Geoinformatics Application for Urban Utilities Information System: A Case Study of Pune City, Maharashtra, India

Sagar Mali
Dept. of Geography,
Shivaji University,
Kolhapur, India

Santosh Bhailume
Dept. of Geography,
KVN Naik College
Nashik, India

Sandipan Das
Symbiosis Institute of
GeoInformatics,
Pune, India

ABSTRACT

Indian cities are experiencing an increasing use of utilities. As a matter of fact there is a wide gap between the utility availability and need for the utilities, which is reportedly due to the perennial influx of rural population to urban center. As a result the existing infrastructure gets burdened. Pune Municipal Corporation (PMC) in India, growing at a very fast rate, acquired a complex urban structure over the years. The central part or the core has gone through unusual changes in terms of social and physical transformations. Geographical Information system (GIS) is one of the most efficient ways to get the hypothetical view of any object or phenomena on the earth's surface similar to the actual situation. Remote sensing (RS) technique is an effective tool for identifying the urban growth pattern from the spatial and temporal data. Here an attempt has been made to understand the urban infrastructure using GIS and Remote Sensing. The precise aim of this present study is to find out the pattern of utilities and which reason is responsible for lack of utilities and with the help of Remote Sensing, GPS and GIS to suggest a solution and how to manage utilities for the increasing population. The satellite data and Survey of India (SOI) toposheets were used to map the utilities of Pune Municipal Corporation (PMC). Ward wise population and data like Ambulance, Blood Bank, Education Sector, Hospital, and road network data were collected and analyzed in order to identify areas high amenities and areas lacking in amenities. Urban growth has transformed most of the agricultural land of PMC into industrial, commercial and residential area

KEYWORDS

GIS, GPS, Remote sensing, Geoinformatics, Urban Utility mapping.

1. INTRODUCTION

Urbanization is the processes through which the forests, fertile agricultural lands, surface water bodies are being irretrievably lost, (S. K. Pathan 1989, 1991). In India the percentage of people living in cities and urban area almost doubled to 27.78% in year 2001, was low when compared to developed countries. This kind of uncontrolled, haphazard, low density settlements will be lead to urban sprawl (J. Anthony Vinothkumar 2005). The traditional role of Municipal Corporation had been one of providing basic utilities of civil life for their well being and happy social life. Services such as water supply and sanitation, roads and drains, street lights, collection and disposal of solid waste material and sewerage disposal network maintenance of public places, registration of births and deaths, maintenance of markets have long been seen as the function of the Municipal Corporation. In addition, they performed certain regulatory functions relating construction of buildings, public areas and commercial places for public well-being like banks, ATM centers, fire stations, ambulance, school and colleges, hospitals and blood banks, police station and shopping malls, entertainment locations establishments in a proper place in the city. In the urban areas due to uncontrolled urbanization has been responsible for many of the problems, like vertical and horizontal urban growth, high land cost, acute problems of drinking water, noise and air pollution, disposal of waste, traffic congestion etc.

The PMC (Pune Municipal Corporation) developed mainly due to the rapid growth in the information technology sector, industrial, people migrating from rural area to Pune city e.g. Solapur, Nagar Nashik, Osmanabad etc. Pune district has a growth rate of 38.58 %, while the state is experiencing the growth rate of 22.5 %. Therefore it is necessary to add the past and present growth trends of these rapidly growing cities, for effective urban management (S. Shekhar 2005). In order to prepare a development plan for utility planning of a city, there is a need of good and reliable information regarding the location of existing facilities, their accessibility, adequacy and development trends in relation to the socioeconomic structure of the city. The significance of the present study is to represent various kinds of utility services like blood banks, hospitals and ambulance services, school and colleges, in the Pune Municipal Corporation for providing better facilities to the civilians.

Advancement of information technology has provided wide arrays of new digital tools that can support the generic activity of geographical analysis and urban model. The modern technology of remote sensing which includes both aerial as well as satellite based systems, allow us to collect lots of physical data rather easily, with speed and on a repetitive basis, and together with GIS helps us to analyze the data spatially, offering possibilities of generating various options (modeling), thereby optimizing the whole planning process.

This study will aid management to town planning schemes, urban and estate management and property tax- related matters. It will also help in the better transport management of the city. The urban resource information system is a step towards it useful during emergency services like since all information is brought around the hot spots with the click of a button. Utility centers will be provided with better facility to civilians and study will provide potential locations for establishments of new service centers for reducing the stress on the particular service center place.

2. AIMS & OBJECTIVES

The aim of the research is to study the present various utility services in the city by using Geoinformatic techniques. Following are some objectives have been used during the research.

1. To access the demographic profile of PMC.
2. To access the land use and land cover Map of PMC using satellite imagery
3. Delineate service areas of public/private health services using network analysis in a vector modeling environment in GIS.

3. STUDY AREA

Pune city lies between 18° 25' to 18° 37' North latitude and 73° 44' to 73° 57' East longitude. The study area shown in figure 1 covers 229.42 sq. km composed of 144 general electoral wards according to 2007 which comes under 14 administrative wards of Pune Municipal Corporation.

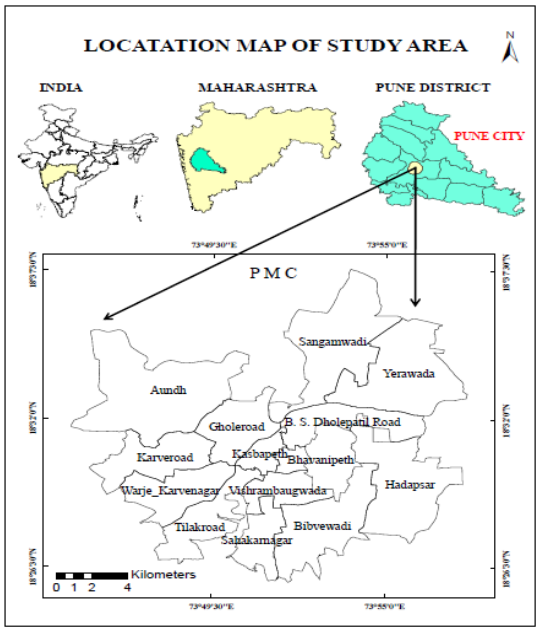

Figure 1: Location Map of Study Area

The city is located in saucer shaped basin at an average altitude of 560 m. from mean sea level. The area is surrounded by Sahyadri hills which extend mostly from west to east. Pune is located on bank of rivers Mula and Mutha on Deccan plateau.

4. DATABASE AND METHODOLOGY

The data was collected from various sources as shown in table 1. The SOI toposheets were subjected to georeferencing in arcgis 9.1 software using 12 well distributed ground control points in 3rd polynomial order. The resampled image was given projection with WGS 84, 43 North Zone. The IRS P6 LISS IV satellite imagery of same area was georefranced using the reprojected toposheets. 15 well distributed ground control points were used in geofererencing satellite image and RMS error was kept below 0.5.

The attribute data for utility features were arranged in excel database with unique ID. GPS and Google Earth were used for collecting geographical location points of various utility features. The Excel file created for different service areas with latitude and longitude and different fields, were displayed as a point layer. The non spatial data of were then attached to spatial data of utility services in a GIS environment. The road network was generated from toposheets of Pune election ward wise city map. The methodology flowchart is given in figure 2.

Table 2: Data details of the Area

Segment	Data Name	Source
Spatial data	1. Map of the Pune city 2. Toposheet	Pune Municipal corporation Scale : 1:25,000
	3. Satellite Imagery–LISS-IV Dated: 13 April 2004 Path: 202 Row: 111	National Remote Sensing agency (NRSA), Hyderabad
Non-Spatial data	Hospitals data	Pune Municipal Corporation, Indian Medical Association, Indiacom Yellow Pages
	Population data	Census year book 2001

4.1 GENERATION OF HOSPITAL UTILITY DATABASE

The hospital facility in Pune city plays major role in public utility. Not only in peoples in Pune city but also from all parts of the India peoples come in Pune for taking medical facility. Pune has many hospitals with all modern medical instruments and technology. In present we consider only the medical services (hospitals). At a present PMC categorized in 14 administrative wards are having no. of 341 Hospitals in PMC. Govt. added hospitals and medical colleges with hospitals, Blood banks, Ambulances. But there are concentrated in core areas. As urban built-up expands all around peripheral areas of the city. There newly added PMC areas lacks special and super specialty hospitals. Here Table 2 show number of hospitals in various administrative wards. In the present study with the help of GIS one can easily approach any kind of medical information such as nearest Blood bank, Ambulance and hospital providing at glance information such as hospital location, etc. and as well as we can see the nearest place of such kinds of facilities using map of spatial analysis

5. RESULT AND DISCUSSION

5.1 Land use / Land cover Map

Land use – Land cover map shows the distribution of study area (figure 3 & 4) in various purposes like built-up, hills, vegetation, water bodies, fallow land and barren land etc. Remote sensing technology plays important roles for land use mapping and the trend of their changes over time of period. The land use/ Land cover mapping was done using high

resolution IRS P6 LISS IV imagery acquired on August 2009. The study area was divided in six major classes as shown in table 3:

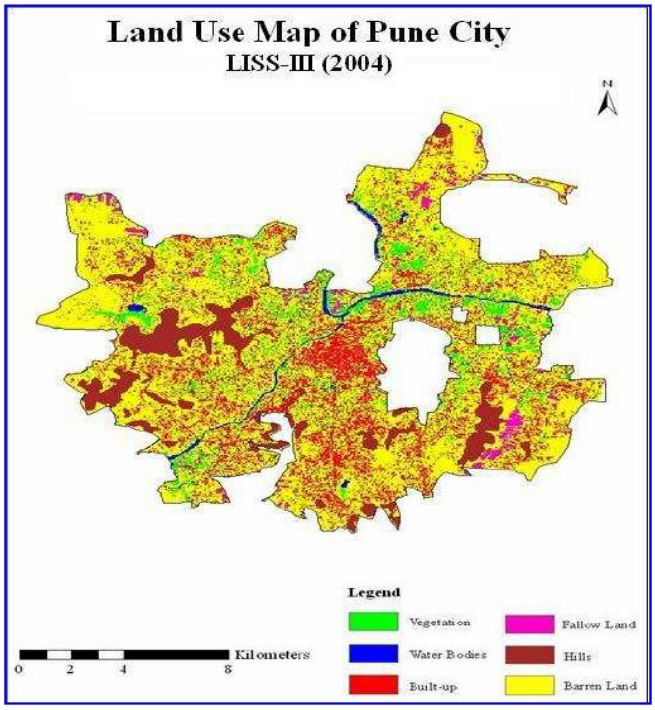

Figure 3: Land use map of Pune City using LISS-III

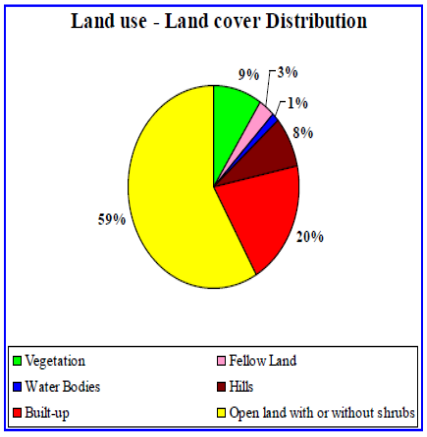

Figure 4: Land use-land cover distribution

5.2 Generation of Road Network Map

Road network map of the city is important for taking benefits from various utility services like bank, ATM, school-colleges and hospitals etc. The figure 5 shows the ward wise road network of the Pune city. It is useful for establishment of utility centers. In Pune city road network is very well connected and mainly concentrated at the city center part.

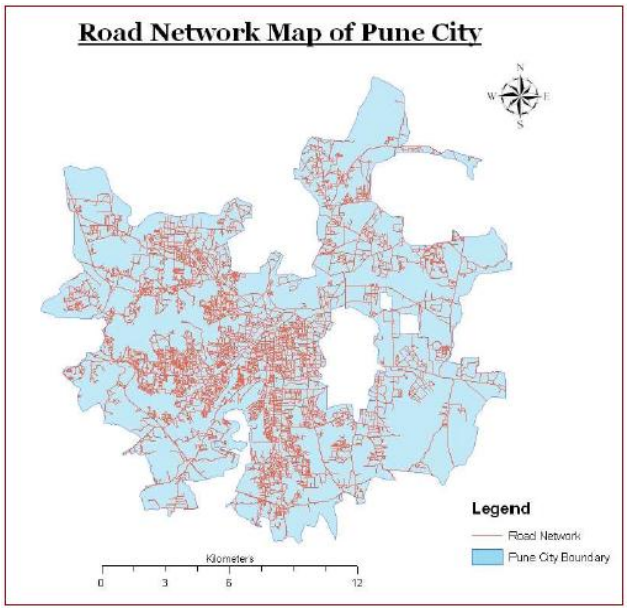

Figure 5: Road network map of Pune city

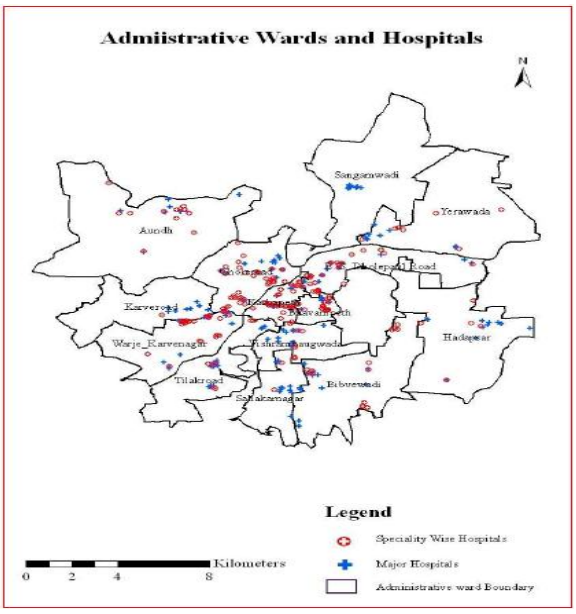

Figure 6: Administrative wardwise hospitals

5.3 Utility Map of Ambulance, Blood bank & Medical Colleges

Ambulance and blood bank handle a key role for providing urban utilities in health sector. The figure 6 shows the wardwise hospitals distribution and figure 7 shows the spatial distribution of ambulance, blood banks and medical colleges. The Blood banks are mainly concentrated near to the hospital and central part of the city. There is need of new blood banks and ambulance centers establishment in outer peripheral parts of the city for well being of civilians. Medical colleges also established near to the Hospitals and central part of the city. In future city peripheral area needed establishments of number of medical colleges and centers for provide better health facility to city civilians.

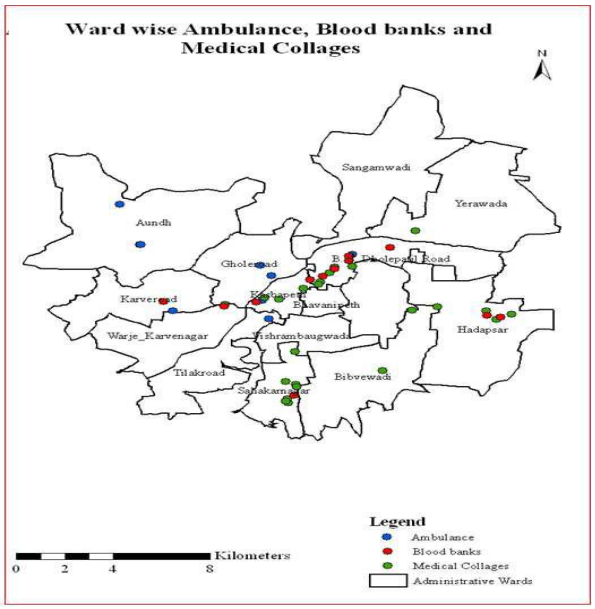

Figure 7: Ambulance, blood bank & colleges

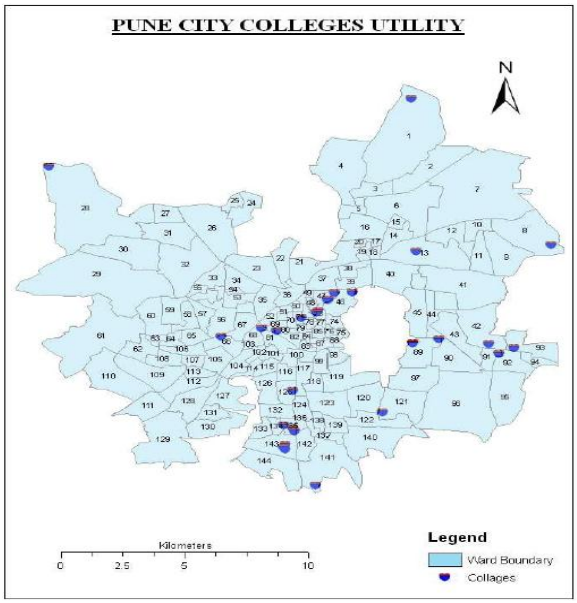

Figure 8: Utility map of colleges

5.4 Utility Mapping of Colleges

Urban area are always famous for their good and advance education facilities. Some cities are famous for only high and standard quality of education, Ex: Oxford, Allahabad and Pune etc. Pune is one of the famous cities for good quality of education and education centers. Large number of colleges and schools are giving standard Quality of specialized educations. So many students from India and outside of the India come to Pune for only getting good education for good professional careers so Pune is a "Educational City". In the given figure 8 college utility map shows the spatial distribution of colleges in the Pune city. Maximum colleges found at central and South part of the Pune and needed some more colleges establishment in the south north peripheral part of Pune city.

5.5 Population Distribution & Density Map:

Population is important element affecting utility distribution and establishment of new utilities or service centers. Population is not evenly distributed in the entire city. The following population distribution and population density map (figures 9 and 10) shows overall distribution of population and population density among the city.

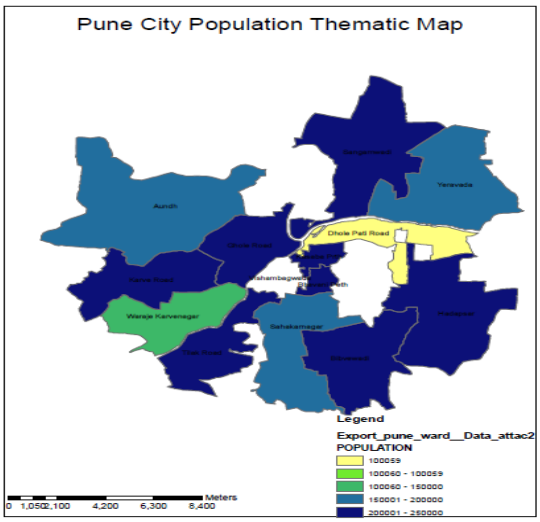

Figure 9: Population distribution map

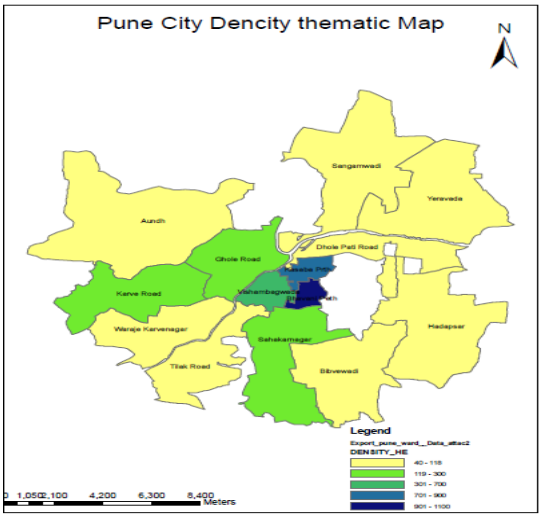

Figure 10: Population density map

Above map (figure 9) shows the more population are concentrated in the outer part of the city, but here outer side ward is big than central part so we feel more population is in peripheral part and that's why we need to study population density map of the city. Population density map shows number of population in Sq.Km area. The population density map shows more population lies in central part of the city and less in the peripheral area. City center have more population in less area and vice versa.

5.6 Euclidean Distance of Ambulance Services:

The euclidean distance tool measures straight-line distance from each cell to the closest source. By calculating the straight line (euclidean) distance, you can determine how far

each cell is from the nearest source. In the present ambulance service of the pune city is showing the ambulance service distributaion is good over the city (figure 11). The eastern side of Pune city needs more ambulance service centers and hospitals.

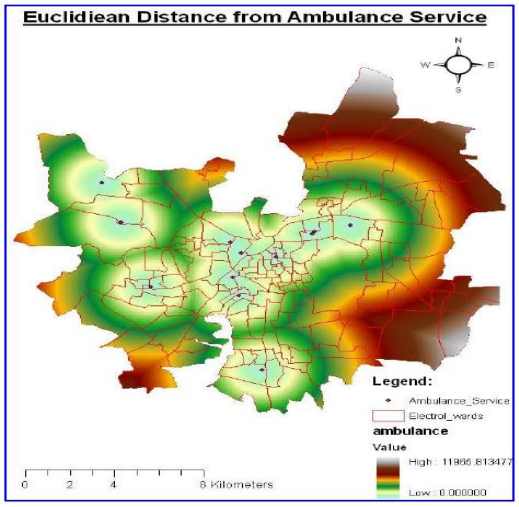

Figure 11: Euclidean distance of Ambulance services

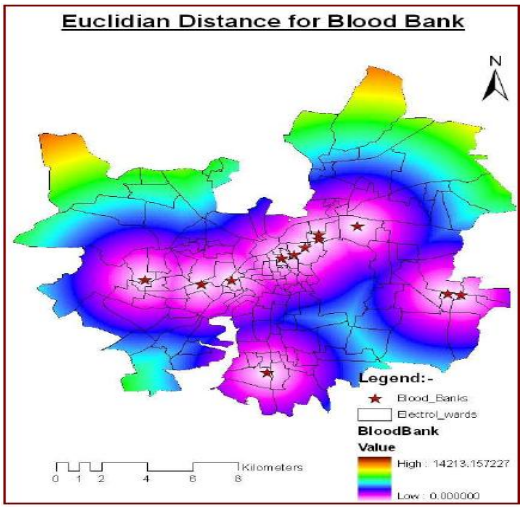

Figure 12: Euclidean distance of blood bank services

5.7 Euclidean Distance of Blood Bank:

In Pune city there are mainly 12 major blood banks and they are mostly concentrated near hospital which is central part of the city as shown in figure 13. The outer parts of the city have less blood banks and hospitals. City periphery required more hospitals and blood banks because horizontal growth of the city is increasing.

5.8 Euclidean Distance of Hospitals & Colleges:

In the given figure 13 and 14 major hospitals and colleges are shown. The map shows that major hospitals and colleges are located in core part of city because of the population highy concentrate in core part of city. The core part of city represents Pimpri, Chinchwad, Bhosari and Nigdi. The population is increasing very fastly all over city so pmc need to provide hospital facility all over the region .

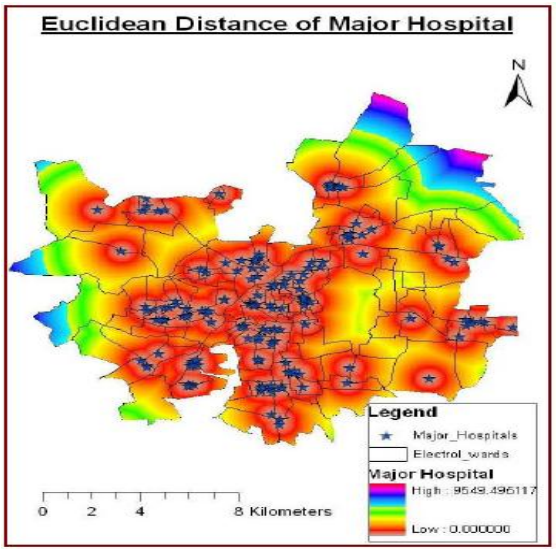

Figure 13: Euclidean distance of Major Hospital

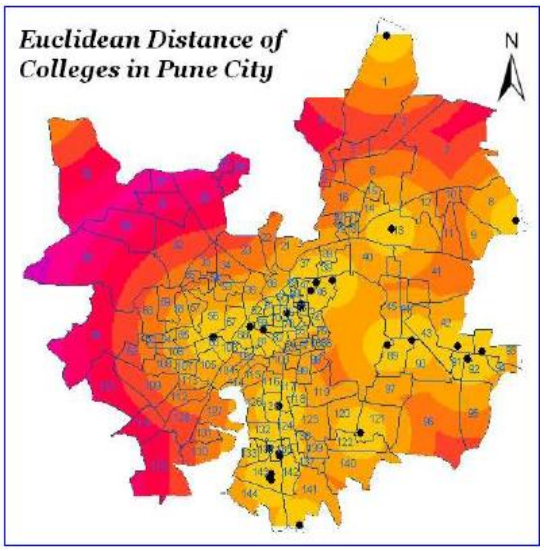

Figure 14: Euclidean distance of Colleges

6. Conclusion

In the present day scenario, cities are increasing in vary rapid rate and needed to develop various urban utilities for fulfill the urban need. In this context, urban development monitoring, urban sprawl monitoring and utility mapping are necessary to make effective policy for development of unplanned areas. The momentum of urban growth has out-paced the traditional techniques of surveying and mapping. Remote Sensing techniques and GIS tools have become important in management of urban environment. Remote Sensing and GIS tools have been an effective technology for the urban growth monitoring and utility mapping, utility information, 3D model of city and network analysis. In Pune city rate of vertical and horizontal growth of the city is increasing very rapidly. Vertical growth of city is more in central part of the city and horizontal growth is in city

periphery. Maximum city density is in central part due to vertical growth of city and density decreasing towards to outer part of the city. Urban utility map shows the distribution of various utilities among study area. Urban utility facility like: Colleges, Ambulance, Hospitals are mainly concentrated at city center or core part of city, now need to be the decentralizations of these utilities for fulfill civilian utility demand of city peripheral areas. Land Use / Land Cover map show the distributions of city land in various classes for change detection analysis, city planning and establishments of new city services and utility centers. As compare to the present and future population of the city there is need to establishment of more public utility centers in the various part of the city. City peripheral part required more service and utility center than central part.

7. References

[1] Burrough, P. A., 1986, Principles of Geographical Information Systems for Land Resources

[2] Assessment (Oxford: Clarendon Press).

[3] Delaney B., (2000), Visualization in urban planning: they didn't build LA in a day, IEEE Computer Graphics and Applications, May/June 2000, pp.10-16.

[4] Dickinson R.E., 1959: The scope and status of urban geography: an assessment, in Mayer, H.M. and Kohn, C.F. eds., Readings in Urban Geography, The University of Chicago Press, Chicago, pp.10-26.

[5] More R. & Hulsure C. (2009), Utility Information System of Aurangabad Municipal Corporation Using GIs and RS Technology", Project Submitted to University of Pune.

[6] Mali Sagar P. (2008), "Urban Utility Information System Using Digital Photogrammetry & GIS Technology", Project Submitted to University of Pune.

[7] Pathan, S. K., P. Jothimani, et al. (1989). "Urban land use mapping and zoning of Mombay Metropolitan region using remote sensing data. ." Journal of Indian Society of Remote Sensing, Vol. 17, pp 11-22.

[8] Pathan, S. K., V. K. Shukla, et al. (1991). "Urban land use mapping-a Case study of Ahmedabad city and its environs." Journal of Indian Society of Remote Sensing, vol.19, pp 95-112.

[9] Shekhar S. (2005), Monitoring urban sprawl of Pune by using Remote sensing And GIS techniques" Ph.D thesis submitted to University of Pune

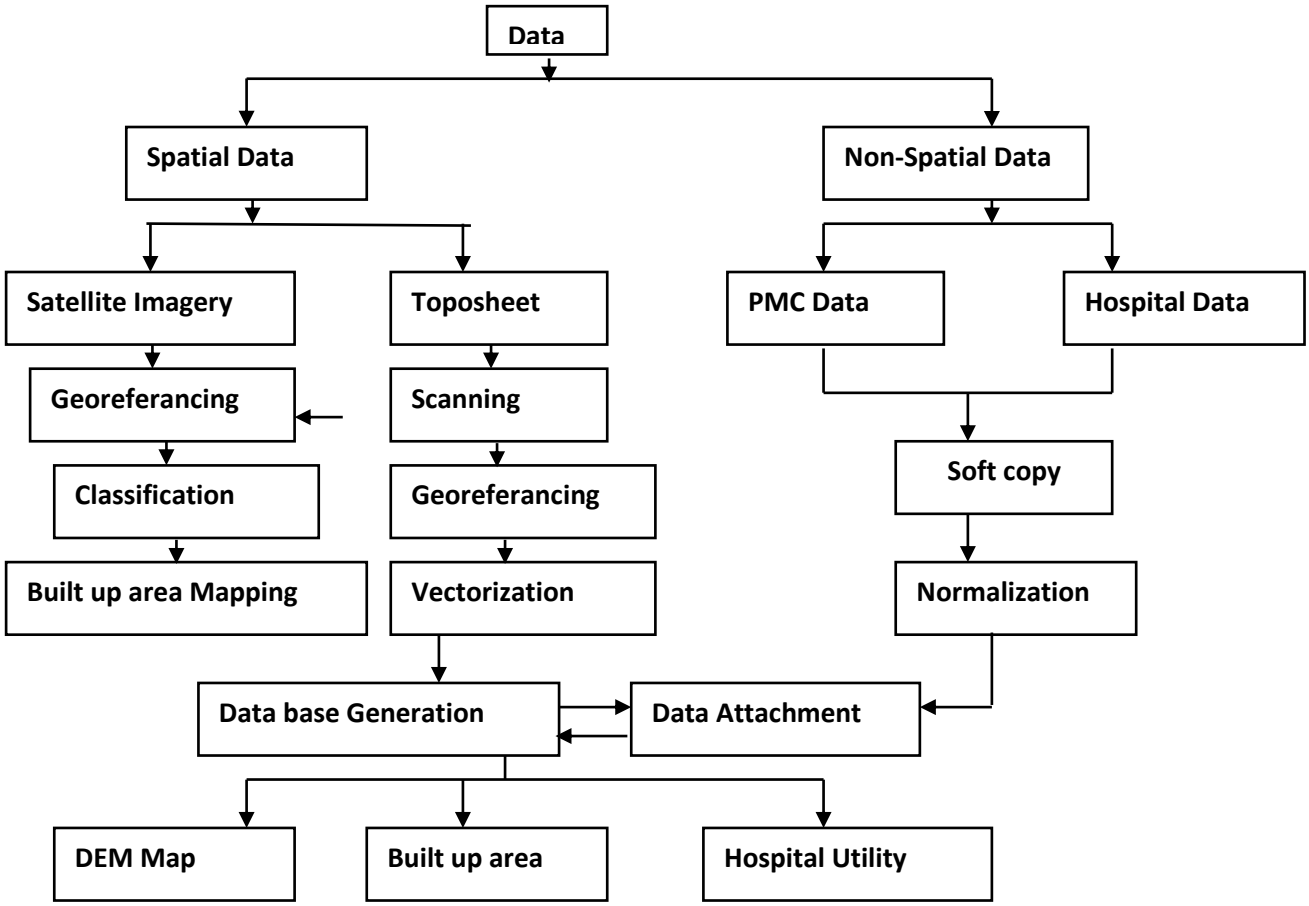

Figure 2: Flowchart Methodology

Table 2: Administrative ward wise Hospital Distribution

Administrative ward wise Built-up and No of Hospitals Distribution					
Sr. No.	**Administrative Wards**	**Total Area in %**	**Built-up Area in %**	**No.of Hospitals**	**% of Hospitals**
1	Aundh	17.77	11	20	6
2	Karveroad	6.76	6	9	3
3	Gholeroad	5.95	6	51	15
4	Warje Karvenagar	6.46	7	39	11
5	B.S.Dholepatil Road	5.74	6	32	9
6	Hadapsar	11.62	10	15	4
7	Yerawada	7.07	6	16	5
8	Sangamwadi	11.56	7	10	3
9	Bhavanipeth	1.22	4	25	7
10	Kasbapeth	2.00	5	44	13
11	Vishrambaugwada	3.75	6	22	6
12	Tilakroad	6.18	7	19	6
13	Bibvewadi	9.89	13	25	7
14	Sahakarnagar	4.01	6	14	4
	Total Area	**100.00**	**100**	**341**	**100**

Table 3: Land use / Land cover distribution

Classes	**Area in sq. km.**	**Area in Percentage**
Vegetation	21.20	9.24
Fallow Land	6.86	2.99
Water Bodies	3.03	1.32
Hills	18.82	8.20
Built-up	45.51	19.84
Open land with or without shrubs	134.00	58.41
Total	229.43	100