



TRANSPORTATION NETWORK ANALYSIS IN BAGALKOT CITY, KARNATAKA, INDIA

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ABSTRACT

Transportation plays a vital role in the socio-economic development of urban areas by facilitating the efficient movement of people, goods, and services. Rapid urbanization and increasing vehicular traffic have created significant challenges such as congestion, longer travel times, and unequal accessibility to essential public services. Geographic Information Systems (GIS) have emerged as an effective tool for transportation planning by integrating spatial data with advanced analytical techniques. This study examines the transportation network of **Bagalkot City, Karnataka**, using GIS-based Network Analysis to evaluate road connectivity, accessibility, and route efficiency. A transportation network database was developed from digital road network data in ArcGIS, and analyses including route optimization, closest facility identification, and service area modelling were performed. The study investigates the spatial structure of the city's road network and assesses its effectiveness in connecting residential, commercial, educational, healthcare, and administrative areas. The findings identify well-connected corridors, accessibility patterns, and areas requiring transportation improvements. GIS-based network analysis provides scientifically reliable information for improving urban mobility, reducing travel time, and enhancing public service accessibility. The study demonstrates that GIS serves as a powerful decision-support system for transportation planning and infrastructure management. The methodology and results can assist municipal authorities, planners, and policymakers in formulating sustainable transportation strategies and can be applied to other medium-sized cities facing similar urban transportation challenges.

KEYWORDS: Transportation Network, Geographic Information System (GIS), Network Analysis, Accessibility, Route Optimization, Urban Planning, Bagalkot City.

1. INTRODUCTION

Transportation is a fundamental component of urban development and plays a crucial role in economic growth, social interaction, and regional integration. An efficient transportation network ensures the smooth movement of people, goods, and services, thereby improving accessibility to educational institutions, healthcare facilities, commercial centres, industries, and government offices. With rapid urbanization and population growth, cities are experiencing increased traffic congestion, longer travel times, higher fuel consumption, and environmental pollution. These challenges emphasize the need for scientific transportation planning approaches that improve network efficiency and support sustainable urban development.

The advancement of Geographic Information Systems (GIS) has transformed transportation planning by providing powerful tools for managing, analysing, and visualizing spatial information. GIS integrates geographic and attribute data to evaluate road networks, accessibility patterns, travel routes, and service coverage. Among its various applications, Network Analysis has become one of the most effective techniques for transportation planning because it enables route optimization, accessibility assessment, service area analysis, and emergency response planning. By representing transportation systems as interconnected nodes and links, GIS can determine the shortest or fastest routes while considering road characteristics such as distance, travel time, speed limits, and direction of travel.

Bagalkot City, the administrative headquarters of Bagalkot District in northern Karnataka, has experienced rapid urban expansion during the past decade. The city serves as an important educational, commercial, and administrative centre

and is well connected to surrounding towns such as Badami, Hungund, Bilagi, Ilkal, and Mudhol through state highways and district roads. Continuous growth in residential areas, commercial establishments, educational institutions, hospitals, and public infrastructure has increased travel demand and placed greater pressure on the existing transportation network. Consequently, evaluating road connectivity and accessibility has become essential for improving mobility and supporting future urban development.

Traditional transportation planning methods relied primarily on field surveys, paper maps, and manual calculations, which were often time-consuming and lacked spatial precision. Modern GIS-based transportation analysis overcomes these limitations by integrating digital road network data with advanced analytical tools. ArcGIS Network Analyst enables the creation of transportation network datasets and performs analyses such as optimal route determination, closest facility identification, origin–destination cost estimation, and service area delineation. These analyses provide accurate spatial information that supports evidence-based planning and infrastructure development.

The present study focuses on the transportation network of Bagalkot City using GIS-based Network Analysis techniques. A digital transportation network database has been developed to evaluate road connectivity, accessibility, and travel efficiency. The study analyses the spatial characteristics of the city's road system and demonstrates the application of GIS as a decision-support tool for transportation planning. The results are expected to assist municipal authorities, transportation planners, and policymakers in improving road infrastructure, enhancing accessibility to public services, and

promoting sustainable urban development. Furthermore, the methodology adopted in this research can serve as a model for transportation planning in other medium-sized cities in Karnataka and India facing similar urban transportation challenges.

Objectives of the Study

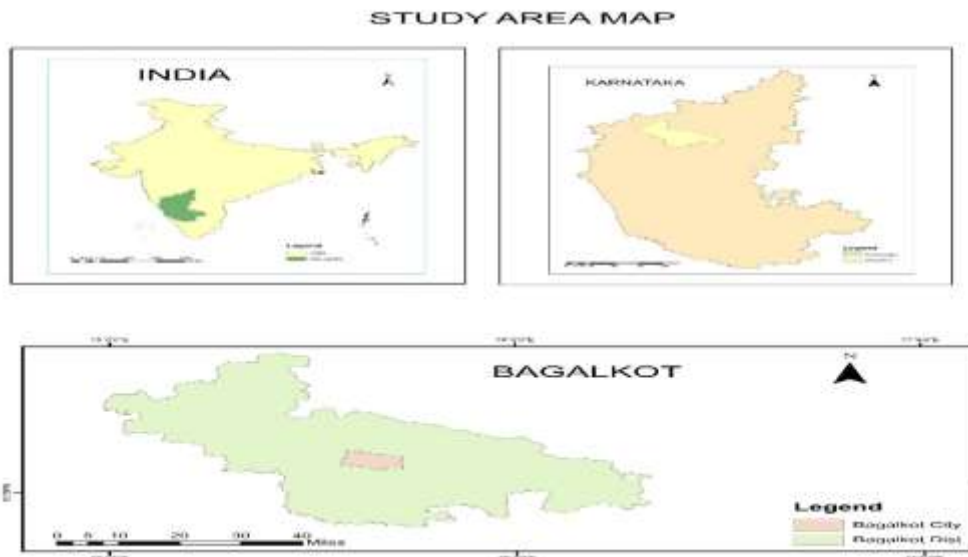
The present study has the following objectives:

1. To prepare a GIS-based transportation network database for Bagalkot City, Karnataka.
2. To analyse the spatial structure and connectivity of the urban road network.

3. To evaluate transportation accessibility using GIS Network Analysis techniques.
4. To identify optimal travel routes within the city road network.
5. To assess the efficiency of the existing transportation network for urban planning and sustainable development.

The results of this study are expected to assist municipal authorities, transportation planners, and policymakers in developing efficient transportation strategies, improving urban accessibility, and strengthening infrastructure planning for the future development of Bagalkot City.

2. STUDY AREA



Bagalkot City is the administrative headquarters of Bagalkot District in the northern part of Karnataka, India. It is geographically located between **16°09'–16°13' N latitude and 75°38'–75°42' E longitude**, at an average elevation of about **532 m above mean sea level**. The city is situated on the left bank of the **Ghataprabha River**, a major tributary of the Krishna River, and serves as an important regional centre for administration, education, healthcare, trade, and transportation.

Bagalkot has experienced rapid urban growth due to increasing population, commercial expansion, and infrastructure development. According to the **2011 Census of India**, the city had a population of approximately **112,068**. The urban road network consists of national and state highways, major district roads, collector roads, and local streets that connect residential areas with educational institutions, hospitals, commercial centres, government offices, and transportation terminals. Road transport is the dominant mode of travel, supported by KSRTC buses, private buses, auto-rickshaws, taxis, and private vehicles.

The city experiences a **semi-arid tropical climate**, with hot summers, moderate monsoon rainfall, and mild winters. Average annual rainfall ranges between **550 and 700 mm**, while temperatures vary from **15°C in winter to over 40°C during summer**. The relatively flat terrain and well-developed road infrastructure make Bagalkot suitable for transportation network analysis.

Bagalkot occupies a strategic location in northern Karnataka and is well connected to major cities such as **Vijayapura, Gadag, Hubballi, Belagavi, Ilkal, Badami, Hungund, and Koppal** through an extensive road network. However, rapid urbanization and increasing vehicle ownership have led to traffic congestion, especially around markets, educational institutions, hospitals, and commercial areas.

The present study focuses on analysing the road transportation network of Bagalkot City using Geographic Information System (GIS) and ArcGIS Network Analyst. The road network was modelled as a network dataset consisting of road segments and intersections to evaluate connectivity, accessibility, and route efficiency. The study aims to assess the existing transportation network and demonstrate the usefulness of GIS-based network analysis in supporting urban transportation planning, improving accessibility, and promoting sustainable urban development in Bagalkot City.

3. LITERATURE REVIEW

Transportation network analysis has become an important application of Geographic Information Systems (GIS) in urban planning, accessibility assessment, and transportation management. GIS-based network analysis enables the evaluation of road connectivity, optimal route selection, service area delineation, and accessibility to public facilities. With the advancement of geospatial technologies, transportation planning has shifted from conventional methods



to spatial decision-support systems that provide accurate and efficient solutions.

Several researchers have demonstrated the effectiveness of GIS in transportation studies. Burrough and McDonnell (1998) highlighted the importance of GIS for spatial data management and network modelling. Longley et al. (2015) emphasized that GIS supports transportation planning through spatial analysis and visualization. Chang (2016) reported that network analysis is an effective tool for identifying the shortest travel routes and improving urban mobility. ESRI (2023) described ArcGIS Network Analyst as a comprehensive platform for route optimization, closest facility analysis, and service area modelling.

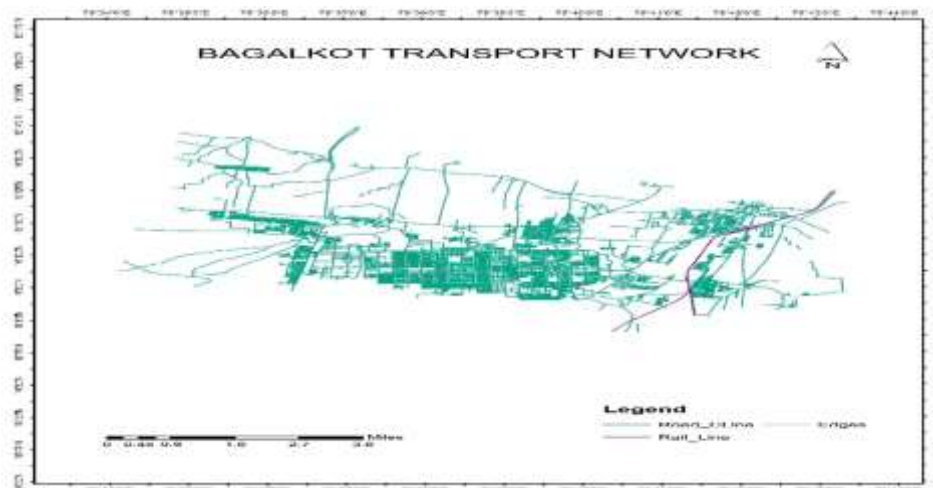
Studies conducted in India have also shown the usefulness of GIS in transportation planning. Singh and Kumar (2018) applied GIS techniques to analyse urban road networks and recommended route optimization for reducing travel time. Rani et al. (2020) assessed accessibility to healthcare facilities using network analysis and found that GIS significantly improves emergency response planning. Patil and Desai (2021) demonstrated that service area analysis helps identify

underserved regions and supports infrastructure planning in rapidly growing cities. Similar studies by Sharma et al. (2022) and Prasad et al. (2023) confirmed that GIS-based transportation analysis enhances accessibility, connectivity, and decision-making for urban development.

Despite the growing number of GIS-based transportation studies, limited research has focused on medium-sized cities in northern Karnataka, particularly Bagalkot City. Most previous studies have concentrated on metropolitan areas, while rapidly expanding district headquarters have received comparatively less attention. Therefore, there is a need to evaluate the transportation network of Bagalkot City using GIS-based network analysis.

The present study addresses this research gap by developing a GIS-based transportation network for Bagalkot City and analysing road connectivity, accessibility, and route efficiency using ArcGIS Network Analyst. The findings are expected to support sustainable transportation planning, improve urban accessibility, and provide a scientific basis for future infrastructure development in the city.

4. DATA AND METHODOLOGY



This study employed Geographic Information System (GIS) techniques to analyse the transportation network of Bagalkot City, Karnataka. The methodology involved the collection, preparation, and analysis of spatial data using **ArcGIS 10.2** with the **Network Analyst** extension. The road network of Bagalkot City was digitized and converted into a network dataset to evaluate road connectivity and transportation efficiency.

4.1 Data Sources

The study utilized both spatial and non-spatial data obtained from secondary sources. The road network map of Bagalkot City was collected from the **Bagalkot City Municipal Council (CMC)** and updated using **Google Earth imagery** and field verification where necessary. Attribute data, including road names, road classifications, intersections, and public facilities, were incorporated into the GIS database. Administrative boundary data were also used to define the study area.

4.2 Data Preparation

The road network was digitized in ArcGIS and stored as a polyline feature class. Topological errors such as disconnected road segments, duplicate lines, and overshoots were corrected to ensure network continuity. Road intersections were established as nodes, while road segments were treated as links. A network dataset was then created by assigning connectivity rules and travel distance as the impedance parameter.

4.3 Network Analysis

The prepared network dataset was analysed using the **ArcGIS Network Analyst** extension. The following analyses were carried out:

- **Route Analysis:** Determined the shortest and most efficient travel routes between selected origin and destination points.
- **Closest Facility Analysis:** Identified the nearest public facilities based on road distance.



- **Service Area Analysis:** Evaluated the accessibility of different parts of the city by delineating areas that could be reached within specified travel distances.

4.4 Methodological Workflow

The overall methodology consisted of the following steps:

1. Collection of road network and administrative boundary data.
2. Preparation and digitization of the road network in ArcGIS.
3. Creation of a GIS-based network dataset.
4. Topology validation and connectivity analysis.
5. Route, Closest Facility, and Service Area analyses using ArcGIS Network Analyst.
6. Interpretation of results and preparation of thematic maps.

The adopted methodology provided a reliable framework for assessing the efficiency of Bagalkot City's transportation network and demonstrated the effectiveness of GIS as a decision-support tool for urban transportation planning and infrastructure management.

5. RESULTS AND DISCUSSION

The GIS-based transportation network analysis of Bagalkot City was carried out using ArcGIS Network Analyst to evaluate road connectivity, route efficiency, and accessibility. A network dataset was successfully created from the city's road network, enabling the analysis of transportation routes and spatial connectivity.

The **Route Analysis** identified the shortest travel paths between selected origin and destination points within the city. The generated routes followed the existing road hierarchy and minimized travel distance, demonstrating the effectiveness of GIS in identifying efficient transportation routes. The results indicate that major arterial roads play a significant role in connecting residential areas with commercial centres, educational institutions, hospitals, and government offices.

The **Closest Facility Analysis** was used to determine the nearest public facilities based on the road network. The analysis showed that hospitals, educational institutions, and government offices are generally well connected through the existing road infrastructure. However, some peripheral residential areas require longer travel distances to access essential public services, indicating the need for improved road connectivity and future infrastructure development.

The **Service Area Analysis** evaluated the accessibility of different parts of Bagalkot City through the existing transportation network. Areas located along major roads exhibited high accessibility, whereas newly developed residential layouts at the urban fringe showed comparatively lower accessibility. These findings suggest that urban expansion has increased the demand for additional road infrastructure and better transportation planning.

Overall, the study demonstrates that GIS-based network analysis is an effective tool for assessing urban transportation systems. The results provide valuable information for identifying efficient travel routes, evaluating accessibility, and supporting evidence-based transportation planning. The methodology can assist municipal authorities in improving

traffic management, emergency response, public service accessibility, and future road network development.

The findings indicate that the existing transportation network of Bagalkot City provides good connectivity in the central urban area, while peripheral regions require further infrastructure improvements to ensure balanced and sustainable urban development. GIS-based transportation analysis therefore offers an effective decision-support system for planners and policymakers involved in urban transportation management.

6. CONCLUSION

This study demonstrated the application of Geographic Information System (GIS) and ArcGIS Network Analyst for analysing the transportation network of Bagalkot City, Karnataka. The road network was modelled as a GIS-based network dataset to assess connectivity, accessibility, and route efficiency. The analyses, including Route Analysis, Closest Facility Analysis, and Service Area Analysis, provided valuable insights into the spatial characteristics and performance of the city's transportation system.

The results revealed that the existing road network offers good connectivity within the central parts of Bagalkot City, while some peripheral areas have comparatively lower accessibility to essential public facilities. GIS-based network analysis successfully identified the shortest travel routes and evaluated the accessibility of important services, demonstrating its effectiveness as a decision-support tool for urban transportation planning.

The study highlights the importance of integrating geospatial technologies into transportation planning to improve mobility, reduce travel time, and enhance access to public services. The findings can assist municipal authorities and urban planners in identifying areas that require road network improvements, optimizing transportation infrastructure, and supporting sustainable urban development.

Although the present study is based on the existing road network, future research can incorporate real-time traffic data, travel speed, road conditions, public transport routes, and population distribution to improve the accuracy of transportation analysis. The methodology adopted in this study can also be applied to other medium-sized cities for efficient transportation planning and infrastructure management.

Overall, GIS-based transportation network analysis provides an effective and reliable framework for evaluating urban road networks and supporting evidence-based planning. The study demonstrates that the use of GIS technology can significantly contribute to the development of an efficient, accessible, and sustainable transportation system in Bagalkot City.

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