Development of Transportation Networking Information System using Geospatial Technology-A Case Study

G. Sharmila, P. J. Chandra Sekhar, Sanjeet Kumar, S. S. Asadi

Abstract: Road network plays a vital role in progress of any country of its sustainable development. Recently, digital road network mapping has become a vital tool for prompting and evaluating the road network. Due to the increase of utilities of roads, network analysis helps in finding superlative road network connectivity and solving routing problems. In this study, an attempt is made to give an imminent on evaluation of digital road network for the management of various services in Amaravati capital city of Andhra Pradesh, India. The satellite images (Landsat-8, world view-2), master plan of city is used for attaining centerline for the data analysis and arc-gis network tool is used to optimized the path of connectivity. The study findings show the possibility of query for possible alternative routes, in case of emergency, heavy traffic to access to the nearest facility depending on road network. This will helped in defining the closest facility for hospitals, optimal service area analysis for schools depending on time and distance. This type of study will helpful in developing country, where traffic is raising at very higher rate and transportation network analysis will help to solve vehicle routing problems automatically.

Index terms: Network, Amaravati, Landsat, Mapping, Road

I. I. INTRODUCTION

Transportation system represents development stage of any country. There are numerous types of transportation networks including street networks, rail-road, pedestrian walkway, river, utility, and pipeline networks. Road transportation is the dominant mode of travel of human in any country around the world[1]. Roads network form the backbone of public transport in world, giving connectivity to large number of population during a short period of time[2]. Due to the rise in population and advancement of automobiles, given the rise traffic congestion of transportation system throughout the world and are facing many problems and spending lots of money and time, specially populated and developing countries[3]. To reduce these problems an effort is made during the last few decades for solving urban transportation and to provide efficient, safe levels of mobility to support human needs, preserve environment and road safety[4]. In recent years development of Geographic Information System (GIS) provides a framework for gathering information and solving the problem in a short duration of time[5].

For solving spatial and non-spatial data GIS tool is a powerful extension, tool includes routing, travel directions, travel cost, closest facility, and service area analysis for finding best route depending upon traffic conditions, travel time, distance, and speed [6,7]. Arc GIS based network analysis helps a person for finding road network routes for his daily travel[8]. In this study, an attempt is made for developing the transport networking system using geospatial technologies to the problem of traffic and will help full in reducing the time and cost [9]. The objectives of the study are framed for the basis requirement of the people of city, which are basis need of any developing new city around the in India.

1. To identify existing service areas for schools.
2. Calculating the closest facility to the nearest hospitals from the incident zones depending upon travel time, speed and distance.

II. MATERIALS AND METHODOLOGY

A. Study Area

The study area is Amaravati, the fast growing capital city of Andhra Pradesh in the southern state of India. The capital city is lies in Guntur district, on the banks of River Krishna and is about 40 kilometers south-west of Vijayawada and 32 kilometers north of Guntur in the Andhra Pradesh. The capital city of Amaravati is a pioneering smart city and a "True people's capital". Amaravati consists of 27 townships, 13 zones and divided into 9 sub-cities such as finance city, health city, tourism city, knowledge city, justice city, government city, sports city, cultural city. Road network of capital city is about 642.17 km and city has a good road network system with different hierarchy. National Highway 5 and National Highway 9, are two National Highways which intersect at Vijayawada. The Table 1 below shows the different types of roads in Amaravati study area of Andhra Pradesh and Figure 1 shows the location of the study area.

Table – I Types of Roads (Amaravati Capital City)

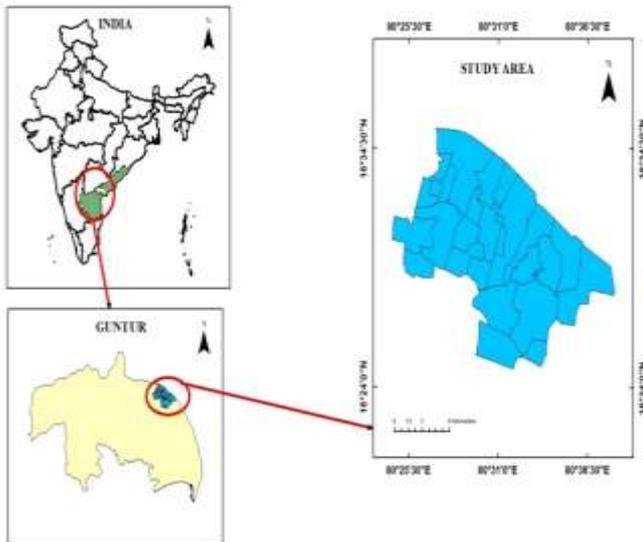| S.No	Road Type
1	Major Arterial Road
2	Arterial Road
3	Sub-Arterial Road
4	Seed Access Road
5	Collector Road
6	Local Road

Figure -1 Study area of Amaravati capital city, Andhra Pradesh, India

B. Data and software used for the study

The two satellite images i.e., World view 2 2014 image and Landsat 8 image(30m) 2018 image are used for network analysis for Amaravati capital city. The SOI Toposheets, Master Plan and the transportation data regarding to capital city are collected from APCRDA. The Software used for the Network Analysis is ARCMAP 10.2, because it provides network based spatial analysis tools for resolving different routing problems. The hospitals, schools data are obtained from google earth and the shape files are been prepared.

C. Geodatabase Creation

The base map of the capital city is prepared using SOI toposheet i.e., the basic information like settlements, water bodies, canals, roads etc are extracted on to a shape file in ARCMAP 10.2 in a vector format, so that the land features can be easily identified. The shape file is prepared for all the types of roads (Arterial, Sub arterial, Major, Village roads) in Amaravati capital city using satellite image and master plan. Using the latitude and longitude data obtained from Google earth for hospitals, schools, and police stations, the shape files of database are generated in ARCMAP 10.2.

D. Data processing and analysis

The satellite image registration or georeferencing is done in Erdas Imagine 2014 by using the control points. The center line is been generated for the roads shape file, because it promotes the accuracy while performing the network analysis. Network Geo-dataset is been created in order to bring all the layers to a single dataset which becomes ease for the complex routing analysis. The topology is been generated to check whether the roads are exactly connected or not (to check edges are connected or not) and to correct all the errors which are generated. This indorses the level of accuracy in network analysis. In this study using the network analysis tools in ARCMAP 10.2 the closest facility and service area analysis is been found out for hospitals and schools by taking speed, time and distance into consideration.

D. Methodology

A methodology flowchart is framed to consummate the Network Analysis for Amaravati study area. The flow chart-1 below explains data collection of study area which includes Toposheets, Remote sensing data, Tabular data of Hospitals and schools. Digitization of Road network layer, incident zones, hospitals and schools are produced. Creation of road class layer, hospitals, schools and incident zones are created as one Database. Depending upon speed, distance and time network dataset has been created and network analysis like closest facility and service area analysis and best route is represented.
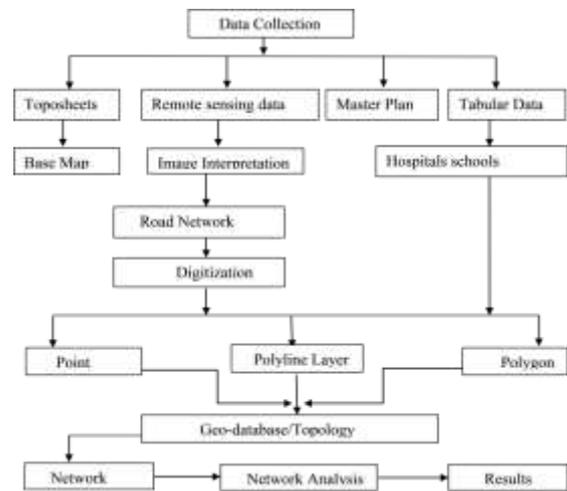
Flow chart - Flow chart showing the methodology to analysis the road network

III. RESULTS AND DISCUSSION

GIS Spatial analysis perform the operations like Minimum path analysis; databases integration and updating, overlay, distance, thematic mapping. This study deals with spatial searches, buffering and network analysis using ArcGIS 10.2 software. This analysis help us to create framework for Transportation Network.

A. Road Layer creation

Transportation road network system can generate economic growth, physical transformation and improve connections. Using Arc GIS 10.2 Digitization of road network shown in figure- 3and generation of shape files like hospitals, schools are created. Creation of Geo-database is used for storing data for further analysis.The next step includes creation of topology to remove errors and find whether roads are connected are not.

B. Network Dataset

Transport network includes connectivity and development of road depending upon travel time, distance, speed, cost. Network includes connections like set of points (nodes) and lines (edges) as shown in figure- 4 The route analysis layer is made up Stops, Routes, Point Barriers, Line Barriers, and Polygon Barriers are the classes. Connections include for further solving the problems and analysis which include closest facility and service area analysis and much more.

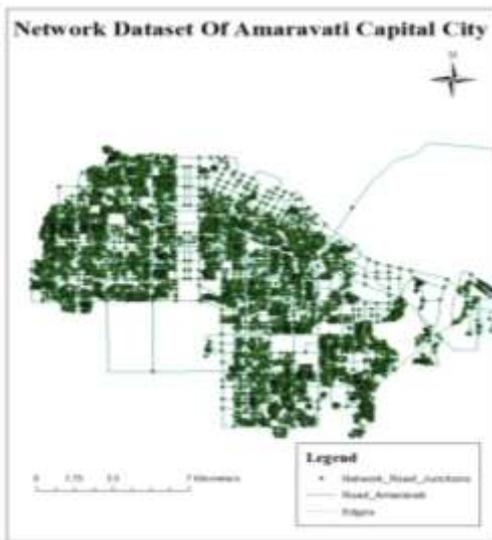**Figure-. 3. Road Center Line Layer for Amaravati capital city, Andhra Pradesh, India.**

Figure- 4. Network Dataset Layer for Amaravati capital city, Andhra Pradesh, India.

C. Service Area Analysis

The "New Service Area" analysis in Network Analyst was used to calculate the amount of area covered by a schools within 5 mins, 10 mins, 15mins time interval. The below figure- 5 show the service area accessibility of different schools in the study area. From the above analysis the ability of schools within a specified interval of time can be obtained. Map shows the service area analysis of schools with in average travel time.
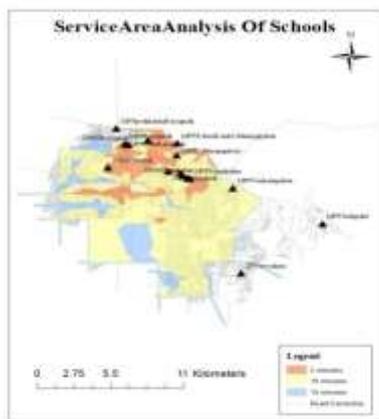

Figure- 5. Service Area Analysis of Amaravati Capital city

D. Closest Facility

The closest facility analysis figure- 6a measures the travelling time between incidents zone to hospitals depending upon speed, distance and determines which are nearest to one other. From the figure- 6b closest facility we can find whether the incident is toward or away from the hospital. Closest facility can find the best route. Through network analyst can increase facilities depending upon the incidents.
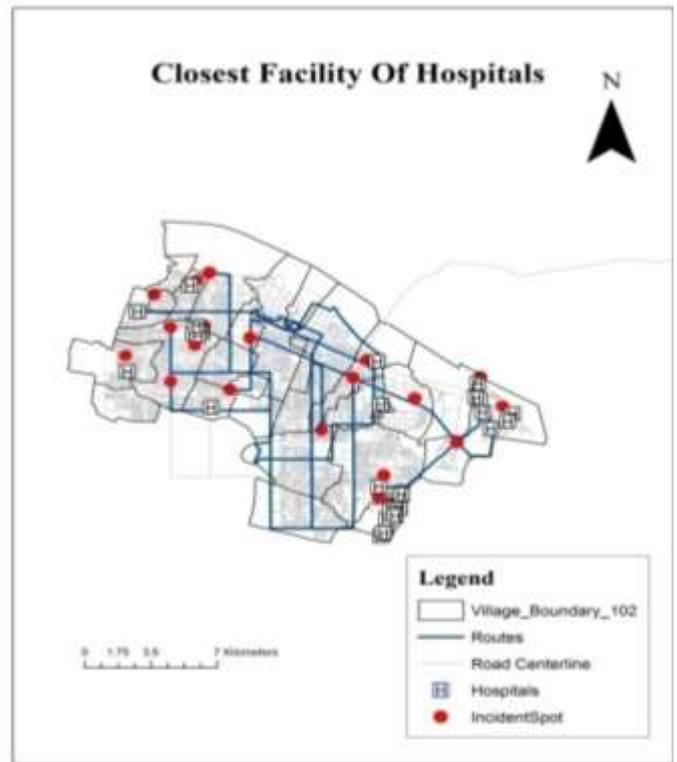

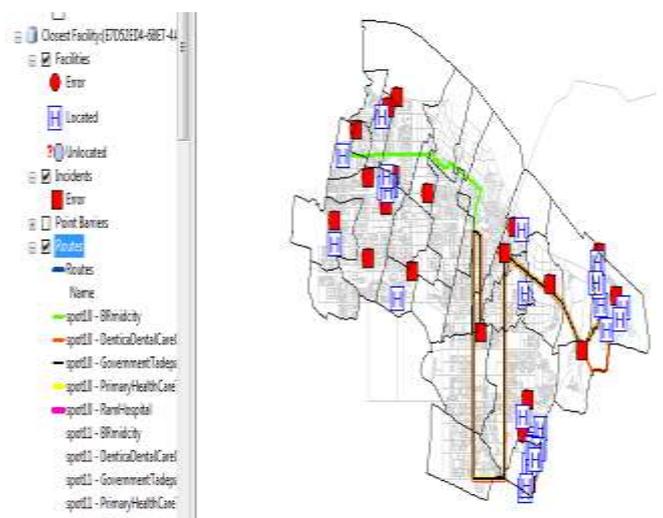**Figure- 6a Closest Facility of Amaravati Capital City**

Figure- 6b Finding the best route from 1 incident to 5 hospitals depending on Distance, Time and Speed.

IV. CONCLUSION

The design and creation of spatial database for digital road network for Amaravati Capital City were carried out. GIS based network analysis tool is efficient in solving different transportation problems such as finding the closest facility, service area analysis, best route and much more. Transport network allows movement of people, traffic and connectivity of whole urban area. Closest facility for hospitals and service area analysis for schools is been carried out in ARCMAP 10.2 with the use of efficient tools like Network Analysis which generated expected result when compared to the field survey, network analysis data gives more accuracy. For transport based planning this type of analysis is very crucial for developing Capital City like Amaravati. The GIS based network analysis survey help the government, individual to find solution for different transport problems.

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REFERENCES

1. Peng, Zhong-Ren., "A methodology for design of a GIS-based automatic transit traveler information system," *Computers, Environment and Urban Systems*, 1997, vol 21, Issue 5, pp. 359-372.
2. Zeng, Wen., Chang, Xiao-Jie., Lv, Jian-Jan., "Design of Data Model for Urban Transport GIS," *Journal of Geographic Information System*, vol 2, 2010, pp. 106-112.
3. Sidhtharthan, Durgadevagi., "Road Network Analysis of Pondicherry Union Territory using GIS", *International Journal of Technical Innovation in Modern Engineering & Science*, vol 2, Issue 1, 2015, pp. 32-41.
4. Chowdhury, A.I., Haider, R., Abdullah, A.Y.M., Christou, A., Ali, N. A., Rahman, A.E., et al., Using Geospatial Techniques to Develop an Emergency Referral Transport System for Suspected Sepsis Patients in Bangladesh. Vol 13, Issue 1, 2018, pp. 20-44
5. Sutton, John., "Data attribution and network representation issues in GIS and transportation," *Transportation Planning and Technology*, vol 21,Issue 1-2, 1998, pp. 25-41.
6. Kharel, Subham., Ramesh, Shivanand., Jothi, Naga., Raj, Ganesha., "Transportation Network Model For Route And Closest Facility Analysis In Central Bangalore," *International Journal of Application and Innovation in Engineering and Management*, vol 7, Issue 4, 2018, pp. 58-62
7. Nagne, Ajay D., Vibhute, Amol D., Gawali, Bharti W., Mehrotra, Suresh C., "Spatial Analysis of Transportation Network for Town Planning of Aurangabad City by using Geographic Information System," *International Journal of Scientific & Engineering Research*, vol 4, Issue 7, 2013, pp 2588-2594.
8. Demirel, Hande., Korkutan, Merve., Shoman, Wasim., Alganci, Uğur., "Geographic Information System (GIS) Based Accessibility Analysis for Highway Transportation," Sigma J Eng & Nat Sci.,vol 8, Issue 4, 2017, pp 339-344.
9. Liu, Gang., Long, Wen., Wang, Jingchao., Gao, Peichao., He, Jing., Luo, Zhiyong., Li, Lian., Li, Yongshu., "Improving the throughput of transportation networks with a time-optimization routing strategy,"

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