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Importance of Traffic and Transportation Plan in the Context of Land Use Planning for Cities – A Review

P. Sangaradasse[1], S. Eswari[2]

[1]*Department of Civil Engineering, Pondicherry Engineering College, Puducherry- 605 014, India.*

[2]*Department of Civil Engineering, Pondicherry Engineering College, Puducherry- 605 014, India.*

Abstract

Traffic congestion is one of the important issues in developing cities and it depends on the change in land use. Regulation of zoning and land use playsa major role to mitigate the traffic congestion. Integration of Land use and transport system is one of the best solution to manage the traffic congestion is developing cities. In the past decades, Urban sprawl has resulted in to loss of high quality agricultural land and open space, fragmentation of ecosystem, spatially segregated users inducing high dependency on private vehicles and unfavourable conditions for use of Public transport. Simultaneously an increase in the built up area has been experienced in the cities without and regulation of the land use. At present the carrying capacity of road space cannot be increased with respect to the increasing vehicle population and hence it leads to traffic congestion. This paper reviews land use and transportation planning with respect to the traffic congestion with reference to the Indian cities and to derive the methodology to regulate the traffic congestion.

Keywords: Land use, Traffic congestion, Transportation Planning, Geographical Information System.

1. INTRODUCTION

Traffic congestion is one of the major an important issues in urban agglomeration of any developed and developing cities all-round the world and even though many measures have been fairly taken to reduce and regularise the traffic congestion. Traffic congestion leads waste of time, fuel, delay, air pollution and imposes cost on society. There are two principal categories of causes of congestion and they are: (a) Micro-level factors (e.g. relates to traffic on the road) and macro factors relate to overall demand for road use. The macro level factors are, for example many people and freight-want to move at the same time, too many vehicles for limited road space, poorly timed traffic signals special events like mass social gathering, political rallies, bad weather condition etc. The micro level factors e.g. land use-pattern, employment patterns income levels, car ownership trends, infrastructure investment regional economic dynamics etc. also may lead to congestion [1].

Day by day the vehicle population is increasing without the widening road space. The regulation of road network has not been monitored with respect to the rapid growth of the city. The depth of traffic impact measurements and traffic impact analysis (TIA) has not been adequately considered in urban plans. TIA in the most concealed component in urban planning laws and regulations and its approach level of execution and functional standard are neither exposed nor put into urban planning operations [2].

Public transport plays an important role for probably in urban areas, particularly with regard to while trips and trips generation to central areas. The travel demand for public transport is highly concentrated in the peak hours of morning and evening peak hours [3,4], though the peak periods occupy small proportion of a day, a high proportion of passengers travel during these critical periods [5]. Public transport systems have the potential to significantly affect period traffic congestion [6, 7]. According to the International Association of public transport in 2001, the average speed of vehicle on Bangkok streets was 15km/h, while in Manila, Jakarta and Singapore were 18km/h, 19km/h 20km/h respectively [8].

However, traffic congestion does not occur only due to increasing level of motorized vehicles, but also in cities with low levels of motor vehicles. For instance, in Dhaka in Bangladesh and Varanasi in India, traffic flow is slow and causes heavy congestion. Notably, Varanasi has only 7% of total motorized vehicles. It suggests that congestion also occurs due to mismanagement between demand and supply for transport services[9].While preparation of comprehensive Development Plan, of the respective developed / developing city, the traffic impact analysis report has not been included for assessment of future traffic congestion for rapid growth urbanization. The change of land use and increasing of traffic volume are also not included in Social Economical Impact Assessment (SEIA). Saunal factor have contributed to transportation's secondary role in local planning effort. First governmental responsibilities for land use and transportation, traditionally have been divided with land use assigned to the planning department and transportation assigned to the engineering. Many planners have little training in transportation and have been satisfied to leave what they view as a technically based matter to another department. May engineers similarly are unskilled in land use planning and lack interest in the policy issues in details. Land use and transportation activities thus have tended to proceed along separate paths, reflecting differences in the training to the respective staff as well as differences in the scope of responsibilities. [10].

This paper reviews land use and transportation planning with respect to the traffic congestion problems. Review also been

done with reference to Indian cities conditions to derive the methodology for regulation of traffic congestion in developing countries.

2. INTERNATIONAL STUDY ON TRAFFIC CONGESTION

Traffic congestion is a condition in which the number of vehicles attempting to use a roadway at any time exceeds the ability of the roadway to carry the load at generally acceptable service levels [11].Traffic congestion occurs when travel demand exceeds the existing road system capacity [7]. Congestion may be defined as state of traffic flow on a transportation facility characterized by high density and low speeds, relative to some chosen reference state (with low density and high speed)[12]. Congestion is a condition that arises because more people wish to travel at a given time than the transportation system can accommodate: a simple case of demand exceeding supply [13].Congestion is the impedance of vehicles that impose on each other, due to the speed-flow relationship, in conditions where the use of a transport system approaches its capacity [14]. When vehicular volume on a transportation facility (street or highway) exceeds the capacity of that facility, the result is a state of congestion [15]. Traffic congestion is a condition of traffic delay (when the flow of traffic is slowed below reasonable speed) because the number of vehicles trying to use the road exceeds the traffic network capacity to handle them. [16]. In the transportation realm, congestion usually relates to an excess of vehicles on a portion of roadway at a particular time resulting in speed that are slower-sometimes much slower-than normal or "free flow" speed [17,13]. Congestion is an imbalance between traffic flow and capacity that causes increased travel time, cost and modification of behavior. Traffic congestion refers to the incremental costs resulting from interference among road users [18]. Traffic congestion is travel time or delay in excess of that normally incurred under light or green-flow travel conditions [19]. Congestion is the presence of delay along a physical pathway due to presence of other users [20]. Congestion can defined as the situation when traffic is moving at speed below the designed capacity of a roadway [21]. Boarnet et al. [22] identified three issues that must be addressed in measuring congestion. It should (i) reflect the full range of highway performance, (ii) be based on widely available data, and (iii) allow comparison across metropolitan areas. Turner [23] examined indicators of congestion and suggested that measures to quantify the level of congestion should (i) deliver comparable results for various systems with similar congestion level (ii) accurately reflect the quality of service for any type of system, and (iii) be simple, well-defined and easily understood and interpreted among various users and audiences. Robert and Theodore [25] discussed various approaches for quantifying congestion and how these different measures affect the perception of the problems. In a study done for the state of New Jersey, thresholds of the volume-capacity ratio on any given roadway were adopted to identify where congestion was occurring. The severity of this congestion was then analyzed by using both distance-based and time-based measures to describe the magnitude of the problems. Aworemi et al. [26] examined the causes / effects (road condition accidents etc.) and possible ameliorative measures of road traffic congestion in some selected areas of Lagos State. Stathopoulos and Karlaftis[27] studied how to estimate the duration of congestion on a given road section and the probability that, of its onset, and the end during the following time period. The results indicated that the Log logistic functional form best describes congestion duration. Hongsakham et al. [28] proposed method for estimating degrees of road traffic congestion by using Cell Dwell Time (CDT) information available from cellular network and classified into degrees of congestion. Choi et al. [29] conducted a study by applying Travel Time Index (TTI) to show the level of traffic congestion. It was observed that TTI index describes the traffic congestion in both time and space with minimum of data collection effort. The methodology for estimating and predicting the total annual traffic congestion attributable to recurrent and non-recurrent congestion, and this methodology is applicable to freeways, conventional highways, and urban streets. Thurgood [30] developed an index called Freeway Congestion Index, which simultaneously captures the extent and duration of congestion on freeways. Owusuet al. [31] demonstrated that efficient vehicle monitoring can be achieved by integrating Global Positioning System (GPS) derived traffic data such as vehicle speed and direction of traffic flow into a Geographical Information System (GIS) environment. The system developed has been used to show the second-to second positional changes in speed and directions of vehicles travelling in Kumasi, the second largest city in Ghana. The aim of the study performed by Ishizaka et al. [32] is to discuss the feasibility of a system to collect traffic information using probe vehicles in a developing city (Bangkok) in terms of cost efficiency. Congestion may be defined as state of traffic flow on a transportation facilities characterized by high density and low speed, relative to some chosen reference state (with low density and high speeds) [13].

2.1. Asian Countries

Lam and Tam [33] investigate why the standard modeling and evaluation procedures currently used by the Hong Kong Government are inadequate for assessing the traffic congestion measures. Empirical evidence is given together with discussion on modeling and evaluation issues raised by the existence of suppressed / induced traffic. Pattara-atikom et al. [34] investigates way to estimate degrees of road traffic congestion based on GPS measurements from main roads in urban areas of Bangkok and Thailand. The study used human perception to obtain classification thresholds and evaluated the performance of the proposed methods. Haoet. al. [35]classify the traffic states and define types or recurrent congestion according to their evolvement. An approach of identifying traffic control area and congestion source using spatial-temporal speed figure introduced. Sun et. al. [36] studied the relations between traffic flow parameters of traffic bottleneck and phase transitions in profiles of traffic flow fundamental parameters. There were more than 11.3 million motor vehicles in Jakarta in 2011, while the city population was below the population of motor vehicles and was 9.6milion. It indicates that 70% of city households own motor

vehicles. Moreover, it is revealed that the number would increase to 12million as around 1500 new motor cycles and 500 new motor cars will continue to be injected into the city on daily basis. Bangkok increased the number of streets to accommodate more vehicles; Shanghai reduced urban congestion through a network of elevated freeways. Manila and Jakarta have also undergone such transition to create more space per urban vehicles movement. Singapore created of – the- art urban transport facilities [10].

2.2. Indian Cities

The migration of rural population to urban areas in search of better job prospects has made cities densely populated. About 27 per cent population live in urban areas. There are 4,000 cities and towns in India. About 400 cities have population over 1,00,000. Eight cities have population more than 3 million.

India has more truly congested cities than any other nation, which is not surprising, since it is also the world's second-most populous country, after China. Vehicles in India are distributed somewhat unevenly. Delhi, Mumbai, Kolkata and Bangalore have 5% of India's population but 14% only are its registered vehicles. Traffic is growing four times faster than the population in six cities: Mumbai, Delhi, Ahmedabad, Bangalore, Chennai and Hyderabad. Indeed, Delhi is now said to have as many cars as Mumbai, Kolkata and Chennai combined.

Traffic is well known for moving at the pace of its slowest component. Most countries have automobiles, buses, trucks, trains, motorcycles, motor scooters and bicycles. But in India, in addition to this routine urban transportation and contributing substantially to the congestion are networks of auto-rickshaws and two-wheelers, as well as bullock carts and hand-pulled rickshaws (disappearing from some urban areas).

There has been a staggering 100 fold increase in the population of motorized vehicles; however, the road network has not been to commensurate with this increase. While the motor vehicle population has grown from 0.3 million in 1951 to over 30 million in 2004, the road network has expanded from 0.4 million km to 3.32 million km, i.e. only a 8 fold increase in terms of length during the same period. However, upgrading of roads by way of widening of carriage-ways, improved surface quality, strengthening/ reconstruction of old/ weak bridges and culverts, etc. has been carried out.

Dewan and Ahmad [37] conducted a survey for car-pooling in Delhi and willingness of commuters for car-pooling and they observed that car-pooling is one of the solutions to reduce the traffic congestion in Delhi.

In the recent past, Delhi Traffic Police has introduced a number of technological innovations like Online Prosecution System, the Area Traffic Control System, and SMS facility for information dissemination and GIS base Accident Information System – to mention a few. The most satisfying aspect of these changes is that they have proved to be very relevant to the needs of the people of Delhi.

The average journey speed in Indian cities is also low, particularly in cities which have high car volumes [38]. In 2007, a study commissioned for the Ministry of Urban Development, Government of India, found that the average journey speed in Delhi was around 16 km/h and only slightly higher in Mumbai.

The Delhi's Master Plan 2021 aims to attract 80% of road travel to public transport by 2020. An estimate indicates that by the year 2021 travel demand in Delhi will increase to 27.9 million passenger trips as compared to 13.9 million passenger trips in 2001. This increase in travel demand is more than double. It implies that in future, public transport will cater to 22.3 million passenger trips. However, according to the statistics of the Ministry of Road Transport and Highways, the number of registered buses in New Delhi has seen little growth, while private vehicles, particularly two-wheelers, are increasing at their highest rate over the last few years.

Similarly in Mumbai, congestion on roads is a regular phenomenon. Despite the fact that in Mumbai, sub-urban rail link meets most suburban travel demand, road congestion is not reduced. During peak hour, traffic in Mumbai flows at a speed of 20 km/h speed [39]. The total vehicles in Bangalore and Hyderabad are around 6.8 million, of which around 70% are two-wheelers. On the other hand, cars and other passenger vehicles such as jeeps, taxis, and auto-rickshaws, account for around 25% while buses account for only 0.7% of the total motorized vehicles registered in the cities of Hyderabad and Bangalore. This indicates that there is a growing tendency of ownership of two-wheelers, car, taxis and others in Indian cities.

The study found the average journey speed to be below 20 km/h in Hyderabad, Chennai and Bangalore, as well as low in cities with slow moving vehicles such as Varanasi and Bhuvaneswar[40].

Varmora and Gundaliya[41] in their study in the city of Ahmedabad, have shown that due to change in carriageway width and vehicle composition, the traffic stream speed and flow also encounter more congestion level along the length of link.

Roy et al. [42] discuss a novel and interesting way to detect the congestion on the urban arterials in India. They suggest using a Wi-Fi signal-emitting device and a receiver across the road to identify the congestion. This method was found to be successful in terms of high accuracy of classifying the road as congested or free flowing [43].

Sen et al. [44] discussed the characteristics of the Intelligent Transportation System (ITS) techniques that need to be developed to cater to the traffic conditions and congestion in developing regions and presented a brief description of a few efforts being made in this direction, and the characteristics of the ITS techniques that need to be developed to cater the traffic conditions and congestion in developing regions and presented a brief description of a few efforts being made in this direction.

3. PARAMETERS INFLUENCES ON TRAFFIC CONGESTION

3.1. Change of Land Use

In general the land use planning and Zoning regulation traditionally have been in activities of local government. The land use and transportation planning have been divided, with land use assigned to the planning department and transportation assigned to engineering. Many planners had only little training in transportation and have been satisfied to leave what they view as a technically base matter to another department. Many engineers similarly unskilled in land use planning and lack of interest in the policy issue details. The land use is categorized into residential, commercial, Industrial, public and semipublic, traffic and transportation, water body, mixed land use. According to the human utility and direction of city growth, the land use can be updated. The change of land plays a major role in traffic congestion. Normally the depth of the traffic impact measurements and traffic impact analysis has not been adequately considered in urban plans. The effect of land use change and the extent of the increased traffic volume in transport network. The master plan prepared by local authority required traffic impact analysis (TIA) to be performed for manufacturing and processing industries, container and bus terminal, ware house, housing estate, sports grounds and commercial centers, but there are few development project which have performed Traffic Impact Analysis (TIA). Due to said land use changes in the urban agglomeration area, the traffic volume also increased but saves with the road space as maintained. When consistency / implement of new project / scheme with respect to the land use changes, the Traffic Impact Analysis should be concluded. The traffic depends on the location and size of the development and has an impact on the surrounding areas and on the existing local and arterial transport network and most of the time it creates traffic congestion, air pollution and safety issues to public. Therefore for the decision makers to take decision recording new development traffic impact analysis are assessment issued as the tool to guide them to assess each development. All land use planning process and decision have an impact on society and communities and affect people's livelihood and amenity and any consequences of planning decision affect the society for long time. Izreli and McCarthy [45]studies, shows that understood that the residential area had an effect on congestion; there was a significant positive correlation between population density and commuting time. Handy [46] analyzed the impact of land use on travel characteristics and discovered that the frequency of traveling decreased as the density of land use increased and that the distance of traveling increased as the speed of traveling decreased. Gordon et al. [47,48] analyzed satellite data of 82 US metropolitan areas in 1980 to extract the information on the densities of different types of the land use (the type of the resident, the industry and the commerce). When considering the employment rate at that time, it was found that the increment of the industrial density would lower the car commuting time, as well as the residential and commercial densities. Ewing et al, [49] investigated the impact of land use on commuting time and pedestrian delay using cross-sectional data of 83 metropolitan statistical areas in 1990 and 2000.

However the mixed-use places compatible activities side-by-side so that they mutually benefit from one another, such as creating a pleasant pedestrian milieu or allowing the sharing of parking. Mutli-uses are just that – an assemblage of land uses that are not necessarily related to one another in any design or functional sense.

3.2. Traffic Volume

Congestion usually relates to an excess of vehicles on a portion of roadway at a particular time resulting in speed that are slower, sometimes much slower than normal or "free flow" speed [18].

The total number of registered motor vehicles in India was 210023289 as on 31.03. 2015. There were seven states having more than 10000000 registered motor vehicles viz. Maharashtra, Tamil Nadu, Uttar Pradesh, Gujarat, Karnataka, Rajasthan and Madhya Pradesh as on 31.03. 2015.

The number of registered motor vehicles as on 31.03. 2015 was 25562175, 22518669, 21635531, 14784961, 12378929 and 11141127 of Maharashtra, Tamilnadu, Uttarapradesh, Gujarat, Karnataka, Rajasthan, and Madhya Pradesh respectively, and among the Union Territories, Delhi had the maximum number of registered motor vehicles of 8850720 and it is represented in fig.1.

It had a share of 4.21% in the total number of registered motor vehicles in India as on 31.03. 2015.https://data.gov.in/catalog/road-transport-year-book-2013-14-and-2014-15 [50].

3.3. Level of service

Level of service is one of the important factors to reduce the traffic congestion. The following areas need to be processed in terms of information management, performance monitoring to provide better service.

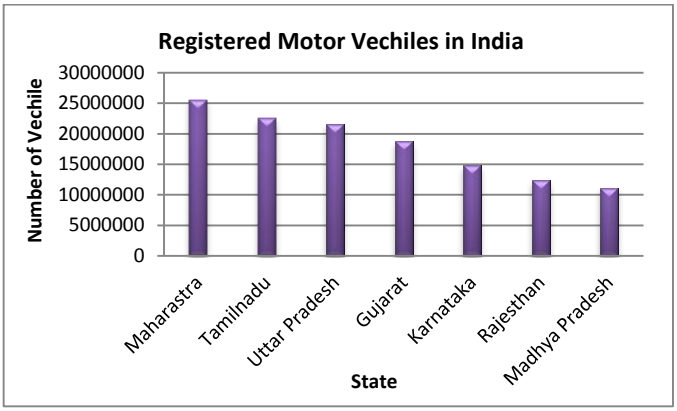

Fig.1 Number of registered vehicles above 1crore in India

- Land use transport integration
- Quality and financial sustainability of public transport system.

- ITS facilities in a city.
- Parking system and population level in a city.
- Pedestrian / NMT safety and infrastructural facilities.

3.4. Demand/ capacity related

Congestion is an imbalance between traffic flow and capacity that causes increased travel time, cost and modification of behaviour. Congestion is a condition that arises because more people wish to travel at a given time than the transportation system can accommodate: a simple case of demand exceeding supply [13]). Congestion is the impedance vehicles impose on each other, due to the speed-flow relationship, in conditions where the use of transport system approaches its capacity [14]. Congestion is a condition in which the number of vehicles attempting to use a roadway at any time exceeds the ability of the roadway to carry the loads at generally acceptable service levels [11]. When vehicular volume on a transportation facility (street or highway) exceeds the capacity of that facility, the result is a state of congestion [15]. Congestion prevents traffic from moving freely quickly and / or predictably.

4. BY LAW AND ZONING REGULATIONS

Zoning regulate the use of land by defining the purpose for which the land can be used and what can be built on that land. Some Zoning orginallyapply "bulk" control over land and building with the aims of controlling the density of population and the generation of traffic. Zoning regulations are usually passed by local authorities; although in some countries municipal (or) provincial or central government retain the power to appraise Zoning regulation.

Building regulations are applied to regulate the intensity of land use by enforcing standards in building coverage and Floor Area Ratio (FAR). These regulations also have an influence on reducing the traffic impact.

5. MITIGATION METHODS IN PRACTICE

Most of the mitigation methodologies can be integrated into land-use and transportation system planning provided proper coordination among state and city administration authorities takes place. There are a number of technical solutions available, which are used at present to mitigate the traffic impact caused by new developments in urban areas. These include the drawing-up of a master plan, zoning ordinances, building regulations and by-laws, the issuing of permits, and charging impact fees. Fig.2 shows the factors that influences the Traffic Congestion

Fig.2 Parameters for Traffic Congestion

6. CONCLUSION

As urbanization proceeds, cities are swelling and obviously the growth of the cities cannot be curtailed. There must be effective and efficient land use pattern for the cities which have to be studied in depths by taking traffic and transportation plan to be effective with land use plan. Establishment of decentralization of social infrastructure facilities to be provided in the outside of the urban area is one of the factors to reduce the traffic congestion in peak hour. While implementation of new project, traffic impact analysis (TIA) report may incorporate to analysis the future traffic congestion of the developing cities. Master plan/ Comprehensive development plan plays major role to regulate the land use and so as to ensure balance development of all settlement within the cities. While making plan process with using the remote sensing and Geographical information systems (GIS) it provide accuracy to integration of both spatial and attribute data, identify the spatial growth of cities and laying of physical infrastructure facilities in anticipation with the projected growth of cities and laying of physical infrastructure facilities in anticipation with the projected growth of population. The cities should have neighborhood concept in relation with work place as well as Central Business District (CBD). Mixed land use is also one of the factors to reducing the traffic congestion at city level. While

execution of building Bye- law, mixed land use concept should adopt in local planning area and organizing the physical form and land use pattern of the city such that the travel demand, trip lengths and travel times are minimized. Transit Oriented Development (TOD) highly depends on establishing mixed land and reducing distance between work place as well as journey time.

REFERENCES

[1] Rao, A. M., and Rao, K. R., 2012, " Measuring Urban Traffic Congestion—A Review, International Journal of Traffic and Transport Engineering," 2(4), pp. 286–305.

[2] Wilfred Kazaura, G., and Marco Burra, M., 2017, "Land Use Change and Traffic Impact Analysis in Planned Urban Areas in Tanzania: The Case of Dares Salaam City," 5(1), pp. 1-19.

[3] Meyer, J.R., and Gomez-Ibanez, J.A., 1981, "Autos, transit and cities, Cambridge, Massachusetts" Harvard University Press.

[4] Jones, D. W., 1985, "Urban transit policy: an economic and political history, Englewood Cliffs," NJ: Prentice Hall.

[5] Thomson, J. M., 1977, "Great cities and their traffic, London," Victor Gollanez Ltd.

[6] Rosenbloom, S., 1978, "Peak-period traffic congestion: a state-of-art analysis and evaluation of elective solution," Transportation, 7(2), pp.167-191.

[7] Kittelson and Associates Inc., KFH Group Inc., Parsons Brinckerhoff Quade& Douglass Inc. and Dr. Katherine Hunter-Zaworski, 2003, "Transit capacity and quality of service manual," 2nd ed., Transit Cooperative Research Program TCRP Report 100, Washington, DC: Transportation Research Board.

[8] Boquet, Y., 2010, "Changing Mobilities in Asian cities, Southeast Asian Geography Conference," Vietnam.Online proceeding.

[9] AbsarAlam, M., and Faisal Ahmed, 2013, "Urban Transport System and Congestion: A Case Study of Indian Cities," Transport and Communications Bulletin for Asia and the Pacific. 82, pp. 33-43.

[10] Elizabeth Deakin, 1989, "Land Use and Transportation Planning in Response to Congestion: The California Experience," The University of California Transportation Center, UCTC No. 54 Working Paper.

[11] Rothenberg, M. J., 1985, "Urban congestion in the United States-what does the future hold," Institute of Transportation Engineers Journal, 55(7), pp. 22-39.

[12] Bovy, P. H. L., and Salomon, I., 2002, "Congestion in Europe: measurements, patterns and policies. In Monograph Travel Behaviour: spatial paerns, congestion and modeling. pp. 143-179.

[13] Miller, M. A., and Li, K., 1994, "An investigation of the costs of roadway traffic congestion: a preparatory step for IVHS benets' evaluation," Berkley: Institute of Transport Studies, University of California, 53 p.

[14] ECMT, 1999, "The spread of congestion in Europe. Paris: OECD Publication Service," 237 p.

[15] Vuchic, V. R., Kikuchi, S., 1994, "The bus transit system: its underutilized potential," Report DOT-T-94-29, Washington, D.C.: Federal Transit Administration, 82 p.

[16] Weisbrod, G., Vary, D., and Treyz, G., 2001, "Economic implications of congestion," NCHRP Report 463, Washington, D.C., transportation Research Board, 47p.

[17] Cambridge Systematics Inc., 2005, "Texas Transportation Institute (TTI), Traffic Congestion and Reliability: Trends and Advanced Strategies for Congestion Mitigation," Washington, D. C., Federal Highway Administration, 140 p.

[18] Victoria Transport Policy Institute (VTPI), 2005, Congestion reduction strategies: identifying and evaluating strategies to reduce congestion.

[19] Lomax, S. T. T., Turner, S., Shunk, G., Levinson, H. S., R. Pra, R. H., Bay, P. N., and Douglas, G. B., 1997, "Quantifying congestion, Volume 1, NCHRP Final Report 398, Washington, D.C.: Transportation Research Board. 1997, 108 p.

[20] Kockelman, K, 2004, "Traffic congestion. In Monograph Handbook of transportation Engineering," 32 p.

[21] Downs, A., 2004, "Still stuck in traffic: coping with peakhour traffic congestion, Washington, D.C., The Brookings Institution,455 p.

[22] Boarnet, M. G., Kim, E. J., and Parkany,E., 1998, "Measuring traffic congestion," Transportation Research Record: Journal of the Transportation Research Board, pp. 93-99.

[23] Turner, S. M., 1992, "Examination of indicators of congestion level, Transportation Research Record," Journal of the Transportation Research Board, 1360, -157.

[24] Dowling, R., Skabardonis, R., Carroll, M., and Wang, Z., 2004, "Methodology for Measuring Recurrent and Non recurrent Traffic Congestion," Transportation Research Record: Journal of the Transportation Research Board. 1867-08, 1867, pp. 60-68.

[25] Robert, R. J. A., and Theodore, F. E., 2002, "Contrasting time-based and distance-based measures for quantifying traffic congestion levels," Transportation Research Record: Journal of the Transportation Research Board, 1817, pp. 143-148.

[26] Aworemi, J. R., Abdul-Azeez, I. A., Oyedokun, A. J., and Adewoye, J. O., 2009, "A study of the causes,

effects and ameliorative measures of road traffic congestion in Lagos metropolis," European Journal of Social Sciences, 11(1), pp. 119-128.

[27] Stathopoulos, A., and Karlaftis M. J., 2002, "Modeling Duration of Urban Traffic Congestion," Journal of Transportation Engineering, 128:6(587), 128(6), 587-590.

[28] Hongsakham, W., Pa□ara-atikom W., and Peachavanish, R., 2008, "Estimating road traffic congestion from cellular handoff information using cell-based neural networks and k-means clustering," In Proceedings of the 5th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology, pp. 13-16.

[29] Choi, J., Lee,S. and Yu, J., 2007, "Development of the traffic congestion index for freeway corridors in South Korea," Proceedings of the 7th international conference of Eastern Asia Society for Transportation studies.

[30] Thurgood, G. S., 1995, "Development of freeway congestion index using an instrumented vehicle," Transportation Research Record, Journal of the Transportation Research Board, 1494, pp. 21-29.

[31] Owusu, J., Afukaar, F., and Prah, B. E. K., 2006, "Towards Improving Road Traffic Data Collection,The Use of GPS/ GIS," In Proc. of the 5th FIG Regional Conference Accra, 11 p.

[32] Ishizaka, T., Fukuda, A., and Narupiti, S., 2005, "Evaluation of probe vehicle system by using micro simulation model and cost analysis, Journal of the Eastern Asia Society for Transportation Studies, 6, pp. 2502-2514.

[33] Lam, W. H. K., and Tam, M. L., 1997, "Why standard modeling and evaluation procedures are inadequate for assessing traffic congestion measures," Transport Policy, 4(4), pp.217-223.

[34] Pattara-atikom, W., Pongpaibool, P., and Thajchayapong,S., 2006, "Estimating Road Traffic Congestion Using vehicle Velocity," In Proceedings of the 6th Intentional Conference on ITS Telecommunications, pp.1001-1004.

[35] Hao, Y., Wang, W., Sun, L., and Xu, T. D., 2008, "Research on spatial-temporal features of urban freeway congestion. In Proceedings of the 1st International Symposium on Transportation and Development Innovative Best Practices, Beijing, China, 31p.

[36] Sun, W., Zhengyu, D., and Xue, Y., 2009, "Experimental Features of Urban Freeway Traffic Flow," In Proceedings of the International Conference on Transportation Engineering, (345)592, pp. 3590-3595.

[37] Dewan, K. K., and Ahmad, I., 2007, "Carpooling: A Step to Reduce Congestion (A Case Study of Delhi)," Engineering Leers, 14(1), pp. 61-66.

[38] Ghate, A. T., and Sundar, S., 2013, "Can we Reduce the rate of growth of car Ownership?, Economic and Political weekly, 48,(23), pp.32-40.

[39] Kumar, K and Naryana, 2013, "Daunting Traffic scenario: Delhi Comes to a standstill in coming years," The Economic Times, March 17.

[40] Wilbur Smith Associates, 2008, "Study on Traffic and Transportation Policies and Strategies in Urban Areas in India," Ministry of Urban Development.

[41] Varmora, K. K. C., and Gundaliya, P. J., 2013, "Effect of Traffic Composition and Road Width on Urban Traffic Stream," Indian Journal of Research, 2(4), pp. 168–170.

[42] Mohan Rao, A., and RamachandranRao, A., 2012, "Measuring urban traffic congestion – a review," Internal Journal for Traffic and Transport Engineering, 2(4), pp. 286-305.

[43] Roy, S., Sen, R., Kulkarni, S., Kulkarni, P., Raman, B., and L. Singh, L., 2011, "Wireless across Road: RF based Road Traffic Congestion Detection," In Proceedings of the 5th Annual Workshop on Wireless Systems: Advanced Research and Development, pp. 1-6.

[44] Sen, R, S., Sevani, P., Sharma, Z., Koradia and Raman, B., 2009, "Challenges in Communication Assisted Road Transportation Systems for Developing Regions," Proceedings of the 3rd ACM Workshop on Networked Systems for Developing Regions.

[45] Izraeli, O., and McCarthy, T. R., 1985, "Variations in travel distance, travel time and modal choice among SMSAs, Journal of Transport Economics & Policy, 19(2), pp. 139–160.

[46] Handy, S., 1992, "How land use patterns affect travel patterns: a bibliography," CPL Bibliography, no. 279.

[47] Gordon, P., Kumar, A., and Richardson, H. W., 1989, "Congestion, changing metropolitan structure, and city size in the United States," International Regional Science Review, vol. 12(1), pp. 45–56.

[48] Gordon, P., Richardson, H. W., and Liao,Y., 1997, "A note on travel speeds debate, Transportation Research Part A: Policy and Practice, 31(31), 1997, 259-262.

[49] Ewing, R., Pendall, R., and Chen, D., 2003, "Measuring Sprawl and Its Transportation Impacts, Transportation Research Record, no. 1831, pp. 175–183.

[50] https://data.gov.in/catalog/road-transport-year-book-2013-14-and-2014-15