DOUBLE LANE ROAD CONNECTIVITY WITH MANDAL HEADQUARTERS TO DISTRICT HEADQUARTERS IN ANDHRA PRADESH - A GEOSPATIAL ANALYSIS

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Abstract

Adequate infrastructure is essential to pay the way to development of any region. Road network is one of the key component and it stimulates overall development of the country by providing access to economic and social infrastructure and facilities. It plays an important role in the comprehensive development of a society and in the economic growth of the region. Expansion of the present road network can be proportional to the needs of the newly formed state of Andhra Pradesh. The main objective of the study is to identify the double lane road network connectivity and to build an optimum route between district headquarters and mandal headquarters of the state Andhra Pradesh in order to maximize economic and social benefits. The existing road network was digitized using satellite data of IRS P6 LISS IV and CartoSat PAN images in conjunction with SOI toposheets. The collateral data of the road network is collected from the departments concerned. Optimal route from each mandal to respective district head quarters has been determined using ArcGIS software The detailed analysis revealed that 211 mandal headquarters, out of 670 doesn't have double lane connectivity. The total length of single lane roads required to upgrade to double lane is about 2845.5 km. mandal wise proposed road length information would aid in understanding the status of spatial distribution of roads and its extent. This will ultimately helps to decision makes for further planning and to take appropriate decisions in time for development.

Keywords: Road Connectivity, Double Lane Road, Optimal Route, GIS

Introduction

Globally, roads are recognized as a critical component of social and economic development. They are foundational for the operation and growth of a country, from economic activity to social concerns such as access and mobility. A road is a specially prepared way, publicly or privately owned and connected between the places for the use of pedestrians, riders, vehicles, etc. (Hornby, 2005). A road network system in any area provides a means of transportation of goods, services and interaction of individuals. A well developed transport network has become the basic condition and essential prerequisite for development of the region. The accessibility of the network determines whether or not the material flow, the energy flow as well as the information flow is smooth between the mandal and district headquarters. Roads are keys to the development of economy of any country. A good road network constitutes the basic infrastructure that propels the development process through connectivity and opening up the backward regions to trade and investment. The road network existing in the state of Andhra Pradesh is grossly inadequate and is unable to cope up with high traffic density.

Roads are now recognized as critical infrastructure to economic and industrial growth of the state. Underdevelopment of a place, country or region is associated with the fact that the place or region has not been opened up with required transport routes (Egunjobi, 1991). Few persons would dispute the proposition that a good road infrastructure is an essential basis for economic development. Therefore, it is of great importance for the decision makers to identify the options to minimize the unproductive efforts when moving between points of concern, through suitable traffic management, carriageway expansion, provision of alternative paths, road surface improvements etc. It has become very essential to manage the data of existing road network as well as proposed roads. Geospatial technology is one of the most important tools to manage such data. Geographic Information System (GIS) is a tool which facilitates the planning and management of spatially distributed resources through its capability enabling a decision maker to compare several alternatives with relative ease (Yeung, 2005). This work demonstrates the strength of Geospatial technology which would contribute to enhance the efforts of road and associated infrastructure managers to develop a better transport network for the general public.

Literature Review

The use of GIS technology in development of Urbanization, the transportation information system and management can provide a very strong solution. Information related to

transportation network is used in the efficient planning, designing, construction, maintenance and management of the transport system (Gupta et al. 2003). The various applications of GIS can be used for identification of road network of an area and change detection in road. It can also be used to detect the distance between different places. It is not only detects the distance but also used to show the shortest path between two or more places. These applications of GIS can be used in traffic control to generate the traffic control mechanism that provide fastest route (Nijagunappa et al. 2007). Gopala Raju, et al. (2012) has analyzed shortest route possibilities for major roads in Visakhapatnam city using GIS. Praveen Kumar et al. (2013) demonstrated the use of GIS in Network analysis and determined the optimal route between two or more destinations based on a specific travel expense of part of Varanasi city. Similarly, Patil et al. (2015) studied the transportation network analysis of Nanded Taluka by using Geographic Information System. Ajay and Bharti (2013) have reviewed the potential of Remote Sensing and GIS technology in transportation network analysis. In another study conducted by Ajay et al. (2013) spatial analysis of transportation network for town planning of Aurangabad city has been carried out using geographic information system.

Road Network in Andhra Pradesh

Andhra Pradesh has one of the largest road networks in India. The state's road network consists of National Highways, State Highways, Major District Roads, Other District Roads, and Village Roads with well-recognized lay out standards for construction and maintenance. These roads are under the administrative control of two departments, viz. R&B and Panchayat Raj. The length of National Highways has grown over since independence and that passing through the State of Andhra Pradesh is about 4,423 km. The density of National Highways is 8.95 kms per a lakh population (2011) and in terms of area coverage, a length of 27.60 kms is available for every 1000 sq.kms in the state (Planning Department, 2015). State Highways (SHs) and Major District Roads (MDRs) constitute the secondary system of road transportation in the state. The SHs provide linkages with the National Highways, district headquarters and important towns, tourist centres and minor ports. The data of NHs and SHs network is available in different organizations of the state level system, and it is really utilized effectively by planners (Luo Qi, 2008). The total length of SHs is about 6,167 km at present. Table-1 shows the comprehensive road network statistics in Andhra Pradesh. Major District Roads (MDRs) run within the district that would connect areas of production with markets, rural areas to the district headquarters and connect to the State Highways and National Highways. The estimated length of the MDRs is around 19,674 km. These roads also facilitate to carry medium to heavy traffic.

The MDRs are major carriers of road traffic within the state and a reasonable level of interstate traffic. By acting as linkages between the rural and urban areas, the State Highways and Major District Roads contribute significantly to enhance the rural economy as well as to the industrial development of the state by enabling movement of industrial raw materials and products from and to the interior of the state. Rural roads run within the mandal connecting to all habitations. These roads are enhancing the quality of life in rural areas by meeting the infrastructure needs of the village. The total length of the rural roads under the ownership of Panchayat Raj Engineering Department is 76,894 km. In addition, an emphasis is also laid to ensure villagers quick reach to medical centres during emergencies and the agricultural produce to reach market centres in time for realizing appropriate valuation to their hard work.

Table 1. Statistical distribution of road network in Andhra Pradesh

S. No.	Type of Road	Length in km.
A. Road Network under Roads & Buildings (R&B) Department		
1	National Highways	4,423
2	State Highways	6,167
3	Major District Roads	19,674
4	Rural Roads	15,567
Total		**45,831**
B. Road Network under Panchayat Raj (PR) Engineering Department		
5	Blacktop (BT) + Cement Concrete(CC) (BT-21,010 & CC-2,334)	23,344
6	Water Bound Macadam Surface	10,420
7	Gravel Surface	19,636
8	Earthen Surface	23,494
Total		**76,894**

Source: R&B department and Panchyat raj department

Objectives

The main objective of this study is to identify the double lane road network connectivity and to build an optimum route between district headquarters and Mandal headquarters of the state Andhra Pradesh.

Data

IRS P6 LISS IV Satellite data with the spatial resolution of 5.8 m and Cartosat PAN images of 2.5 m resolution and Survey of India (SOI) toposheets on 1:50,000 scale were used for digitization of road network. Ancillary data of the roads has also been collected from the departments concerned.

Methodology

IRS P6 LISS IV Satellite data and CartoSat PAN images have been geo-rectified with reference to SOI toposheets using ERDAS imagine software. These images were merged to produce a color image with the spatial resolution of 2.5 m. After applying necessary enhancement techniques, images were interpreted for identification of raods by using various visual interpretation techniques. On-screen digitization techniques are used for digitization of road network in Arc GIS platform. Based on the information obtained from the satellite imagery and corresponding ground truth verification in the field, the roads have been identified and categorized with support of the roads attribute data collected from the departments. Incorporating departmental road attribute data, double lane road dataset together with the total spatial accessibility, the raod connectivity with district headquarters have been identified. Finally, network analysis model was performed for optimal route identification.

Results & Discussions

In Andhra Pradesh, most of the road projects are being implemented at state level and district level. From the analysis, it was observed that 211 mandals are not connected with double lane road, out of 670 mandals. The best link option shall be based on the highest benefit that it offers. The maximum accessible link has been identified for provision of connectivity. The district wise spatial distribution of double lane road connectivity from mandal headquarters to district headquarters and unconnected mandal headquarters with double lane road along with its proposed roads shown in figure-1 to figure-13. Table-2 gives comprehensive details of district wise number of unconnected mandal headquarters with double lane road and its required lengths to upgrade to double lane.

Table 2. District wise number of unconnected mandal headquarters with double lane road to district headquarters and its required lengths

S. No	District Name	Total No. of Mandals	No. of unconnected Mandals with Double Lane	Proposed Length to upgrade to double lane in kms.
1	Srikakulam	38	12	132
2	Vizianagaram	34	07	81
3	Visakhapatnam	43	12	236
4	East Godavari	64	26	272.5
5	West Godavari	48	12	128.5
6	Krishna	50	12	130.5
7	Guntur	57	15	129
8	Prakasam	56	30	485.5
9	S.P.S Nellore	46	23	318
10	Chittoor	66	17	245
11	Y.S.R	51	08	89
12	Anantapuramu	63	10	186.5
13	Kurnool	54	27	412
	Total	**670**	**211**	**2845.5**

Srikakulam District: Srikakulam is the district headquarters and the district is one of the nine coastal districts of Andhra Pradesh, located in the extreme north eastern direction of the state. NH16 is passing through Srikakulam city covering a length of 215 km in the district. The analysis reveals that out of 38 mandals, 12 mandals are not having double lane road connectivity. About a length of 132 km has been proposed for conversion of single lane road to double lane road keeping in view of the highest benefit of the connected settlements. Figure-1 shows the spatial distribution of proposed roads and unconnected Mandal headquarters in the district.

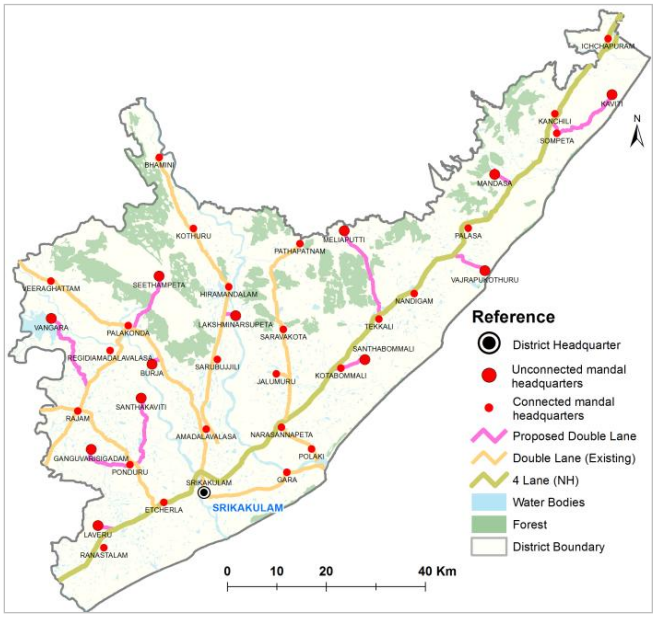

Figure 1. Srikakulam district

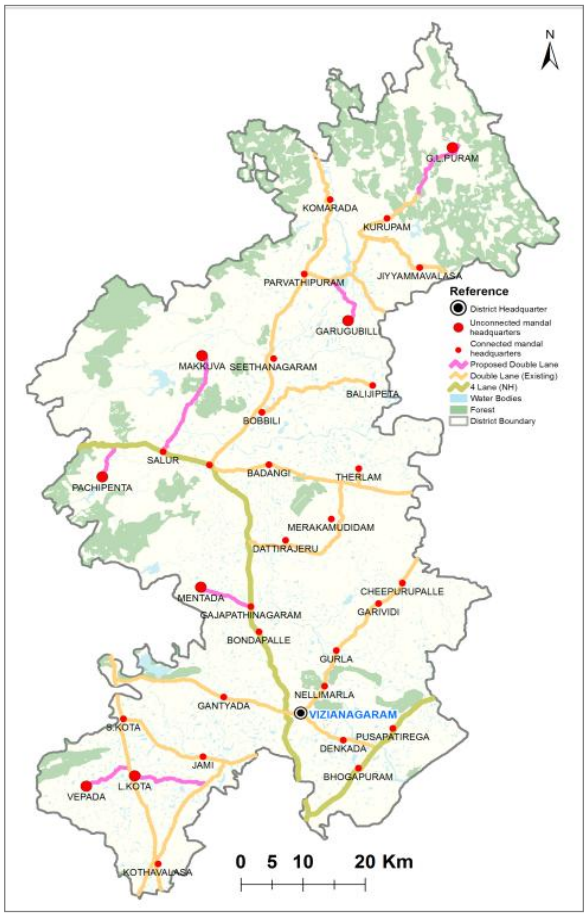

Figure 2. Vizianagaram district

Vizianagaram District: The district is a northern coastal district of Andhra Pradesh. The Vizianagaram town is its district headquarters. Railway and bus services are the major modes of transport for the people in the district. It can be observed that the district has good double lane road network. Only 7 mandals are not covered with double lane connectivity out of 34 mandals and the estimated length to upgrade to double lane is 81 km. NH16 & NH26 are passing through the district covering a length of 123 km. The detailed map of the district is shown in figure-2.

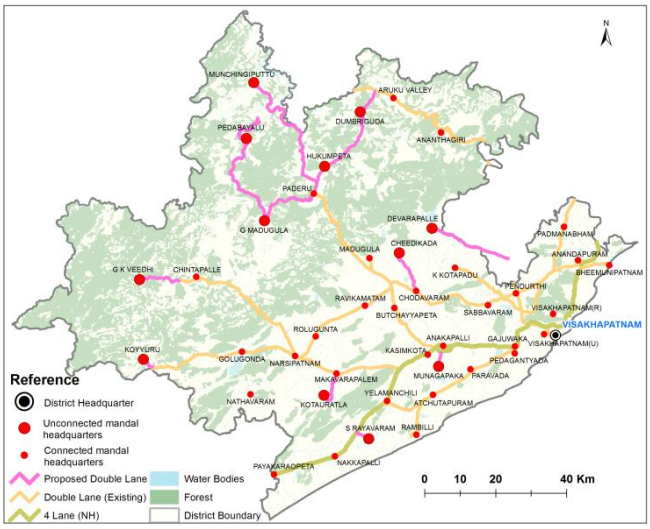

Figure 3. Visakhapatnam district

Visakhapatnam District: The district having good connectivity in plain area and poor in hilly/tribal area. This may be due to high expensive to lane a road in hilly region. Visakhapatnam city act as district headquarters with good connectivity by rail, road, airway and waterway from other states and countries. Visakhapatnam is primarily an industrial city apart from being a tourist destination. Figure-3 shows the spatial distribution of road network in the district. Out of 43 mandals, 12 mandals are not covered by double lane connectivity and the estimated length to upgrade is 236 km. NH16 covering a length of 135 km is passing through the district. For Devarapalle mandal, it is proposed through Vizianagaram district to join at Visakhapatnam-Aruku road.

East Godavari District: The district is well connected by rail and road network and Kakinada town is its headquarters. The analysis revealed that 26 mandals are unconnected with double lane road, out of 64 mandals. 18 mandals are falling in deltaic plain distributed in southern part of the district and 8 mandals are in hilly area (Figure-4). The proposed length to be converted is about 272.5 km. NH16 and NH216 are passing through the district and covering a length of 343 km.

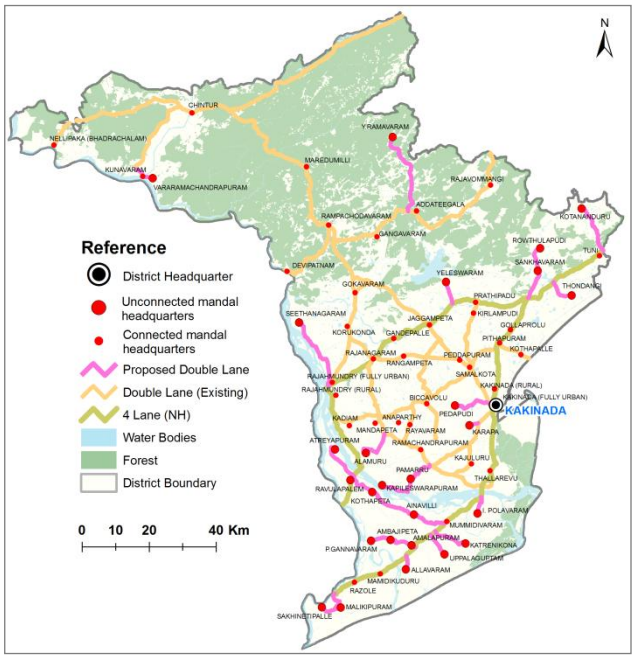

Figure 4. East Godavari district

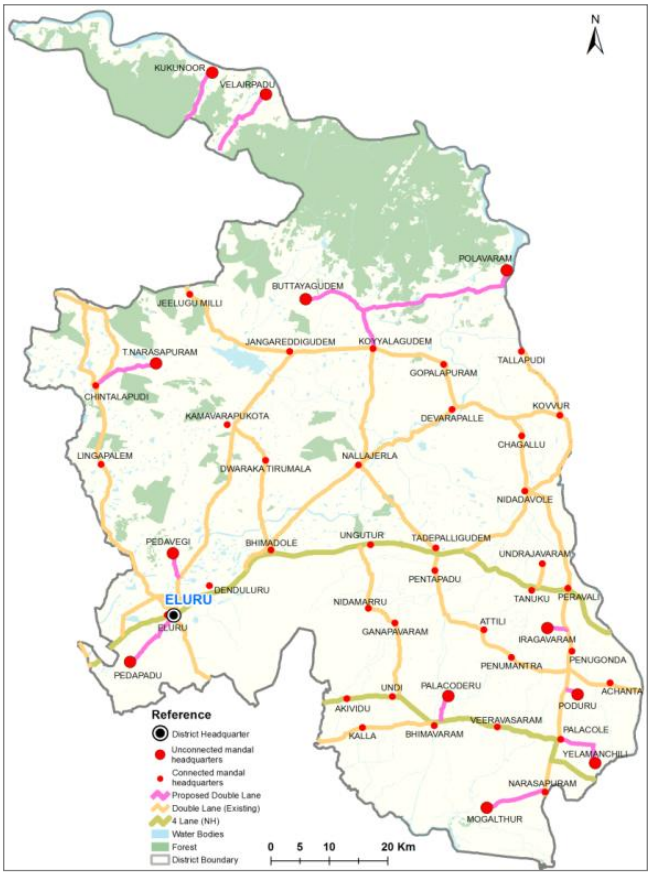

Figure 5. West Godavari district

West Godavari District: It can be observed that the district is having good road network connectivity at its central and less in the northern part covered mainly with hilly region (Figure-5). NH16 and NH165 are passing through the district covering a length of 198 km. 12 mandals are not having double lane connectivity, out of 48 mandals and the proposed length to be converted is 128.5 km. Two mandals (Kukunoor and Velairpadu) which were in Khammam district before bifurcation of the state to be connected through Telangana state.

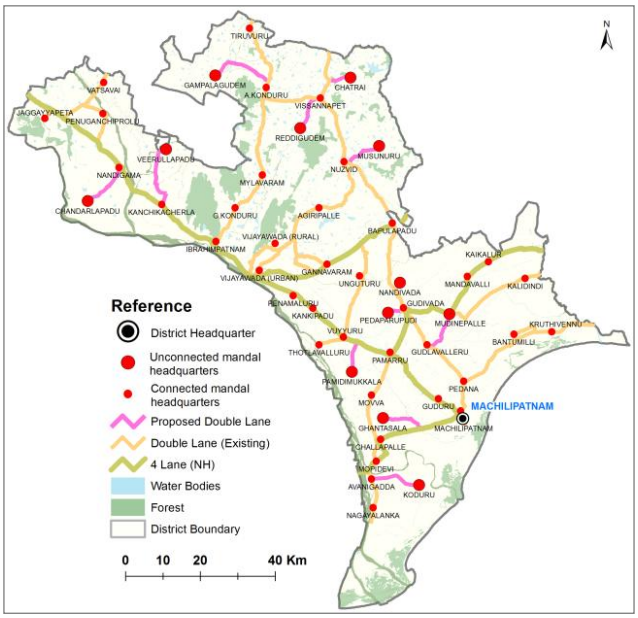

Figure 6. Krishna district

Krishna District: Machilipatnam is the district headquarters and Vijayawada is the biggest city in the district and falls under the Andhra Pradesh Capital Region. Five National Highways with a length of 421 km are passing through the central part of the district i.e. NH16, NH30, NH65, NH165 & NH216 and having good connectivity to all important centres. 12 mandals are not covered with double lane road connectivity and its proposed length for conversion of single lane to double lane is 130.5 km which is shown in figure-6.

Guntur District: It is situated on the right banks of the Krishna River that separates it from Krishna district and extends till empties into the Bay of Bengal. Guntur City is the largest city and district headquarters of the district. It is found that the road network in the district is considerably fair to all mandal headquarters (Figure-7). NH16 and NH216 are passing through the district covering a length of about 211 km. About 15 mandals, out of 57 mandals are not covered by double lane and the length of the proposed road conversion is 129 km.

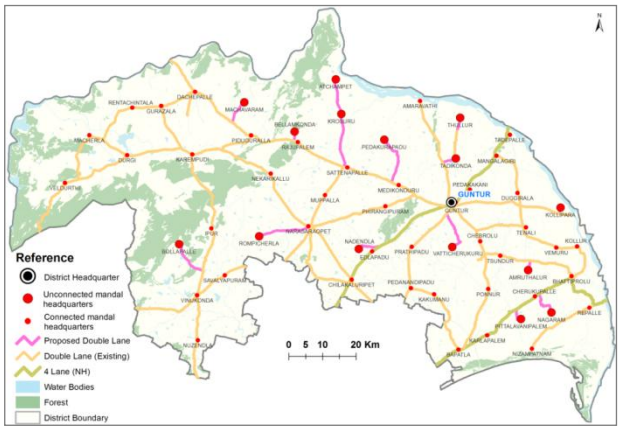

Figure 7. Guntur district

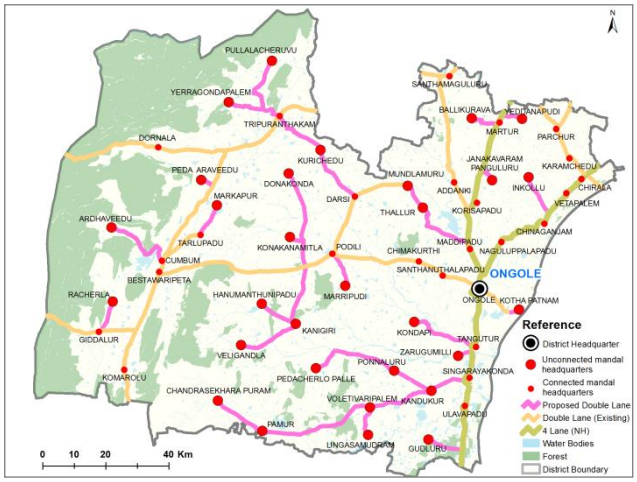

Figure 8. Prakasam district

Prakasam District: It is located in the south-eastern part of the state. The headquarters of the district is located at Ongole. The analysis revealed that though the district has good road connectivity, the double lane coverage with mandal headquarters is considerably less compare to other districts. Figure-8 shows that more than 50% of the mandals (30 mandals out of 56) are doesn't have double lane and the estimated length for conversion is about 485.5 km which amounts to about 17% of the state total requirement. NH16 and NH216 covering a length about 414 km are passing through the district.

S.P.S.Nellore District: It is one of the coastal district and located in south-east of Andhra Pradesh. NH16 is passing through the district with a stretch of 502 km. It serves the major towns of Sullurpeta, Naidupeta, Gudur, Nellore, Kovur and Kavali in the district. 23 mandals are unconnected with double lane road and estimated length to develop double lane road is 318 km (Figure-9). The national railway runs through the district via the district headquarters (Nellore town) and passing through Gudur and Vijayawada Junctions on the Chennai–Howrah main line.

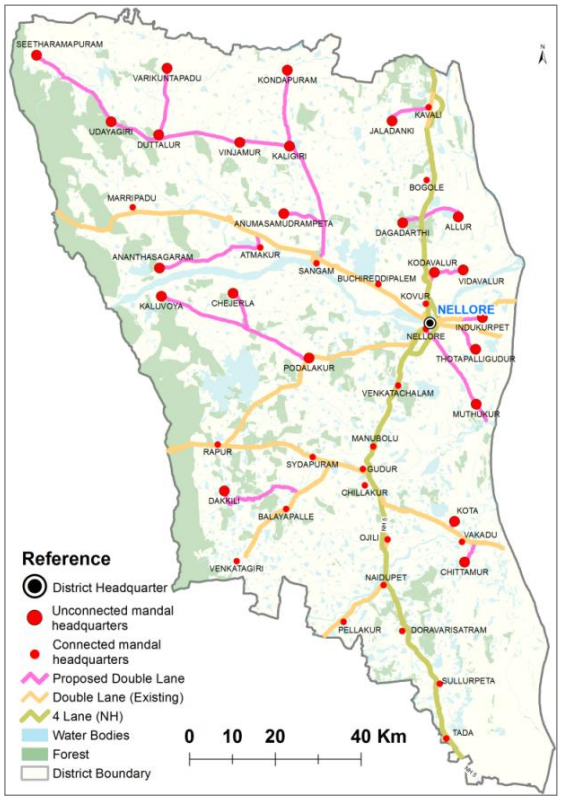

Figure 9. S.P.S. Nellore district

Kurnool District: The district is located in the west-central part of the state with Kurnool town as its district headquarters. NH40, NH44 and NH167 are passing through the district with a length of about 352 km. Analysis revealed that 27 mandals, out of 54 mandals are not having double lane. The total optimum length required to double lane is 412 km. Figure-13 shows the detailed unconnected mandals and proposed double lane roads in the district.

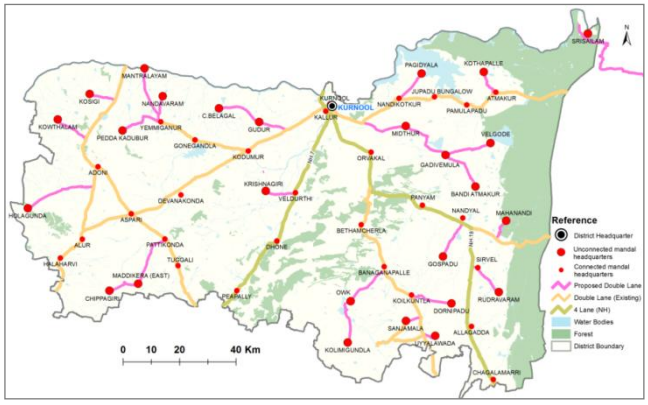

Figure 13. Kurnool district

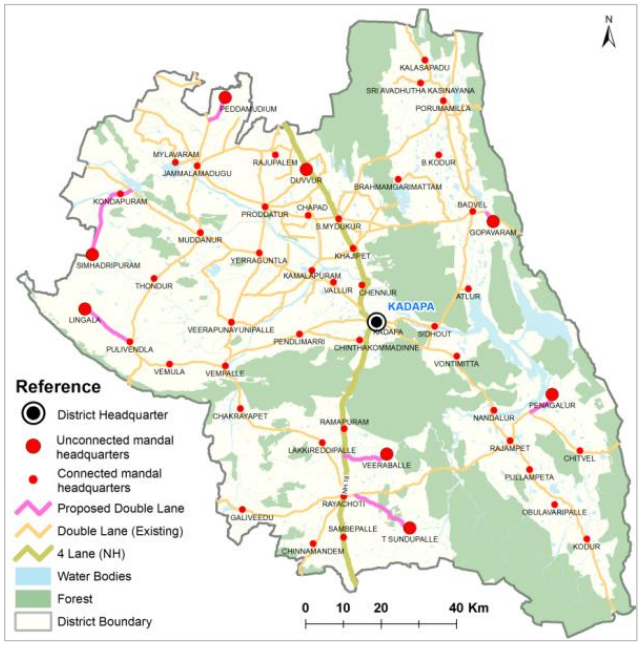

Figure 11. Y.S.R. district

Y.S.R. District: It is one of the 4 districts in Rayalaseema region of the state. The city of Kadapa is the district headquarters. NH40 is passing through central part of the district via district headquarters. The transport network connectivity in the district is considerably good and only 8 mandals are not having double lane road (Figure-11). The optimum estimated length for up gradation is about 89 km.

Chittoor District: Chittoor town is the district headquarters and largest city is Tirupathi. It is having good road network with five national highways - NH40, NH42, NH69, NH71, and NH716 covering a length of 707 km. Only 17 mandals, out of 66 are not connected with double lane road (Figure-10). The optimum length for conversion is about 245 km.

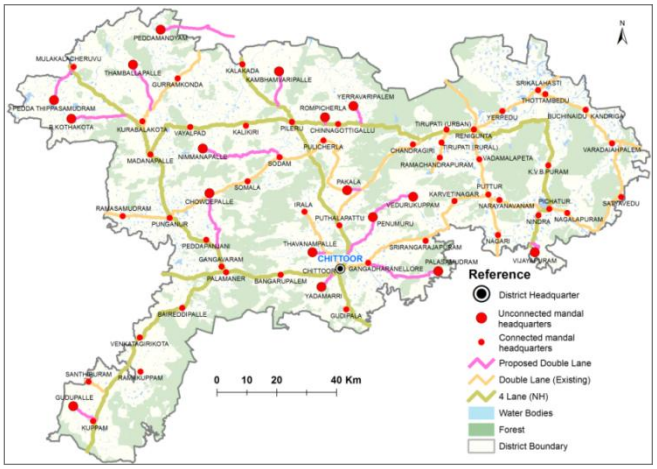

Figure 10. Chittoor district

Anantapuramu District: The district headquarters is very well connected to major cities in the district by the National Highways – NH42 and NH44 with a length of 486 km. Anantapur has a major potential for development of industry due to its strategic location between Bangalore-Chennai and Bangalore-Hyderabad routes and availability of vast tracts of rainfed land. Out of 63 mandals, only 10 mandals are not covered with double lane road. The estimated optimum length conversion of single lane to double lane road is about 186.5 km. The detailed unconnected mandals and proposed double lane roads are shown in figure-12.

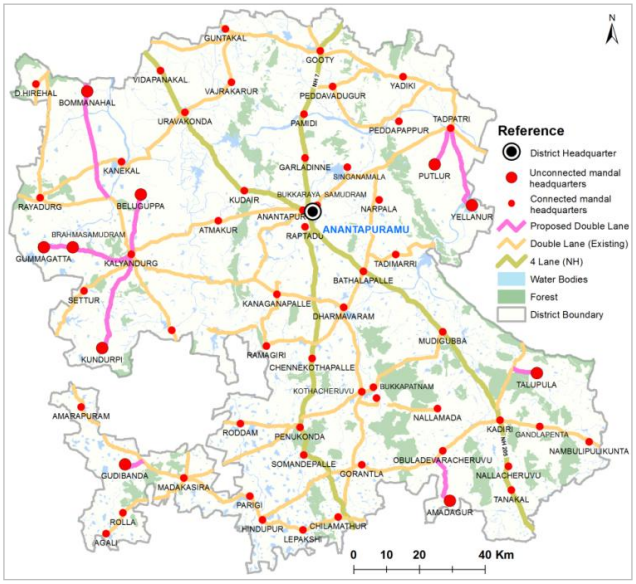

Figure 12. Anantapuramu district

The analysis revealed that, the mandals in Prakasam district are having less double lane connectivity with district. Thus, the required length to develop double lane road in the district is the highest (485.5 km) and that the lowest length (81 km) in Vizianagaram district. Transportation developments that have taken place since the beginning of the industrial revolution have been linked to growing economic opportunities. Transport may be regarded as an important sector of the economy in its own right. Transport network contributes a great share to the Gross State Domestic Product (GSDP) of the state which is about 14% in 2014-15 (Rs.37545 Crore). Economic contribution of the transport sector is not only through for-hire services but also through in-house transportation within non-transportation firms and employment generation. The district wise optimum lengths to convert single lane to double lane is shown in figure-14 and the list of unconnected mandals with double lane road is shown in Table-3.

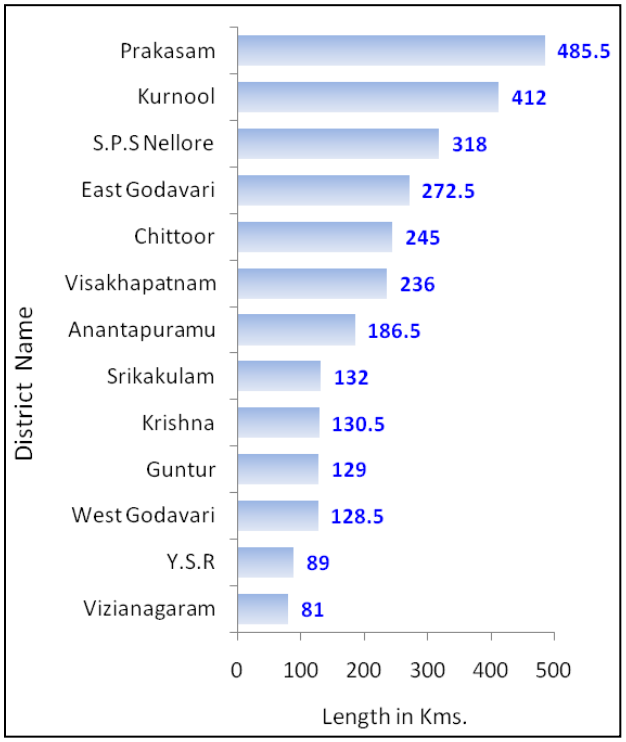

Figure.14. District wise required lengths to develop double lane road connectivity with mandal headquarter to district headquarters in Andhra Pradesh state

Table 3. District wise list of unconnected mandal headquarters with double lane road to district headquarters

S. No	District Name	Unconnected Mandal Names
1	Srikakulam	Burja, Ganguvarisigadam, Kaviti, Lakshminarsupeta, Laveru, Mandasa, Meliaputti, Santhabommali, Santhakaviti, Seethampeta, Vajrapukothuru and Vangara
2	Vizianagaram	Garugubilli, G.L.Puram, L.Kota, Makkuva, Mentada, Pachipenta and Vepada
3	Visakhapatnam	Cheedikada, Devarapalle, Dumbriguda, G.K.Veedhi, G.Madugula, Hukumpeta, Kotauratla, Koyyuru, Munchingiputtu, Pedabayalu, S.Rayavaram and Munagapaka
4	East Godavari	Ainavilli, Alamuru, Allavaram, Amalapuram, Ambajipeta, Atreyapuram, I. Polavaram, Kapileswarapuram, Karapa, Katrenikona, Kotananduru, Kothapeta, Malikipuram, P.Gannavaram, Pamarru1, Pedapudi, Ravulapalem, Rowthulapudi, Sakhinetipalle, Sankhavaram, Seethanagaram1, Thondangi, Uppalaguptam, Vararamachandrapuram, Y.Ramavaram and Yeleswaram
5	West Godavari	Buttayagudem, Iragavaram, Mogalthur, Palacoderu, Pedapadu, Pedavegi, Poduru, Polavaram, T.Narasapuram, Yelamanchili, Kukunoor and Velairpadu
6	Krishna	Chandarlapadu, Chatrai, Gampalagudem, Ghantasala, Koduru, Mudinepalle, Musunuru, Nandivada, Pamidimukkala, Pedaparupudi, Reddigudem and Veerullapadu
7	Guntur	Amruthalur, Atchampet, Bellamkonda, Bollapalle, Kollipara, Krosuru, Machavaram, Nadendla, Nagaram, Pedakurapadu, Pittalavanipalem, Vatticherukuru, Tadikonda, Thullur and Rompicherla
8	Prakasam	Ardhaveedu, Ballikurava, Chandrasekhara Puram, Donakonda, Gudluru, Hanumanthunipadu, Inkollu, Janakavarampanguluru, Kandukur, Kanigiri, Konakanamitla, Kondapi, Kotha Patnam, Kurichedu, Lingasamudram, Markapur, Marripudi, Pamur, Peda Araveedu, Pedacherlo Palle, Ponnaluru, Pullalacheruvu, Racherla, Thallur, Veligandla, Voletivaripalem, Yeddanapudi, Yerragondapalem, Mundlamuru and Zarugumilli
9	S.P.S Nellore	Allur, Ananthasagaram, Anumasamudrampeta, Chejerla, Chittamur, Dagadarthi, Dakkili, Duttalur, Indukurpet, Jaladanki, Kaligiri, Kaluvoya, Kodavalur, Kondapuram, Kota, Muthukur, Podalakur, Seetharamapuram, Thotapalligudur, Udayagiri, Varikuntapadu, Vidavalur and Vinjamur
10	Chittoor	B.Kothakota, Chowdepalle, Gudupalle, Kambhamvaripalle, Nimmanapalle, Pakala,

		Palasamudram, Pedda Thippasamudram, Peddamandyam, Penumuru, Vedurukuppam, Rompicherla, Thamballapalle, Thavanampalle, Vijayapuram, Yadamarri and Yerravaripalem
11	Y.S.R	Duvvur, Gopavaram, Lingala, Penagalur, Veeraballe, Simhadripuram, T.Sundupalle and Peddamudium
12	Anantapuramu	Amadagur, Beluguppa, Bommanahal, Brahmasamudram, Gudibanda, Gummagatta, Kundurpi, Putlur, Talupula and Yellanur
13	Kurnool	Bandi Atmakur, C.Belagal, Chippagiri, Dornipadu, Gadivemula, Gospadu, Gudur, Holagunda, Kolimigundla, Kosigi, Kothapalle, Kowthalam, Krishnagiri, Maddikera (East), Mahanandi, Mantralayam, Midthur, Nandavaram, Owk, Pagidyala, Pedda Kadubur, Rudravaram, Srisailam, Uyyalawada, Velgode and Sanjamala

Conclusions

For integrated development of road connectivity, upgradation is required to be included in addition to new connectivity links. The detailed analysis revealed that 211 mandal headquarters are not having double lane connectivity with the district head quarters and the optimum length required to upgrade to double lane road is 2845.5 km. The generated information of the proposed road lengths and routes will aid in understanding the spatial distribution and extent which will ultimately help in further planning and taking in time appropriate decisions by administrators for development of the state. The district wise results shown in the form of maps would be useful to a resource manager/planner/engineer to assess priority areas and for execution in phased manner for development.

This paper demonstrates the strength of GIS technology for identifying the optimal routes between the districts headquarter to mandal headquarters based on double lane connectivity. The results obtained in the study have shown that geospatial technology could play an important role in the planning, managing and updating of road network. Geospatial technology has opened up new horizons in transport network planning and especially in highways. GIS provides a means of communication that allows for an interactive understanding between the public and transportation professionals.

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