

Megalopolis development along the Bangalore – Mysore urban corridor using Remote Sensing and Geographic Information System techniques

M.R.Vijandra*, Sudha Ravindranath, M.S.Nathawat*****

**M.Sc. M.Tech Remote Sensing Student, Birla Institute of Technology, Ranchi*

***M.Sc, Scientist, Regional Remote Sensing Service Center (ISRO), Bangalore*

**** M.Sc, Ph.D., Head, Dept. Remote Sensing, Birla Institute of Technology, Ranchi*

Abstract

The study region is the southern part of Karnataka. A buffer has been used to extract the study area, which sprawls over the districts of Bangalore urban, Bangalore rural, Mandya and Mysore. Covering 4582 square kilometer, with high population. The reason for selecting this particular area is firstly because of availability of data and also the potentiality of this region, which has been well known as a tourist attraction with the Towns of Shrirangapatna and Mysore and Bangalore as the “Silicon Valley” of India. The study area has a roadway, which is excessively used, and there is a huge population commuting between the big cities on a daily basis. So, this area was selected. There has been the use of toposheets of 1973 and satellite images of 1999 to see the Landuse change especially in the settlements to know if there is a Megalopolis developing. The use of EASI/PACE software has been done to carry out various image-processing tasks like supervised classification, filtering, and contrast enhancement. ARC/INFO has been used to carry out the operations of creating landuse layer from the toposheet. There has been use of three spatial theories namely Growth Pole Theory, Gravity Potential Model and Heggerstrand’s Diffusion Theory. These theories have been used to prove the fact of a Megalopolitan structures occurrence. By the comparison of the landuse of the 1973 toposheet and 1999-satellite image the spread of urban area has been noticed. The spatial increase has been understood. The amount of urban area, which has increased over the years and with the association of secondary data the reason for such increase, has been noticed.

Introduction

Megacities are the cities having a population of more than ten million. There are currently 23 Megacities with 18 of them in the developing countries. The point is, the world is becoming more and more urbanized, as that is the route for many people to greater choice, opportunity and wellbeing. This is a pattern, which our country has steadily followed since the dawn of independence. The planned city of Chandigarh designed by the French planner Corbusier was just a stepping stone to make a country of villages in to a country of metro’s and Cosmo’s. India now has 12 Metropolitan cities and more than 225 cities having population over a lakh.

The study of Megalopolis is essential, as it is the parameter of growth and development for any country. The study of megalopolis if carried out through the conventional method we face difficulties as the conventional maps are very old and consume a colossal of time, money and manpower for preparation,

not only that their updating is a big hassle which involves extensive field survey, men and money. When such a map comes to planning table for recommendation the scenario in reality would have changed giving way to only piecemeal implementation. In this respect the satellite data with temporal resolution acts as a boon providing instant information, which has repetitive coverage, synoptic view and which is true, explicit and untampered.. The spatial display of imagery better shows the relationship between the environment such as the geology and soil conditions, and the related topography, landuse and infrastructure. Which when processed to desired need gives near perfect information depending on the resolution of the sensor, which decides the clarity of the imagery. The present study is regarding this type of change between the cities Bangalore the current capital of the state of Karnataka and Mysore the city of Maharajas and elephants the erstwhile capital of the state of Mysore under the regime of the British empire. The theme being dealt here is to find out the causes and consequences of the urban growth between the two cities and the changes in the surrounding environment. Also to suggest methods to solve some of the problems caused by the urban growth using ancillary and satellite data so effective planning and monitoring can be carried out.

Study Area Details

The study region lies between the city of Bangalore and Mysore the highway road leading from Bangalore to Mysore is taken in to consideration. 10 kilometers buffer on either side of the road has been taken for this purpose; the buffer includes parts of the Bangalore urban, Bangalore rural, Mandya and Mysore districts. The reason this particular region has been selected is that the availability of digital data and due to the rapid urbanization which is taking place in this region. The study area is covering an area of 4584.15square kilometer area. Located in southern Karnataka. The coordinates between which the study region lies are given below.

Direction	Longitude	Latitude
Upper Left	76d 33'41. 41"E	13d 00'00.63"N
Lower Right	77d 39'03. 75"E	12d 15'08.17"N

The extraction of the buffer area is based on the highway road running between the two of the major cities of the state Bangalore and Mysore. Two paths of road have been selected to know the density of the traffic flow and its repercussion on the adjacent social environment. In the year 1120 AD, the Chola King, Veera Ballalla ruled the Deccan plateau or the South of India. On a hunting trip in the forest he lost his way. After a long search he met an old lady in the forest who offered him shelter for the night and served him baked beans for dinner. To show his gratitude to this lady for having saved his life, the King constructed a town and named it as Benda Kalooru, which means Baked Beans. Later in 1537, a local chieftain, Kempe Gowda helped design this town and give it its modern shape. The city has now come a long way. Bangalore being the current capital of Karnataka state also being the Silicon Valley of India is fostering the growth in Tertiary and Quaternary industry like Information technology, Software Industry, Automobile industry, Banking, Insurance, Finance, Education, Trade, Commerce etc.,

Objectives

The main aim of the study is to prepare a report on the existing status of the Megalopolis formation between Bangalore and Mysore cities along the state-highway connecting them, which forms the study area. The study also focuses on the change occurring due to the emerging Megalopolis in the socio-economic and ecological realms of the major towns existing on the Highway. Attempts are made to suggest a few measures to plan and execute strategies for development of the region as a whole. The specific objectives of the study are as follows.

- i) To prepare a landuse map of the study area at two points of time and detect the change from the 1970's to 2000.
- ii) To map the urban and rural settlements of the study area to know the change and increase in human settlements from past to present.
- iii) To apply Gravity Potential Model to the two main cities and find its zone of influence and assess the major contributing factors for it.
- iv) Imbibe growth pole theory for the cities of Bangalore and Mysore to bring out the major growth promoters for the major urban settlements, which have contributed to its growth over the years.
- v) To determine the extent of megalopolis formation between Bangalore and Mysore cities.

Data Used

The spatial data used for the project are that of topographical maps published by the Survey of India. The region was surveyed in the year 1970-71 and printed in 1973. The scale of the topographical maps are 1:50,000. Ten toposheets are used for the study purpose. The use of satellite data acquired from the Indian Remote sensing satellite IRS 1D, which has LISS III sensor, which provides multispectral information. The spatial resolution of LISS III is 24meters, which is ideal for carrying out regional studies.

Software Used

ARC/INFO & ARC/VIEW: ARC/INFO is a geographic information system with tools for automation, analysis, display, and management of geographic information. The version is 7.2. ARC/INFO is a powerful GIS toolbox that supports the entire spectrum of GIS applications. Arc view version 3.1 has been used to create the GIS. The same software can be used to query the data.

EASI PACE: PCI Inc. is a pioneer in the development of innovative geomatica software systems with capabilities in remote sensing, GIS, terrain analysis, digital photogrammetry, data visualization and image analysis. Over the years, the software has been continually improved to make it easier to use, to adapt it to new developments in computer hardware and peripherals and, most importantly, to add new functions which users are constantly finding they need in their work. The PCI software comprises of more than 500 inbuilt programs. The version used for the project work is 6.2. The major work of the project as been executed using the image works, xpace and gcp works menu. Which perform various image processing work.

Methodology

It has been demonstrated in India and many other countries that remotely sensed data can be used to identify the problem of any area map and monitor the changes on the land surface over a period of time. The detection of abrupt changes is possible using satellite images in many cases where the changes produce an extreme visual contrast between the old and the new. Satellite remote sensing data have been used since 1980 for studying urban growth. In the present study

remote sensing data, obtained from IRS 1D satellite have been used. The various techniques used in the study can be grouped in to remote sensing techniques and GIS techniques.

A brief account of the remote sensing techniques is given below:

Data Loading: From the CDs the digital data has been loaded band wise using EASI/PACE software and is saved on to a file, and the toposheets of the study area is scanned from a A0 scanner and saved as tiff files and exported to EASI PACE software for preprocessing.

Image rectification: Geocoding is processes of taking ground control points on the map and collect more of them and see to it that the RMS error is under the permissible limit. On each of the 10 toposheets an average 14 GCP's per toposheet has been taken to get more accuracy and while mosaicking edge matching using BI-Linear matching algorithm is done. For the satellite data the four scenes were cut in to subsets to the required study area. So that data handling is easy and space occupied by the image could be managed then the three-subset scenes using the geocoded and mosaiced toposheet as reference the satellite images were geocoded scene by scene and then they were mosaiced.

Buffer extraction: The mosaiced toposheet is converted in to a tiff file and exported to ARC/INFO where the buffer of 10 km on either side of the highway road between Bangalore and Mysore is created. The area under this buffer has been considered as the study area. The mosaiced satellite data under the buffer is extracted.

Data enhancement: The mosaiced image's contrast is enhanced to improve the visual interpretability of the image by increasing the apparent distinction between features in a scene. The objective of image enhancement is to manipulate the gray level tones in a monochrome image in order to more effectively display and therefore increase the amount of information that can be visually interpreted from the image.

Supervised classification: The mosaiced image after contrast stretching has been classified using supervised classification. The goal of supervised classification is to use your knowledge of the scene in order to "train" the computer to recognize the spectral signature of each image pixel as belonging to one of a number of learned signatures. There are three basic steps in the supervised approach:

- a) Training,
- b) Classification, and
- c) Post classification analysis and presentation of results.

With the help of toposheet and ground knowledge collected training sites are taken on the mosaiced image. The training sites are taken throughout the image so, that there would be less misclassified pixels. Nearly seventy training sites have been taken. With approximately ten classes for each landuse. In the waterbodies the turbid water bodies, deep-water bodies, shallow water bodies and dry water bodies were taken. In the similar manner trains has been taken for

other landcovers too. Then, the image was classified and MLR program was run to get the statistics of the classified image. The classified raster image has been converted in to a vector layer in GIS environment using a series of steps in EASI/PACE and ARC/INFO.

A brief account of the GIS techniques is given below:

Layer creation: Using the tiff file of mosaiced toposheet as base vector layers of Roads, Railways, Waterbodies, Vegetation, Settlement, Wasteland and Agricultural area are created. From the 1971 town census report the thirteen major towns for which the Urban information system has to be created were drawn on tracing sheets and four points were earmarked on each of the town municipal boundary map for geocoding them. Basically the road crossing and railroad intersections were considered as tic points. These transparencies were scanned as tiff file and then using command tools in Arc/Info the files have been converted to grid file and finally in to line vector layers. These were then geocoded with the help of the already geocoded toposheet. Later these have been clean built as polygons.

Topology creation: The vector layers, which were created in arc mode, are cleaned and built so that topology could be created. Topology is the term used to describe the geometric characteristics of objects, which do not change under transformations such as stretching or bending and are independent of any coordinate system. Topology creates adjacency, containment, and connectivity.

Attribute creation: The attributes to all the vector coverages are given so that they can be distinguished. The road layer is given RDCODE in which 01- highway, 02- Mettalled road, and 03- Unmettalled road, RLCODE for railway and so on.

Landuse layer creation: The waterbody, settlement, wasteland, agriculture, and vegetation layers are given LUCODE's and a new coverage is created in which all these coverage were brought in and saved as a Landuse layer of 1973. The classified image of the satellite data, which was imported to ARC/INFO, is converted to vector. Thus a landuse layer of 1999 is created.

Statistics generation: On both the Landuse layers on the basis of LUCODE's area statistics are generated to show the change in the Landuse from 1970's to 2000. The Landuse maps have been prepared with a purpose to detect change in the study area and try to estimate the urbanism, which has expanded over the decades with a motive to accept the fact that land conversion is an active process which has to be monitored and properly planned towards fostering development of the region as a whole.

Results

A) Changes in Landuse/Landcover

The amount of land utilized by particular functions and their spatial distribution reflect the influence of social and economic systems. Landuse and landcover are two terms, which sound same but have diverse meaning but are always used together. Landuse means the use of land for various places. This has a theoretical approach to it whereas, landcover is the practical reality which can also be called ground reality the actual use which the land is being put to.

With the help of toposheets and field observations the classification was done using training sites identified in the toposheet and recently done field checks. Throughout the satellite image training sites were taken.

There is noticeable variation in the two-timeperiod landuses. Definitely time has played its part in causing changes with the aids of science and technology developing and spreading at a very fast pace in this region. As, the satellite data has helped in doing detailed classification compared to toposheet the different classes have been amalgamated and their total area is compared with the toposheet area.

The increase in the built-up area is remarkable from 4.95% in 1970's it has increased to 11.37%. In the 70's the agricultural area, which included the fallow land, plantation, weeds totally accounted for the highest proportion of land area occupying 82.5% area but in the 1999 the cropped area has shrunk to 11.95%. As the fallow area, plantation, grasslands is considered a part of the agricultural land the total adds up to 59.09%. There is a decrease of 23.41% area in the agricultural land which can be amalgamated to the reasons of population increase, growing number of agro- based industries increasing number of settlements. On the other hand a positive increase in forestland can be seen. There is an increase from 7.93% to 12.46%. There is decrease in waterbodies from 3.39% to less than a percent. A devastating detail is the rapid increase in wasteland, which was, has doubled though some of these areas are being reclaimed to protective forests. But, the piecemeal measures by the government machinery are not good enough.

The scarcity of water is quite acute in the urban areas due to precarious position of the reservoirs. The people in urban areas are facing high amount of problems especially this year the situation was worst as many interior parts of this region faced moderate drought conditions.

The increase in the urban stretch is a clear indicator of a fact that the theory of sustenance by Malthus stating that the population of a region do not expand they are limited by natural resources does not hold well. It is a noticeable fact that the living conditions are expensive, which include the bare essentials like food and shelter even then people motivated by the thought of better education, good jobs, speculative thought are moving in to overcrowded cities like Bangalore, Mandya and Mysore. This has given a feature to the planning community known as sprawl or spread of the urban area in to the rural area. The transformation of the fringe area in to predominantly urban mostly along the roads is noticeable change. This has lead to the development of high-class residential areas like Indiranagar, in Bangalore City. The development of exclusively industrial town like Bidadi is also noticed.

The urban area has not just expanded it has expanded at the cost of other land uses. The 13 major towns of the study area have engulfed about 196.19 square kilometer of agricultural area.

The steady growth in various factories based on Motorvehicles, Information technology, Computers, specialized services of quaternary and quinnenary nature have risen to a great extent providing exclusive and highly specialized nature of services. Leading to special type of employment recruitment and also socio- cultural services to patronize such people which include high profile clubs, bar and restaurant, discotheques, restaurants specializing in foreign delicacies, special dress boutiques, makeup shops, sports complexes, malls, massage parlors etc.

B) Results from Spatial Theories

The application of three spatial theories has been done to understand the changes happening in the study region with the sole purpose of determining whether the urban development is a amalgamating process imbibing all the major cities and towns in to a continuous chain of urban corridor. The theory application to the study area and the outcome are as follows:

i) Growth Pole Theory

The theory speaks of growth occurring as discontinuous spurts which means that growth does not occur only at the center of any important unit but can sprawl over to distinct locations leading to a sprinkled effect leading to several growth points to occur. This aspect can be proven with respect to Bangalore and Mysore cities.

Bangalore City has various types of growth poles, which can be classed, as Markets, Commercial centers, Industries, Educational centers, Socio-Economic precursors.

- Markets: Sri Krishnarajendra Market, Malleshwaram, Sheshadripuram, Wilson garden, Visveswarapuram, Magadi road, Chamrajpet, Gandhinagar, Russell, Ulsoor, Murphytown, Coxtown, etc.,
- Commercial centers: Gandhi bazaar, M.G. road, Brigade road, Commercial street, Avenue road, B.V.K Iyengar road, Basvangudi etc.,
- Industries: IT park (Hoskote), Toyota industry (Bidadi township), Electronic City (Kormangla), Bharat heavy electricals limited (Yashwanthpur), Bharat electronics limited (Mathikere), Hindustan Aeronautical Limited (Indiranagar) etc.,
- Educational centers: Bangalore University and R.V Engineering college (Kengeri satellite town)
- Socio-Economic precursors: Hospitals (Mallya, Victoria, Vanivilas, Minto, Bowring, Wockhardt), Religion (Mohammedan block at Banashankari, Anglo-Indians at Austin town, Punjabi's at Sindhi colony Brahmins at Rajajinagar)

Mysore City is also having various growth foci's like Bangalore City. The city's main attraction is the city palace built 400 years back. The Manasgangothri university know for its post graduate education and the Regional Engineering college for its professional education. The commercial areas like Jaynagar.

All these five major growth propulsion units branch out in to many growth poles inducing growth and change as stated at the very beginning of this chapter. The Theory of inter-industry linkages and Industrial interdependence

maintains that growth occurs only at points and spreads along diverse channel with varying terminal effects to the whole economy. This is a phenomenon, which is noticeable clearly along the highway roadline between the two main cities. Any inception of new technology or other cultural fervors like variety stores, cyber cafes, special type of industry, education, fashion, trend always spreads through the path of communication may be road or rail. People coming in contact through lines of communication leads to spread of goods and services with its technology and potential leading to growth of all the places which come along its way. As Bangalore and Mysore are chief cities attracting everything good and bad are passed to the other less propulsive towns and cities through these cities.

The industrial growth is a factor, which has caused the change in the workers ratio, which was basically agrarian to industrial with the increase in their number the towns have also expanded.

The inputs of growth is transferred from a higher order town to lower order town in a systematic manner leading to these receiving towns growth and providing it an opportunity to break the shackles of ignorance. Through this process the intermediate points between growth focal points grow and prosper and through the focal points the minor centers depending on them grow.

The increase in population can be attributed to natural increase of population and urban to urban, suburban to urban, rural to urban migration due to industrialization, job opportunities. The industries and other urban growth poles are luring the people from surrounding areas to move in to the big cities at nodes of employment such as the growth precursors stated before.

ii) Gravity Potential Model

The movement of people along the lines of communication is considered as the parameter proving the power to attract or repel the flow of people. Weekly there are 32 trains moving towards Mysore if on an average 800 people are carried to Mysore then in a week 25600 people travel towards Mysore. Whereas, there are 50 trains coming toward Bangalore every week then, on the same scale on an average 40000 people are migrating towards Bangalore. This simple statistics shows there is a bond of steady transit between these two cities.

Workers, students, and businessmen commuting from Mysore to Bangalore or vice versa usually use the daily trains. There is also a part of tourists who commute through the trains to and fro.

$$G_{ij} = K \frac{P_i P_j}{d_{ij}^2}$$

Where G_{ij} represents the gravitational force between centers i and j , P_i and P_j represent the population travelling of the centers i (Mysore) and j (Bangalore), d_{ij} is the distance between them, and K is a constant.

$$G_{ij} = \frac{25600 * 40000}{(157)^2} = 41543.26$$

The gravitational flow between the cities Bangalore and Mysore is 41544 (approx.) people weekly. The buses plying between this area are very high compared to the train services. The bus service details are daily figures. The details are given in *Table 6.8*.

The seating per bus is 52 people. The detail mentioned above is for every 24 hours. The people traveling from Bangalore to Mysore via Mandya are 4316 and the people traveling from Mysore to Bangalore via Mandya are 4524.

$$G_{ij} = K \frac{P_i P_j}{d_{ij}^2}$$

(4316)(4524)

$$G_{ij} = 1 \quad (150)^2 \quad = 867.80$$

The gravitational flow between the cities Bangalore and Mysore via Mandya is 867 (approx.) people daily.

The gravitational pull of the two roads leading to Mysore from Bangalore can be observed clearly by the population flow between these two cities. The figures are as follows:

- Bangalore to Mysore via Mandya = 6656 persons
- Mysore to Bangalore via Mandya = 7072 persons
- Bangalore to Mysore via Kanakapura and Malavalli = 312
- Mysore to Bangalore via Kanakapura and Malavalli = 312

On the Bangalore to Mysore via Mandya and Bangalore to Mysore via Mandya 13728 persons daily commute.

On the Bangalore to Mysore via Kanakapura and Malavalli and Mysore to Bangalore via Kanakapura and Malavalli 624 persons daily commute.

There is no need to apply the gravity potential model to know which route is carrying more traffic and which route has more change of improving and foster towards urbanization. It is quite evident that the Bangalore to Mysore route via Mandya is carrying a huge traffic of more than 23000 people everyday. The figure mentioned here includes only

the Government Buses and Trains. Besides these modes of transportation there are so many people whom commute through private cars, motor vehicles and other means of transportation on a daily basis. A region which is supporting movement of such a huge amount of population with good transport and communication network and becoming more and more urbanized with good infrastructure is definitely enroad to a continuous stretch of urban region known as Megalopolis.

iii) Haggerstrand's Diffusion Model

Diffusion is the process of spread of movement of a phenomenon over space and through time by innovations, which are successful introduction of ideas perceived as new in to a given social economic system. Haggerstrand maintained that by analyzing short distance migration and telephone calls one could find the probability of information being transmitted from an adopter to potential adopter. What Haggerstrand has tried to state is that personal details can prove important when the diffusion of information has to be understood.

The telephone connections of 13 major towns of the study area and their annual increase in numbers are listed below to notice the increase in their number, which helps in diffusion of information. This information is just to show the telephone lines, which have increased for some of the major towns. There are more than 160614 telephone connections in an area of 4582.32 square kilometers. Here, the statistics of only 13 towns have been enlisted if all the telephone lines in each and every settlement are accounted for then it will be an enormously huge number stating the fact that this type of communication system is enroute to better diffusion of knowledge and technology leading to an closely linked and transponding environment living in close contact and depending and supporting each other.

C) Extent of Megalopolis Formation between Mysore and Bangalore cities

A Megalopolis has various salient features and characteristics, which have been dealt in great details in the third chapter. The average density of a Megalopolis should be more than 250 person's per square kilometer. In the study area the average density is much much more. The average density of population for the whole of study area is more than 1517 persons per square kilometer. If population is the only parameter then the region can be called a Megalopolis. The total area of Karnataka is 3200000.9 square kilometers and total population is 30774988. Of this the study area constitute a meager 0.143% of the total area and is supporting more than 22.58% population of the state. Jean Gottmen said that if a region contains 15 percent to 40 percent of the population on less than 5 percent of the total area. Then it is the general pattern that leads in the more extreme and larger cases of Megalopolitan formation. So, with this norm it is hence, proved that the Bangalore Mysore highway with its surrounding area is enroute to become a Megalopolis engulfing more and more area and in the process developing in to a very highly urbanized economy.

Conclusion

The greatest hindrance to the progress of any society, individually or collectively, has not been ignorance, but an adamant refusal to face realities, discard the 'status quo' attitude and learn from experience. Apart from direct benefits, space technology has clearly demonstrated the inter-connectivity of both natural and anthropogenic phenomena occurring anywhere on earth. The solution to provide food security and meet the growing demands of increasing population with limited land resources, lies in the adoption of a holistic approach for achieving environment friendly, development. The change in any environment titillating its general level of equilibrium will do more harms than good. The Bangalore – Mysore highway corridor has shown the growth of urban legions far beyond the thought of any person in this region 20 years back. This growth may have helped the economic sector of this region but it is harming the environment, which is a big price to pay for urbanization.