

ANALYZING SUSTAINABLE TRANSPORT INDICATORS- A CASE STUDY ON LUDHIANA

A thesis report submitted in the partial fulfillment of requirement of the
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IN

CIVIL ENGINEERING

(Specialization in Transportation Engineering)

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DECLARATION

I hereby declare that the thesis work entitled “**Analyzing Sustainable Transport Indicators-A Case Study on Ludhiana**” is an authentic record of my own work carried out as requirements of thesis for the award of degree of M. Tech. in Civil Engineering (Specialization in Transportation Engineering) from Lovely Professional University, Phagwara (Punjab), under the guidance of Mr. Ajay Kumar, during 2013 -2015.The work has not been submitted to any other Institute for any degree.

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CERTIFICATE

This is to certify that the declaration statement made by this student is correct to the best of my knowledge and belief. The thesis “**Analyzing Sustainable Transport Indicators- A Case Study on Ludhiana**” submitted by “**GURPYAR SINGH**”, bearing registration no. 11301851 student of school of Civil Engineering, Lovely Professional University, Phagwara, Punjab who carried out the thesis work under my supervision.

This report has not been submitted to any other university or institute for the award of any degree.

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ABSTRACT

This report provides guidance on the use of indicators for sustainable and livable transportation planning. It defines *sustainability*, discusses sustainable development and sustainable transport concepts, and how sustainability indicators can be applied in transport evaluation and planning. Ludhiana is metropolitan city of Punjab. Due to urbanization, transport needs are increasing there. This leads to congestion problem because of poor management system. Cycling and walking facilities are negligible there. Here as main concern is to promote sustainability. So indicator selected to analyses it. Indicators are require to get knowledge and measurement to manage it. Indicators are necessary to guide policy and benchmarking the city issues. This is future requirement for putting strategy for healthy transportation environment. Future estimation is done for some indicator to know the impact in future. Target is to be set for achieving that goals for better healthy environment. Benchmark is done for various indicator to check sustainability

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List of Abbreviations

Symbol	Meaning
BRTBus	Rapid Transit
GHG	Green house gases
ISBT	Inter State Bus Terminal
IPT	Intermediate Public Transport
NAAQS	National ambient air quality standards
NMT	Non Motorised Transport
OECD	Organization for economic cooperation and development
PM2.5	particulate matter less than 2.5 micron in diameter
PM10	particulate matter upto 10 micron in diameter
RITES	Railway Infrastructure Technical and Economic Services
TSM	Traffic System Management
WHO	World health organization

INTRODUCTION

1.1 Introduction

Sustainable development balances environmental, social and economic objectives. Sustainable transport leads to safely movement of vehicles and be compatible with nature to eradicate all problems which are affecting health, ecosystem and equity of people. Most of world population living in urban areas and increasing at very faster rate in these areas. So striving for more ecological development is necessary. Efficient energy production and consumption is very necessary. These are especially for developing countries. Most of GHG emissions are from transport sector. This topic is new for study and so selecting some indicators which can measure through its value in different years regarding the transport.

Indicator measures the status of various transportation aspects in terms of trends data. Sustainable development in terms of transportation system is growing trend in developing countries, as Ludhiana is metropolitan city of Punjab has not properly managed transportation system according to existing transportation plan. Mixed development along road effect the capacity of road. Traffic delay lead to more vehicular emission deteriorating the environment. More use of two-wheeler and cars leads to more congestion on road. Public transport is inadequate and use is not proper. So these aspect and indicators are analysed in terms of trends and existing conditions to find out the problem related and for benchmarking the city. Future estimate has been worked out to better mobility in future without affecting resources of future

1.2 Need of the Study

Transport systems have significant impacts on the environment in Ludhiana city instead of industries. Greenhouse gas emissions from transport are increasing at a faster rate than any other energy using sector. Road transport is also a major contributor to local air pollution and smog.

There are various impacts on social costs due to road crashes, air pollution, while going from one place to another, due to this there are many negative impacts on social groups and affecting mobility in city. There is wastage of time due to traffic congestion which is affecting the economy overall. So there is need to highlight sustainable transport issues.

1.3 Objective of the Study

- To analyze indicators of road specific transport problems and benchmarking its sustainability
- Comparing and evaluating the indicator data with the benchmark indicator database using a “gap analysis” approach.

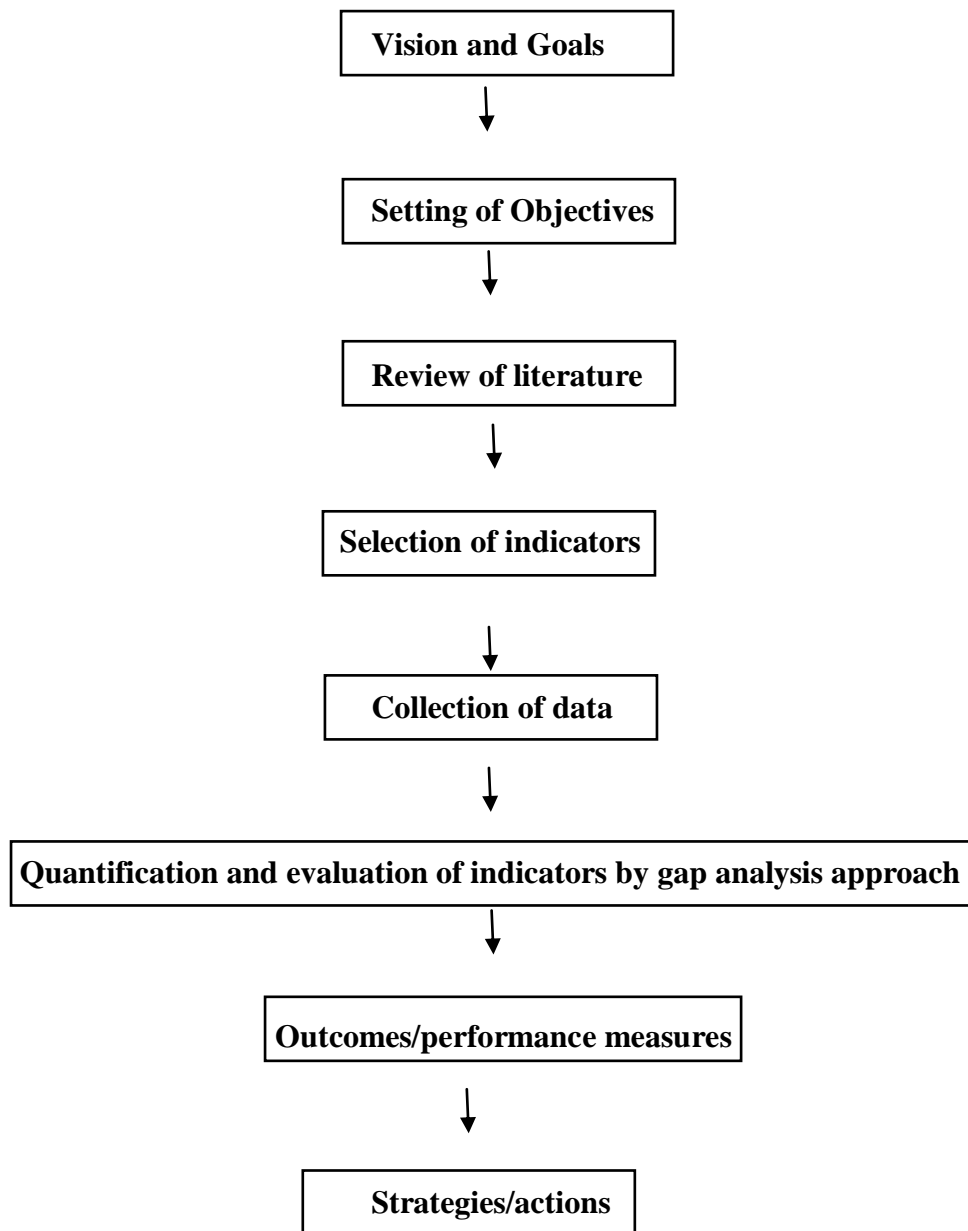
1.4 Scope of the Study

This includes level of work to do in project. Sustainability s objectives and goals are defined for its evaluation in road transport for city in future in terms of standards. As traffic congestion and air pollution are increasing in Ludhiana so transport indicators are selected and data to be collected to do analysis and sorting out problems which will effecting the sustainability

This will include majors as follows:

- Sort out problems and potentials
- Selection of indicators based on objectives
- Data collection related to various transport sectors
- Traffic characteristics

1.5 Methodology of study



1.6 Terminology

Benchmarking: it is comparison of actual data analysis with standard level

Gap analysis: *Gap analysis* is the comparison of actual performance with potential or desired performance

Micro level: The level of analysis at local level or small

Macro level: Level of analysis at large level or for most population

Landuse: The use of land in urban areas like Residential, commercial, industrial et

REVIEW OF LITERATURE

According to (Meier and Brudney, 2002), air quality to be meet standards for fine particulate matter (PM_{2.5}) and its concentration should less than 15ug/m³, so its concentrations serve as indicator. Regarding sustainable development, probably the most off cited definition comes from the Brundtland report, “to ensure that development meets the needs of the present without compromising the ability of future generations to meet their own needs,”. If we simply define sustainability as the capability to “maintain the capacity to provide non declining well being over time”(Neumayer, 2003).sustainable development as process by which current generations pass on as much, or more, capital to future generations, with capital being defined as human made natural, social and human(Serageldin 1996). The OECD (2002), e.g specially defines a sustainable transport system based on fulfillment of WHO guidelines for air pollution, noise levels.

2.1 Principles of sustainable transport

There are some principles to achieve sustainable transport objectives which are to be followed in study:

Diversity in improved transport system:

It means to enhance the other modes of transport in city like cycling, walking, carpooling public transit and creating more walkable distances to reach destinations

Smart growth of landuse in city:

This includes more compact and affordable housing at accessible locations and should be incorporated in policies

Conserve energy and lowering emissions:

This includes use of more efficient vehicles, finding out alternatives for operation of vehicles, so that there will be lesser emissions due to transportation. There should be another types of vehicles which could not environment like cycling, electricity cars and increase accessibility to various facilities

Table 2.1: Principles of sustainability

	Economic	social	environment
Present generation	Balanced economic growth in all ways transportation Rising income	Equity in various levels of societies	Enhance environmental quality and justice
Future generation	Keeping safe oppurtunities for future generations	Maintain interactions between social systems	Protect natural ecosystem

Source: www.vtpi.org

2.2 Indicators and measureness

Indicator of transportation is taking out any kind of aspect related to transport which can easily measure its transportation condition in city like capacity of road can be seen by its level of service. Same at macro level, like for megacities it can be seen through its indicators to describe the existing condition of city. Actually indicators are numbers that tell stories of variables with time component included in this to see its trend in different years.it is called performance indicators in different ways and some of list as follows:

Economic

- Energy use
- Injuries and fatalities
- Personal vehicle movement
- Length of paved roads

Environmental

- Particulate matter in air

These all to be tracked to check the performance of its sustainability in city and benchmarking its level with respect to standards

Sustainability include three aspects to be studied but I will studied its some only economic and environmental because of there is lot work to study all in detail.it may depends on availability of data. These are as follows

Economic: affordable transportation system for all and balanced land use development

Environmental: there is balanced ecosystem safeguard, to have minimum impact through emissions

Social: equity in all social systems

At last, there should be balanced development in all the three aspects for taking proper decisions in policy decision in further planning of city. Also like we do the feasibility study to start the project. Also there should be prerequisite for sustainable development to be there to enhance the social health with its economic growth to remove any kind of problems existing in city.

2.3 Main issues in transport

2.3.1 Climate change

As there is lot of GHG emissions from vehicles increasing day by day. Urban population is increasing and rich people buy their more number of cars. So it increase the number of private vehicles in city

2.3.2 Air pollution

There is lot of carbon and lead content emitted by vehicles which are affecting air.

2.3.3 Congestion

It has major negative effect on gross domestic production of country.it creates more delays for local population affecting economy and time loss is there

2.3.4 Consumption of Energy

Non Renewable sources of energy are depleting. We more dependent in these while operating vehicles. So these create more danger to these resources

2.3.5 Equity of access

Affordable transportation is not there in city. Public transportation is not upto the mark to provide accessible for low income group peoples

2.3.6 Road safety

Accident are major cause of deaths in young's and increasing at alarming rate as no one follows proper rules and regulations. More victims are two wheelers, cyclists and pedestrians

Selections of indicators

There are various factors to be consider while selection as it depicts the clear picture of metropolitan cities and their transportation scenario. A set of indicators is used to select out gap that is to be achieve by applying various objectives

Indicators can be defined in terms of goals, objectives, targets and thresholds. For example, congestion is measured in terms of indicators in planning process. Here our main desire will be efficient travel movement, objectives will be to set strategies like enforcement to reduce congestion. What we should achieve is our targets like feasibility changes by congestion impacts and threshold is gap between objectives and goals. As there is some threshold value like air quality level in city to be safe for health, we can measure the data of different year regards particulate matter in city if it is upto mark.

Table 2.2: Types of analysis

Type	Purpose
Descriptive analysis	To know the clear description of transport emissions
Regression analysis	To study various causes of emission like congestion, old vehicles,

2.4 Sustainable transportation goal

Its main goal is balanced regional development in jurisdiction of city in terms of economic , social and environmental terms

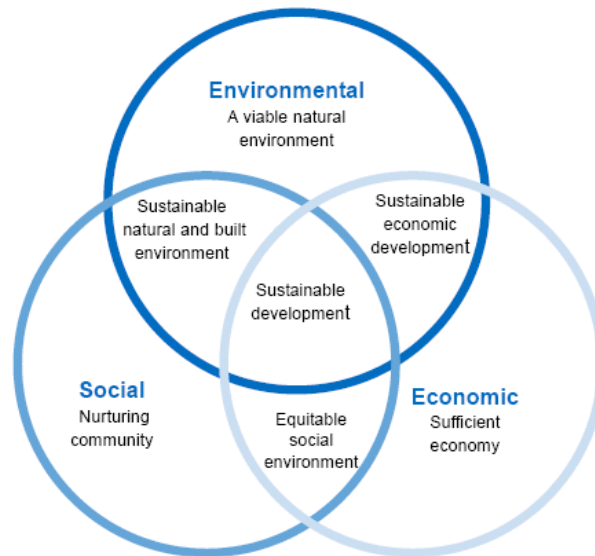


Figure 2.1 Sustainability goals

Source: www.winesofchile.com

2.5 Key indicators of more sustainable transport

- Environmental
- GHG emissions
- PM_{2.5} and PM₁₀ are particulate matter in air

Social

- Road accidents
- Share of public transport in city

Economic

- Vehicle travel
- Fuel consumption

2.6 Case Study of Kuala Lumpur and Penang

Sustainable transport indicators: case study of users from Kuala Lumpur and Penang

Introduction

The various types of indicators are selected to study the character of Kuala Lumpur and Penang in terms of physical, social and environmental. There was a recent issue regarding the sustainability there.

Study approach

Transportation statistical data such as annual average daily traffic, vehicle registration, transit ridership etc are collected from various transportation planning agencies.

Survey

Evaluates the level of resistance towards the attainment of sustainability in terms of personal attitude towards transportation, level of public involvement in policy decision making and support for various government initiatives in sustainable transportation development

Findings

- Environment protect receives high public support
- Public transit system has given much importance

Shortlisted sustainable indicators as below:

- Environmental
- GHG emissions
- Annual average daily traffic
- Landuse of transportation purposes
- Economy
- Movement of freight
- Fuel prices
- Travel time
- Household expenditure

Findings

- Road safety is major taken into account
- Pollution caused by gasoline is taken into account
- Public transit system has not given much importance due to lack of knowledge in evaluation and availability of data
- of understanding towards the significance of these indicators in evaluating the sustainability of transportation system

Conclusion

Indicators are evaluation in terms of trends and its performance with standards are marked and gaps are fulfilled with time with public support and give guidelines in policy to cope out major issues in both cities

2.7 Selection of indicators for Ludhiana city

Ludhiana has variety of transportation characteristics like slow and fast moving vehicles in city. Ludhiana is first metropolitan city of Punjab in terms of population and its vast past of evolution. Selection is done on basis of major issues in city as follows:

- number of private vehicles in different years
- modal split
- injuries and fatalities
- public transport character
- walking and cycling condition
- particulate matter in air
- interconnectivity in different modes

Outcomes

problems and issues can be select out from these indicators which can help in make out suggestive guidelines while making policies and to represent goals and for better transport functioning of roads, policy makers can get guidelines to plan the strategies to remove the problems from the city and better planning of city

2.8 Traffic Management

There is sudden explosion of fast moving vehicular traffic in last few decades and as such, various techniques and methods are to be found out to make the movement of vehicles smoother and easier. The mere widening of roads or providing new roads do not solve the problems connected with traffic of any town.

Traffic management is a science by itself and it includes the study of regulations for traffic, controlling and guiding measures for traffic, flow of traffic at junctions, parking areas, traffic survey, engineering elements of road system affecting traffic operation, improvement of traffic facilities in existing towns

Traffic capacity of any road depend on factors as follows:

- Characteristics of road such as gradients, number of lanes, visibility, cross traffic, pedestrian movement
- Characteristics of traffic such as speed of vehicles, type of vehicles, driving habits of road users

The entire economy depends on the capacity to move people and goods rapidly and smoothly. Every effort should therefore be made to improve the traffic conditions in existing town by suitably applying measures and methods of traffic congestion and traffic control

2.9 Comprehensive Traffic and Transportation Plan for Ludhiana City

There is haphazard development of Ludhiana city without proper norms and standards. All major roads have mixed land use along it, hence affecting transport system. All major roads that are Jalandhar-Delhi road, Chandigarh road, ferozepur road, Bangaroad, sidhwan road have poor traffic management system and not sustainable for traffic. The inner part of city have high congestion problem that are ghantaghar and main bazaar because hardly any space left for future widening of road. There are two types of areas that are developed and undeveloped of city. As per master plan land use under transport sector is 6.24% out of total area which is less according to demand. As this land use is decreasing according to proposed plan 2011 because of over exploitation

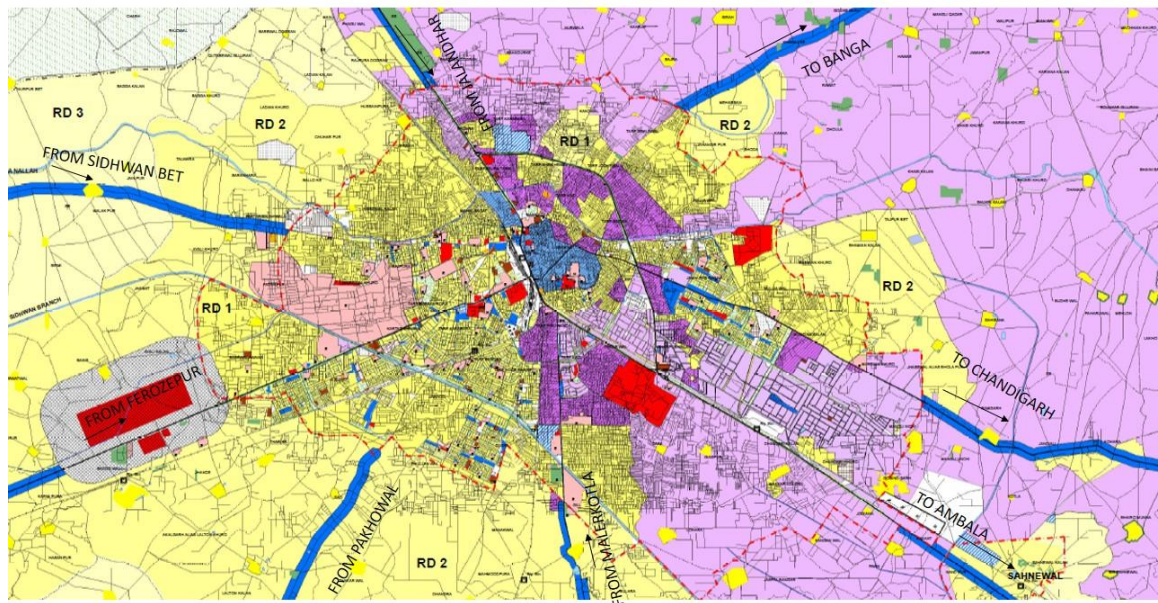


Figure 2.2 Map of Ludhiana

Source: www.puda.com

2.10 Existing Transport Infrastructure

2.10.1 Road Network

Overall, city follows the radial pattern of roads. The municipal area of city is over 159 sq.km. The area of 12.72 sq.km is coming under road network. Which is 8% out of total

area of municipal boundary. The 3390km road length is coming under it. There is range of road width is 6-35m

Instead of this bypass is connecting to major roads like Chandigarh road. There is irregular alignment and frequent intersections in inner part of city. Link road that is circular in nature used for intercity and intracity traffic.

2.10.2 Parking

There is not proper 'on street' and 'off street' parking system in city. Wherever empty spaces are available, people are parking their vehicles along road. This affecting the capacity of road. This leads to road accident due to reduced widths of road. So illegal parking areas are increasing. During peak hours, mostly congestion due to the onstreet parked vehicles. There is need to development of offstreet parking in well mannered with pricing. The major problem areas regarding parking as follows

- Fountain Chowk Area
- BastiJodhewalChowk
- Railway Station Area
- Gill Road
- Field Ganj Area
- Ferozpur Road

There is only one six storied parking space is available that is near chaura bazaar and in addition to this some are feroz Gandhi market, ghumarmandi area, book bazaar area etc. but there is need to construct more these legal spaces to resolve the problem.

2.10.3 Pedestrian Facilities

Most of commuter prefer to walk for short distances in city for various purposes. But facilities like footpath their related infrastructure is not provided in city. Pedestrians also facing while crossing the road because absence of zebra crossing particularly in center of city.

The areas like Bharat Nagar Chowk, Mini Secretariat, BhaibalaChowk, AartiChowk, Railway Station Area, ISBT area, DugriChowk, Gill Chowk, etc. has to be improved for pedestrians facilities.

2.10.4 Mixed land use

Most of arterial and sub arterial roads are developing as mixed landuse. There is direct access from properties, industrial and commercial establishments on road without any service lane for allow moving vehicles. Various spaces along road are occupied by vendors, hawkers and illegal encroachment by shopkeepers affecting capacity of road. So

traffic system management schemes has to be enforced for smooth flow of traffic. Traffic signs and signals to be installed for various institutions like schools, hospitals and district offices.

2.10.5 Public Transport System

This transport is require for mass transportation in city and local areas. It reduces the congestion on road and save money for each household. Due to affordability, it can promote mobility with efficient frequency. Here safety is main concern to achieve the with mass transportation system. But there is not adequate this system in city. Only some IPT system is used but not at standard level. There is about 30000 autos and 14000 cycle rickshaw to cater the local area traffic. These are increasing every year to keep the mobility to some extent.

2.10.6 Urban Goods Movement

As Ludhiana is major industrial city of Punjab. So there is more movement of trucks for trade and commerce. They require to entre in central part of city that is near railway station. It creates various traffic problems in central part of city because management practices. There are 1500 registered transport companies, out which 900 are near samralachowk and 3300 truck movement are recorded on an average week day. Area of transport nagar is 114 acres. The main areas for trade and commerce are clock tower, bypass market area, samralachowk, danamandi. Loading and unloading activities creating traffic jams. So areas for these activities are to be required. There is requirement for development of facilities in transport nagar like demarcation of parking area for well mannered.

2.10.7 Vehicular Growth

The usage of private vehicles are increasing every year. Mostly two wheelers are plying on road. As there is not proper mass transit system, so commuter using there own vehicles mostly. Also most percentage of people have good economic status, so vehicle ownership is common there. More than 70% are two wheelers there which affecting the capacity of road. Generally motor vehicles are increasing @ 7-10 % per annum. This will demand more road space in future

2.10.8 Traffic Safety and Enforcement

Mostly pedestrians or two wheelers are involved in road accidents. As there are inadequate facilities for cyclists and pedestrians due to poor management system. Footpaths are not provided. So pedestrians have to use carriageway. And this creating road accident. Rash driving, do not follows rules and regulations and heterogeneous

traffic are some reasons for accidents. There is fluctuation of fatal road accidents year wise but has to be controlled by proper enforcement practices

2.10.9 Environmental Issues

It is major concern for quality of life. Noise and air pollution are affecting the health of people. As it is industrial city, so more threatened to air pollution. More use of private vehicles polluting the environment. Major pollution is due to as follows

- Usage of more private vehicles and there is not proper pollution check
- Inadequate public transportation
- Use of kerosene oil for IPT

DATA COLLECTION AND ANALYSIS

3.1 Data to be collected

- Number of private vehicles trends
- Modal split
- Injuries and fatalities
- Travel speeds
- Roadway length and condition
- Public transport character
- Walking and cycling condition
- Particulate matter in air
- Interconnectivity in different modes

3.2 Method of analysis

Gap analysis approach

The various collected data to be arranged year wise statistically, then analysis required for various variables comparison with different standard values regarding the city whether its performance is towards goal or not.

e.g 15 $\mu\text{g}/\text{m}^3$ or less particulate($\text{PM}_{2.5}$) matter per year in air should be there according to guidelines as it is threshold value by national ambient air quality standards(NAAQS) and should be 150 $\mu\text{g}/\text{m}^3$ for PM_{10} . Like capacity measure depend on operating characteristics under various level of service.

These measures can be taken with indicators:

- Alert – What is going on ?
- Diagnose – How did we get here?
- Review – How are we doing?
- Learn – How can we do better?
- Decide – What should we do?
- Forecast – Where are we heading?

DISCUSSION AND RESULTS

4.1 Description

There is analysis related to various indicators. It may be in terms of trends, increasing or decreasing during different years. Comparison is done for different variables to find out the gap which creates problem. Mainly number and type of vehicles, capacity analysis, modal split, accident trend is done.

Table 4.1: Number of registered vehicles

year	Four wheeler	Three wheeler	Two wheeler	others
2001	7843	1425	29167	8
2002	8749	1272	31865	15
2003	9835	1487	35142	37
2004	11300	1806	39380	48
2005	13383	2241	40825	90
2006	14463	2353	41467	102
2007	16246	2693	43232	123
2008	17231	2743	45231	151
2009	19234	2942	47234	160
2010	21457	3178	49982	171

Source: Rites survey, 2009

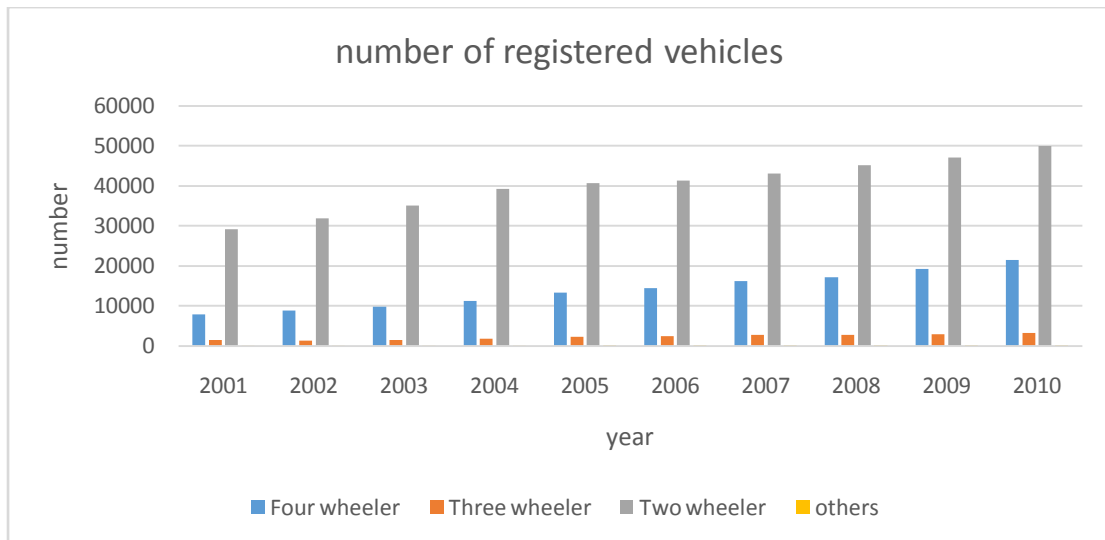


Figure 4.1: Number of registered vehicles

Number of vehicles increasing each year in city effecting the environment of city and increasing congestion level. Number of two wheeler are increasing each year which affecting the capacity of road.

Table 4.2: Total Registered Vehicles

year	No. of vehicles
1992	219628
1993	238412
1994	258056
1995	291384
2001	680494
2006	941694
2007	961988
2011	1282312
2012	1295534
2013	1315326

Source: District Transport Office, Ludhiana.

As number of motor vehicles crossing over 1315326 which is harmful for environment of Ludhiana city. Here we should consider green vehicle concept to save the ecosystem and quality of life. Number of trips per household to be controlled for easy flow of traffic.

Table 4.3: Forecasting of vehicular traffic

year	Four wheeler	Three wheeler	Two wheeler	others
2001	7843	1425	29167	8
2002	8749	1272	31865	15
2003	9835	1487	35142	37
2004	11300	1806	39380	48
2005	13383	2241	40825	90
2006	15257	2622	44091	126
2007	17393	3068	47618	176
2008	19828	3589	51428	247
2009	22603	4199	55542	346
2010	25768	4913	59985	484
2011	29375	5749	64784	678
2012	33488	6726	69967	949
2013	38176	7869	75564	1328
2014	43521	9207	81609	1859
2015	49614	10772	88138	2603
2016	56560	12603	95189	3645
2017	64478	14746	102804	5102
2018	73505	17253	111029	7143
2019	83796	20186	119911	10001
2020	95527	23617	129504	14001

Vehicle traffic is increasing each year so road to be designed accordingly. As four wheeler will be near about 95527 in 2020 in Ludhiana city as local traffic. This is calculated by simple growth factor derived from trend of preceding years. So this is predicted value. So this growth leading to less sustainability in future. So traffic management is required for smooth flow of traffic

Table 4.4: Category wise share of registered vehicles

	Mode wise share			
year	Four wheeler	Three wheeler	Two wheeler	others
2001	20.4	3.7	75.9	0.02
2002	20.9	3	76.1	.04
2003	21.1	3.3	75.6	.1
2004	21.5	3.5	74.9	0.1
2005	23.7	3.9	72.2	0.2
2006	23.7	3.8	72.3	0.2
2007	24.5	3.9	71.1	0.5
2008	25.1	3.4	71.2	0.3
2009	25	3.4	71.4	0.2
2010	25.1	3.3	71.4	0.2

Source: District transport office, Ludhiana



Figure 4.2: Heterogeneous traffic and more two wheelers

Table 4.5: Road accidents by type Ludhiana (2003-2009)

year	No. of accidents	Persons killed in fatal accidents	Persons injured
2003	456	188	353
2004	432	219	331
2005	438	259	334
2006	476	242	307
2007	422	218	268
2008	390	226	229
2009	368	223	271

Source: Traffic police department, Ludhiana

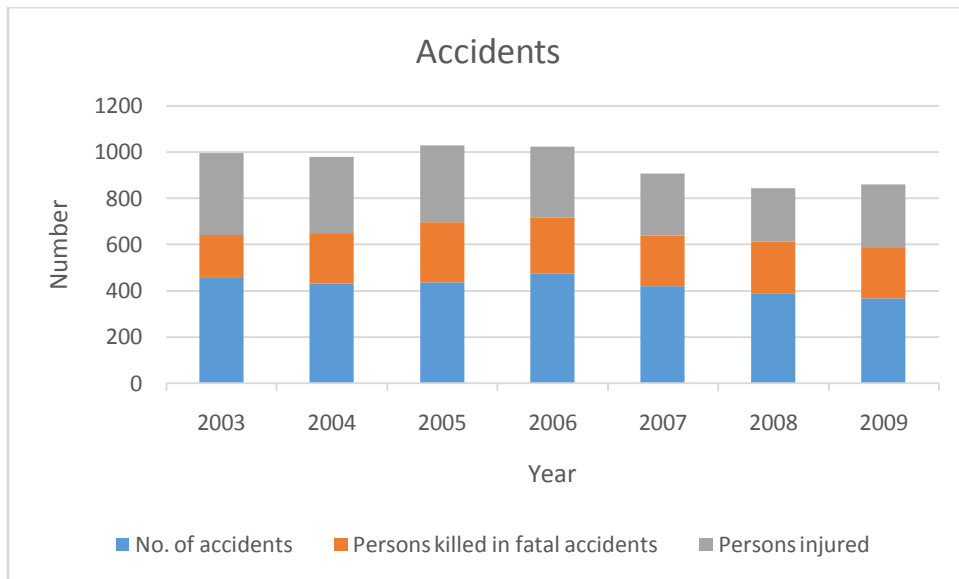


Figure 4.3: Number of accidents

There are measures taken to control the accidents with proper signs and signals and enforcement measures. But overall effecting economy of nation and safety

Accident rate = $10000 \times \text{number of accidents} / \text{number of registered vehicles}$

$$= 10000 \times 260 / 1320200 = 2$$

Table 4.6: Death rate based on registration

year	number	Number of persons killed	Death rate
2003	46501	188	40.42924
2004	52534	219	41.68729
2005	56539	259	45.80909
2006	58385	242	41.449
2007	62294	218	34.99534

2008	65356	226	34.57984
2009	69570	223	32.05405

Source: computed values

Death rate is fluctuated about 32-45 per year. So this has to be eradicated for proper safety in city. Accidents are due to complex flow of patterns of vehicular traffic, presence of mixed traffic and pedestrians

General observations as follows:

- Most of road accidents occur on straight roads
- The greatest number of sufferers in road accidents is that of pedestrians

Table 4.7: Modal split

purpose	Vehicular trips		Walk trips		Total		Grand total
	intra	inter	intra	inter	intra	inter	
Work	72851	447387	75403	34702	148254	482089	630343
	38%	58%	34%	36%	36%	56%	49%
education	64066	154180	80915	323616	144981	186496	331417
	34%	20%	37%	33%	35%	22%	26%
Others	52651	168292	63773	29961	116424	198253	314676
	28%	22%	29%	31%	28%	23%	25%
Total	189569	769858	220091	96979	409660	866837	1276497
	100%	100%	100%	100%	100%	100%	100%
Total home based	189569	769858	220091	96979	409660	866837	1276497
	68%	98%	98%	96%	82%	97%	92%
Non home based	87633	18970	4702	4234	92335	23204	115539
	32%	2%	2%	4%	18%	3%	10%
Total	277202	788828	224793	101213	501995	890041	1392036
	100%	100%	100%	100%	100%	100%	100%

Source: RITES survey

Most of trips is personalized based that is 49 % by cars and scooters, 36% is by intermediate transport system, 5% by bus. There is only 5% usage of buses for share for home based trips. For ipt is 58% and 37% for vehicular trips. So it concluded that more usage of private vehicles.

Table 4.8: Problem matrix for road corridors

Road	Pcu/day	v/c ratio	Problem identified
Ferozpur road	7070	1.2	<p>Long distance road. Attracts heavy traffic destined to city centre, traffic</p> <p>congestion throughout the day due to commercial and residential activities,</p> <p>on street parking, large volume of pedestrian traffic. The road will require</p> <p>traffic management measures and parking management.</p>
Rahon road	2263	1.7	<p>The road connects many villages to the city. Traffic congestion in morning</p> <p>and evening peak hours till the city limits due to commercial activities, the</p> <p>roads are narrow after city limits, encroachments by hawkers and vendors,</p> <p>no footpath, onstreet parking. The road condition is very poor. The road will</p> <p>require traffic management measures and parking management.</p>
Chandigarh road	3797	2.4	<p>Frequent traffic congestion in peak hours due to industrial and commercial activities upto city limits.</p>

Delhi road	5309	1.8	Traffic congestion in morning and evening peak hours due to commercial and industrial activities. Heavy Truck traffic is seen on this road. The road requires traffic management measures and parking management.
Link road	5334	2	t is the road carrying major intracity traffic and this is the road connecting to ISBT. Heavy congestion is seen entire the day due to commercial activities. 5 villages are joined on this road. This road requires traffic management measures and parking management.
Gtbyepass	5456	1.4	This is the road carrying Bypassing traffic and city traffic. This road also has serious congestions throughout the day. Transport Nagar is connected onto this road. It also connects to Dana Mandi and Vegetable Market. The road requires traffic management measures and parking management.
Jalandhar road	3568	1.3	It mainly carries truck traffic. This road is seen with the major

			developments. This road has enough ROW, requires small management measures.
Hambran road	3685	1.7	Traffic congestion in morning and evening peak hours due to commercial and residential activities. The roads are to be widened. Onstreet Parking is seen till the city limits, encroachments by hawkers and vendors. Footpath should be provided. The road requires traffic management measures and parking management.
Malerkotla road	3561	3	Congestion throughout the day due to commercial activities. Encroachments by hawkers and vendors. Onstreet parking. Footpaths are required.

Source: RITES survey, 2009

Table 4.9: Indicator status

Accidents rate	Overall it increases, so affecting safety
vehicles	Number of vehicles, mainly two wheelers are more plying on road, hence affecting capacity
Vehicular emissions	It is PM10 that is 233ug/m ³ in air more than standard value that is 150ug/m ³
Capacity	Overall it is more than 1 i.e. is v/c ratio
Share of transport	More private vehicles, because not efficient public transportation system
Cycle track/pathways	it is not provided along any road
Road condition	It is not good some of road, so increasing fuel consumption and maintenance
Social equity	Public transportation is not adequate according to income level of persons means affordability

4.2 Identification of Issues

- There is more concentration of mixed land use along major routes that are nh1, near samralachowk, towards sahnawal from phillaur which is affecting smooth flow of traffic
- There is inadequate mass transportation system. So affordability and social equity is affected
- Air quality level is beyond the standards that is pm2.5 is 150 ug/m³ in city
- Capacity of each major road that is volume/capacity ratio is more than 1. So it depicts that volume is greater than road carrying capacity
- Parking spaces is not provided for all economic activities. Off street parking is insufficient.
- No enforcement for heterogeneous traffic
- There is not safety for pedestrians because of direct access from shopping centres and institutional buildings

4.3 Suggestions

- There is need to prepare efficient land use-transportation model, for better town planning in future
- Mass transit system require for better mobility with cover all areas of city equally
- Facilities for pedestrians and non motorized is required
- Traffic system management practices are needed for safe flow of traffic
- There should be integration of different modes of traffic like IPT, private and mass transport.
- Enforcing the use bypass for through traffic
- Enhancing the Car pooling or car sharing
- Use of Electric vehicles

4.4 Future scope

These analysis of transportation can be incorporate in preparation of master plan, transportation plan of city for better mobility in future taking care of safety. Problematic areas can be managed properly after this

CONCLUSION

We have studied advantages of indicators in formulation of proper performance of transportation status in city. It is to find out gap between existing transport character of city and standard value of sustainability. Which can be improved by applying measures by studying existing data trends related to Ludhiana city. Collected data to be analyzed by different methods to study the transport impacts on environment.

Vehicular growth affecting capacity on roads as public transport share is less because of more usage of bikes and four wheeler are increasing at very fast rate. There is not proper parking locations along road. People parked along road that affecting capacity of road and lateral clearance. Accident rate is fluctuating in city. Road condition is not good some of roads affecting economy and safety. Sustainable development in terms of transportation system is growing trend in developing countries, as Ludhiana is metropolitan city of Punjab has not properly managed transportation system according to existing transportation plan. Mixed development along road effect the capacity of road. Traffic delay lead to more vehicular emissions asdeteriorating the environment. Public transport in adequate and use is not proper. So these aspect and indicators are analysed in terms of trends and existing conditions to find out the problem related and for benchmarking the city.

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