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Research Article

LAND USE/LAND COVER CHANGES THROUGH THE APPLICATIONS OF GIS AND REMOTE SENSING AND THE IMPLICATIONS ON SUSTAINABLE LAND MANAGEMENT

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ABSTRACT
Urban land use is a dynamic phenomenon, changing with time and space. The information on existing land use and its periodic change is useful for urban planners. Land use and land cover changes in Visakhapatnam city over a period of 70 years were studied using Remote Sensing data. Multi temporal satellite data and GIS provide the potential for mapping and monitoring of urban land use changes. Land use and Land cover maps of Visakhapatnam city for various temporal periods, starting from 1941 to 2009 were prepared using topographical maps of Survey of India and updated by satellite data of IRS-1D LISS-III of 2003 and Cartosat-I satellite data of 2009. These maps were interpreted and land use and land cover changes were identified. Replacement of many agricultural villages by the establishment of steel plant in 1991 and replacement of fishing villages by Gangavaram port in 2005 are the important land use changes in the study area. Reclamation of tidal swamp for port based industries is the major land use change.

Key Words: *Land Use, Remote Sensing, GIS and Visakhapatnam City*

STUDY AREA
The present study (*Figure* 1) is an attempt to assess the Land Use and Land Cover (LULC) changes in Visakhapatnam city, over a period of 70 years. Visakhapatnam, a port city on the east coast of India is strategically located midway between Kolkata and Chennai and situated between $17^0$37’30” & $17^0$45’00" N lat. and $83^0$07’30” & $83^0$22’30” E long. The Government of Andhra Pradesh has reconstituted the municipal corporation of Visakhapatnam in the year 2005 by extending its jurisdiction by merging the adjoining municipality and 32 villages. The reconstituted Greater Visakhapatnam Municipal Corporation (GVMC) has an area of 540 sq.km with a population of more than 4 million. It is ranked as the second largest urban agglomeration in Andhra Pradesh.

INTRODUCTION
LULC is perhaps the most prominent form of global environmental change since it occurs at spatial and temporal scales. The change in the land use in cities is the result of urbanization and at the same time it is the cause of number of environmental problems. Most of the metropolitan areas face the growing problems of urban sprawl, loss of natural vegetation and open space. Cities have changed from small isolated population centers to large inter connected economic, physical and environmental agglomerations. The process of urbanization often leads to haphazard growth in metropolitan cities, deterioration in living conditions and worsening of environmental scenario. It is, therefore, desirable to plan for the city and its peripheral areas in an integrated manner (Pahan et al, 1991). The United States Geological Survey’s project on Urban Dynamics Research (UDR) studies the landscape transformations that result from the growth of metropolitan region over time. An understanding of the growth dynamics of urban agglomeration and land use changes is essential for ecologically feasible developmental planning. Thus there is an obvious need for continuous monitoring of the phenomena of growth and mapping and analyzing LULC changes.

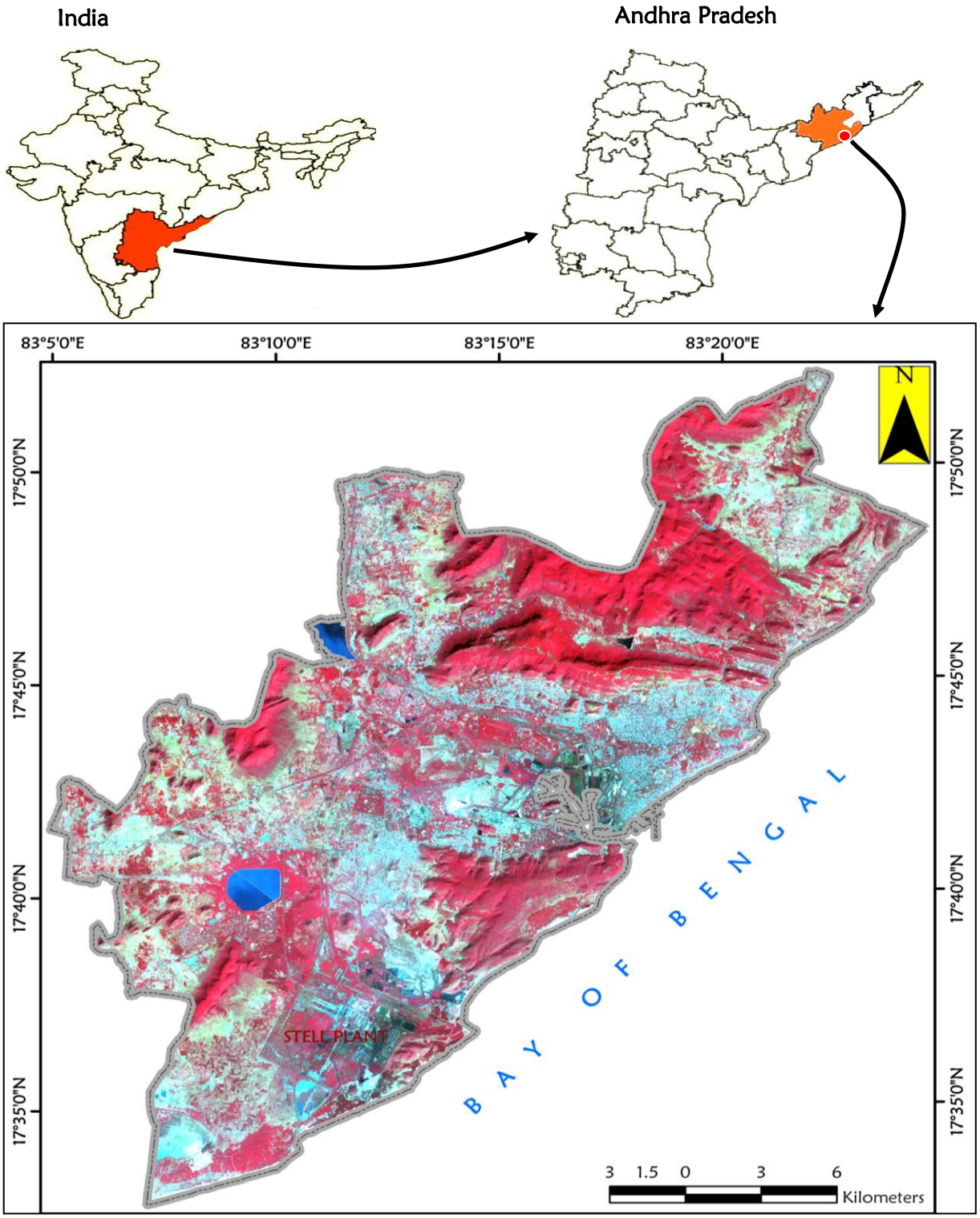

***Figure* 1: Location Map of Study Area (Greater Visakhapatnam)**

The inventory of urban changes is required not only to have up-date information of existing land use but also to record the recent improvements as well as to monitor the changes that are constantly occurring in different parts of the town (Jain et al, 1991). It is expected that million hectares of productive agriculture land in the urban peripheral regions will be lost due to urbanization and urban sprawl. Thus it is important to plan and control the urbanization process in a systematic way that would give the people maximum benefits (Pathan et al, 1992). The development of spatial data infrastructure is a key to sustainable land development (Madan Mohan, 2005). Information on exiting LULC, its spatial distribution and change are essential prerequisite for planning (Jaiswal et al, 1999). Remote Sensing and GIS technologies now provided the potential for mapping and monitoring the spatial extent of the built environment and the associated urban land use changes. Chauhan and Shailesh Nayak (2005) have analyzed LULC changes in Hazira area near Surat, Gujarat using IRS-LISS-III data. Urban land use mapping of greater Bombay was carried out using Land Sat TM data by Pathan et al, 1989. The main objective of land use analysis is to provide a balanced pattern of land use for the people.

MATERIALS AND METHODS:

The study is based on the following primary and secondary sources of data.

1. Survey of India topographical maps
   a. 65O/2 & O/3 & O/6 of 1941 of 1941 (Scale 1:63,360)
   b. 65O/5/SW, 65O/5/SE, 65O/6/NW, 65O/2/NE, 65O/1/SE of 1975 (Scale 1:25,000)
   c. 65O/5/SW, 65O/5/SE, 65O/6/NW, 65O/2/NE, 65O/1/SE of 1995 (Scale 1:25,000)
2. Remote Sensing Satellite data
   a. IRS-1D (PAN+LISS-III) satellite data of March, 2003
   b. IRS-P5 (Cartosat-1) satellite data of Feb, 2009
3. Secondary data obtained from
   a. Visakhapatnam Urban Development Authority
   b. Visakhapatnam Municipal Corporation

Various software techniques and methodologies were used to analyze both vector and raster data sets. GPS techniques were used to ground control points, ground truth and demarcation of boundaries. Arc Info, Arc View 3.2a, Arc GIS were used to vector data modeling, editing and analysis. Arc View-3.2a projection utility wizard has been used to measure and obtain the area, perimeter statistics of the polygonal features as well as lengths of the linear features. To acquire the LULC statistics, overlay techniques were used on various temporal data sets. Image processing analysis was carried out by ERDAS. Using this software raster data sets were imported into imagines and Tiff formats etc. to enable the application of Geo-metric corrections, Geo-coding, resolution merge between PAN and multispectral bands with principal component method and bilinear interpolation resampling technique. These operations were applied to obtain better LULC visibility and information. Supervised classification methods and natural colour techniques were used to take appropriate spectral signatures to obtain change detection statistics. LULC of Visakhapatnam city for three temporal periods, 1941, 1975 and 1995 is mapped in order to study the land use changes. For this study, the main city core area has been analyzed. Using Survey of India topographical maps of 1941, 1975 and 1995, the land use categories are traced out, scanned and vectorized using AutoCAD (Ver.2009) and ArcGIS (Ver.9.1). The statistics obtained through the polyconic projection utility from the maps 1975 and 1995 are presented in table 3.1.

As Visakhapatnam city has been declared as Greater Visakhapatnam Municipal Corporation (GVMC) in 2005 and geographical area extended from 111Sq.Km to 540sq.km, the land use study is extended for entire GVMC for three temporal periods of 2003 and 2009. To prepare base map of the city, the topographical maps of Survey of India of 1975 and 1995 on 1:25000 scale are used and LULC maps are prepared. These maps are updated by satellite data, IRS-1D LISS-III and PAN merged image of March, 2003 and Cartosat-I satellite data of Feb, 2009 using ERDAS imagine supervised classification method. To obtain qualitative changes, the land use maps of the three temporal periods of the city are

overlaid with the maps prepared by satellite data and changes are identified. These changes are confirmed with ground verification.

RESULTS AND DISCUSSION

Land Use Land Cover Changes (1941 – 1995)

The land use and land cover of Visakhapatnam city during 1941 is shown in Fig-2. The city is bounded by hill ranges on the north as well as on the south and on the west there was vast area of tidal swamp. Until 1940, the general growth of the town was very slow. The total population of the town in 1941 was 70,243 within the municipal area of 15.62 sq.km. There was not much development identified in the town in all land use categories. Residential colonies were confined to southern part of the town and a few colonies extended towards Waltair uplands in the northeast. There were a number of hamlets/villages scattered in and around the town area especially along with the foot hill zones in the north and peripheral zones in the west (Fig-2).

The opening of the harbor in 1933 brought a distinctive change in the cultural landscape of the town. The establishment of Shipbuilding Industry in 1941 and a Naval Base in 1942 added to the growth of the town in the subsequent years. The city has gained real importance from 1970 onwards due to location of many industries which had resulted in considerable spread with the establishment of new colonies in the north, south and southwestern part of the town. Since the growth of the city has been rapid from 1970 onwards, the changes in land use have been analyzed from 1975 to 1995 and the study is confined to main city area of 111 Sq km

Table 1 shows the land use statistics of Visakhapatnam. Residential land use which occupied 15.87% of the total area in 1975 increased to 33.17% in 1995 and industrial area increased to 8.25% during the same period. The land use under hills and forests category is reduced from 8.37% in 1975 to 5.92% in 1995. This clearly shows the encroachment of residential structures along the foot hills and slopes of the hills. Excluding port area, residential

Table-1: Urban Land use statistics Visakhapatnam

S.NO	Category	1975	1995
		% of total area	% of total area
1	Residential	15.87	33.17
2	Industrial	6.80	8.25
3	Roads & Railways	4.72	6.75
4	Agricultural	0.31	0.00
5	Hills, Forests & Water Bodies	8.37	5.92
6	Ports	37.91	38.11
7	Vacant Land	26.21	8.21

land use is the major type of land use followed by industrial land use in 1995 (Table-1). There were several small villages along the piedmont zone of kailasa hill range in the north and also on either side of national highway (N.H-5) in the north. During 1975, the built up area was extended into these neighboring villages and subsequently became part of the urban complex. Hence, residential land use has increased in the north along the foot hill zone (Fig-3).

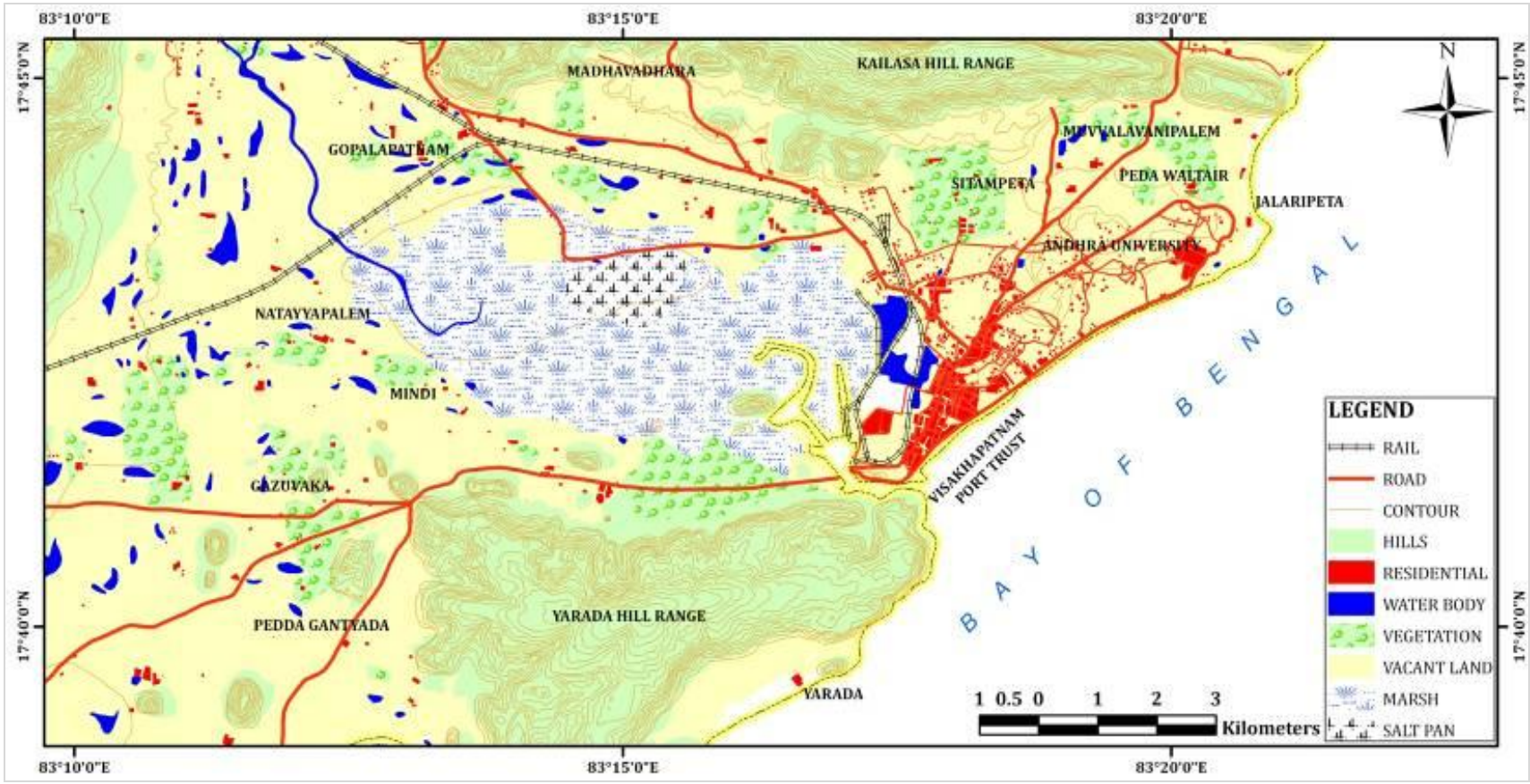

Figure 2: Visakhapatnam – Land use / Land cover (1941)

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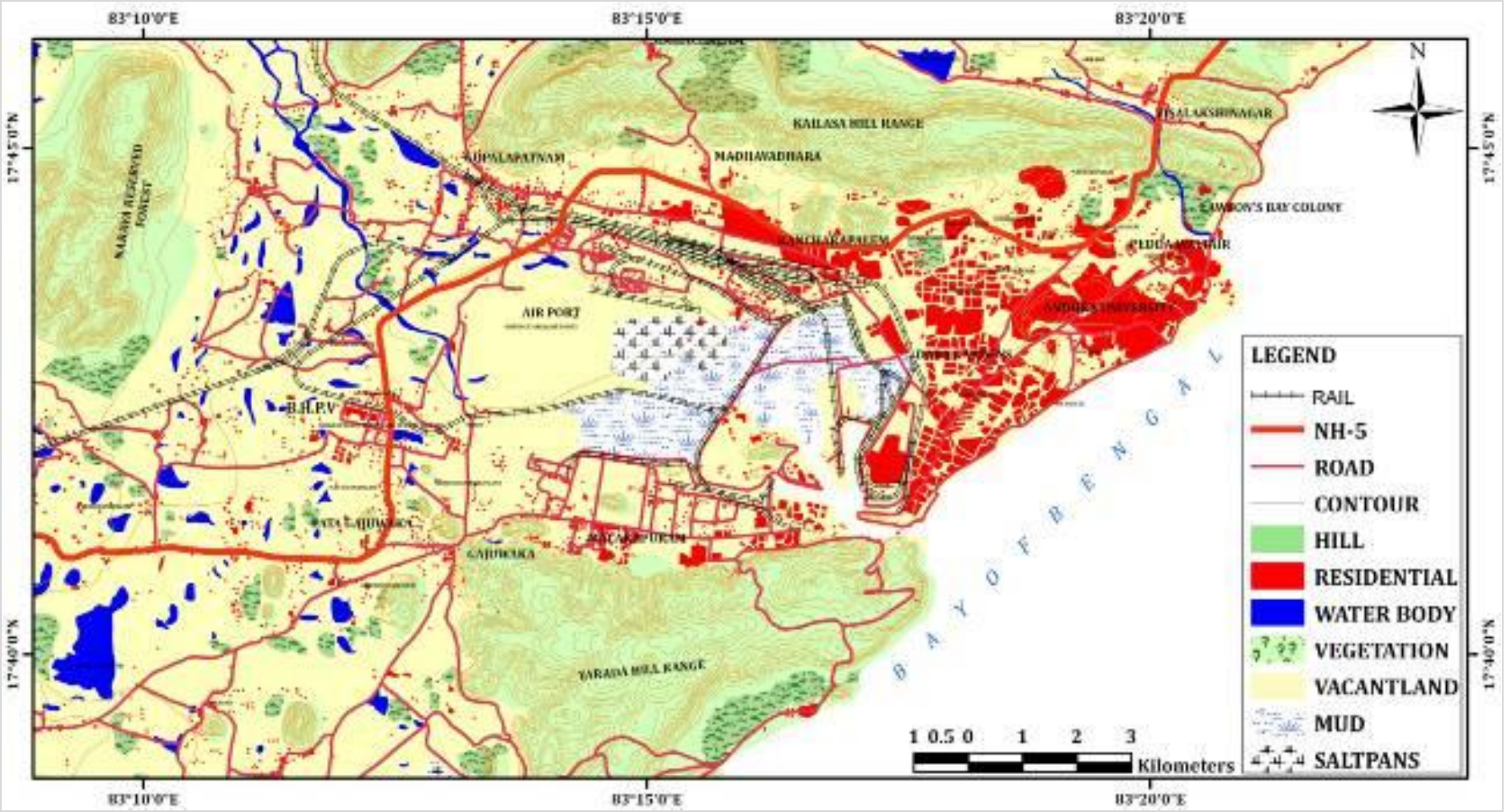

Figure 3: Visakhapatnam- Land use/ Land cover (1975)

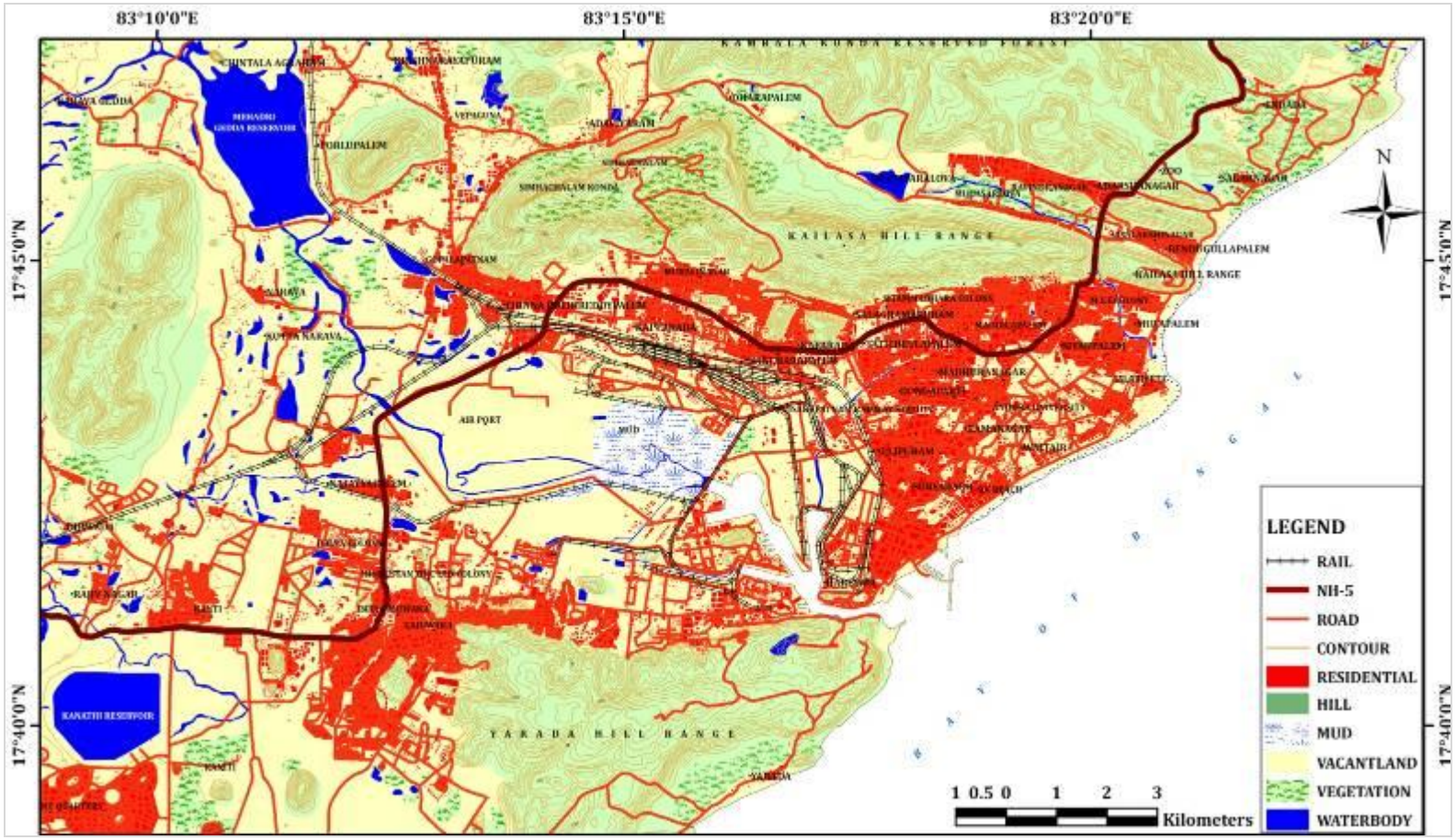

Figure 4: Visakhapatnam- Land use/ Land cover (1995)

The increase of industrial land use between 1975 and 1995 reveals that the growing importance and impact of industries in Visakhapatnam. Agricultural land use constitutes about 0.31% of total geographical area during 1975 reduced to 0% during 1995. It was completely replaced by industrial and residential land use by 1995. The total swamp/marshy area were reclaimed to some extent by industrial expansion during 1975 (Fig-3). Due to rapid industrialization, the transport network was also developed. Hence, the percentage of land use under roads and railways was increased from 4.72% in 1975 to 6.75% during 1995. The city is well connected through roads and railways to the major economic centers. A special effort has been undertaken to provide inter connectivity between major arteries of the city. With regards to Visakhapatnam Port Trust, it occupies one third of the total geographical area and it is one of the major ports along the East Coast of India. The area under vacant land was 26.21% in 1975 reduced to 8.21% in 1995. Most of the vacant land was converted into residential zones and also transformed into commercial use and also institutions.

The LULC map of Visakhapatnam during 1995 (Fig-4) shows that there are significant changes around southwest, northwest and northeast zones. The abnormal increase in the built up area around southwestern part of the city is due to establishment of steel plant and other industries. In the northeast sector also residential land use increased and extended beyond Kailasa hill ranges. There was an increase in built up area of the town during 1995 (Fig-4) and the population increased from 4,50,000 to 10,57,000. Fig-4 indicates the city has developed in the northeastern, northwestern and southwestern directions as the city is constrained by physical barriers on all sides. Hence, the topography plays an important role in the spread of the city and the land use pattern. Commercial areas and institutional areas have attained new shape. The tidal swamp on the western side of the town is reclaimed for port-based industries. A number of buildings were constructed in the port area on the reclaimed land underlain by marine clay. The total area under marshy land was 2590 hectares during 1941 which was reduced to 400 hectares in 1995. Approximately 80% of the total area was reclaimed and the remaining area was also reclaimed during subsequent years. The swamp area is mainly destined for all port based industries. In addition to the port installations, the establishment of port dependent industries brought another fresh impulse for town extension in the tidal basin. It is reclaimed from all sides and this is why the shrinking swamp is exhibiting a typical pattern of town sprawl.

The reclamation of the marshy tidal basin provides an example of large scale metamorphism of natural landscape by man.

Land Use/Land Cover Changes In Greater Visakhapatnam: (2003–2009)

Visakhapatnam city has been declared as Greater Visakhapatnam Municipal Corporation (GVMC) in 2005 and geographical area extended from 111sq.km to 540sq.km by merging one more municipality and 32 villages. Hence, the land use study is extended for entire Greater Visakhapatnam. Upto the period of 2004, the city was bounded by hill ranges on the north as well as south which acted as natural barriers. From 2005 onwards, the city limits extends beyond hill ranges. To prepare the base map of the city, the topographical maps of Survey of India of 1975 and 1995 on 1:25000 scales are used and land use/land cover maps are prepared. These maps are updated by satellite data, IRS-1D LISS-III and PAN merged (March, 2003) and Cartosat-I satellite data (Feb, 2009) using ERDAS imagine. Since satellite data is available for two periods, 2003 and 2009, the land use analysis was carried out for these two periods. The LULC units and their proportions are given in table-2 and it is observed that the land use pattern has considerably changed between 2003 and 2009. Figure-5 depicts the land use/land cover of Greater Visakhapatnam during 2003. The category of hills and forests is the major type of land use during 2003 and 2009 with 26% of the total geographical area (Table-2). Due to merging of 32 villages, the area under agriculture and vegetation is the second significant category of land use and land cover. This category of land use occupied about 16.80% of total geographical area, during 2003 and reduced to 11.02% in 2009.

The residential land use in 2003 occupied 76.41sq.km of area and accounts for 14.42% of total geographical area. Due to merging of 32 villages in Greater Visakhapatnam the percentage of residential land use to total geographical area has reduced. There are many water bodies covering an area of

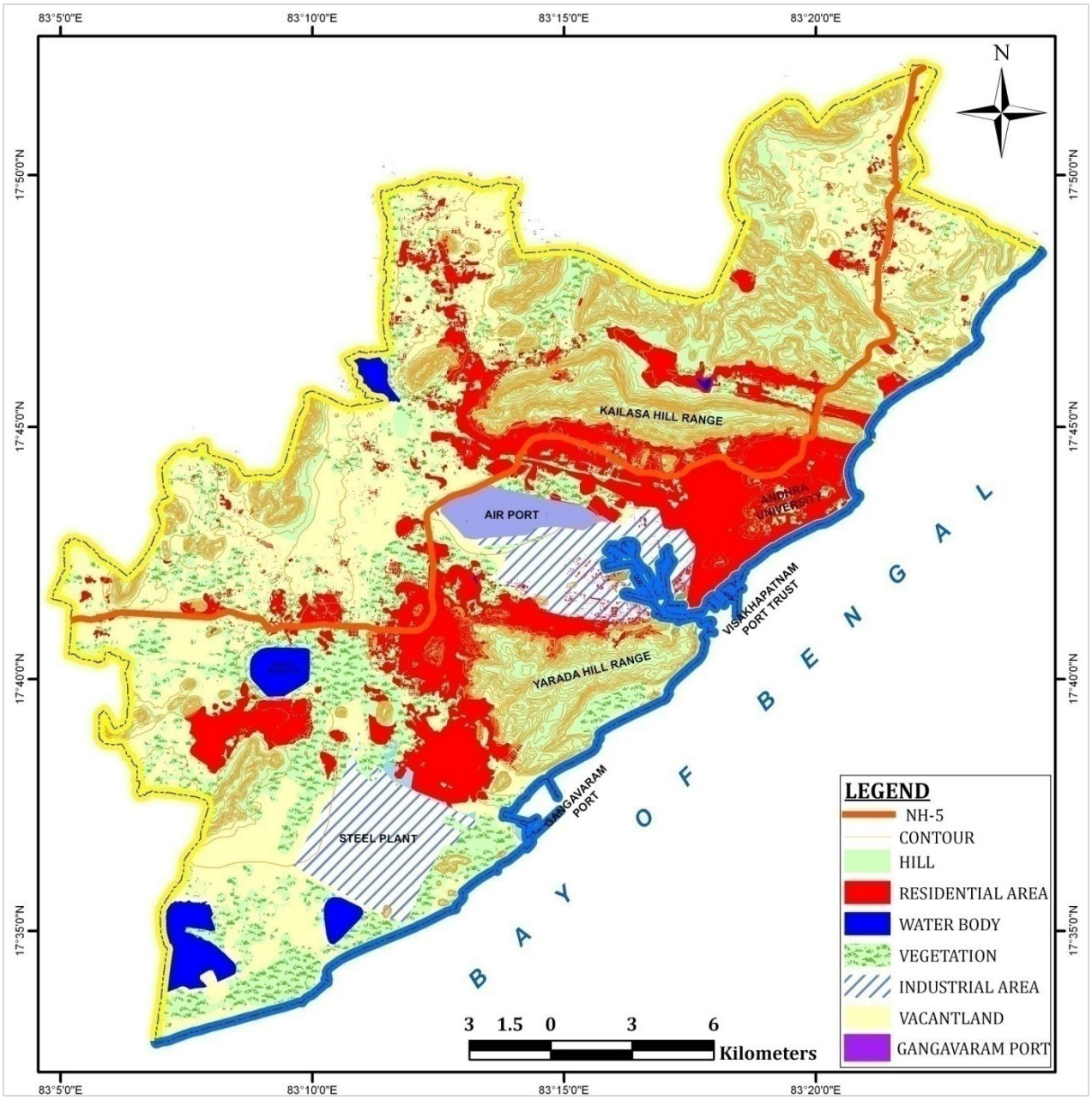

Figure 5: Greater Visakhapatnam – Land Use / Land Cover (2003)

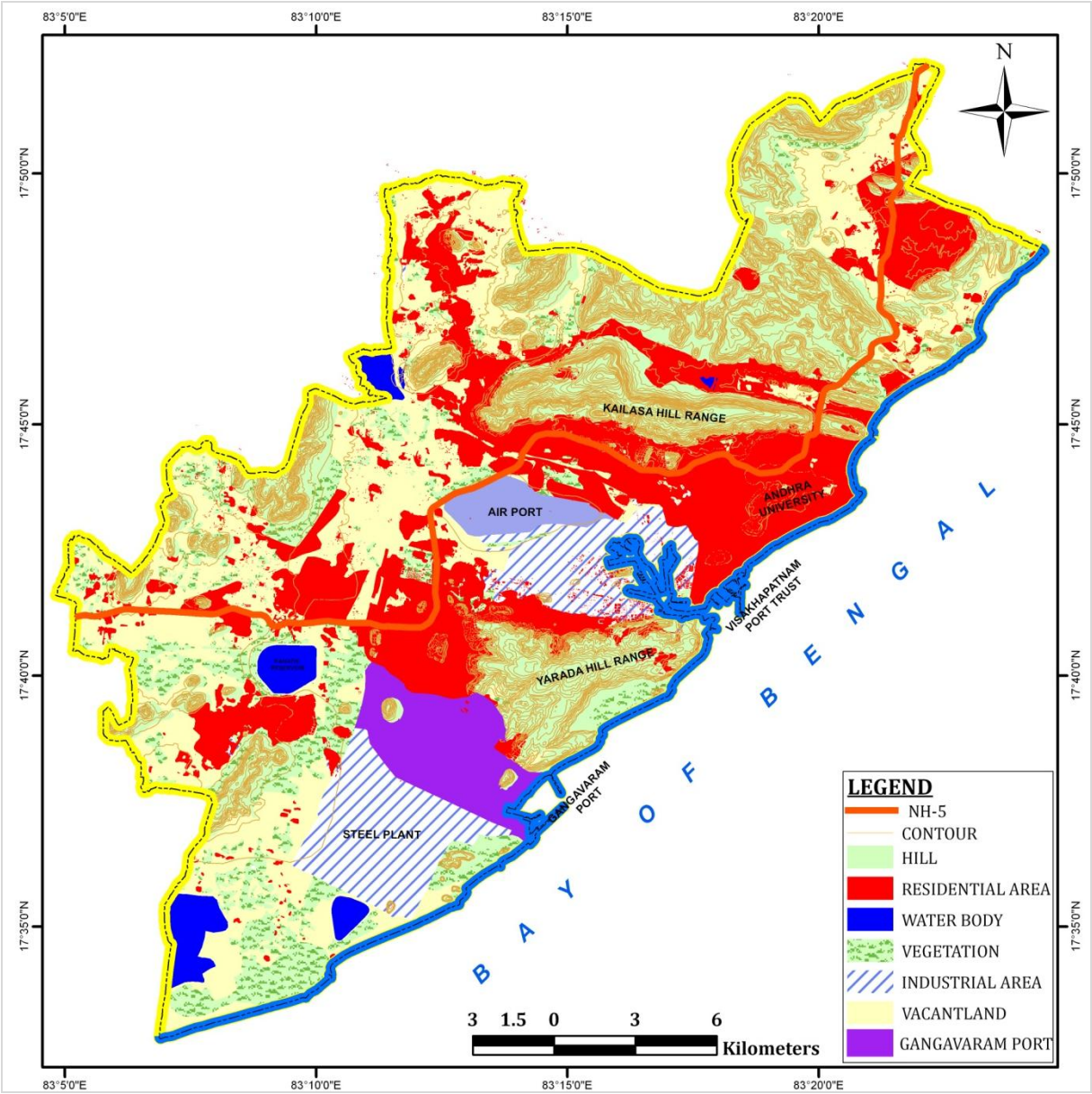

Figure 6: Greater Visakhapatnam – Land Use / Land Cover (2009)

12.30sq.km and they are distributed all over the study area. There are three important reservoirs, Kanithi reservoir in the west and Meghadrigedda reservoir in the northwest and Yeleru reservoir in the southwest (Fig. 5). Kanithi reservoir supplies water to steel plant and its town ship whereas Meghadrigedda reservoir is one of the main sources of water supply to Visakhapatnam city. The land use maps of 2003 (Fig-5) and 2009 (Fig-6) indicate that there are some positive and negative changes in land use categories. Residential land use which occupied 14.42% of the total area in 2003 increased to 20.47% in 2009 which

shows rapid urbanization in the study area (Table-2). The industrial area increased to 4.92% in 2009 from 3.62% in 2003. The land use under the categories of hills & forests and also water bodies is being maintained from 2003 to 2009 (Table-2). There is a significant change in agricultural land use between 2003 and 2009 and it is decreased from 16.8% in 2003 to 11.02% in 2009. This reduction is attributed to increasing built up area due to ever increasing urbanization in the study area. Area under roads and railways is slightly increased from 2003 to 2009 and this is due to improved transport network in Greater Visakhapatnam. Port area occupies 10.65% of total geographical area and Greater Visakhapatnam has two major ports functioning under its jurisdiction. Another major change in the land use pattern is reduction of vacant land from 8.76% in 2003 to 6.7% in 2009 (Table 2). Vacant land is converted to residential, commercial and industrial land uses due to increased urban and industrial activities.

Table 2: Urban Land use statistics of Greater Visakhapatnam

S. No.	Category	2003		2009	
		area in sq.km	% to total area	area in sq.km	% to total area
1	Residential	76.41	14.42	108.47	20.47
2	Industrial	19.19	3.62	26.09	4.92
3	Roads & Railways	91.20	17.21	93.60	17.66
4	Agricultural / Vegetation	89.02	16.80	58.42	11.02
5	Hills & Forests	139.03	26.23	138.94	26.23
6	Water bodies	12.30	2.32	12.30	2.32
7	Ports	56.44	10.65	56.44	10.65
8	Vacant Land	46.41	8.76	35.74	6.74

CONCLUSIONS

The analysis of LULC based on the satellite data has shown significant changes. Area under hills and forests and also under agricultural activity constitutes the major part of the land. The replacement of many agricultural villages by the establishment of steel plant in 1991 and replacement of fishing villages by Gangavaram port in 2005 are the important land use changes in the study area. Above all, reclamation of tidal swamp by port based industries is the significant land use change. The residential area and industrial areas are expected to increase by 2021. An analysis of spatial growth pattern in the past as well as the current indicates stagnation of growth in the old town while the city is growing industrially towards west and residentially towards northeast. In the last decade, development of residential strip along the coastal stretch is witnessed. It has been accompanied by institutional and recreational uses.

The spatial growth of the city has been restricted by physical barriers on the north and south and also on the east and there is scope for development only along the western part of the city. Hence, Special Economic Zones and National Thermal Power Corporation (NTPC), Pharmacity and other industrial and economic activities are established towards west. As the city is witnessing population explosion and urban sprawl, planning especially for infrastructure investments corresponding to the growth pattern, should be oriented accordingly.

REFERENCES

Chang-Qing KE (2008). Urban Land Use Change of Nanjing, China Using multitemporal satellite data. *Proceedings of Geoscience and Remote Sensing Symposium* **3**.

Chauhan HB and Shailesh Nayak (2005). Land use/land cover changes near Hazira Region, Gujarat using Remote Sensing data. *Journal of India Society of Remote Sensing* **33** 3.

Jain AK, Hooda RS, Nath J and Manchandra ML (1991). Mapping and monitoring of urban land use of Hissar town, Haryana, using Remote Sensing techniques. *Journal of the Indian Society of Remote Sensing* **19(**2).

Jaiswal, Rajeev Kumar, Saxena Rajesh and Mukhuerjee Saumitra., 1999. Application of Remote Sensing technology for land use/land cover change analysis. *Journal of the Indian Society of Remote Sensing* **27** 2.

Jagannadha Rao .M., Syam Kumar .J., Surya Prakasa Rao .B and Srinivasa Rao .P., 2003. Geomorphology and Land use pattern of Visakhapatnam Urban-Industrial area. *Journal of the Indian Society of Remote Sensing* **31(**2).

Kamini .J., Satish C., Jayanthi and Raghavaswamy .V., 2006. Spatio-Temporal analysis of Land use in urban Mumbai-using Multi-sensor satellite data and GIS techniques. *Journal of the Indian Society of Remote Sensing* **34**(4)

Madan Mohan., 2005. Urban Land use/Land cover change detection is National Capital Region Delhi; A study of Faridabad district.

Narinah Samat., 2006. Application of GIS in Urban Land use Planning in Malaysis. Paper submitted to *International Conference on "Digital Earth", Taiwan*.

Pathan S.K., Jothimani P., Sampat Kumar D and Pendharkar S.P., 1989. Urban land use mapping and zoning of Bombay metropolitan region using Remote Sensing data. *Journal of Indian Society of Remote Sensing* **17(**3).

Pathan S.K., Shukla, V.K., Patel, R.G and Mehta, K.S., 1991. Urban Land use Mapping- A case study of Ahmadabad city and its Environs. Photonirvachak, *Journal of Indian Society of Remote Sensing* **19**(2) 95-112.

Rajeev Kumar Jaiswal., Rajesh Saxena and Saumitra Mukherjee., 1999. Application of Remote Sensing technology for Land use/Land cover change analysis. *Journal of Indian Society of Remote Sensing* **27(**2).