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Assessment of Level of Service of Urban Transport Infrastructure

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Abstract

Providing an efficient transport system in a city give the smooth mobility for people and issue of private transport, which is one of the main causes of congestion and air pollution can be solved. With the constantly increasing travel demand and the increasingly insufficient private transport infrastructure, public transport in cities presents many advantages, not only in terms of sustainability, but also in terms of efficiency. It provides greater passenger capacity and a considerably smaller environmental footprint per capita, become a viable and sustainable alternative to the city areas. Looking towards the development of Gandhinagar city, it requires efficient transit system. To make overall urban transport system efficient, it is required to find the weaker components by means of level of service and then address the problems.

Keywords: Level of Service, Public Transport, Pedestrian facility, NMT facility, Land Use.

Introduction

Transportation has a major impact on the spatial and economic development of cities and regions. The quantity and quality of transport infrastructure influences the attractiveness and desirability of urban regions. Providing an efficient transport system in a city gives smooth mobility for people and issue of private transport, which is one of the main causes of congestion and air pollution can be solved. With the constantly increasing travel demand and the increasingly insufficient private transport infrastructure (Parking), public transport in cities presents many advantages. It's one of the best example is Multimodal Transit system, which is possible to achieve by better efficiency of all components of urban transport infrastructure.

Aim of the study

As the years pass the development of Gandhinagar city take place, itis required to provide efficient transit system. To make overall urban transport system efficient, it is required to find the weaker components by means of level of service and then address the problems. This study is based on determination of level of service of different components of urban transport infrastructure.

Past Research

Sustainable urban transportation is a transport which "Provides access to goods and services in an efficient way for all inhabitants of the urban area" and their objectives for sustainability are; Economic efficiency and Safety, Liveable streets and neighbourhoods, Protection of the environment, Equity and social inclusion and Contribution to economic growth.

Effective integration of passenger with transport systems requires good integrated networks and services which use to attract potential users. Interconnectivity is a characteristic of a transport network that allows multi - modal or inter-modal transport. This interconnections are the connections between the infrastructures of the various transport networks which can be possible by Making better use of the existing transport infrastructures and integrated ticketing, Baggage handling and Continuity of journeys. (Monika et al, 2012)

Transportation is only a means to an end of getting people, products and information where need to go. We need to encourage forms of transportation that fulfil the mission without harming the environment. Due to demographic changes occur levels of energy use will be change, which directly impact on the environment. Sometimes transportation may not work well because of personal frustration and economic loss. Trip

chaining is also a one of the reason which encourage the automobile dependence. (Statistics, 2000)

The lack of suitable last mile options discourages commuters to shift to public transport. The aspect of providing economical and convenient "last mile connectivity" from the trip ends to the point of accessing a public transport system, is an area of much neglect in Indian cities. Lack of adequate walkable and cyclable environment in the city further create problem for public transport users. (Chidambara, 2012)

Last mile concept in transportation planning, provides guiding policy context, and reviews challenges. It required methodology and approach for the layout of the Path networks within station areas. Possible improvements that may occur along identified Path network routes. Each individual improvement shows how to integrate the specific improvement with the overall Path system. By utilizing the strategies and tools Path networks and component design scenarios are developed. Active transportation modes (walking/biking/ wheelchair/etc.) are the dominant access and egress modes for all riders. (Los Angeles County Metropolitan Transportation Authority, 2013)

Tiwari et al (2015) noted in their study that City authorities and state governments have not invested in upgrading NMT infrastructure resulting in degrading level of service and increasing risk of road traffic crashes to pedestrians and bicyclists.

Literature gives motor vehicle traffic conditions, and newer methods for more multi-modal planning and evaluation. Literature give the idea of impacts which are considered or overlooked during planning like indirect environmental impacts and Impacts on non-motorized travel. From this comparison of auto dependency and multimodal transportation done which shows that Motor vehicle ownership is higher in auto dependency and less in multimodal transportation. From Social expectations point of view Non-drivers are stigmatized and their needs given little consideration in auto dependency while in multimodal transportation Non-drivers are not stigmatized and their needs are considered.

More prominent and used concept like Green Transportation Hierarchy taken from this literature, which favours more affordable and efficient in terms of space, energy and other costs modes. This can be achieve by making provision for Pedestrians, Bicycles and Public transportation.

It also shows that Multi-modal transport planning requires tools for evaluating the quality of each mode, such as Level-of-Service standards which can be used as a tool to indicate problems and ways to improve each mode. (Todd Litman, 2014)

Government of India give different Service Level Benchmarks for Urban Transport. This service level benchmark is use to get the overall level of service for different transportation facility .It conclude level of service for Public Transport facilities, Pedestrian infrastructure facilities, on-Motorized Transport (NMT) facilities, Land use transport integration and Pollution level in a city (Service level benchmark for Urban transport, 2016)

From above literature and guideline we can get overall level of service between levels 1 to level 4 and identify the impacts which affect directly to transportation system. It helps to provide policies which are overlooked during the planning process.

Data

Making city bus service prominent it also helps Intercity Bus service between Gandhinagar-Ahmedabad which have daily average 150 buses and average Passenger travel through bus is 25,000 to 30,000.For NMT Gandhinagar Urban Development Authority (GUDA) recently launched the pilot cycle sharing initiative 'Trin-Trin Green-Green (TT-GG)' Project. In which there are 10 TT-GG cycle share stations located in different parts of the city with 100 G-bikes.

Primary data is collect when we collecting information for the specific purposes of the study. It will collect from the different methods and tool like it will be collect by using surveys, interviews and direct observations. Data for City bus (operator: VTCOS) and bus operated by Gujarat State Road Transport Corporation (GSRTC) is collected from primary survey which gives the information about number of buses usedand passengers travelled.

VTCOS

1. It was started in 2008 with contract system
2. Fleet size - 21 with capacity of 30-50 seats
3. Per day passenger - 40,000 Passenger travel (Up-Down)
4. Major routes are: Sector-6/GH3 to Chilodato to Adalaj-Chandkheda (Ahmedabad), to Unava, to Pethapur, to Sector 21/(13-14-15) and Sachivalaya to Railway station

GSRTC

1. Daily-150 buses travel between Gandhinagar and Ahmedabad
2. From 150 buses, Diesel buses are 135 and CNG buses are 15
3. Total Trips are 636 (Gandhinagar-Ahmedabad-Gandhinagar) and each bus conduct Max. 8 trips
4. Average Passenger travel through bus are 25,000-30,000 among them Passengers Travel for job are 10,000-12,000
5. Central Bus Stand have Two Vehicular park facility in which 500 vehicles are parked per day.

Data Analysis

Ministry of urban development (MoUD) give different Service Level Benchmarks for Urban Transport. This service level benchmark is use to get the overall level of service for different transportation facility.It explains level of service for Public Transport facilities, Pedestrian infrastructure facilities, Non-Motorized Transport (NMT) facilities, Land use transport integration and Pollution level in a city. To make Gandhinagar transport more sustainable first it is important to check the level of service of current transportation facility and on a bases of it new policy should apply in a city limit.

Measuring performance of urban transport activities and taking further action on them has not been institutionalized in urban agencies. It is therefore important that the basic minimum standard for performance benchmarks should require to identify

the existing condition level, which can commonly understood and used by all stakeholders. Depending on the specific needs of a city, performance parameters are defined by MoUD which is used to improve the quality of urban transport. The Handbook on Service Level Benchmarks is prepared by MoUD for ULBs and other city level agencies which implement systems for measuring, reporting and monitoring. Comparison of different Facilities with their definite benchmarks is shown below and over all LoS is find out for different facilities.

Assessment of Level of Service for All Urban Transport Infrastructures

Level of service is a tool which tries to give a qualitative measure. Depending upon the different Service level Benchmark it classified in four levels of service, level 1 to 4 Level 1 represents the best quality of traffic, representing the free flow conditions. Level 4 represents the worst quality of traffic. Following areas need to be focused for the assessment of overall LoS.

Public Transport facilities

Public transport facilities indicates the city-wide level of services provided by public transport systems. Public Transport systems will only include rail, or organized bus based systems. Public Transport systems are characterized by fixed origins and destinations, fixed routes and schedules, fixed stoppage points and fixed fares. Public Transport therefore does not include Intermediate Public Transport (IPT) such as shared auto-rickshaws, three-wheelers, shared taxi or other such vehicles providing point-to-point services.

Presence of Organized Public Transport System in Urban Area (%)

1. Total number of buses operating on road = [150 + 21] = 171
2. Total number of buses under the ownership/concession agreement = 21
3. Presence of Organized Public Transport System in Urban Area (%)
   = [Total number of buses under the ownership (concession agreement) /Total number of buses operating on road] *100 = [21/171] * 100 = 12.28%

Extent of Supply Availability of Public Transport

1. Total number of buses = [150 + 21] = 171
2. Total Current Population (Growth Rate – 10.32%) = 2,91,273
3. Availability of Public transport/1000 population = [Total number of buses/ Total Current Population]*1000 = 0.58
4. Road length on which public transport systems ply in the city = 39.5 km
5. Area of the urban limits of the city = 56.75 Sq.Km
6. Service Coverage = Length of road/ Area of the urban limits = 0.69

Level of comfort in public transport

1. Identification of key nodes / Routes = 5
2. Total passenger count on bus at key identified routes = 20000
3. Total Seats available in the bus = 750
4. Passenger comfort- Load factor for each route = [Total passenger on bus/ Total Seats available in the bus] / Key routes=[20000/750]/5 = 5.33

Table 1: Indicators to calculate LoS of Public Transport Facilities

Level of Service	Presence of OrganisedPublic TransportSystem inUrban Area(%)	Extent ofSupplyAvailabilityof PublicTransport	ServiceCoverage ofPublicTransport intheCity	Level ofcomfort inpublictransport
Level 1	>= 60	>=60	>= 1	<= 1.5
Level 2	40-60	0.4-0.6	0.7-1	1.5-2.0
Level 3	20-40	0.2-0.4	0.3-0.7	2.0-2.5
Level 4	<20	<0.2	<0.3	>2.5

(Service level benchmark for Urban transport, 2016)

Overall Level of Service (LoS) of Public Transport Facilities City wide is identified and mentioned below

LoS = (LoS1 + LoS2 + LoS3 + LoS4)
= (4+2+3+4)
= 13

As per the Service level Benchmark and Calculation table shows it's overall LoS at Level 4 which indicate that the city has very poor/no organized public transport system.

Pedestrian Infrastructure facilities

It indicates the percentage of road length along the arterial and major road network or Public Transport corridors and at intersection that has adequate barrier free pedestrian facilities. The indicators to calculate the adequate pedestrian facilities are as follows-

Percentage of City Covered

Total length of road network = 484 Km
Total length of footpath in a city = 63.4 Km

Percentage of City Covered

= [Total length of footpath in a city/ Total length of road network]*100 = [63.4/484]*100
= 13%

Table 2: Indicators to calculate LoS of Pedestrian facility

Level of Service	Percentage of City Covered
Level 1	>= 75
Level 2	50-75
Level 3	25-50
Level 4	<25

(Service level benchmark for Urban transport, 2016)

Overall Level of Service (LoS) of Pedestrian Infrastructure Facilities City wide is mentioned below

LoS = (LoS1) = 4

As per the Service level Benchmark and Calculation it shows that it's overall LoS at Level 4 which indicate that city required adequate pedestrian facilities.

Non-Motorized Transport (NMT) facilities

NMT Parking facilities at Interchanges indicates the percentage of dedicated cycle track / lane along the arterial & sub arterial road network or public transport corridors with a minimum of 2.5 m width. It is characterized by continuous length, encroachment on NMT lanes, and parking facilities. The indicators to calculate the adequate NMT facilities are as follows:

Percentage of network covered

Total length of road network = 484 Km
Total length of NMT network = 2.5 Km
Percentage of City Covered
= [Total length of NMT network in a city/ Total road network]*100
= [2.5/484]*100
= 0.51 %

Total length of Parking on Cycle Track = 0 Km
Total length of NMT network = 0.51 Km
Percentage of on street parking on cycle track
= [Total length of Parking on Cycle Track / Total NMT network]*100
= [0/0.51]*100 = 0 %
Total no. of interchanges = 22
Total no. of interchanges having bicycle parking = 10
NMT parking facilities at interchange
= [No.of interchanges having bicycle parking / Total interchanges]*100
= [10/22]*100
= 45.45 %

Table 3: Indicators to calculate LoS of NMT facilities

Level of Service	Percentage of network covered	Encroachment on NMT roads by Vehicle Parking (%)	NMT Parking facilities at Interchanges (%)
Level 1	>= 50	<= 10	>= 75
Level 2	50-25	10-20	50-75
Level 3	25-15	20-30	25–50
Level 4	< 15	> 30	< 25

(Service level benchmark for Urban transport, 2016)

Overall Level of Service (LoS) of Non-Motorized Transport facilities (NMT) City-wide is mentioned below

= LoS = (LoS1 + LoS2 + LoS3) = (4+1+3) = 8

It shows that as per the Service level Benchmark and Calculation its overall LoS at Level 2 which indicate to improve the existingNMT facilities.

Pollution level

This indicator indicates the Level of air Pollutants in the city i.e. average level of pollution in urban areas. The indicator to calculate the pollution levels is Annual Mean Concentration Range (µg/m3).

Table 4: Indicators to calculate the Pollution level

Level of Service	SO2	Oxides of Nitrogen	SPM	RSPM (Size less than 10mm)
Level 1	0-40	0–40	0–180	0–40
Level 2	40-80	40–80	180 – 360	40-80
Level 3	80 - 120	80 – 120	360 – 540	80 - 120
Level 4	> 120	> 120	> 540	> 120

(Service level benchmark for Urban transport, 2016)

Overall Level of Service (LoS) for Pollution level City-wide is mentioned below LoS

= (LoS1 + LoS2 + LoS3 + LoS4)
=(1+1+3+4)=9

It shows that as, per the Service level Benchmark and Calculation its overall LoS at Level 2.which indicate that it required some improvements in emission standards, checking pollution etc.

Integrated Land Use Transport System

It Indicates the effectiveness of land use-transport arrangements and Identify the level of integrated land use transport system expected to result in overall trip reduction and mode shift in favour of public transit

The indicators to calculate the Land use transport integration are as follows:

Gross Population Density

Total developed area = 5675 Ha

Population of current year (Growth Rate – 10.32%) = 2,91,273

Population density = [Population of current year/ Total
= [2,91,273/5675] = 51.32

Inventory of land use along major transit corridors (500 meters)= 3630.96 Ha

Percentage of area under non-residential use = 1809.71 Ha = [49.84%]

Intensity of Development – City wide (FSI)

Floor space Index (most part of the city as per Master Plan/DP) = 1.5

Intensity of development along transit corridor

Floor space Index (most part of the city as per Master Plan/DP) = 1.5

Floor space Index (FSI) along transit corridors = 2.25

Intensity of development along transit corridors

= FSI along transit corridors/ FSI in most part of the city as per Master Plan/DP

= 2.25/1.5

= 1.5

Identify major roads and pattern = Grid network

Extent of clarity and completion = High qualitative

Road network Pattern and Completeness = Clear pattern and complete network

Measure overall developed area = 56.75 Sq.Km

Measure overall area under road network = 13.62 Sq.Km

Percentage of area under road network

= [Road network / Developed area]

= [13.62 / 56.75]

= 24 %

Table 5: Indicators to calculate LoS of Integrated Land Use Transport

Level of Service	Level 1	Level 2	Level 3	Level 4
Population Density (Gross)	>= 175	150 - 175	125 - 150	< 125
Mixed Land-use on Major Transit Corridors / Network	>= 30	15-30	5-15	< 5
Intensity of Development – City wide (FSI)	>= 2	1.5 -2	1-1.5	< 1
Intensity of development along transit corridor	>= 3	2 - 3	1.5 -2	< 1.5
Clear Pattern and Completeness of the network	Clear pattern and complete network	Somewhat clear pattern and incomplete network	Somewhat unclear pattern and incomplete network	No clear pattern incomplete / sparse network
Area under Roads (%)	>= 15	12-15	10-12	< 10

(Service level benchmark for Urban transport, 2016)

Overall Level of Service (LoS) for Integrated Land Use Transport system City-wide for < 1 million population is mentioned below

LoS = (LoS1 + LoS2 + LoS3 + LoS4 + LoS5 + LoS6)

= (4+1+2+3+1+1)

= 12

It shows that as, per the Service level Benchmark and Calculation its overall LoSisat Level 2, which indicate that City structure is somewhat in coherence with the public transport system.

Results

In Gandhinagar major peoples traveling through city bus which is almost 75% and people who use their private vehicle are only 21%.But looking towards other mode of travel than people travel with the cycle is only 1%. People who use public transport required to reach at transit stop (Access and Egress trip) for that most of them use walking as a mode rather than cycling.

From the Primary survey (Questionnaire) travel pattern of passengers shows that major 45% traveling people is belong to an age group between 20 to 29 years. Based onoccupation it is found that 38% travelling people are students while very less people travel through public transport whose occupation is business which is only 10%. Survey results of passengers reveal that approximate 28% of passenger trips involve Work based. Other than that people travel more for the shopping and daily needs like vegetable market. On bases of Income level 43% travelling people are unemployed and most of them

are students and very less people whose income level is more than 20,000/- are only 4- 5%.

Secondary data like present air quality status of Gandhinagar city shows that the SO_2 and NO_2 concentrations were well below the National Standards, while the SPM concentrations in residential area were found to be more than the NAAQS, 2009. It shows that increase automobile transportation in city leads to air pollution problems.

Level of Service

After the primary and secondary survey to assess the current level of transportation one tool called Level of service is used which tries to give a qualitative measure. The intention of Level of service is to relate the traffic service quality to a given flow rate of traffic. It is a term that designates a range of operating conditions of different facility.

Figure1 - Existing Cycle sharing station

Gandhinagar Urban Development Authority (GUDA) recently launched the cycle sharing initiative 'Trin-Trin Green-Green (TT-GG)' Project. In which there are 10 cycle sharing stations located in different parts of the city with 100 G-bikes. Figure show the existing condition of cycle sharing station in which 10 cycles can parked.

Figure2 Existing Road pattern of city

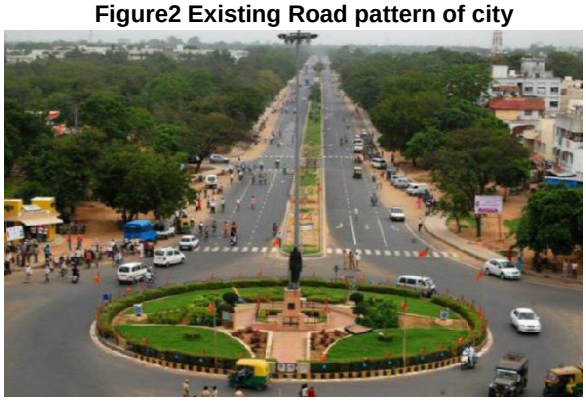

Figure shows the existing road pattern of Gandhinagar city. It shows that due to encroachment of Auto rickshaw on carriage way of road situation like congestion occurred .For pedestrian provision of footpath is there on major roads, but it is not provided on a distributer road. For NMT,GUDA provided a container type cycle sharing station which can easily move from one place to other place but provision for separate Bicycle track is not provided on exisisting road network. This all things are taken into consideration will calculating the Level of Service.

Table 6 Level of service for Different service level benchmark

S.No	Service level Benchmark	Level of Service
1.	Public Transport facilities	Level 4
2.	Pedestrian Infrastructure facilities	Level 4
3.	Non-Motorized Transport (NMT)facilities	Level 2
4.	Pollution levels	Level 2
5.	Integrated Land Use TransportSystem	Level 2

Calculating the LoS for focused area lowest level of service is founded in Public transport facilities and Pedestrian infrastructure facilities. NMT facilities, Pollution level and integrated land use transport in city is at level 2 which give an ideal condition.

Conclusion

In Public transportation, major issue comes from the survey is bus frequency and because of that more people are willing to choose private vehicle as a travel mode. In Non-Motorized Transport facilities major issue is specifically less number of dedicated lane for the Bicycle, because of this, people are not using bicycle as a travel mode. Subsequently, use of private vehicle is increase and it affects the pollution level. Provision of specific lane for NMT on existing road can solve the issue.

In Pedestrian infrastructure the collector road is not facilitate with the footpath and because of it people feel unsafe while walking on these roads. By making provision of footpath on road people feel safe and safely walk on it without any hesitation. This will increase the level of service of pedestrian infrastructure and indirectly it helps to decrease the health issues.

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