

# Application of AHP-GIS Technology to Assess Congestion Vulnerability, a Case Study of Ranchi City, India

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## ABSTRACT

Urban traffic congestion is a multi-dimensional phenomenon and therefore, is sensitive to certain influencing factors behaving in a random manner. Consequently, the possibility of a route characterized by smooth flow of traffic becoming congested cannot be ruled out. The present research investigation attempts to categorize different routes of the study area in terms of their degree of congestion vulnerability. Average Speed (AS), Delay Ratio of Average Speed (DRAS), Stopped Time (ST), Stopped Time Gradient (STG), and Absolute Deviation in Congestion Index Value (ADCIV) were identified as the potential influencing factors. The AHP was employed to rank the importance of the aforementioned influencing factors in triggering congestion that can sometimes lead to traffic deadlock. On the other hand, the GIS Weighted Sum Overlay technique was employed to determine the integrated impact of the influencing factors on the behavior of traffic flow. The results showed close agreement with the real scenario of the traffic congestion observed in the field.

## KEYWORDS

Average Speed, Combinatorial Analysis, Congestion Index Value, Influencing Parameters, Integrated Impact, Multi-Dimensional Phenomenon, Stopped Time Gradient, Weighted Sum Overlay

## 1. INTRODUCTION

Urbanization is a ubiquitous phenomenon and is being witnessed by major cities across the globe. There are several factors which are predominantly responsible for triggering expansion in urban areas such as growing population, increasing economic activities and infrastructure initiatives (Sudhira, 2004). It is estimated that in near decades, ninety-five percent of urban growth would be absorbed by the urban areas of developing countries. Consequently, unprecedented rise of megacities in developing countries is highly likely. Furthermore, it is a well evident fact that cities act as growth engines for a nation and especially, in low-income countries, it contributes up to 55% of gross national product (GNP). While its contribution is 73% and 85% in gross national product for middle-income countries and high-income countries respectively. The aforementioned facts confirm the significance of cities in the economic growth of a nation. However, urbanization in cities create huge challenges for the policy makers and planners to transform the idea of sustainability into a reality, as it poses serious concerns from the perspective of societal and environmental sanity (Keivani, 2010). There is significant rise in the demand of services in the cities of developing world. It has outstripped the capacity of urban areas to meet the demand of a city (Cohen, 2006). The fact remains unquestioned

even for India. Indian cities failed to meet the demand of expanding urban areas. Indian cities have been going through a transforming phase. There are several factors responsible for the transformation of Indian cities, such as increase in population as a consequence of natural growth, migration from non-urban areas to urban areas, increased commercial and industrial activities and consequently dramatic increase in household incomes. Unfortunately, the most ignored and neglected aspect of an Indian city is the transport. Therefore, ominous congestion and pollution emerged as a threatening consequence of failed transport infrastructure (Singh, 2005). Gwilliam (2003) highlighted various reasons for the widespread congestion in developing countries; for example, dense concentration of people, inadequate road infrastructure, weak traffic management and lack of development and management in municipal institutions. Congestion is a multi-dimensional phenomenon and hence its causal factors or consequences cannot be determined with a linear view. Since there are several factors associated with it, the inclusion of uncertainty is quite obvious into its functionality. Therefore, the behavior of congestion pattern can be sometimes abrupt and the reason seems to be unidentifiable. That means, irrespective of the routes which are congested in general scenarios; other routes with smooth traffic flow can be abrupt if the state of any of the causal factors changes due to internal or external factors. In general, past studies focused on the determination of the status of congestion using different methods or prediction of traffic flow on the basis of real time data. However, these investigations do not investigate the possibility of congestion in different routes of the city irrespective of the general characteristics of traffic in those routes.

The aim of the present research investigation is to determine the possibility of congestion in different routes of the study area irrespective of the general characteristics of congestion prevailing in the respective routes. Since congestion is a spatial-temporal phenomenon and therefore, its characteristics is obviously affected by spatial and temporal factors. Thus some technology which can efficiently handle spatial-temporal factors and aid in spatial decision making must be employed in the investigation. Therefore, the utility of Analytic Hierarchy Process (AHP) and Geographic Information System (GIS) were demonstrated in the present research investigation to assess congestion possibility in different routes of the study area. Ranchi, capital of the Jharkhand state, India, which is a fast urbanizing city, was chosen as a case study area (Figure 1) to validate the efficacy of the AHP-GIS technology in assessing congestion possibility.

This paper is composed of five different sections. It begins with an introductory note on urbanization and its obvious relationship with congestion. The introductory section is followed by the description of latest literature pertaining to the different aspects of congestion analysis. The third section of this paper deals with the research methodology of the proposed research investigation. It contains explanation on data collection process, identification and derivation of influencing variables, and techniques employed in the assessment of congestion possibility. Then description of results and their significance from the perspective of research problem is explained. Finally, highlights of the present investigation and future scope of the study are described in the conclusion section.

## **2. LITERATURE REVIEW**

This section covers the literature which provides adequate explanation related to the meaning and consequences of congestion, and their causal factors. Furthermore, works pertaining to different aspects of congestion analysis were included to understand the different dimensions of traffic congestion.

### **2.1. Congestion: Meaning and Its Consequences**

The meaning of congestion is contextual. For example, to a traveler, congestion signifies lost time, missed opportunities and annoyance. However, from the perspective of employer, it is one of the most significant factors that cause decrease in workers' productivity. Therefore, there are negative consequences of it in terms of rise in cost, delay in deliveries, and loss in trade opportunities (Wen, 2008). The negative consequences of rising traffic congestion in major cities are inevitable. It has

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