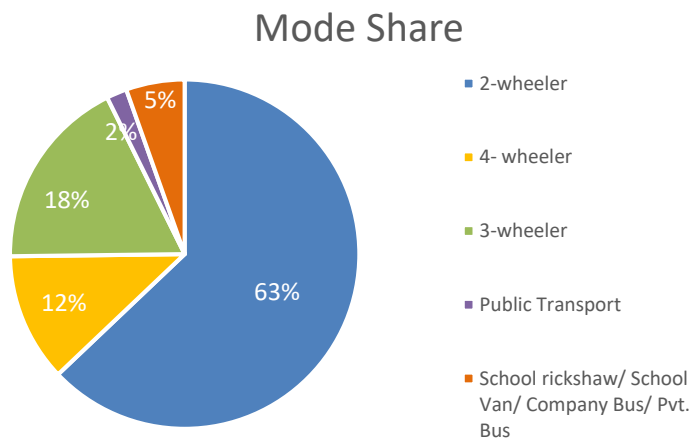
Figure 4 Mode share -without walk trips

Pedestrians in Surat have an average trip length of 2.9 km. Surveys recorded that 29% of pedestrian trips are for educational purposes, 16% for work and remaining 55% for other purposes. The average trip length for a bicyclist in Surat is 4 km. Surveys recorded 42% of bicycle trips for educational purposes, 56% for work and remaining 2% for other purposes. It was observed that the average trip length by public transport is around 10.3 km, followed by 4-wheelers which have a trip length of 7.9 km.

About 28% of work trips are made by 2-wheelers, whereas only 0.52 % trips are made by PT. Work trips made by 3-wheelers contributes to 4.6 %. For education purpose, about 13 % of trips are made by walk and cycle.

Travel Demand analysis shows that 31.3 lakh passenger trips happen by two-wheeler, 5.9 lakh passenger trips happen by four-wheeler, 8.9 lakh passenger trips happen by three-wheeler, 0.9 lakh passenger trips happen by public transport and 2.7 lakh passenger trips happen by school rickshaw or school van or company bus or private bus.

2.5 Public transport system

Currently in Surat, the city bus services (CBS), bus rapid transit services (BRTS) and high mobility corridor (HMC) are being operated on gross cost basis by Sitilink Ltd a SPV under SMC.

City bus service (CBS)

In the existing situation there are 31 routes plying within the study area, with 242 buses on road. Bus routes are scheduled to operate at 8–20 min. headway. The bus system is carrying an average of about 1,00,000 riders per day (June 2018). All these buses are midi buses and operated by three different private operators on Gross Cost Contract (GCC). Currently, the City Bus coverage is 73% of the study area.

City is also expecting another 300 midi buses which would be operated on CBS routes. These would have the additional new City Bus routes in the city and some upgradation in frequencies of the existing 31 routes would be needed. Recently, Surat city has prepared a Public Transport Operations Plan, which outlines about 550 km of PT network proposal for City Bus services integrating with BRTS, to be operated by Sitilink Ltd. A total of 1000 buses are planned for this planned city bus network.

Figure 5 City bus in Surat

Bus Rapid Transit Service (BRTS)

Sitilink inaugurated BRTS Phase I of 30 km in 2014 and now it has the largest BRTS in India, with 102 km network operational. The BRT network is currently attracting about 80,000 passengers per day. Sitilink BRTS connects major transit nodes such as railway station, GSRTC terminal, residential and commercial hubs, recreational and public areas of the city, with provisions for NMT (pedestrian pathways and cycle tracks) along the corridors. The average speed of BRTS buses is 24 kmph, which is quite high in comparison to the existing city bus services and auto rickshaws.

With future proposals of expansion in BRTS and City Bus network under CMP-2046, it is expected to cater 24% of road network by rapid transit network and 76% by the city bus network. This will increase the accessibility to transit by 23% thereby predicting a public transit ridership of 36 lakhs per day by 2046.

Figure 6 BRTS in Surat

High Mobility Corridor (HMC)

The 12 km High Mobility Corridor is around the inner ring road of Surat. It is expected to cater the high mobility demand of the core city area. The HMC in the existing situation has only two major routes of operation.

Figure 7 HMC in Surat

2.6 Intermediate public transport system

The city of Surat is known for auto rickshaw transportation for years. Currently, there are about 38,000 registered autos in the city. Most of the autos in Surat operate on fixed routes with fixed fares based on distance. Around 8.6 lakh trips are being undertaken as per 2016 household surveys on these auto rickshaws. To ensure the last mile accessibility, a feeder system with an initial fleet of 40 rickshaws known as "Pink Autos", had started operating by women in the old city. These autos act as major feeders to the public transport system.

Figure 8 Pink autos as feeder service in Surat

2.7 Issues and challenges

The section summarises the issues and challenges for mobility from the data analysed along with the stakeholder surveys carried out through online consultation and stakeholder workshop done as part of the Comprehensive Mobility Plan -2046.

The key challenges identified are:

- Doubling of population from 60 lakhs in 2016 to 125 lakhs in 2046
- 2.9 times increase in personal vehicles (2-wheelers and cars) on roads from18 lakhs in 2016 to 72 lakhs in 2046
- 2.3 times increase in passenger journeys from 54.64 lakh passenger trips to 125 lakh passenger trips.

- Increase in congested network from 14% to 57%

- Reduction in network speeds from average 28 kmph to below 18 kmph

- 2.6 times increase in the average travel time of Surat's residents from 13 minutes to about 34 minutes

- 2.8 times increase in accident probability

- 2 times increase in GHG (greenhouse gases) emissions

The existing transportation situation in Surat is summarized in the table given below:

Table 2 Existing transport situation

Sr.No.	Parameter	2011	2016
		Existing	
1	**Population (in lakhs)**	44.7	52.1
2	**Household (in lakhs)**	9.8	12.4
3	**Built up Area (sq km)**	101.7	138.5
4	**Employment (in lakhs)**	-	25.0
5	**Density (pph)**	439	376
6	**Personalized Vehicles per 1000 population**		
	2W per 1000 population	96	275
	Cars per 1000 population	19	22
7	**Motorized Trip Rates**	0.8	0.95
8	**Mode Share (%)**		
	2-wheeler	-	63%
	4- wheeler	-	12%
	3-wheeler	-	18%
	Public Transport	-	2%
	School rickshaw/ School Van/ Company Bus/ Pvt. Bus	-	5%
9	**Travel Demand (passenger trips) (in lakhs)**		
	2-wheeler	-	31.3
	4- wheeler	-	5.9
	3-wheeler	-	8.9
	Public Transport	-	0.9
	School rickshaw/ School Van/ Company Bus/ Pvt. Bus	-	2.7

Source: CMP, 2018

3. DATA COLLECTION APPROACH FOR SUTI

The Sustainable Urban Transport Index (SUTI) had been developed by UN ESCAP to summarize, track and compare the performance of Asian cities in respect to sustainable urban transport and the related Sustainable Development Goals (SDGs). SUTI is identified to be a periodically ongoing process wherein data is collected for comparative purposes, enabling the cities to identify the deficiencies thereby to set targets and identify good practices cum lessons in the field of transport.

3.1 Introduction

Data collection for different indicators to develop SUTI comprises of field data collection, data collection from appropriate authorities and reviewing different relevant data sources. Some indicators can be dealt together and can be developed from a single data source, thus initial step will be to identify the indicators having possible common data sources. Based on the defined methodology by SUTI, data for each indicator is then analyzed.

3.2 Data collection approach for different Indicators

The ten indicators of SUTI are as follows:

1. Indicator 1: Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes
2. Indicator 2: Modal share of active and public transport in commuting
3. Indicator 3: Convenient access to public transport service
4. Indicator 4: Public transport quality and reliability
5. Indicator 5: Traffic fatalities per 100,000 inhabitants
6. Indicator 6: Affordability – travel costs as share of income
7. Indicator 7: Operational costs of the public transport system
8. Indicator 8: Investment in public transportation systems
9. Indicator 9: Air quality (PM 10)
10. Indicator 10: Greenhouse gas emissions from transport

The overall data collection procedure and the data sources for each indicator is described below.

Indicator 1: Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes

Indicator 1 is analyzed based on the recent transportation plan which covers walking networks, cycling networks, intermodal transfer facilities and public transport. The recent transport plan that is used to derive the indicator 1 for the city of Surat is the Comprehensive Mobility Plan (CMP) for the year 2046. The CMP-2046 made in the year 2018 focusses on the above said aspects of transportation with ambitious goals and secured funding. The vision put forth under CMP for Surat region for the year 2046 is "SARAL – Safe Accessible Reliable Advanced and Low-carbon mobility in Surat".

Indicator 2: Modal share of active and public transport in commuting

The data required for the indicator 2 were considered based on the Household Survey done as a part of the Comprehensive Mobility plan- 2046. 13,563 households were surveyed within SMC and trip diary of the survey gave the trip information of the people of Surat. The educational and work trips as per the modes were retrieved and found the trip rates. Based on the retrieved data the modal share of active and public transport was calculated to derive the results of the indicator.

Indicator 3: Convenient access to public transport service

The data used to derive the indicator 3 were considered based on the Route and Schedule information from the transit authority -SitiLink (a Special Purpose Vehicle under SMC) and demographic information from Census 2011. Based on the Route and Schedule information a bus flow map was prepared indicating the frequency of bus system i.e. both BRTS and City bus along the scheduled routes, and it was observed that every bus stop of all the operational routes has a frequency of service less than 20 minutes. The population was distributed into TAZs (Traffic Analysis Zones) within SMC and a 500m buffer was made of all the operational bus stops. The total inhabitants within the 500m buffer of the operational bus stops were analyzed to calculate the percentage of people having convenient access to the public transportation system.

Indicator 4: Public transport quality and reliability

To derive the indicator 4 the data from the user satisfaction survey were used which is done as part of the operations plan in Surat. Thus, the data used for the indicator 4 is based on the quarter 5 report of operations plan. In the user satisfaction survey, rather than the 8 specific dimensions specified in the SUTI, the following dimensions were considered: good frequency, breakdown, cleanliness of buses, safe driving, safety while crossing, reliability in the bus passenger information system, staff behavior and fair cum consistent prices. The considered dimensions are in line with the 8 dimensions of the indicator. Rather than providing a scale of 7, the satisfaction survey conducted included either agree or disagree to the 8 dimensions specified in the SUTI indicator 4. A sample of 1000 users were conducted with 35.2% of women composition. All age groups were tried to incorporate within the sample. The survey with proportionate samples were conducted at major boarding bus stations. The time of survey were at peak hours of 8-11am and 5-8pm, 30% of off-peak hour samples were also included. The survey was done at both station and on board.

Indicator 5: Traffic fatalities per 100,000 inhabitants

The responsibility of gathering the accident related data vests in the traffic police department, Surat city. The accident data is retrieved from the FIR (First Information Report) prepared by the respective traffic police department made after an accident has taken place. Based on the accident data which involves the minor, major and fatal accident data, the fatality data for the latest year 2017 was retrieved to find the fatalities per lakh population.

Indicator 6: Affordability – travel costs as share of income

The indicator 6 involves the collection of two data: 1. Costs of using public transport, 2. Average Monthly income of the poorest quartile of the population. The cost of using public transport was retrieved from the single ticket price. It was then converted to monthly cost and further calculated the weighted monthly cost based on the market shares of the bus services. Market shares of the bus services are based on the ridership data derived from the performance assessment of public transport in Surat – Quarter 5 report prepared by the transit authority - SitiLink (a Special Purpose Vehicle under SMC).

The monthly income data is retrieved from the household survey conducted as part of the CMP-2046. It was further analyzed to give the average monthly income of the poorest quartile of the population. The ratio of the weighted public transport monthly cost to the average monthly income of the poorest quartile of the population give the result for the indicator 6.

Indicator 7: Operational costs of the public transport system

The data to derive the indicator 7 require the data of fare revenue and expenses of the public transport system thereby to calculate the fare box recovery ratio. The fare revenue and expenses of different public transport operators were retrieved from the transit authority -SitiLink (a Special Purpose Vehicle under SMC). The data is inputted based on the modes of public transport system available in Surat.

Indicator 8: Investment in public transportation systems

The data required for indicator 8 is the public transport investments in the respective city for the last 5 years. The public transport investments were retrieved from the budget documents of the SMC, whereby of the total transport investments and the public transport investments were retrieved for the latest 5 years. The public transport investments include expenditure on bus procurement, infrastructure development like workshops, depots, terminals, interchanges, BRTS dedicated corridor and bus stops, bicycle and pedestrian infrastructure like cycle track and pedestrian footpaths. The share of the public transport investments of the total investments specified in the budget give the result for the indicator 8.

Indicator 9: Air quality (PM 10)

The data needed to derive the indicator 9 is the air quality information within the city. In Surat, within SMC there are 6 air monitoring stations as given in GPCB (Gujarat Pollution Control Board) 2016-17 report was considered. The stations are located on the building rooftop. Three zoning area were defined based on the wind direction in the city considering SMC zone boundary and ward boundary. The population covered within the individual zones were then calculated. Both PM10 and PM2.5 are being analyzed in the Surat but for the indicator, PM10 values are

considered. The PM10 values and the population covered within its reach data were then weighted to derive the result of indicator 9.

Indicator 10: Greenhouse gas emissions from transport

The data required for deriving the indicator 10 is the greenhouse gas emissions within the city. The greenhouse gas emissions were calculated for both the passenger and freight vehicles. The emission factors were retrieved from Emission Factor development for Indian Vehicles, ARAI Pune Report 2008 and Central Pollution Control Board (CPCB) reports. The passenger vehicle data was retrieved from the household survey done as part of the Surat -CMP. The freight vehicle estimates were done from the activity surveys and road side interview cordon point surveys. The greenhouse gas emissions (CO and CO_2) were then calculated based on the collected data.

4. DATA BASE FOR SUTI

The final data derived for all the indicators is given below.

Indicator 1 - Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes

Aspects	Data Source
Walking Networks	Section 9.5.5 of CMP 2046 - Surat (2018)
Cycling Networks	Section 9.5.4 of CMP 2046 - Surat (2018)
Intermodal Transfer Facilities	Section 9.3.7 of CMP 2046 - Surat (2018)
Public Transport	Section 9.3 of CMP 2046 - Surat (2018)

Indicator 2 - Modal share of active and public transport in commuting

Mode	Trip Rate
Public Transport	0.02
Active Transport	0.33
Individual Motorized Transport	0.87
Total	1.23

The data source for the Indicator 2 is the household survey done as part of the CMP, Surat-2046. The samples considered are 13,563 households within the SMC area.

Indicator 3 – Convenient access to public transport service

Aspects	Quantity
Population within 500m accessibility of Public Transport	48,25,717
Total Population - 2016	52,13,426

The data source for the existing operational stops and thereby the population density within the 500m radius is the Operations Plan done as per Quarter 5, 2018 for the BRTS and City bus service in Surat. The estimated population for 2016 is based on the CMP-2046, Surat.

Indicator 4 – Public transport quality and reliability

Dimension	Dissatisfied	Satisfied	Responses	Percentage of Satisfaction
Frequency of the service	181	819	1000	**81.9**
Punctuality (delay)*	18	982	1000	**98.2**
Comfort and cleanliness of vehicles	72	928	1000	**92.8**
Safety of vehicles	27	973	1000	**97.3**
Convenience of stops/stations	4	996	1000	**99.6**
Availability of information	339	661	1000	**66.1**
Personnel courtesy	11	989	1000	**98.9**
Fare level	172	828	1000	**82.8**
Total Responses	824	7176	8000	**89.7**

The data source for the indicator 4 is Performance Assessment of Public Transport in Surat – Quarterly report 5 (2018) carried out by the Centre of Excellence in Urban Transport, CEPT University.

Indicator 5 - Traffic fatalities per 1,00,000 inhabitants

Year	Fatalities	Population
2017	239	52,13,426

The data source for the Indicator 5 is the FIR details obtained from the City Traffic Police - Surat,2017.

Indicator 6 - Affordability: travel costs as share of income

(Conversion rate of 1 US $ is equal to 72 Indian Rupee)

Factors	Quantity (in US $)
Weighted monthly Public Transport Cost	8.43
Mean Household Income	151.38

The data sources for the Indicator 6 are:

- Performance Assessment of Public Transport in Surat – Quarterly reports 5 (2018) for the public transport cost carried out by the Centre of Excellence in Urban Transport, CEPT University,
- Household survey done under CMP-2046, (carried out by the Centre of Excellence in Urban Transport, CEPT University);
- Surat for the mean household income.

Indicator 7 – Operational costs of the public transport system

(Conversion rate of 1 US $ is equal to 72 Indian Rupee)

Factors	Amount (in US $)
Fare box revenue	6,44,030
Operating Expense	11,78,089

- The data sources for the indicator 7 are Performance Assessment of Public Transport in Surat – Quarterly reports 5 (2018) carried out by the Centre of Excellence in Urban Transport, CEPT University. And

Investments by the City (in million US $)	2013-14	2014-15	2015-16	2016-17	2017-18	Average
Public Transport Investment	1.4	0.3	6.5	4.3	3.2	3.1
Total Transport investment	11.3	10.8	9.9	8.6	7.1	9.5

- Revenue and Expense sheet from Surat SitiLink Ltd., which is an SPV for public transport operation under SMC. The revenue and expense include both the BRTS and City bus services.

Indicator 8 – Investment in public transportation system

(Conversion rate of 1 US $ is equal to 72 Indian Rupee)

The data source for the indicator 8 is the budget data of SMC, which was considered for the last 5 years. The public transport investments also included the private investments in public transport.

Indicator 9 – Air quality (PM10)

Station	Location	PM 10 (yearly mean)	Population within the area	Population (in %)
1	SVR College	85	796138	15.3
2	GIDC Pandesara	100	766524	14.7
3	BRC, Udhana(Darshan Processors)	100	766524	14.7
4	Air India Building	96	961413	18.4
5	Delhi Gate Police Chowki	102	961413	18.4
6	Hi-Choice Processers, Sachin	105	961413	18.4
	Total city population		5213425	100

The data source for the indicator 9 is the Gujarat Pollution Control Board (GPCB) report 2016-17, wherein 6 air monitoring stations within the SMC are considered for the PM10 values.

Indicator 10 – Greenhouse gas emissions from transport

GHG Emissions (CO+Co2)	Total Vehicle (Passenger + Freight)
Tons/day	2,998

The data source for the indicator 10 include the goods vehicle estimates from the roads side interview survey, passenger vehicles data and trip length details from CEPT Surveys for CMP.

ANALYSIS OF DATA

The methodology of the data analysis for all the indicators is explained below.

4.1 Indicator 1: Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes

The indicator 1 analyses the extent to which the recent transport plans for the city cover public transport, intermodal facilities and infrastructure for active modes. The aspects considered for indicator include Walking networks, Cycling Networks, Intermodal transfer facilities and public transport. The minimum and maximum values for this indicator are 0 and 16 respectively. Each aspect is to be ranked on a scale of 4, with 4 indicating the best.

4.1.1 Data Analysis

The recent transport plan done in the city of Surat is the Comprehensive Mobility Plan (CMP) for the year 2046. The vision put forth under CMP for Surat region for the year 2046 is "SARAL – Safe Accessible Reliable Advanced and Low-carbon mobility in Surat".

To achieve the strategic goals of the plan, seven proposals were recommended.

1. Improving Street Network

In view of the future mobility challenges, improvements in the street network are proposed to ensure connectivity, enhance accessibility and improve the efficiency. The plan proposal aids in completing the network, improving hierarchy and adding second and third level network. It is proposed that all roads 18m and above will be developed as transit streets with middle lane reserved for transit and priority for same at the junctions.

2. Integrated Multi-Modal Public Transport System

The Integrated Public Transport System aims at providing seamless connectivity across all the public transport modes of Surat. A total of 240 Km of network was identified as the strategic network, which is part of a higher order road network, connecting the main city to existing and upcoming regional centers. The proposal identifies 36 interchanges for seamless transfer through physical integration; the Surat Railway station, Majura gate and High-Speed Rail station are some of the major ones. To integrate the public transport system in Surat, specific provisions in City Bus system, BRTS, Surat Metro, High Mobility Corridor, Feeder System and Fare Integration have

been done to attain a complete system. Intelligent transport systems such as Automated Fare Collection, Automatic Vehicle Location System, Passenger Information System, Vehicle Scheduling and Dispatch System, Depot and Incidence Management System etc. will act as the backbone for efficient functioning of the system.

3. Transit Oriented Development

Transit Oriented Development (TOD) is proposed to have a sustainable alternative to low density sprawl which is due to use of private automobiles that results in long commutes, more cars, higher congestion and higher pollution. The components of TOD include improving walkability in transit area thereby encouraging the use of public transport. Considering a constructive approach by taking a buffer of 200m on either side of transit, 140sq.km of area within 72 TOD zones will be obtained. A sensitive Local Area Plan (LAP) will incentivize the redevelopment along TOD and FSI of 4 (1.8 base and 2.2 chargeable FSI) in the transit zones are being provided.

4. Pedestrians and Cyclists

The plan focuses on providing basic infrastructural elements such as lane markings for bicycle tracks along all public transit routes and new footpaths cum widening of existing ones on all Public Transport routes. The components of non-motorized transport includes 488 Kms of footpaths above 1.8m and 288 Km of cycle network is identified with lane marking. Renovation of the street network that are with adequate width but lacking walkability, bicycle sharing systems with 1600 cycles and awareness campaigns are some of the initiatives that help propagate the idea of walking and bicycling in the city. Walkable streets with public plazas are also proposed as a part of this plan to encourage walkability and enhance the cultural life.

5. Safety and Security

As part of the mobility management measures proposed, accident management is one of the key focus of the plan. The components of safety and security includes design improvement and junction signalization for which a total of 257 junctions have been identified, setting up of speed limits for the city as per hierarchy of roads and accident monitoring cell which is GIS based accident management cell which would look at monitor and analyze the accident occurrences.

6. Urban Freight Management

Some of the initiatives under the proposal are new outer ring road for through freight and vehicular traffic, 'Textile corridor' with logistic park proposed near Palsana to help reduce freight vehicle intrusion into the city, Entry-Exit restrictions for freight vehicles (HCVs and MCVs), Parking regulations and Provisioning for farm to market.

7. Fiscal Measures

Fiscal measures proposed include taxation like environment improvement tax, fare regulation, value capture, parking charges and congestion charging have been suggested as part of the CMP.

4.1.2   Result

In line with the Comprehensive Mobility Plan the SUTI Indicator 1 is being analysed.

Table 2 Indicator 1- Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes

Aspects	Explanation	Score
I) walking networks	The goals are ambitious, with much designation over city. The Comprehensive mobility plan -2046 for Surat city do envisages increased walking networks with secured new funding	4
II) cycling networks	Cycling networks are existing in present scenario, and plan foresees greater networks along major corridors allocated with phasing and have realistic budget	3
III) intermodal transfer facilities	Seamless mobility has been a priority of the plan and factors leading to intermodal transfers like interchanges, integration of modes, fares and feeder services are given due consideration with secured new funding	4
IV) public transport	Present public transport mode share is not predominant and thus ambitious goals are indeed set with increased mode share and greater investments with secured funding is proposed in the plan	4
Total (sum)		15

4.2 Indicator 2: Modal share of active and public transport in commuting

The indicator 2 analyses the modal share of active and public transport modes. The active modes include the cycling and walking trips, whereas the public transport includes the formal modes

and their trips like bus, BRT, tram, rail and scheduled ferry. The minimum and maximum values for this indicator are 10 and 90 respectively.

4.2.1 Data analysis

The trip rates of each mode for educational and work trips is to be retrieved and thereby calculate the share of active and public transport modes. The indicator is derived by considering both active and public transport modes.

The data of 13,563 household surveys (within SMC) conducted as per the Comprehensive Mobility Plan-2046 are used. The educational and work trip rates as per the modes are retrieved to derive the results of the indicator.

4.2.2 Result

- Trip rates across modes

Table 3 Trip rates across modes

Modes	Trip Rate
2Wh	0.55
3Wh – Private	0.02
Shared Auto	0.08
4Wh	0.03
BRTS	0.01
Bus	0.01
Company Bus	0.01
Cycle	0.03
GSRTC	0.0023
Other	0.0001
Private Bus	0.0020
Rail	0.0047
School Van	0.08
School/ College Bus	0.04
Walk	0.30
School Rickshaw	0.05
Grand Total	1.23

Source: CMP, 2018

Modal share of active and public transport with informal transport modes

Table 4 Indicator 2-Modal share of active and public transport with informal transport modes along with collective modes

PURPOSE	COMMUTING (WORK AND EDUCATION)	
MODE	#	subtotals
a. Scheduled bus and midi bus (*)	0.017	
b. Train, metro, tram	0.005	
c. Ferry	0.000	
d. Public transport	**(a+b+c)**	**0.02**
e. Walking	0.3006	
f. Bicycle	0.0329	
g. Active transport	**(e+f)**	**0.33**
h. Passenger car	0.0322	
i. 3W - Private	0.0223	
j. Shared Auto	0.080	
k. Motorcycle	0.5542	
l. Institutional Buses and Auto Rickshaws	0.1825	
m. Other motorized (trucks,etc)	0.0001	
n. Individual motorized (**)	**(h+i+j+k+l+m)**	**0.87**
o. Total	**(d+g+n)**	**1.23**
p. Public and active	**(d+g)**	**0.36**
q. Modal share of active and public transport		**29**

* Scheduled bus and midibus include BRTS, Bus, GSRTC services and Institutional Buses

** Individual Motorized include Passenger car and two-wheeler

4.3 Indicator 3: Convenient access to public transport service

Indicator 3 checks the convenient access to public transport system. The indicator requires an estimate of how many inhabitants are living within 500-meter buffer zones around stations and bus stops with a 20 minute or more frequent scheduled service interval. The minimum and maximum values for this indicator are 20 and 100 respectively.

4.3.1 Data analysis

The data used for the indicator involve the Route and Schedule information from the transit authority -SitiLink (a Special Purpose Vehicle under SMC) and demographic information from

Census 2011. The number of operational bus stops of both city bus and BRTS within the SMC are 604 stops.

To arrive at the indicator, a bus flow map was prepared indicating the frequency of bus system i.e. both BRTS and City bus along the scheduled routes as shown in Fig 2. It is observed that every bus stop of all the operational routes has a frequency of service less than 20 minutes.
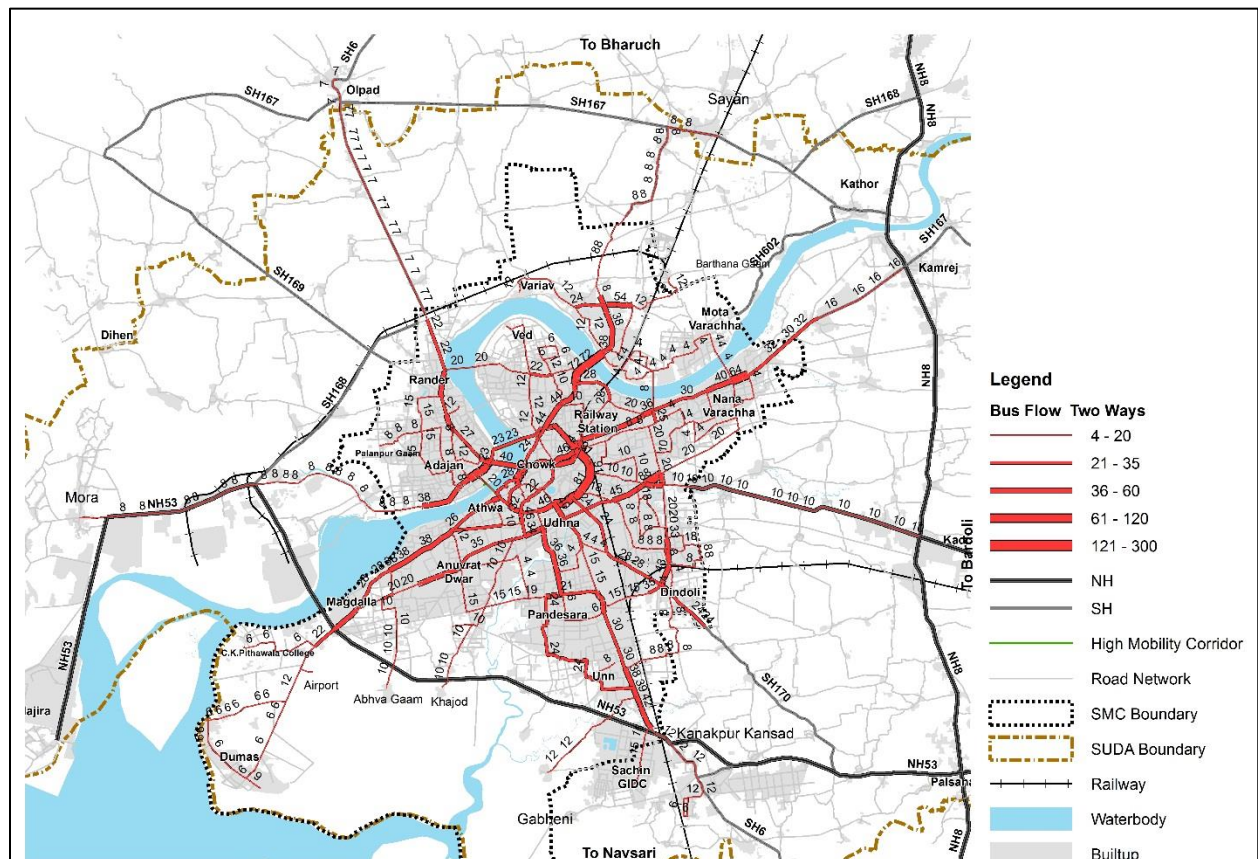
Figure 9 Bus flow both direction

The operational stops of both BRTS and city bus within SMC were considered and a buffer of 500m was made to identify the population inhabiting within the buffer.
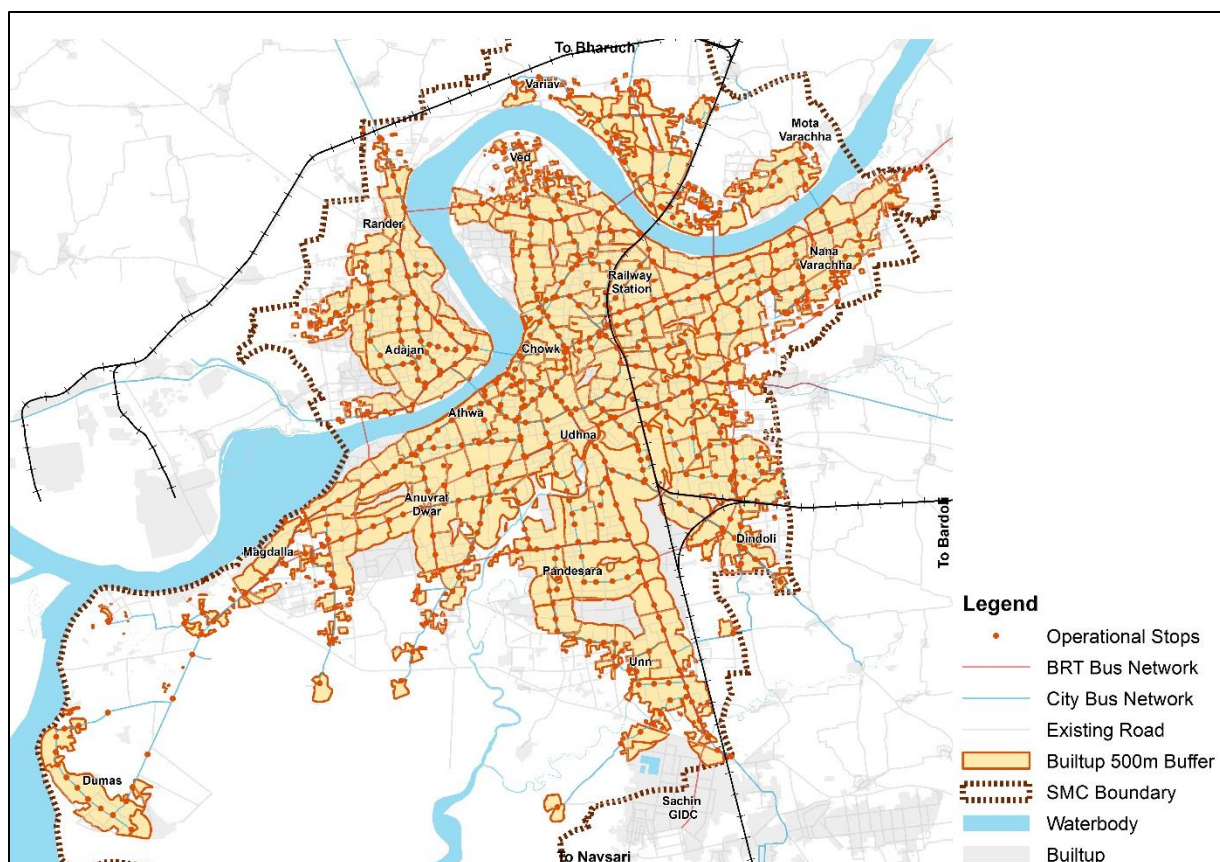
Figure 10 Inhabitants within 500 m buffer of operational stops

4.3.2   Result

Table 5 Indicator 3 -Convenient access to public transport service

Number of bus stops	Coverage area within a radius of 500m	Pop. density	Inhabitants
	km2	In h/km2	#
604	118.0	40901	48,25,717
Total Population (*)			52,13,426
% within 500m buffers			93

*Source: * The total population is based on the CEPT estimates for SMC, on year 2016*

4.4 Indicator 4: Public transport quality and reliability

The indicator 4 analyses the degree to which the passengers of the public transport system are satisfied with the quality of service while using the different modes of public transport. A user satisfaction survey of sample size between 250-300 is to be conducted of which user has to grade the 8 dimensions based on a scale of 7 and the sample should at least have 30% women samples. The survey can be carried forward at major stations or corridors of ridership. The minimum and maximum values for this indicator are 30 and 95 respectively.

4.4.1   Data analysis

The user satisfaction survey was carried out as part of the operations plan in Surat. Thus, the data used for the indicator 4 is based on the quarter 5 report of operations plan. Rather than providing a scale of 7, the satisfaction survey conducted included either agree or disagree to the 8 dimensions specified in the SUTI indicator 4. A sample of 1000 users were conducted with 35.2% of women composition. All age groups were tried to incorporate within the sample. The survey with proportionate samples were conducted at major boarding bus stations. The time of survey is at peak hours of 8-11am and 5-8pm, 30% of off-peak hour samples are also included. The survey was done at both station and on board.

4.4.2   Result

Table 6 Indicator 4- Public transport quality and reliability

Dimension	Dissatisfied	Satisfied	Respondents	Satisfaction
			RESP	%ge
Frequency of the service	181	819	1000	**81.90**
Punctuality (delay)*	18	982	1000	**98.20**
Comfort and cleanliness of vehicles	72	928	1000	**92.80**
Safety of vehicles	27	973	1000	97.30
Convenience of stops/stations	4	996	1000	99.60
Availability of information	339	661	1000	66.10
Personnel courtesy	11	989	1000	98.90
Fare level	172	828	1000	82.80
Responses	**824**	**7176**	8000	**89.70**

* For the parameter "Punctuality", the survey data for "Breakdowns" were available, therefore in the satisfy column respondents disagreed to breakdown has been considered.

4.5 Indicator 5: Traffic fatalities per 100,000 inhabitants

The indicator 5 analyses the fatalities in traffic (road; rail, ferry etc.) in the urban areas per 1,00,000 inhabitants. As defined by the WHO, a death counts as related to a traffic accident if it occurs within 30 days after the accident. The minimum and maximum values for this indicator are 35 and 0 respectively.

4.5.1   Data analysis

The data for the indicator is being retrieved for the last 7 years from the traffic police department, Surat as shown in the table below.

Table 7 Fatalities over last 5 years

Years	Fatalities	Serious Injuries
2011	249	453
2012	196	460
2013	203	462
2014	222	457
2015	291	444
2016	283	462
2017	239	584

Source: Traffic Police, 2017

4.5.2   Result

The recent fatality data of 2017 was used to derive the results of the indicator.

Table 8 Indicator 5 -Traffic fatalities per 100000 inhabitants

Fatalities	Numbers
Road transport	239
Railway transport	0
Tram	0
Ferryboats	0
Other	0
Total	239
Inhabitants	52,13,426
Fatalities/100,000 inh	**4.6**

4.6 Indicator 6: Affordability – travel costs as share of income

The indicator 6 analyses the affordability of public transport system in the city by comparing the travel costs with the share of income. The method involves deriving the ratio between the mean monthly income for the poorest quartile of the population of the city to cost of a monthly network wide public transport ticket covering all main modes in the city. The minimum and maximum values for this indicator are 35 and 3.5 respectively.

4.6.1 Data analysis

The indicator involves the collection of two data: 1. Costs of using public transport, 2. Average Monthly income of the poorest quartile of the population. The cost of using public transport and thereby to calculate the weighted average, the ridership data required to find the market share are derived from the performance assessment of public transport in Surat provided in Quarter 5 report prepared by the transit authority -SitiLink (a Special Purpose Vehicle under SMC). The monthly ridership data and the average fare is being provided in the below table. The average monthly income of the poorest part of the population is being derived from the Household survey done as part of the CMP.

Table 9 Monthly ridership data

	CBS	BRT	Month
Passengers (in no.s)	2415771	2726978	June 2018
Revenue (in US $)	2,85,021	3,52,518	
Fare (by average passengers) (in Cents)	11	17	

Source: Sitilink Ltd., 2017

4.6.2   **Results**

Table 10 Indicator 6-Affordability - Travel costs as share of income

Services	Monthly Ridership	Market shares (in%)	Single ticket price (in Cents)	Monthly cost (60 tickets) (in US $)	Weighted monthly cost (in US $)
City Bus	24,15,771	47.0	11	7	3
BRT	27,26,978	53.0	17	10	5
Total	51,42,749	100			8
Mean Household Income, 2016					**151**
					5.6

4.7 Indicator 7: Operational costs of the public transport system

The indicator 7 identifies the operational costs cum fare revenue of the public transport system and thereby deduce the fare box recovery ratio. The indicator can be derived based on the account statement or audited balance sheet for public companies. The minimum and maximum values for this indicator are 22 and 175 respectively.

4.7.1   Data analysis

The data of fare revenue and expenses were retrieved from the transit authority -SitiLink (a Special Purpose Vehicle under SMC) whereby they collect data of different operators. The data is inputted based on the modes of public transport system available in Surat. The data collected is of the month January 2018. The city bus and BRTS system has defined routes and the system is operated by five different operators. This indicator is a critical parameter measuring the financial stability of the public transport system. The city with low percentage of public transport mode share cannot ideally have high fare rates for public transport as Surat is in a phase of increasing public transport usage, thus lesser fares and more reliability will bring people to use the system. The 54.77% of fare box recover ratio is a good result in the context of Surat with lower public transport mode share, but with optimum cum continuous investments and greater ridership leading to efficient system usage will bring higher fare box recovery from the existing scenario.

4.7.2   Results

Table 11 Indicator 7- Operational costs of the public transport systems

Services	Fare Revenue (in US $)	Expenses (in US $)	Fare box ratio
City bus	3,11,379	6,07,792	51%
BRT	3,32,651	5,70,297	58%
Total	**6,44,030**	**11,78,089**	**54.77**

Source: Surat Sitilink Ltd., 2017

4.8 Indicator 8: Investment in public transportation systems

The indicator 8 analyses the share of all transport investments made by the city that is directed to public transport. Data of last 5-year investment in public transport is to be retrieved for the city. The minimum and maximum values for this indicator are 0 and 50 respectively.

4.8.1   Data analysis

The data of public transport investments were retrieved from the budget documents of the SMC, whereby of the total transport investments and the public transport investments were retrieved for the latest 5 years. Over the last 5 years it is evident that, there has been a consistent share of budget been kept aside specifically for the development of public transport system.

4.8.2   Results

Table 12 Indicator 8 -Investment in public transportation systems

Investments by the City (Rs in US $)	13-14	14-15	15-16	16-17	17-18	Average
Public Transport Facilities	1.4	0.3	6.5	4.3	3.2	3.1
Total Transport	11.3	10.8	9.9	8.6	7.1	9.5
Share						**33**

4.9 Indicator 9: Air quality (PM 10)

The indicator 9 defines the annual mean levels of fine particulate matter (PM10) in the air (population weighted) compared to the health threshold. The air quality data of the city is to be

retrieved from environmental and human health authorities in each country. The minimum and maximum values for this indicator are 150 and 10 respectively.

4.9.1   Data analysis

In Surat, within SMC there are six air monitoring stations as given in GPCB (Gujarat Pollution Control Board) 2016-17 report was considered. The stations are located on the building rooftop. 3 Zoning area were defined, and it is based on the wind direction in the city considering SMC zone boundary and ward boundary. The population covered within the individual zones were then calculated. Both PM10 and PM2.5 are being analysed in the Surat but for the indicator, PM10 values are considered.
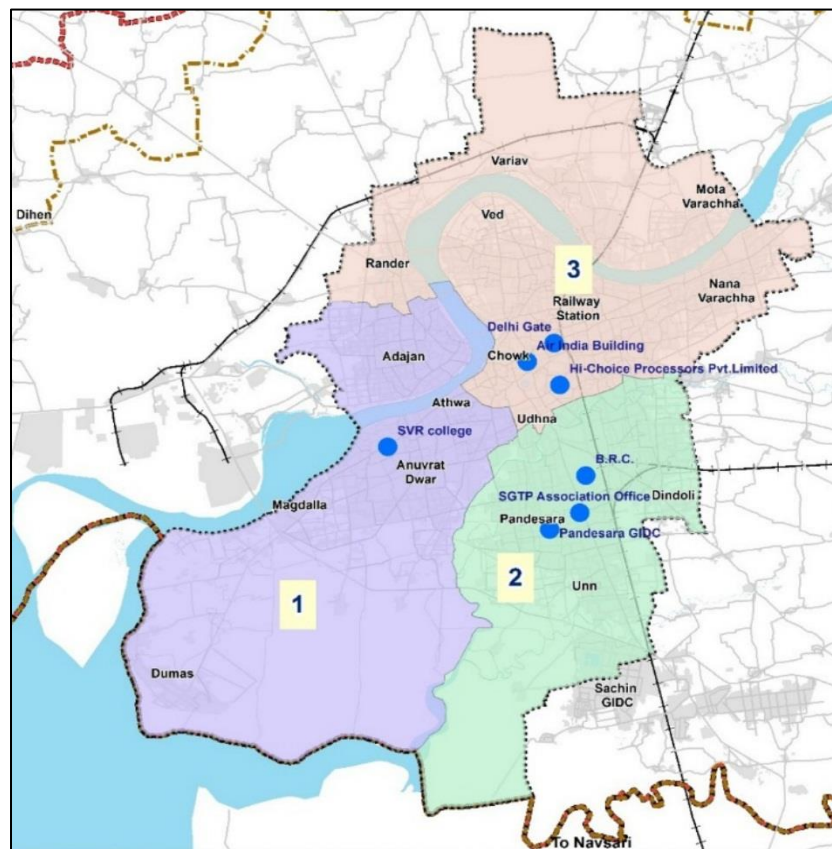

Figure 11 Air quality monitoring stations

4.9.2 Results

Table 13 Indicator 9 - Air quality (PM 10)

Station	Location	PM 10 (yearly mean)	Population within the area	Population (in %)
1	SVR College	85	796138	15.3
2	GIDC Pandesara	100	766524	14.7
3	BRC, Udhana(Darshan Processors)	100	766524	14.7
4	Air India Building	96	961413	18.4
5	Delhi Gate Police Chowki	102	961413	18.4
6	Hi-Choice Processers, Sachin	105	961413	18.4
	Total city population		5213425	100
	Population weighted concentration	**98.26%**		

Source: Gujarat State Pollution Control Board -GPCB

4.10   Indicator 10: Greenhouse gas emissions from transport

The indicator 10 analyses the greenhouse gas emissions from the transport sector within the city. The indicator is a calculated value of emissions of Greenhouse gasses (CO_2eq) from transport in a city per year, divided by the population number. The minimum and maximum values for this indicator are 2.75 and 0 respectively.

4.10.1 Data analysis

The greenhouse gas emissions were calculated for both the passenger and freight vehicles. The emission factors were retrieved from Emission Factor development for Indian Vehicles, ARAI Pune Report 2008, Central Pollution Control Board (CPCB) reports. The passenger vehicle data was retrieved from the household survey done as part of the Surat -CMP. The freight vehicle estimates were done from the activity surveys and Road side interview cordon point surveys. The total vehicle kilometers travelled (VKT) was found mode wise from the trip length and total vehicles. The VKT was then multiplied with the standard emission factors to derive the greenhouse gas emissions (CO and CO_2) in tons per year per capita.

Table 14 Emissions as per mode

Mode	Trip length (km)	Total Vehicles	VKT	2016 Emissions (tons/day)	
				CO	CO2
2Wh (Petrol)	5.8	3008248	17447838	20.56	735.95
3Wh (CNG)	6.1	611416	3729635	7.42	244.25
4Wh	7.9	558528	4412369	6.65	623.83
Petrol				5.24	413.95
Diesel				0.97	158.91
CNG				0.44	50.96
Buses (Deisel & Electric)	10.3	143	28611	0.18	14.64
Company Bus/ Pvt. Bus/ School-College Buses	8	17014	136109	0.86	69.66
3w Goods	27.1	1508	40919	0.11	5.39
LCV (4W Temp)	6.8	268429	1834693	5.72	752.22
HCV (Multi axle trucks, tractor)	28.0	29632	830286	10.55	500.00
Total				**52.04**	**2945.94**

4.10.2 Results

Table 15 Indicator 10 - Greenhouse gas emissions as per mode

Year 2016	Total (tons/day)	
Modes	**CO**	**CO2**
Pass. Vehicles	35.66	1688.33
Goods Vehicles	16.37	1257.61
HCV	10.55	500.00
LCV	5.83	757.61
Total	52.04	2945.94

Table 16 Indicator 10 - Total greenhouse gas emissions

GHG Emissions (CO+Co2)	Total Vehicle (Passenger + Freight)
Tons/day	**2997.98**
Tons/year (per capita)	**0.18**

5 OVERALL RESULTS

SUTI index provides a quantitative analysis on existing transportation situation. The SUTI indicators articulate the following for the city of Surat.

1. City's vision towards sustainability mobility is very well articulated in its **Comprehensive Mobility Plan**.

2. **Low and rapidly increasing Public Transport Ridership** - Current efforts of SMC (Surat Municipal Corporation) to promote public transport through bus procurement, metro rail building etc., are resulting in rapid increase in ridership.

3. Surat PT is being developed as an integrated system through a major city program. PT system coverage both in population and area is high.

4. People of Surat, in general, find the public transport system to be **convenient and reliable**.

5. Though, **fatality rates** are lower, plans to bring down further through management and educational measures including introduction of technology are underway.

6. The fares set at an **affordable** level**.**

7. **Operational Cost Recovery** – Surat is making efforts to build transit market. Recovery levels are likely to increase with increase in ridership. It may also be noted that some gap in the revenue expenditure is likely to remain. This needs to be filled up from other sources including the viability gap funding scheme of the state government.

8. The city government is committed towards development of public transport and active mobility, which may be seen in high levels of **public transport investments** during the past five years.

9. With the manufacturing as economic base, high levels of **PM10** is on the expected line. Contribution from transport sector is low as trip lengths are shorter. Efforts are underway to introduce electric mobility in the city.

10. **GHG emissions** from the transport sector is low, because of shorter motorized trips and higher share of active mobility trips. This is likely to be maintained as cities mobility plan integrates land use transport and focusses on multimodal public transport and active modes.

Table 17 Overall result as per Indicator

|	INDICATOR	SUTI Value
1	Extent to which transport plans cover public transport, intermodal facilities and infrastructure for active modes	93.75
2	Modal share of active and public transport in commuting	23.71
3	Convenient access to public transport service	90.70
4	Public transport quality and reliability	91.85
5	Traffic fatalities per 100.000 inhabitants	86.90
6	Affordability – travel costs as part of income	93.42
7	Operational costs of the public transport system	21.42
8	Investment in public transportation systems	65.67
9	Air quality (pm10)	36.96
10	Greenhouse gas emissions from transport	93.29
T	**Geometric Mean - Total**	**61.1**
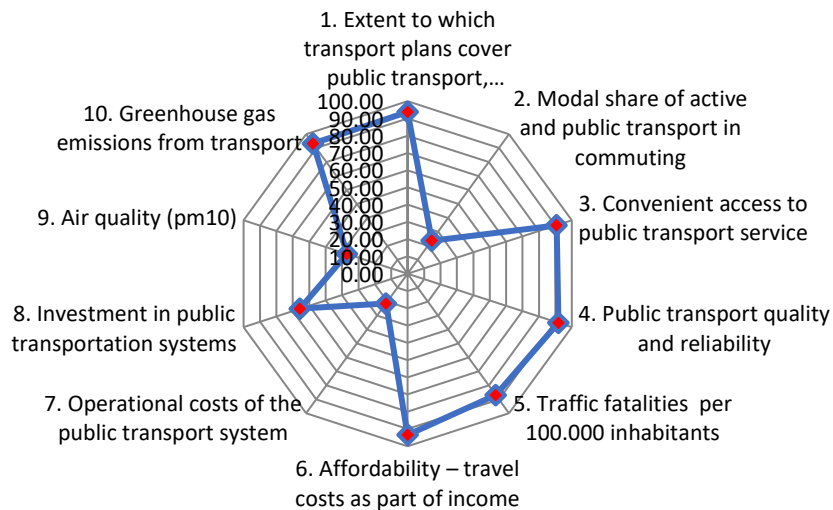
Figure 12 SUTI spider diagram

6 PERSPECTIVES

SUTI provided new insights into the areas of focus for SMC. These include:

- Promotional activities along with induction of new fleet towards improving formal public transport system.
- Explore alternative operations financing models for meeting the revenue-expenditure gap as the gap is wide and unlikely to be covered fully even with increased ridership.
- Work with the state government for wider geographical spread for PM10/PM2,5 monitoring and also actions for better air quality management.
- Induct cleaner vehicles both for PT and IPTS

7 REFERENCES

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Annexure – Visual images