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Sustainable Transportation System for Emerging Metropolitan Cities

Anas Furquan Khan[1] , Ashish Hakke[2], Supriya D. Shinde[3]

1. *Assistant Professors Department of Civil Engineering P.G Moze College of Engineering, Pune, India*
2. *Assistant Professors Department of Civil Engineering P.G Moze College of Engineering, Pune, India*
3. *Assistant Professors Department of Civil Engineering P.G Moze College of Engineering, Pune, India*

ABSTRACT

Traffic Congestion is increasing in extensive manner globally as a result of inadequate road development, increasing number of vehicles, decreasing speed, increasing in accident rate, increasing fuel consumption rate etc. It increases the necessity for the concept of intelligence transportation system (ITS) for the conventional transportation system. ITS have a major role to play in developing countries economy, increasing driver's safety, enhancing mobility and convenience, bring environmental benefit, increasing productive economic and employment growth. In this paper, comparative study of intelligent transportation system with conventional transportation system is done with the help of some analytical equations. And the impact analysis and sustainability of ITS and sustainable transportation system is done, in which different ITS is compared using some fraction unit in terms of value of time, emissions and safety values. By using urban mobility report calculations can be easily performed for emerging metropolitan cities. In this paper equations are proposed for calculating annual congestion cost, value of time benefit, value of emission savings and the safety savings.

Keywords: Annual Congestion Cost, Sustainable Strategies, Intelligent Transportation System

I INTRODUCTION

Sustainable transportation can be defined as the most profitable and favorable movement of people and vehicles with minimum amount of energy, at most favorable costs and with minimum amount of congestion and environmental impacts such as air and noise pollution and a greater social impacts.

Sustainable transportation is a long term goal to attain, and the progress towards it is cumulative progress. Improvement in transportation is often misunderstood as only constructing bridges, widening roads and having rapid transport systems. Although it includes all these techniques, transportation can become sustainable only when it integrally considers social, economical and environmental aspects. Good land use planning required minimum need to travel, transportation network friendly for all type and classes of people, transportation modes causing minimum amount of air pollution, and transportation options demanding minimum cost and effort of people can be considered as various aspects of a sustainable transportation system.

Thus sustainable transportation involve with the impacts of transportation developments on economic

efficiency, environmental factors, resource consumption, land use, and equity. It includes the application of systems, management and technologies, which would help achieve the continuous economic development without having adverse effect on environmental and human resources. It aims at the efficiency of transport of goods, services and distribution systems with least accessibility problems. Sustainable transportation system aims at designing of congestion free planning, with bicycle and pedestrian friendly areas. It focuses on moving people and not only the vehicles, which reduces air pollution as well as the increasing congestion problem. Sustainability can be attained with the change in behavioral aspects of people. When people understand the impacts of transportation, they can make choices that reduce the need for resources and thus minimize the negative impacts.

1.1 Measures (indicators) of Sustainability

Various researchers are conducting research to define measures of sustainable development, but no definitive set of measures has been arrived at as acceptable by everyone. Indicators of sustainability can be the units of measuring progress towards sustainable development. There are three basic functions of indicators - simplification, quantification, and communication. Indicators generally simplify in order to make complex phenomena quantifiable so that information can be communicated. The general public is concerned about sustainable development and the environment. They like to be informed about the state of the environment and the economy and how and why they are changing. Performance should be measured in ways that meet both governmental standards and public needs and wishes. A primary performance measure can be devised which indicates how regional travel time delay is affected by the recommended strategy. Other secondary benefits could be identified and measured that are of interest to stakeholder groups. A clear additional benefit is how equitably people across a region share in the primary benefit of congestion relief. For some travelers, having more travel choices, especially safe non-motorized modes, is a benefit. Money that is freed up with a cost effective regional solution would also constitute a benefit. It could be applied to local transport problems or to important social purposes. Other measurable benefit indicators include: reductions in health impacts, environmental damages, and accident costs, as traveler shift to transit, ride share and non-motorized modes. The University of Reading gives the indicators for sustainable transportation in terms of car use and total passenger travel, short journeys, real changes in the cost of transport and freight traffic.

While there is no simple or single means of achieving efficient transportation, measures for the study could include the following:

- Congestion index.
- Reduction in pollution levels.
- Per capita energy consumption (Alberta Round Table on the Environment and the Economy -- May, 1993).
- Reduction in travel times or the travelling costs.

- Percentage of excess of capacity over the demand.
- Benefit-Cost Ratio (B/C) of travel; B/C > 1 is a sustainable condition.

Transportation planners face major challenges in exploring affordable, efficient and reliable transport services for the citizens, minimizing negative environmental impacts. For achieving the sustainability, impact of each development and improvement has to be studied in deep and its benefits have to be calculated. Sustainability is attained when there is social comfort and equity with least consumption of resources.

Urban areas in developing countries require new approaches to address their transportation problems. Although the problems appear to be universally the same, their solutions differ. Developing countries face a challenge in finding innovative solutions. Transportation planners often tend to apply methods developed in developed countries to problems in developing countries with little concern for differences in causes, need, condition, resource availability and climate. These solutions may demand enormous costs. It is important for developing nations to develop a transportation system with limited resources, thus avoiding consumption of excessive amounts of land and other sources. Policy makers should realize that solutions designed for cities of developed countries cannot be directly applied to the urban areas of developing countries. They can and should learn from the experiences of developed countries. These countries should also acknowledge the interrelationships that exist between different urban trends and impacts. Addressing problems in isolation would not be very effective because of the complex nature of the urban transportation system. Interrelated problems require integrated strategies implemented over time, from the immediate and short term to the gradual and long term. Developing countries need to make approaches city specific, even for cities within the same country. For instance, developed countries face a problem of urban sprawl, which essentially means the dispersion of population in low densities.

II. METHODOLOGY

2.1 TBL Methodology

Triple Bottom Line means improving socio-economic value of lifestyle while minimizing impact of transportation on the environment. In triple bottom line method there are long term benefits to the society and as well as to the transportation system. TBL methodology includes study on sustainable transportation on the basis of social, economical and environmental factors.

Fig2.1 Triple Bottom Line Method

Annual Congestion Cost

All the information i.e. congestion related traffic information is gathered from a report which is related to that particular city is known as urban mobility report (UMR) or draft plan. From that report congestion related information such as wasted time, value of fuel, operational treatment related time and fuel savings. This analysis creates conditions that how traffic affects if there is no sustainable and intelligent transportation system on the roads in congested areas of emerging metropolitan cities compared with the congested areas with the use of sustainable and intelligent transportation system on the road networks. Total cost of congestion is the sum of annual delay hour and wasted fuel cost, as shown in equation (1) below.

$C_{AC} = [C_{PVD} + C_{PVF}] + [C_{CVD} + C_{CVF}]$

C_{AC} - Annual congestion cost

C_{PVD} – Annual passenger vehicle delay cost C_{PVF} - Annual passenger vehicle Fuel cost C_{CVD} – Annual commercial vehicle delay cost C_{CVF} - Annual commercial vehicle fuel cost

In this equation(1) every component has its own parameters such as average passenger and commercial vehicle in percentage on roads, average fuel cost, fuel saved or wasted annually, occupancy rate of passenger and commercial vehicle, time value of commercial and passenger vehicle. From these parameters and components the cost of congestion or cost savings due to ITS and sustainable transportation system can be easily calculated.

2.2 ITS Strategies

Present Transportation System is not a Sustainable and Intelligent transportation system, due to which the Fuel consumption and Delay cost increases and safety savings minimizes. To make transportation system sustainable we proposes some intelligent transportation strategies, due to which private vehicle ownership decreases and trend of public transportation increases due to which releasing of toxic gases minimized, delay cost reduces, journey time reduces, and safety increases and overall economy of transportation system increases. In Nagpur Draft Plan it is already proposed some ITS system for the Nagpur city.

One of the goals identified as part of the vision is to increase the public transport share to 30% from the existing 10%. For this purpose, we could consider augmentation of Bus System, including Route Rationalization, before embarking on capital intensive system(s). Bus systems only may not be able to meet the desired goal and on key corridors (mobility corridors) a case exists for installing a higher order mass transit system namely BRT / Monorail / LRT/ Metro.

1) Route Rationalization :-

The existing route network requires substantial modification to increase the catchment.. The remaining area need to be connected with updated routing and scheduling plan which in technical terms called as a route rationalization plan. It is analyzed that Nagpur is growing with rapid developments happening beyond inner ring road and need improved connectivity to bus routes with ease of access.

2) **Bus Augmentation :-**

As part of the public transport strategy, augmenting the city bus services should be considered by taking 50 buses per lakh population as a rule of thumb. The public transport strategy for Nagpur is derived considering all the factors of existing situation and the best possible reorganization factoring all components of an efficient and sustainable system.

3) **Higher Order Public Transport Strategy :-**

The system – Higher Order Public Transport refers to the rapid transit system including Bus Rapid Transit, Monorail, LRT, Commuter Rail, Metro etc. These systems have higher carrying capacity and network speed compare to the existing city bus service in Nagpur. The role of higher order system is to cater more trips along the mobility corridors by public transport mode in efficient manner. The higher order system selection is based on the Passengers per Hour per Direction (PPHPD) and feasibility of implementation, along with other parameters.

4) **Modal Integration :-**

Any public transit system is incomplete without intermodal integration. Intermodal integration is crucial for success of multimodal transport system. Intermodal integration involves integrated Public transit network planning, development of feeder networks; use of NMT is these routes, etc. Strategies include –

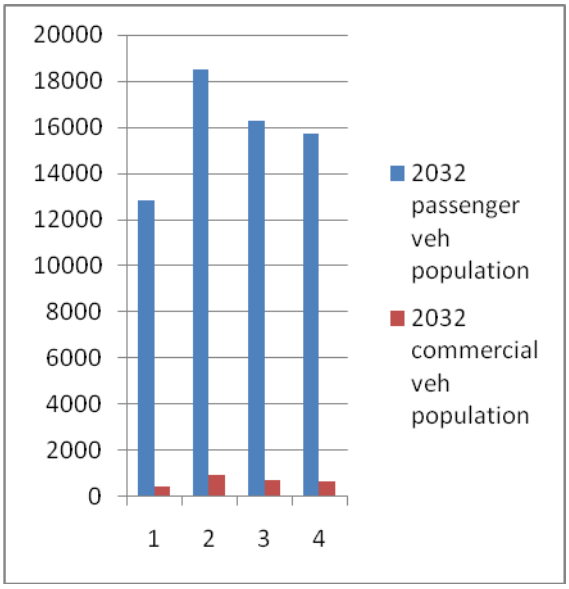
- Intermodal Stations to minimize delay/transfers. Big hubs/transfer stations may be integrated with commercial services like groceries, laundry, city services, mobile re-charge kiosks, etc for the convenience of users.
- Intelligent Transportation Systems (ITS) for user convenience and real-time information.
- Access to the public transit network that includes integration with auto-rickshaws, taxis, and NMT modes like cycle rickshaws, and inland water transport.
- Park and ride Facilities along transit corridors.
- Integrated Fare policy and ticketing, to ensure a single travel experience.

Table 2.1 Vehicle population at different intersection in 2032 after using ITS

(Source: Nagpur Draft Plan)

Data Collected at.	2032 passenger veh population (ITS implementation)	2032 commercial Veh population (ITS implementation)
Hingna Road (CRPF intersection)	8110	748

Sitabuldi Intersection	11670	1495
Kamptee Road (intersection)	10271	1157
Airport Road (Chatrapati Square intersection)	9915	1072



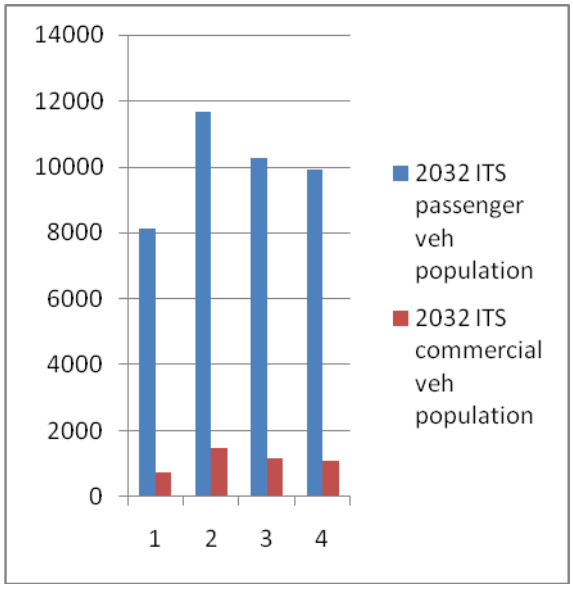


Fig2.2Vehicle Population in Do nothing Scenario for2032 Fig 2.3 Vehicle Population in 2032 after Applying ITS

Above graph number 1st is showing the result of vehicle population in 2032 when the transportation system is not change by any other new technology, or no new system is implemented to transportation system and it showing that the vehicle population is increasing enormously, particularly private vehicle and public transport is increasing slightly low rate. And in 2nd graph it is showing that vehicle population is increasing at low growth rate, particularly private transport is increasing at lower rate and public transport is increasing at higher rate which is beneficial to the transportation system.

III. RESULT AND DISCUSSION

3.1 Anticipated Impact of Proposed Projects

Projects evolved in Comprehensive Mobility Plan will help to achieve sustainable development goals by means of reducing private mode share, emission levels and travel time. The anticipated impacts of proposed projects are presented in the table below.

Table 3.1 Saving of annual congestion cost due to implementation of ITS

Data Collected at.	2032 Annual Congestion cost Do nothing scenario (Million Rupees)	2032 Annual Congestion cost After ITS implementation (Million Rupees)	Cost saved (Million Rupees)
Hingna Road (CRPF intersection)	232.6	150.24	82.36
Sitabuldi Intersection	447.21	284.22	162.99
Kamptee Road (intersection)	441.78	280.82	160.96
Airport Road (Chtrapati Square intersection)	341.86	219.13	122.73

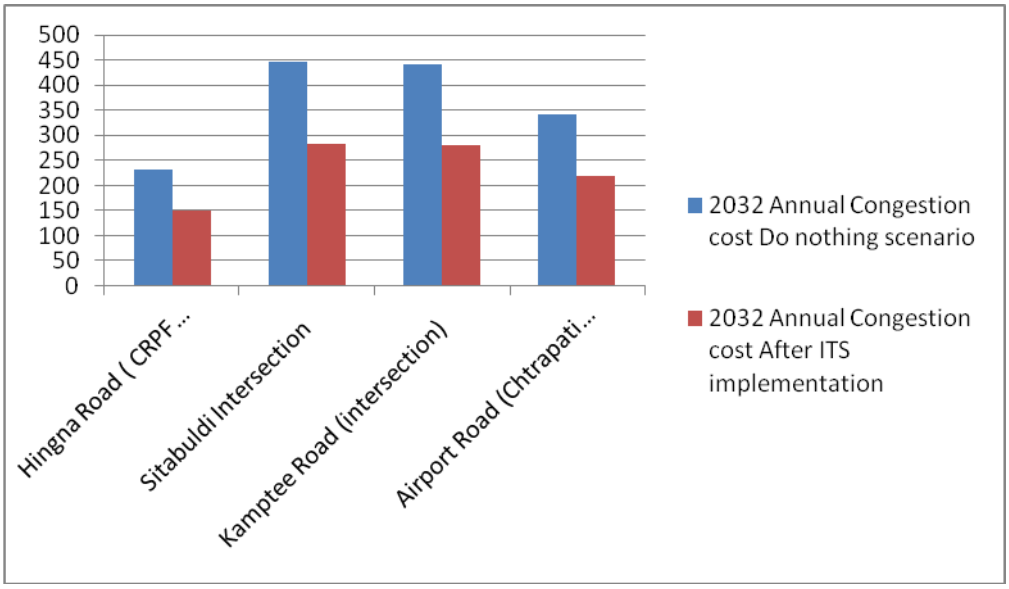


Fig 3.1Annual Congestion Cost at different intersection (Million Rupees)

Table 3.2 Anticipated Impact of Proposed ITS Projects

(Source- Nagpur Metropolitan Area)

Scenario	Private vehicle share (%)	*IPT Share (%)*	PT Share (%)	Average Trip length (PT) (km)	Emission in Tons/ day	Speed in Kmph
Base Year	77	*13*	10	9.3	29.76	27
1. Do Nothing -2032	86	*9*	5	7.12	69.37	23
2. Bus Augmentation	86	*6*	8	8.39	67.28	23
3. Bus Augmentation + Route Rationalization + Rapid Transit System	79	*6*	15	12.25	63.03	24
4. Bus Augmentation + Route Rationalization + Rapid Transit System + TOD	74	*6*	22	18.98	61.79	24

3.2 Direct and Indirect Environmental Savings:

The figures presented below indicates the direct savings (i.e. operational related savings) and indirect savings (i.e. total impacts of TBL`s direct and indirect savings). In other words, TBL methodology provides the data for the fuel consumption sector related direct and its related sector`s indirect savings under the figure headings for indirect savings. Some environmental concerns, such as water consumption, do not include any operational (i.e. direct) savings.

3.3 Direct and Indirect Socio-Economic Savings:

The most significant impact of congestion relief through ITS stemmed from a reduction in annual, since, these hours was underemployment hours for industries in the past. Although cost savings accrued as a result of reduced person and commercial vehicle hours, fuel savings reduced the profit and employment of some industries, especially petroleum refineries. Taxes that are paid with per gallon fuel purchases and its production related (i.e. indirect) impacts reduced the government revenue. Hence, there is a need to analyze these indicators

in the TBL model. It is also crucial to highlight that TBL results presented as indirect impacts, however, they include direct impacts related to the primary sector and supply chain sectors activities.

IV. CONCLUSION

B.

Nagpur is an emerging metropolitan city, and the population is growing very enormously. according to present condition the transportation system of the city is not sustainable i.e. facility and service provided in existing public transportation is not satisfactory to the commuter level which results in increasing private vehicle trend and growth of private vehicle increasing day by day which results in emission of toxic increases, economy decreases , social factor get affected, to overcome such problems , in this study we proposed some sustainable transportation system such as light rail transit, bus augmentation, public transport strategies, route rationalization.

In this study, we calculated congestion cost saving by triple bottom line methodology. In annual congestion cost of Nagpur in present condition annual congestion cost of study area for e.g. Hingna road (CRPF Sq.) is calculated 75.05 Million rupees in which fuel wasted and delay cost is included.

Again by Do Nothing Scenario till 2032 in which no changes and no implementation made in transportation system due to which the annual congestion cost calculated as 232.6 Million Rupees which is enormously high wastage of fuel and money. In this condition delay increases in high rate and fuel wastage is also high, private vehicle growth is also increases and public transportation decreases.

To overcome these problems we proposed some sustainable and intelligent transportation methodologies which is also a key part of comprehensive mobility plan of Nagpur city. By applying ITS methodologies annual congestion cost in 2032 is reduced to 150.24 Million Rupees i.e. the congestion saving is 82.36 Million Rupees , which is directly and indirectly related to environmental factors and socio-economic indicators get benefited due to this sustainable strategies.

REFERENCES

[1] Replogle, M. (1991). Nonmotorized Vehicles in Asia..: The World Bank.

[2] León, T., Liern, V., Ruiz, J.L., Sirvent, I.: A fuzzy mathematical programming approach to the assessment of efficiency with DEA models. Fuzzy sets system (2003).

[3] Coffey, R., and Lowson, M.V. “A comparative analysis of energy consumption and emission of urban transport systems”, in “Urban Transport and the Environment II”, Eds. Baldasano Recio and Sucharov, Computational Mechanics Publications, Southampton ISBN 1996

[4] Black, J. A., Paez, A., and Suthanaya, P. A. ~2002! “Sustainable urban transportation: Performance indicators and some analytical approaches.” J. Urban Plann. Dev., 128~4, 184–209.

[5] Litman, T.(2003) “Sustainable transportation indicators.” Victoria Transport Policy Institute ~VTPI!,

Victoria, Canada.

[6] Banister, D. (2006). "Sustainable urban development and transport." Keynote Speech for Swiss Transport Research Conf. (STRC): Exchanging Ideas for Transport, STRC Switzerland.

[7] Dhingra, S. and Rajaram, B. (2004). "Sustainable transportation strategy for Mumbai (Bombay) region using an integrated mass transit systems approach." Urban Public Transp. Syst.

[8] Deakin, E. (1989). "Land use and transportation planning in response to congestion problems: A review and critique." Transp. Res. Rec., 1237, 77–86

[9] Roth, A., Kaberger, T.(2002). "Making transport systems sustainable." Cleaner Production. J. 10 (1)

[10] Akinbami, K., Fadare, S.O. Fadare.(1997). "Strategies for sustainable urban and transport development in Nigeria." Transport Policy. J. 4 (4)

[11] Button, K.,Nijkamp, P.(1997). "Social change and sustainable transport." Transportation Geography. J. 5 (3)