Transitional Impact of influencing factors leading to Traffic Congestions

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ABSTRACT

Hyderabad, a major metropolitan city in India, is undergoing rapid urbanization and motorization, resulting in escalating traffic congestion across its road network. This study investigates the transitional impact of influencing factors contributing to traffic congestion, with a specific focus on the role of arterial and sub-arterial roads in urban mobility. These roads form the core of the city's transportation hierarchy, yet they are increasingly burdened by rising vehicle density, land-use changes, and infrastructure limitations.The research employs QGIS (Quantum Geographic Information System) mapping techniques to spatially analyze traffic flow patterns, congestion hotspots, and the evolving structure of the road network. By integrating spatial data with traffic volume and urban growth indicators, the study provides visual and data-driven insights into how congestion is concentrated along key corridors and junctions over time.Findings highlight that congestion is predominantly influenced by unbalanced development, limited public transport accessibility, and inadequate integration of land use and transportation planning. The QGIS-based spatial analysis helps identify high-stress zones on arterial and sub-arterial roads, which can guide targeted interventions and policy planning.This research contributes to the development of informed strategies for traffic decongestion, sustainable mobility, and improved infrastructure planning, reinforcing the importance of spatial analysis tools in urban transport studies.

Keywords: Traffic Congestion, Hyderabad, Urban Transportation, Arterial Roads, Sub-Arterial Roads, QGIS, Spatial Analysis, Road Network, Urbanization, Traffic Flow, Congestion Hotspots, Sustainable Mobility, Transportation Planning, GIS Mapping, Infrastructure Development.

I. INTRODUCTION

Traffic congestion is an ever-increasing issue across urban road networks in developing countries. One potential mitigation strategy is to improve our understanding of how the geographical patterns of urban land use influence congestion. Unfortunately, there is no much attention paid towards this influencing Several interrelated factors contribute to the worsening traffic conditions, resulting in increased travel time, air pollution, and reduced quality of urban life.

These contributing factors include a sharp rise in private vehicle ownership, inadequate and underutilized public transportation systems, poor traffic management, narrow or encroached roadways, and unplanned urban development. Additionally, the lack of integrated transport policies, improper land use planning, and insufficient parking spaces further aggravate the issue.

Understanding these influencing factors is essential for developing effective, long-term strategies to reduce traffic congestion and improve mobility. This section of the project explores each factor in detail and examines their collective impact on Hyderabad's traffic scenario.

1.1 Transitional Impact of Influencing Factors in Traffic Congestion

Urban traffic congestion is a dynamic issue shaped by a range of social, economic, infrastructural, and environmental factors. In cities like Hyderabad, the transitional impact of these influencing factors is especially significant due to rapid urban growth, evolving transportation needs, and shifting travel behaviors.

Transitional impact refers to how changes over time — such as rising population, urban sprawl, increased vehicle ownership, and technological shifts — progressively alter traffic patterns and congestion levels. These transitions are not static; they interact with one another, creating complex effects on traffic flow, road capacity, and commuter experience.

For instance, the transition from traditional public transport systems to increased reliance on personal vehicles has significantly increased vehicular density on roads. Similarly, unplanned commercial developments without supporting infrastructure have disrupted traffic distribution, creating localized bottlenecks.

Understanding these evolving factors and their transitional effects is critical for effective traffic planning and sustainable urban mobility. This study aims to identify, analyze, and assess the key influencing factors contributing to traffic congestion in Hyderabad and examine how their impact has changed over time, leading to the current transportation challenges faced by the city.

II. LITERATURE SURVEY

This chapter provides a comprehensive analysis of how various socio-economic, infrastructural, and behavioral factors interact and evolve to influence traffic congestion in Hyderabad. Unlike traditional studies that examine traffic issues in isolation, this chapter adopts a transitional lens focusing on how these factors change over time and shape congestion patterns dynamically.

Banik B.K et al. [1] proposed a research work on the road traffic accident and degraded road safety situation in Sylhet zones which in particular, discussed the key road accident problem characteristics by identifying the hazardous roads and spots, most responsible vehicles and related components, conditions of drivers and pedestrians, most victims of accident, effects of accident on society, safety priorities and options available in Sylhet. They concluded that pedestrians are the most victims of road accidents due to lack of awareness. When they move on road, they are not at all conscious about the cause of accident and the right of drivers to use the road. Three wheelers (with four stroke engine), lighter vehicle, compete with the heavy vehicles which are overloaded and have high momentum.

Anitha Selvasofia S.D and Prince Arulraj.G [2] reported that the success of traffic safety and highway improvement programs hinges on the analysis of accurate and reliable traffic accident data. They analysed the present state of traffic accident information on three highways namely NH 47 Gandhipuram to Avinashi, NH-209 from Gandhipuram to Annur and NH 67 Gandipuram to Mettupalayam, Coimbatore district. They also discussed about the identification of high accident rate locations using ArcGIS software

Nilesh Deshpande et al. [3] developed a model utilizing the data available through old records, by extracting factual and relevant information. The model performed the analysis based on various parameters such as location of accident, severity, date and time of accident, population proximity to educational institutions etc. Different methods of statistical and spatial analysis, such as Kernel density estimation and spatial autocorrelation, were compared so as to determine the most appropriate way to analyze the acquired data. Geographical Information System was used as a tool for statistical analysis. They suggested that few areas are to be further investigated and recommendations are to be made accordingly.

Deelesh Mandloi and Rajiv Gupta [4] developed a model to identify black spots on roads using prioritization and Geographical Information Systems. The usefulness of GIS and point pattern techniques for describing road-accident black zones within urban agglomerations were presented. The outlines of the steps needed by investigators to carry out black spot accident investigation were also presented

ACCIDENT REDUCTION FACTOR (ARF)

Gary A. Davis [5] predicted the change in accident occurrence which a counter measure can be expected to cause using accident reduction factor. Since ethical and legal obstacles preclude the use of randomized experiments when evaluating traffic safety improvements, empirical support for the causal effectiveness of accident countermeasures comes entirely from observational studies. Structural knowledge is combined with Bayesian network methods to calculate the probability of necessity due to speeding for each of a set of vehicle/pedestrian collisions. Gibbs sampling was used to carry out the computations.

Fatih Keskinet al. [6] To prevent traffic incidents, it is crucial to understand where and how they take place, the relations among the incidents, and the locations. The incidents on road are used in the kernel density estimation with network distances along the road network. Nearest Neighbor Distance and the K-function exploration methods have been applied to determine the spatial relation in terms of distance between the incident locations. The results of different methods are compared with each other in order to identify the hot spot zones on roads.

Jayasudha.K and Chandrasekar.C, [7] The aim of this study was to show the applications of data mining techniques in the feild of accident investigation. Association rules are proposed to use to discover the patterns and rules that cause the occurrence of accidents. Our method validate variation in crash occurrence and traffic safety measures. The determination of specific precautionary measures to reduce crashes requires study of other factors such as the identification of specific road sections that need work, etc.

Guler Yalcin and Sebnem Duzgun.H [8] aims to analyze road traffic accident distribution according to the vehicle types involved in the accidents for urban areas in sample of Osmaniye, Turkey. While chi-square test was used for non-spatial analysis kernel density, nearest neighbor distances and K-function analysis are applied to determine the existence of clustering and hotspots. The network statistics are executed through SANET (Spatial Analysis on a NETwork) V4.1 that runs on ArcMap 10 and for better visualization and understanding the analysis 3D analysis are generated in ArcScene 10. It is realized that the accidents involving two-wheeled vehicles have a high percentage in all accidents.

Joseph Nanzala et al. [9] improved the road traffic data storage and accessibility through the use of Web GIS by creating a road traffic accident data management system. The AMSYS platform documents the set of procedures necessary to store and query road accident data. Through the developed system, it was shown that Nairobi County Road traffic accident data can be better managed using Web GIS. This can be achieved by replacing the existing patchwork of fragmented individual and uncoordinated efforts by stakeholders with the one-stop system.

Kumari Pritee et al. [10] summarized the review of web-based technology for storing road accidents data, accident analysis and reporting which can be integrated with GIS Technology. A real time dynamically changing traffic flows with shortest path analysis provided optimal routing in case of traffic congestion. Open-source software makes more enhancements for updating data in road management system and provides decision support system for road maintenance. Data integration enables better and faster decision on data from heterogeneous sources and provides savings in time and money.

Debasish Chakraborty et al. [11] provided an efficient approach to customize and integrate an application using Free and Open Source Software GIS, FOSS web development software and database. It was observed that the presented application developed using FOSS technology enables user to plot the locations of interest, display, navigate the map and satellite image of area of interest, perform spatial query, search the geographic location in the map, identify features, measure the distance between points and area of the object in the map in web environment.

III. EXISTING SYSTEM

The existing traffic management system in Hyderabad primarily relies on conventional traffic monitoring methods, manual traffic surveys, fixed traffic signals, and limited road expansion measures to address congestion issues. Most studies and urban planning approaches focus on individual factors such as vehicle growth, road capacity, or public transportation deficiencies without considering their combined and transitional impacts over time. Although some traffic management initiatives, including flyovers, signal synchronization, and road widening projects, have been implemented, they often fail to provide long-term solutions due to rapid urbanization, increasing vehicle ownership, and unplanned land-use development. Furthermore, the lack of advanced spatial analysis tools and integrated transportation planning limits the ability of authorities to identify congestion hotspots accurately and predict future traffic patterns, resulting in persistent traffic congestion across major arterial and sub-arterial roads.

IV. PROPOSED SYSTEM

The proposed system utilizes QGIS (Quantum Geographic Information System) as a spatial analysis platform to examine the transitional impact of influencing factors leading to traffic congestion in Hyderabad. The study integrates traffic volume data, road network information, land-use patterns, and urban growth indicators to identify congestion hotspots and analyze traffic flow dynamics on arterial and sub-arterial roads. Through GIS-based mapping and visualization techniques, the system provides a comprehensive understanding of how factors such as urbanization, infrastructure limitations, public transport accessibility, and changing mobility patterns contribute to congestion over time. The proposed approach enables planners and policymakers to detect high-stress traffic zones, evaluate the effectiveness of existing transportation infrastructure, and develop data-driven strategies for sustainable urban mobility, traffic decongestion, and future infrastructure planning.

V. SYSTEM ARCHITECTURE

The proposed system architecture is designed to analyze the transitional impact of factors leading to traffic congestion in Hyderabad using QGIS-based spatial analysis. The process begins with Data Collection, where information is gathered from multiple sources such as traffic volume records, road network data, land-use information, population growth statistics, public transportation details, and vehicle registration data. These datasets provide a comprehensive view of the factors influencing traffic conditions across arterial and sub-arterial roads.

The collected data undergoes Data Preprocessing, which includes cleaning, integration, georeferencing, and spatial data conversion. This step ensures that the data is accurate, consistent, and suitable for spatial analysis. The processed data is then imported into the QGIS Platform, where GIS databases and thematic layers are created for mapping and road network analysis.

Within the Spatial Analysis Module, various analytical techniques are applied to evaluate traffic flow patterns, identify congestion hotspots, analyze arterial and sub-arterial road performance, and assess the impact of urban growth on transportation networks. The results are further represented through Visualization and Mapping, including heat maps, traffic density maps, road network maps, and land-use maps, providing a clear understanding of congestion distribution and severity.

The analyzed information is then utilized by the Decision Support System, which helps urban planners and policymakers identify high-stress traffic zones, plan infrastructure improvements, formulate traffic decongestion strategies, and promote sustainable mobility solutions. Finally, the system generates Outputs such as congestion hotspot reports, traffic pattern analyses, urban planning recommendations, and policy support measures that assist in improving transportation efficiency and reducing traffic congestion in Hyderabad. This architecture enables data-driven decision-making and supports the development of a sustainable urban transportation system..

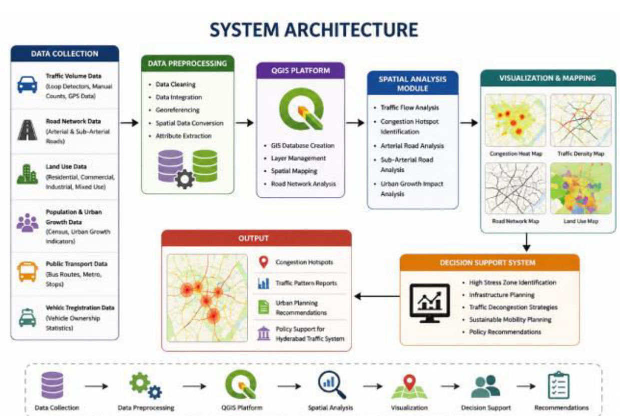

Fig 5.1: System Architecture

VI. IMPLEMENTATION

Fig 6.1: Loop Detectors for Vehicle Detection

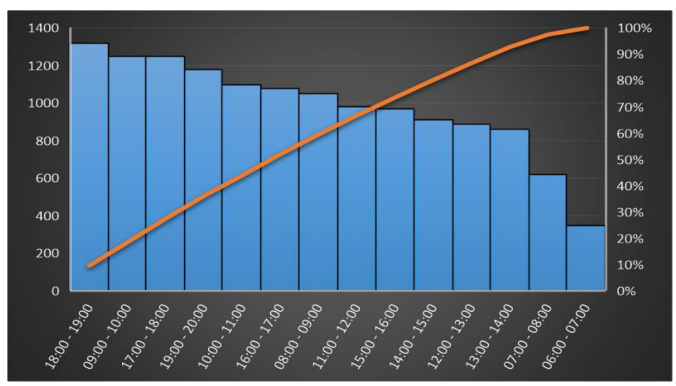

Fig 6.2: MTraffic Volume Data on NH-65 (Miyapur to LB Nagar)

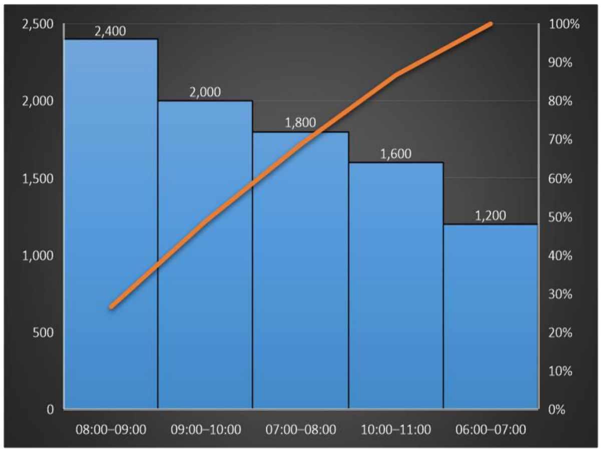

Fig 6.3: Traffic Volume Data on PV Narasimha Rao Expressway

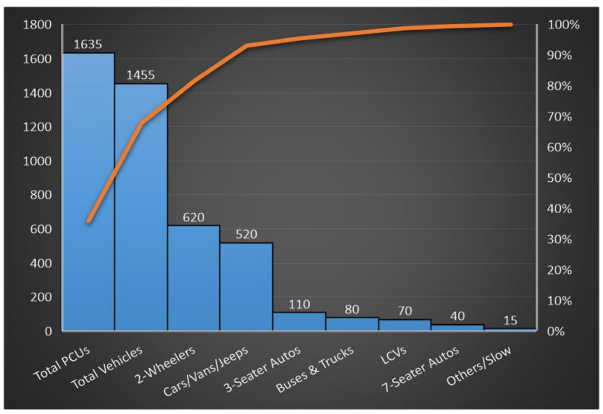

Fig 6.4: Inner Ring Road and Outer Ring Road (ORR) traffic data

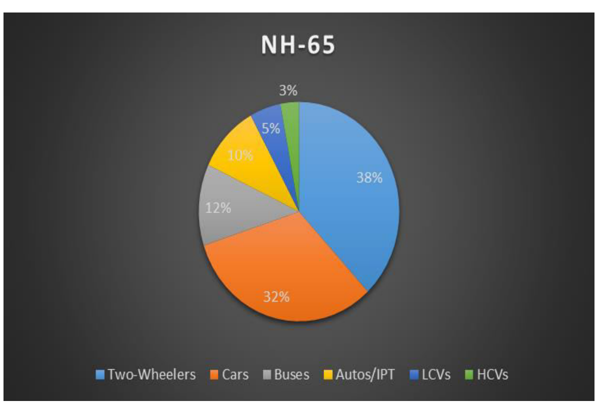

Fig 6.5: Traffic Volume Distribution by Vehicle Type

VII. CONCLUSION

The spatial distribution and classification of roads in Hyderabad highlight the crucial role of arterial and sub-arterial roads in urban mobility. Arterial roads such as NH-65, PV Narasimha Rao Expressway, and the Ring Roads connect major economic and residential hubs but frequently encounter congestion due to encroachments, mixed traffic, and limited access control. Sub-arterial roads like Road No. 36 and the Tolichowki-Gachibowli Link Road act as feeders, further burdened by narrow widths and high pedestrian activity. A QGIS-based spatial analysis of these roads reveals high-stress congestion zones and underscores the transitional impact of various influencing factors—such as land use patterns, intersection density, and traffic mix. This geospatial insight can support targeted interventions and strategic policy planning to alleviate urban traffic congestion and enhance road network efficiency.

VIII. FUTURE SCOPE

The future scope of this study lies in enhancing the effectiveness and predictive capability of traffic congestion analysis through advanced technologies and data-driven approaches. The integration of real-time traffic data obtained from GPS devices, CCTV surveillance systems, and IoT-based sensors into the QGIS platform can significantly improve the accuracy of congestion monitoring and enable dynamic traffic management. Furthermore, the incorporation of Multi-Criteria Decision Analysis

(MCDA) within the GIS environment can assist decision-makers in prioritizing traffic management interventions based on factors such as socio-economic benefits, environmental impact, implementation cost, and feasibility. Future research can also expand the spatial analysis framework to include peripheral urban regions and rural connectivity corridors surrounding Hyderabad, enabling the identification of emerging congestion patterns resulting from rapid urban expansion. Additionally, integrating traffic simulation and forecasting tools such as SUMO and VISSIM with GIS-based analysis can facilitate the prediction of future congestion scenarios and allow planners to evaluate various mitigation strategies in a virtual environment before their real-world implementation. These advancements can contribute to more efficient transportation planning, sustainable urban mobility, and smarter traffic management systems.

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