Factors Affecting Traffic Management using Two Step Cluster

Rachna Yaduvanshi, Sanjeev Bansal, Anita Kumar

Abstract**:** ***The concept of traffic congestion and traffic management is ambiguous in nature. The traffic and congestion is dependent on a number of factors that might impact the stretch of road or the framework of the traffic management systems. As the evolution of internet in last one decade and its reach to the very last person on this planet, this provides the basket of new opportunity of managing the traffic and its patterns on the basis of live traffic data from the onsite cameras, sensors, and the google maps traffic forecast the situation of traffic congestion would be avoided, which directly helps in reducing the load on environment and saving some valuable time of the commuters, and indirectly having large savings on the countries resources. In this research paper the authors have identified the factors affecting the management, flow, and working of traffic on the toll roads, national highways, and dedicated fright corridors in specific from the literature. The identified factors have been analyzed using quantitative statistical tools such as: relative importance index, Cronbach's alpha, and cluster analysis to know the predictor importance. For this study a total of 192 valid responses were received using structured questionnaire survey. On the basis of data analysis the recommendation have be drawn and shared with the government authorities to be implemented on the highways to facilitate the commuters and all the other stakeholders associated with the traffic and traffic management. The findings of the relative importance index conclude that the most significant attributes of traffic management are No tolling for e-vehicles, use of information boards to avoid any traffic situations, and savings on fuels. Furthermore the findings of the cluster analysis concludes that the most important predictor is no-tolling for e-vehicles, followed by savings on fuels.***

Keywords: Traffic management, cluster analysis, traffic congestion, transport management.

I. INTRODUCTION

The dynamic traffic management system is defined as "Dynamic traffic management employs technologies for real-time traffic management: the management of traffic flows, traffic adaptive control to respond to changing conditions in the transportation system while improving the efficiency, safety and travel conditions of the overall transport network" [1].

Revised Manuscript Received on October 15, 2019
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Economic costs of traffic congestion

The management and control of traffic are linked with the congestion of traffic on roads and the kind of infrastructure provided to manage the flow of traffic. The parameter to describe road traffic are such as speed, flow and density of vehicles moving on that particular section of road. While estimating the traffic congestion, different parameters were used. However, the models used to estimate the traffic patterns sometimes fails to report the underline issues. In such cases, the real-time live traffic data shall be considered for the traffic state, e.g. traffic counts and speed/travel time measurements [2]–[6].

"Most of the problems faced by today's traffic networks are caused by the ever-increasing usage of the traffic system" [7]. Congestion in roads and highways is considered to be one of the prominent issues that should be analyzed and correction measure shall be taken to minimize the loss of extra money, time and to reduce the impact over the environmental (sustainability). Researcher's, academicians, and policymakers need to work together to manage the swift flow of traffic. The problem of traffic congestion shall be resolved by laying extra roads for the vehicles, or lanes to cope with the traffic demand, or either imposing extra taxes to limit the demand. Feasibility and applicability of both the cases are difficult, because for the laying extra roads need money and resources, and for raising the taxes our political leadership feels vulnerability in that case. Now the last hope is to use the currently available infrastructure efficiently to manage the traffic flow and save our environment [8]–[11].

The other important part of the traffic system has enabled with intelligence gadgets such as onboard sensors, navigation tools, GPS enables, real-time traffic input, an alternate route option is also suggested on the basis of historical and live data patterns [12]–[15].

Dynamic traffic management system

The structured planning and swift management/flow of traffic are one of the significant need of any city. To be specific in the urban dominated cities like Delhi, Mumbai, Noida, Gurgaon, Vadodara, Kolkata, and many more due to the high level of urbanization in these cities. The swift flow of traffic is the lifeline of these cities to enable the residents to move across from one location to the other location for a number of reasons like movement of goods, going for office, students going for schools located in the outer proximities of the cities, and furthermore the critical medical services, and etc. Traffic management enables the authorities to route, re-route and provide alternate movement routes for the vehicular movements. Dynamic traffic management system works on the inputs provided by the police/traffic personals working to manage the traffic. Let's assume a scenario where one of the lanes of the main highways is affected due to some sort of vehicle break-down or any other accidental issues, which creates a bottleneck in the midways of a highway. Resulted in heavy traffic jams, high level of sound, and environmental pollution. This may be resolved only once the break-down vehicle should be towed away with the help of tow truck. And meanwhile the traffic is re-routed to the other highways to manage the situation. In dynamic traffic management this full operation takes no less than 10-12 hours. But in case of integrated traffic management systems this sort of situation/issue could be resolved in few hours i.e. 1-2 hours. The moment vehicle break-down and resulted into slowing the traffic, an acknowledgement from the sensors installed throughout the road is sent to the control centre and with the help of CCTV cameras and patrolling party this information is confirmed and a tow truck is requested to tow the break-down vehicle and to resolve the situation.

II. LITERATURE REVIEW

In 2005 [16] has studies the role of York Council in the development of the UK's Urban Traffic Management and Control (UTMC) programme. There major focus on the establishment and functioning of a centralized and common database for sharing the information between information sources and applications. The new database adopted in York id the heart of the system, and it is used for storing the data and development and implementation of control algorithms and data processing.

[17] Studied the impact of automation technology on the traffic patterns and the implementation of fine and penalties on the flow of traffic. This scheme is sponsored by the government for using RFID (Radio-Frequency Identification) tag is an electronic label, known as an advanced form of barcodes. They concluded that the issuance and management of traffic are possible by implementing and utilizing the integrated traffic management systems.

Table 1categorization of traffic management strategies

Categorization of traffic management strategies		
Factors	**Attributes**	**References**
Operating restrictions & pricing	Road, congestion and cordon pricing: tolling, distance pricing, or pricing based on time-of-day or congestion levels	[9], [11], [16], [18]–[25]
	Low/zero emission zones	[26]
	Vehicle operating	[27]
	Supply and pricing strategies	[28]
Lane management	High occupancy vehicle (HOV), High Occupancy Toll (HOT), and eco-lanes	
	Truck and/or bus lanes	[18][3], [19], [25]
	Lane capacity changes (road diets, peak shoulder running)	
Speed management	Lower speed limits	[9], [13]
	Variable speed limits	
	Speed control devices: traffic calming such as humps, chicanes, micro-roundabouts	[10], [14], [29]
	Speed enforcement devices & programs	[24], [30], [31]
	Eco-driving, eco-routing (not requiring significant new technology)	[10], [14], [29]
Traffic flow control	Ramp meters	[28]
	Electronic toll collection	[32]
	Incident management systems	[24]
	Signal, stop signs, and roundabout	[33]
	adaptive signal systems, transit signal priority, and signal coordination	[34]
Trip reduction strategies	Shared-ride programs: carpool/vanpool/rideshare programs, incentives, and services	[35]
	Employer programs for trip reduction: flex-time, telework	[11], [30]
	Transit improvements: pricing, service quality, etc.	[36]
	Pedestrian and bicycle facilities: roadway & trip-end facilities	[28], [32]
	Outreach & marketing (to reduce auto use)	[24], [28], [33]

Table 2 attributes selected for the study

1	Quality of roads
2	Congestion and tolling
3	Pricing should be based on the number of vehicles passing by
4	Zero-emission zones
5	No tolling for E-vehicles
6	Benefit for using CNG/other eco-friendly vehicles
7	Parking management/logistics support
8	automated lane management
9	High tech speed governing devices
10	Use of modern micro roundabouts
11	Traffic flow control using ramp meters
12	Integrated incident management systems
13	Financial viability
14	Contribution to the development of the region
15	Saving on fuels
16	Helps in achieving the sustainability
17	Helps to reduce pollution
18	Live traffic detection and management software's
19	Setting up dynamic signal timings (changes on the basis of traffic pattern)
20	Employers contribution towards flexible office timings
21	Carpooling groups
22	Ideas to promote cycling
23	Use of information boards to avoid any traffic situations
24	Local bodies support
25	Public as a primary stakeholder

III. RESEARCH METHODOLOGY

The methodology adopted for this research paper is to adopt a primary data collection, interpretation and analysis. The quantitative research method is used for this study. The primary data was collected using structured survey and offline on-site data collection. To complete the objectives of the study a joint research methodology is adopted. Which is to collect the data about the factors affecting traffic management using a structured questionnaire. It was considered that a survey of the stakeholders associated directly or indirectly with the traffic management will be conducted through a questionnaire. Keeping the above and the objective of the study in view, a preliminary questionnaire was prepared after having number of discussion with the industry experts. Personal discussions were held with few eminent personalities of the subject matter of expertise, and on this preliminary questionnaire and their suggestions were sought to improve the quality & coverage of the questionnaire. The suggestions made by these persons were incorporated in the preliminary questionnaire and after a detail deliberation with the supervisor, a questionnaire was finalized. The questionnaire primarily comprises of the 3 (three) parts:

a) General information about the study.

b) The questionnaire itself.

c) The third portion to provide feedback or any suggestions for the study.

The collected data were analysed using SPSS 23 package, and Excel spreadsheets. The following tests were performed on the data:

Reliability analysis (Cronbach's alpha test)

This test is used to check the level of consistency of the data collected through on-line and off-line questionnaire survey method. The value of reliability analysis is the measure of how reliable and quality of your data. Its value varies from 0-1, higher the value of reliability better is the quality of data collected. As a rule of thumb and previous literature review a value of more than 0.5 is considered good for the study. For the current research it is 0.89 which is excellent in terms of consistency of data collected.

Table 3 Cronbach's alpha

Reliability Statistics	
Cronbach's Alpha	number of Items
0.8921	25

IV. DATA ANALYSIS

Gender demography of the respondents shows that the survey was dominated by male respondents as compared to female respondents. The age demography explains that the respondents participated in the survey is from different age groups which provides a mix blend of all the age ranges used in the survey. And the maximum number of responses were from the age group of 36-45 years old, followed by 25-35, and 46-55 age group respectively. The educational qualification demography reveals that the major part of the respondents is occupied by middle school pass followed by high school pass and under-graduate respondents respectively.

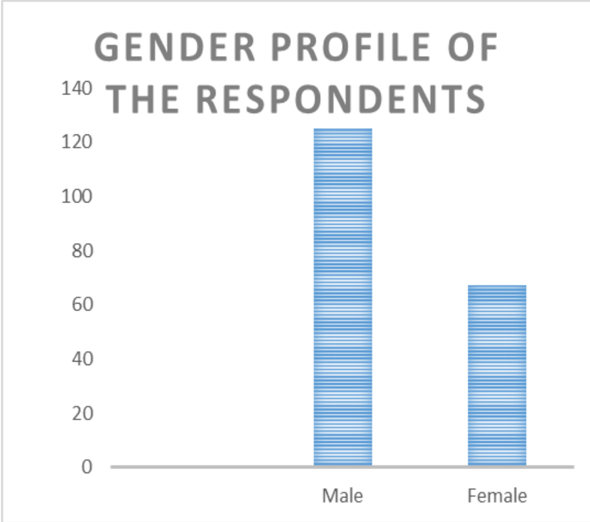


Figure 1gender demography of the respondents

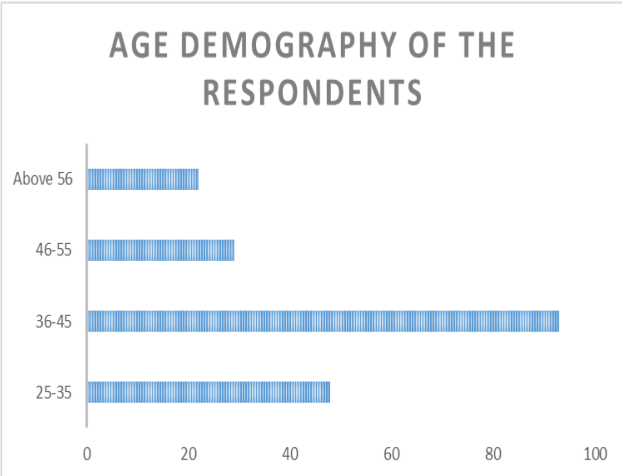


Figure 2 age demography of the respondents

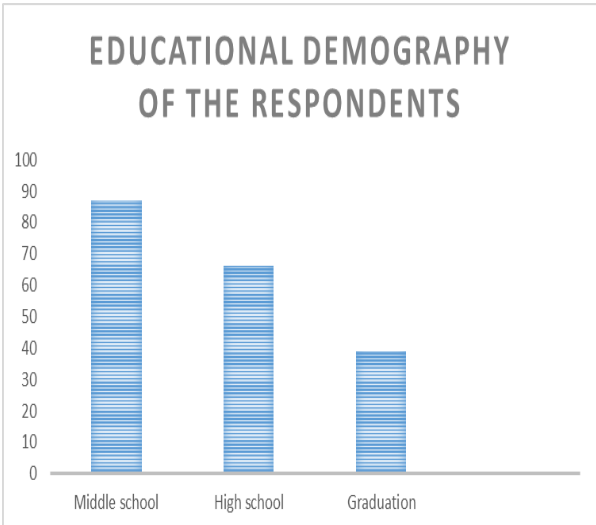


Figure 3 education level of the respondents

Relative importance index (RII)

RII is the weighted average of the received responses and provide us a ranking of all the significant attributes based on their relative score. It has two components one is the rating of Likert scale and second is the number of responses for that specific attribute. Which enables the researchers to focus on the most significant attributes.

The most significant attributes affecting the traffic management

The most significant attributes that affecting traffic management as per the RII value were No tolling for e-vehicles, use of information boards to avoid any traffic situations, saving on fuels, automated lane management, and pricing should be based on the number of vehicles passing by on a certain amount of time having a RII value of 84%, 83%, 83%, 81%, and 79% respectively.

Significant attributes affecting the traffic management

The significant attributes that affecting traffic management as per the RII value were traffic flow control using ramp meters, congestion and tolling, use of micro roundabouts, parking management and logistics support, and local bodies support having a RII value of 79%, 79%, 77%, 77%, and 77% respectively.

Least significant attributes affecting the traffic management

The least significant attributes that affecting traffic management as per the RII value were helps to reduce the pollution, zero emission zones, idea to promote cycling, employers contribution towards flexible office timings, and quality of roads having a RII value of 69%, 68%, 65%, 62%, 59% respectively.

Table 4 relative importance index table with RII scores

The attributes	**Attribute number**	***Total score on Likert scale***	***No. of responses***	***RII value***
No tolling for E-vehicles	A5	807	192	84%
Use of information boards to avoid any traffic situations	A23	793	192	83%
Saving on fuels	A15	792	192	83%
automated lane management	A8	779	192	81%
Pricing should be based on the number of vehicles passing by	A3	760	192	79%
Traffic flow control using ramp meters	A11	760	192	79%
Congestion and tolling	A2	757	192	79%
Use of modern micro roundabouts	A10	743	192	77%
Parking management/logistics support	A7	742	192	77%
Local bodies support	A24	741	192	77%
Financial viability	A13	730	192	76%
Setting up dynamic signal timings (changes on the basis of traffic pattern)	A19	721	192	75%
Public as a primary stakeholder	A25	717	192	75%
High tech speed governing devices	A9	715	192	74%
Helps in achieving the sustainability	A16	712	192	74%
Carpooling groups	A21	707	192	74%
Live traffic detection and management software's	A18	688	192	72%
Contribution to the development of the region	A14	681	192	71%
Benefit for using CNG/other eco-friendly vehicles	A6	669	192	70%
Integrated incident management systems	A12	663	192	69%
Helps to reduce the pollution	A17	659	192	69%
Zero emission zones	A4	651	192	68%
Ideas to promote cycling	A22	626	192	65%
Employers contribution towards flexible office timings	A20	596	192	62%
Quality of roads	A1	567	192	59%

Two-step cluster analysis

It is an exploratory quantitative approach which is usually used in different domains of management, social science, engineering, and other areas of research It helps in the identification of structures within the data of samples used for the analysis by performing exploratory analysis [37]–[44]. It creates groups on the basis of homogeneity exists inherently on the data strings [37], [38]. For this study SPSS 23 package used and a two-step clustering was performed on the top nine most significant attributes identified from RII [16], [45]–[47]. The findings of the two-step cluster analysis has been explained with model summary, number of clusters, predictor importance, and cluster size.

The total number of inputs selected for two-step cluster analysis is 9, and the number of clusters formed is 7. The size of the biggest cluster is 21.9% highlighted in red (second cluster), and the ratio of largest to the smallest cluster is 3, which is considered good for the study as per the literature support. Predictor importance helps the researchers to know the initiating attributes that is having the maximum significant in terms of impact and grouping of the other attributes. For the current study the predictor having the value of one is No tolling for e-vehicle, followed by savings on fuels, and parking management and logistics support provided.

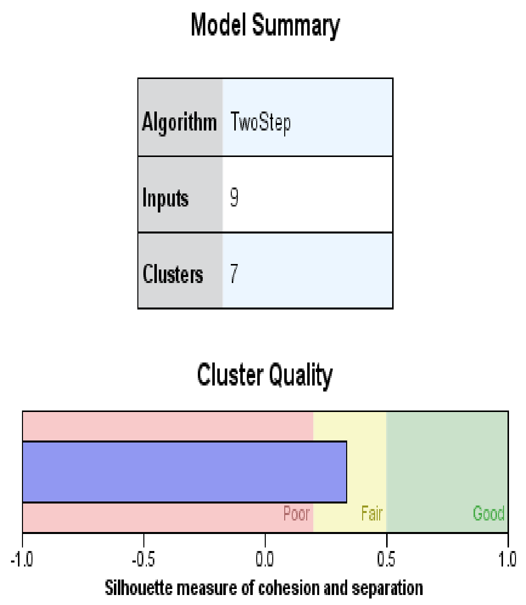
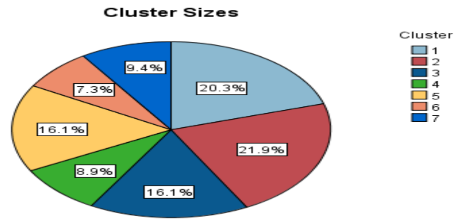


Figure 4 model summary two-step cluster analysis



Size of Smallest Cluster	14 (7.3%)
Size of Largest Cluster	42 (21.9%)
Ratio of Sizes: Largest Cluster to Smallest Cluster	3.00

Figure 5 cluster sizes

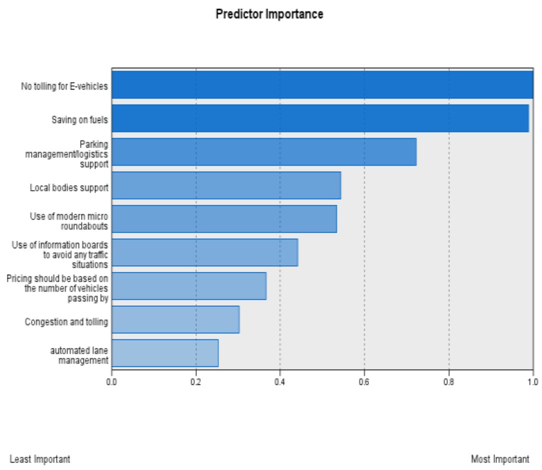


Figure 6 predictor importance

Figure 7 cluster analysis summary

V. Discussion

The current traffic congestion in our highway networks should be addressed with topmost priority. And steps to identify the issues and challenges associated with traffic congestion in our highway networks including National highway, state highways, fast-transit corridors, and traffic hubs shall be analyzed to understand the basic root causes of traffic congestion. And an integrated traffic management system (ITMS) shall be proposed for pilot study in Noida-Greater Noida region of Uttar Pradesh. The process of automation and integrating the other functionalities of traffic management such as on-time traffic pattern information, traffic flow, weather condition, automated lane management, and decision taking smart algorithm will result in ITMS that distribute intelligence between roadside infrastructure and vehicles, which furthermore handles the situation of traffic and congestion on roads. The current study also highlights that the issue of traffic congestion and traffic management should be deals with priority and the use of automation and more integrated approach to resolve such issues would be used. The concept of integrated traffic management system is now the demand of the hour and it will helps in reducing the traffic load and congestion on our life line highways systems.

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