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Monitoring Urban Land Use Land Cover through Remote Sensing and GIS: A case study

Rupesh Gupta, Delhi

Abstract

In this paper, an integrated approach incorporating satellite data and GIS techniques in conjunction with socio-economic data are used to assess urban land use land cover of Jaipur city, the capital city of Rajasthan in India. Based on the multi resolution and multi temporal satellite data, the spatial and temporal changes in the various types of land uses are detected and discusses. Its population has grown from 0.3 million in 1951 to 2.3 million in 2001 and 2.9 million in 2009. The annual average growth rate from 1971 to 2001 has been in the range of 4.1 to 4.7. The growth rate was the highest in the year 1981 but declined sharply by 0.6 per cent in 1991 and in grew again by 0.2 per cent in 2001. The impact of such growth is seen in the change in land use and created many urban problems in the city and led to the congestion of walled city. The crop land has shrunken 1.60 sq km/year, fallow land 2.94 sqkm/ year, wasteland 0.59 sq km/year during 1975-2009, whereas the built-up land has increased in the rate of 4.46 sq.km/ year or 1.02 per cent/year.

Introduction

Urban growth is one of the processes of urban development. The occurrence of urban expansion is so general, and its implications are so wide, that it is possible to view much of recent social and economic history in terms of the attempts to cope with its varying consequences. The rise of great cities and their growing spatial influence initiated a change from largely rural to predominantly urban places and patterns of living that has affected most countries over the last two centuries. Today, not only do large numbers of people live in or immediately adjacent to towns and cities, but whole segments of the population are completely dominated by urban values, expectations, and life styles. From its origins as a locus of non-agricultural employment, the city has become the major social, cultural and intellectual stimulus in modern urban society (Clark, 1982).

Urban development is the process of emergence of the world dominated by cities and by urban values. It is important to draw clear distinction between the two main processes of urban development-*urban growth and urbanization* (Clark, 1982). Urban growth is a spatial and demographic process and refers to the increased importance of towns and cities as a concentration of population within a particular economy and society. It occurs when the population distribution changes from being largely hamlet and village based to being predominantly town and city dwelling. Urbanization, on the other hand, is a spatial and social process which refers to the changes of behavior and social relationships that occur in social dimensions as a result of people living in towns and cities. Essentially, it refers to the complex change of life styles which follow from the

impact of cities on society (Bhatta et. al., 2010).

However, this study deals only with the pattern and process of urban growth. Urban growth should be analysed both as a pattern of urban land-used-i.e., a spatial configuration of a metropolitan area in a temporal instant-and as a process, namely as the change in the spatial structure of cities over time. Urban growth as a pattern or a process is to be distinguished from the causes that bring such a pattern about, or from the consequences of such patterns. If the urban growth is considered as a pattern it is a static phenomenon and as a process it is a dynamic phenomenon. Analysis of urban growth, as a pattern or process, is an essentially performed operation by the city planners and administrators, proponents, and other stakeholders. However, stakeholders are generally interested in the future pattern of urban land-cover rather than the past or present in view of their investment goals; but the city administrators/planners and proponents require analysing the pattern of urban growth for the past and present in order to prepare for the future.

Urban growth, as a pattern, although helps us to understand the spatial distribution but as a static phenomenon. In fact, areas that can be identified as sprawl for a specific time are typically part of a dynamic urban scene (Ewing, 1997; Harvey & Clark,1965). Some parts of the city may pass through a sprawled stage before eventually thickening so that they can no longer be identified as sprawl (Herold et al., 2005). Therefore, the urban growth analysis should take into account both the pattern and as well as the process. Analysis of urban growth, as a pattern and process, helps us to understand how an urban landscape is changing with time. This understanding includes (1) the rate of urban growth, (2) the spatial configuration of growth, (3) whether there is any discrepancy in the observed and expected growth, (4) whether there is any spatial or temporal disparity in growth, and (5) whether the growth is sprawling or not. Analysis of urban growth can be performed for the past, present, and for the future as well. However, the case of past and present is different than the future; because the former is based on empirical evidences whereas the later is based on simulations. However, the simulation is obviously dependent on the past and present evidences.

In the recent years, remote sensing data and geographic information system (GIS) techniques are widely used for mapping (to understand the pattern), monitoring (to understand the process), and monitoring and modelling (to simulate) the urban growth, land-use, and sprawl. The physical expressions and patterns of urban growth and sprawl on landscapes can be detected, mapped, and analysed by using remote sensing data and GIS techniques (Angel et al., 2005; Barnes et al., 2001; Bhatta et.al., 2010). The decision support systems within the GIS can evaluate remote sensing and other geospatial datasets by using multi-agent evaluation (Parker et. al., 2003) which can also predict the possibilities in the subsequent years using the current and historical data. In the last few decades, these techniques have successfully been implemented to detect and monitor the urban growth dynamics.

This study is aimed to analyse the urban growth (rather than the urban development that includes urbanization), by using the current and historical remote sensing data with the help of simple statistical models

that can be applied on different spatial and temporal dimensions. In this study, remotely sensed satellite imageries of different temporal instants (1975 to 2009) were used to determine the urban land-cover class over the study area.

It is worth mentioning that the main objective of the study is to describe the approach, monitoring and understanding the past and present urban growth situations; not to simulate the future growth or not to make comments on the causes or consequences of such type of growth. Furthermore, this paper is not to analyse the transitions among the land use/ land-cover classes or the environmental impacts that may result from such transitions. In specific, the objectives of this research are (1) to identify the spatial pattern of urban expansion in the city, (2) to illustrate the impact of urban expansion on the changing land use, and (3) to find out the environmental consequences of urban growth and development. All of these study will be demonstrated from three different aspects-patterns, process, and overall condition of urban growth.

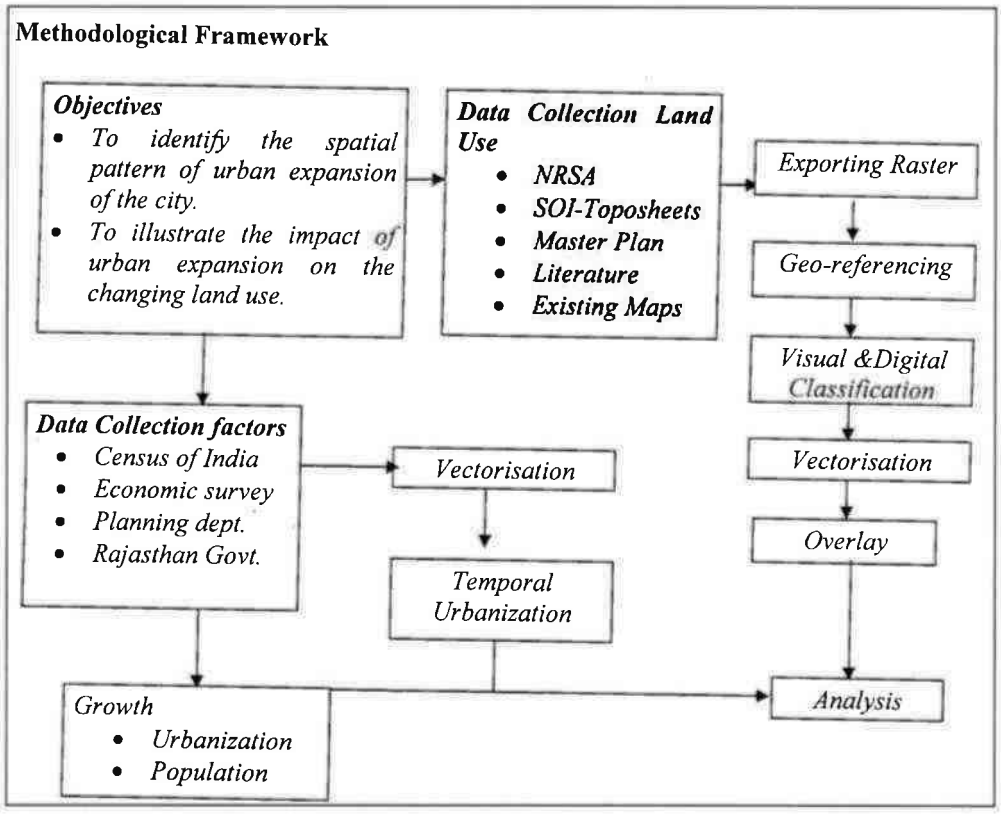
Study Area

Jaipur Region is considered for the purpose of land use and land cover studies. This is bounded by 26°54' north latitudes and 75° 45' east longitudes. This work is focused on one particular city i.e. Jaipur. The studies cover the area of Old JDA boundary with 444.72 sq. km area. The whole city has experienced an emergence of environmental crisis in terms of depletion of ground water, forests, soil erosion, flora and fauna and climate changes. Whole area towards east has experienced substantial deforestation. This has further deteriorated due to mining operations for building stones. Devastation of tree and soil cover has turned hilly areas to rocky exposures. Wasteland areas are continuously increasing and degrading the environment. Salinization is prominent in west and the south west of the region. All these phenomena adversely put heavy pressure on the environment, which in turn has created environmental changes in the ecosystem and their subsystems.

Research Methodology

In the present study, three aspects of urban evaluation planning and management have been demonstrated. Firstly, the study of urban land use and change detection in urban land use has been done. Secondly, planning for urban development has been projected and thirdly, monitoring environmental impact in the city has been discussed.
Remote sensing techniques are mainly used for finding urban land use transformation patterns of land, urban sprawl and change detection with the help of ERDAS Imagine software. GIS tool are used for developing information regarding urban land use in ARC Info, Arc View software in such a way that different kinds of queries can be sought to the data base related to the point, distance and polygon features (Figure 1).

The base map has been prepared by SOI toposheets and updated by the base maps prepared by the Jaipur Development Authority (JDA) at the scale of 1:20,000 and updated by the IRS satellite data. Land cover maps are mainly based on visual interpretation of satellite imagery adopting deductive approach by studying image characteristics and terrain information in conjunction with a prior knowledge of general land use/ land cover setting of the area. Land use map of 1975, 1986 were



obtained by the LANDSAT (MSS, TM) data whose spatial resolution is 79m and 30m respectively. Indian satellite data IRS 1B-LISS II with spatial resolution of 36.5m was used for the preparation of land use/cover map of 1991 of entire Jaipur region. Land use/ land cover map for 2003 was prepared by visual interpretation of IRS 1C LISS (III), IRS 1DLISS III data. 2009 map was prepared though visual on screen classification on the base of Google earth image data. Google earth image is downloaded from google earth and then mosaics registered and classify it. When interpreting past urban land uses from imagery, detailed historical documents such as the historical records of urban planning and urban construction provide the valuable references to temporal events.

Results and Discussions

Conversion of urban – fringe land is a natural economic response of increasing demand for space in a growing urban economy. The history of spatial expansion of a city, in most cases can be explained in terms of waves of urban growth. Each wave engulfs large area of land beyond the city limits. The magnitude and direction of waves depend upon various exogenous and endogenous factors.

The statistics reveal that in 1975 cropped area was 35.38 per cent, Fallow Land was 27.68 per cent, Sandy Area was 10.85 per cent, degraded forest was 6.55 per cent and 3.21 per cent land under transformation. Only 10.42 per cent of total study area was built-up land which is further classified

into three parts: high density 2.25 per cent, medium density 3.42 per cent and low density 4.75 per cent (Figure 2) (see page 72). In this period Jaipur was a small city and Land Under Transformation was only 3.21 per cent. This shows that the area exhibits low growth rate during this period (Table 1).

After the gap of eleven years since 1975, following observations are made, 41.20 per cent of the total study area was cropland, which has increased by 2.98 per cent than its previous percentage in 1975 due to utilization of fallow land for production of vegetables or other crops to meet the demands of these products. As a result fallow land decreased. Degraded forest increased, while due to afforestation 2.53 per cent of area was converted to forest class (Figure 3) (see page 72).

Areal extent of Built up land indicates that the development of the city during this period, which has occupied 19.27 per cent of the total study area under built up, comprises of high density (2.85 per cent), medium density (9.48 per cent), and low density (6.94 per cent). 9.95 per cent of the total area comes in land under transformation category, thus indicating the developmental stage of the city. City shows spatial growth and physical development in semi-circular form, west and south-west of Aravali hill range (Table 1).

During 1991, the built up land has grown from 19.27 per cent to 25.47 per cent registering an increase of 6.20 per cent area of built up land. During this period cropped area and land under transformation categories cover 35.54 per cent and 13.49 per cent of total geographical area respectively, which indicates that city is in growing stage (Figure 4) (see page 73).

Fallow land has decreased from 8.86 per cent (in 1986) to 6.66 per cent (in 1991) due to utilization of fallow land for growing vegetables or converted into built-up land. Similarly crop area decreased by 5.5 per cent. City is continuously showing its spatial growth towards north and south west directions in semi circular form, encroaching nearby agricultural and fallow lands (Table 1).

A remarkable change has been observed in land use during this period. Area statistics show that city is growing at very fast rate, as built up land has increased by 33.98 per cent (Figure 5) (see page 73). Crop area covered 26.62 per cent, 3.47 per cent under gullied and 4.36 per cent saline lands respectively (Table 1).

During 2003 to 2009, the high density built up land increased (88 per cent) by around 19 sq km where the total built up land reached 197 sq km within 6 years. Most of the built up land increased was on the cost of fallow land or little more on crop land. Hence the growth of medium density and low density built up land is very slow and it's negligible during this period, so most of the land which converted into high density is a medium to high or low to high density. (Table 1 and figure 6) (see page 74).

In a little span of time, the land use drastically changed specially in fallow land, waste land, which was either converted into low density settlement or slum. A large number of villages merged in municipal area and lost their identity and living style. Ultimately it will again affect the ecology and environment of surrounding.

The table 1 reveals that the growths of less density are much more as compared to high and medium density land. It was 4.75

Table 1: Change Area Under Land Use/ Land Cover in 1975- 2009

Land Use/ Land Cover	Share in total area percentage					Decadal Percent Growth			
	1975	1986	1991	2003	2009	1975-1986	1986-1991	1991-2003	2003-2009
High Density	2.25	3.91	6.72	4.84	9.12	73.7	71.8	-28.0	88.5
Medium Density	3.42	8.39	9.29	5.50	6.37	144.9	10.8	-40.9	15.9
Low Density	4.75	6.57	9.46	28.48	29.02	38.2	44.0	200.9	1.9
Built up Land	**10.43**	**18.87**	**25.48**	**38.82**	**44.51**	**80.9**	**35.0**	**52.4**	**14.7**
Cropped Area	35.48	40.99	35.47	26.62	23.24	15.5	-13.5	-24.9	-12.7
Fallow Land	27.68	8.87	6.66	6.54	5.22	-68.0	-24.9	-1.8	-20.2
Agricultural Land	**63.15**	**49.85**	**42.13**	**33.07**	**28.46**	**-21.1**	**-15.5**	**-21.5**	**-13.9**
Forest (Degraded, Actual, Plantation)	6.55	11.91	12.86	12.77	12.70	**81.9**	**8.0**	**-0.7**	**-0.6**
Mining Area	0.11	0.38	0.15	0.18	0.17	242.9	-60.7	24.2	-7.3
Gullied Area	0.56	0.94	0.98	3.47	3.87	66.8	4.8	253.1	11.7
Saline Area	0.75	0.44	0.41	2.33	2.23	-41.6	-7.2	473.5	-4.3
Rocky	1.78	1.78	1.78	1.78	1.78	0.0	0.0	0.0	0.0
Sandy	10.85	2.93	1.07	2.08	1.44	-72.9	-63.5	94.3	-30.6
Waste Land	14.05	6.46	4.38	9.84	9.50	**-54.0**	**-32.2**	**124.5**	**-3.5**
River	0.57	0.56	0.56	0.56	0.45	-2.0	1.2	0.0	-21.1
Other	5.25	12.35	14.60	4.93	4.38	135.0	18.2	-66.2	-11.1
Total	100.00	100.00	100.00	100.00	100.00				

Sources: Multi Temporal Satellite Data

per cent in 1975 which reached 29 per cent in 2009. Due to increasing demand of housing there has been rampant growth of colonies which do not have proper infrastructure. During 1975-1986 it shows 80.9 per cent growth whereas in 1986-91 it was 35, 52.4 in 1991-2003 and 14.7 in 2003 to 2009.

It affects the city environment. If we look at the table 1, it seems there is hardly any change in the crop land but fallow land has decreased in an alarming way from 27 per cent to 5 per cent, wasteland 14 to 9 per cent. But if the geographical position of the crop land is considered, it has shifted from plain area to a dirty nallah or clean farms to sewerage farms.

The statistics reveals that the area continued increasing from 1975 to 2009. Due to barrier of hill and mountains in the north, north east and east part, the city grows towards south, south west and west direction along with the major roads and plain area. Most of the settlements on the basis of fallow land and crop land. The high density settlement is based on low density land and the low density encroached the fallow land, crop land and outskirt area.

During 1975 to 1986, the high density built up land increased by 73 per cent whereas, the medium density showed the

increase of 144 per cent but the low density shown less growth of only 38 per cent (Figure 7) (see page 74). The high density urban built up land grow much more during 2003 to 2009 where it was 88 per cent. During 1991 to 2003 more than 200 per cent growth has been recorded in terms of low density areas. But at the same time high density and medium density did not show much more growth.

If we discuss the area of built up land during 1975 to 2009, the total area of built up land was 46.39 sq km, in 1975, 83.92 sq km in 1986, 113.3 sq km in 1991, 172.62 sq km in 2003 and 197 sq km in 2009 (Figure 7). Here the area has grown up much rapidly than last decade due to development of infrastructure and industries.

Conclusion

Urbanization and population growth raised demand for residential complexes which has resulted into formation of concrete jungles. Land use change is taking place in two forms in the city. First emergence of slums and unauthorized colonies to meet the demand of housing for rising population through high immigration. Secondly, in search of better living conditions from congestion and pollution. Emergence of real estate to fulfill this need of elite group is another reason for land use change. The growth of built land like dense built-up land has increased from 10.02 sq km or 10 per cent in 1975 to 40.58 sq km or 45 per cent in 2009 (0.89 sq.km/year or 1.02 per cent/year). While the low density built up land has increased from 21.14 sq km to 129.06 sq km (3.17 sq.km/year) in the same period. The growth of built up land effected agriculture land like crop land that is from 35 to 23 per cent, fallow land from 28 to 5 per cent, wasteland from 14 to 9 per cent during 34 years. The crop area has shrinked 1.60 sq km/year whereas fallow land has reduced 2.94 sq km/year.

Unprecedented growth of industries is another major factor for land use change. The space is not occupied by industries but also by allied institutes (Banks, Insurance offices etc.). Labourers who work in the industries want to live nearby and unauthorized colony or slums come in existence at the cost of natural landscape. Apart from these improvements, road infrastructures give a chance to spread outwards as relative time to reach centre is reduced due to better network. Adjacent rural areas change into Suburbs, subsequently urban. Improper planning is the major reason for this unprecedented phenomenon. In all the master plans only urban area has been considered for planning and rural areas have been neglected, but this is where the real problem lies because these rural areas are being converted into urban landscape and creating environmental problems which are threats to sustainable development.

References

Angel, S., Sheppard, S. C., & Civco, D. L. (2005): The dynamics of global urban expansion. Available from. Washington D.C.: Transport and Urban Development Department, The World Bank.http://www.citiesalliance.org/doc/resources/upgrading/urban-expansion/worldbank reportsept2005.pdf p. 200.

Barnes, K. B., Morgan, J. M., III, Roberge, M. C., & Lowe, S. (2001): Sprawl development: Its patterns, consequences, and measurement. A white paper. Available from. Towson University. http://chesapeake.towson.edu/landscape/urbansprawl/download/Sprawl_white_paper.pdf. Accessed 10.01.07.

Bhatta, B., Saraswati, S., and Bandyopadhyay,D. (2008): Quantifying the degree-of-freedom, degree-of-sprawl, and degree-of-goodness of urban growth from remote sensing data. Applied Geography, 30 (2010) 96–111 www.elsevier.com/locate/apgeog.

Clark, D. (1982): Urban geography: An introductory guide. Taylor & Francis. p. 231.

Ewing, R. (1997): Is Los Angeles-style sprawl desirable? Journal of the American Planning Association, 63(1):107–126.

Gupta, R., and Sen, A. (2008): Monitoring Physical Growth of Ranchi City by Using Geo-Informatics Techniques, A quarterly (Refereed) Journal of Indian Town Planner,India, Vol.5, No.4:38-48.

Gupta, R. (2006): Study of Population Change and Urban Land use relationship Using an Integrated Remote Sensing and GIS Approach. The Deccan Geographer, Vol.44:1-12.

Gupta, R. and Nangia, Sudesh. (2005): Population explosion and land use changes in Gurgaon city region-a satellite of Delhi metropolis. In International Conference proceeding of International Union for the Scientific Study of Population. In:http://iussp2005.princeton.edu/download.aspx?submissionId=50502

Gupta, R. and Raghavswamy, V. (2005): Population growth and land transformation in Gurgaon

Haryana: spatio-temopral analysis using remote sensing and GIS techniques. In: *Space Science & Technology for Geographical Research and Applications*. B.S.Publication, Hyderabad, India.

Harvey, R. O., & Clark, W. A. V. (1965): The nature and economics of urban sprawl. Land Economics, 41(1): 1–9.

Herold, M., Hemphill, J., Dietzel, C., & Clarke, K. C. (2005): Remote sensing derived mapping to support urban growth theory. Tempe, AZ, USA, March 14–16, 2005. Available from. Proceedings of the ISPRS joint conference 3rd International Symposium Remote Sensing and Data Fusion Over Urban Areas, and 5th International Symposium Remote Sensing of Urban Areas (URS 2005). www.isprs.org/commission8/workshop_urban/herold_hemphill_etal.pdf.

Parker, D. C., Manson, S. M., Janssen, M. A., Hoffmann, M. J., & Deadman, P. (2003): Multi-agent systems for the simulation of land-use and land-cover change: a review. Annals of the Association of American Geographers, 93(2): 314–337.

Singh R.B. (2007): Land Use/Cover Change, Environment and Climate Change in Delhi Metropolitan Region: Towards Promoting Sustainable City, In Proceedings of the Int. Symp. On Sustainable Urban Environment 2007, Tokyo Metropolitan University, Tokyo.

Rupesh Gupta, M.Tech., Ph.D
Assistant Professor,
Bhim Rao Ambedkar College
(University of Delhi) Delhi
Email : gisrs@oneindia.in

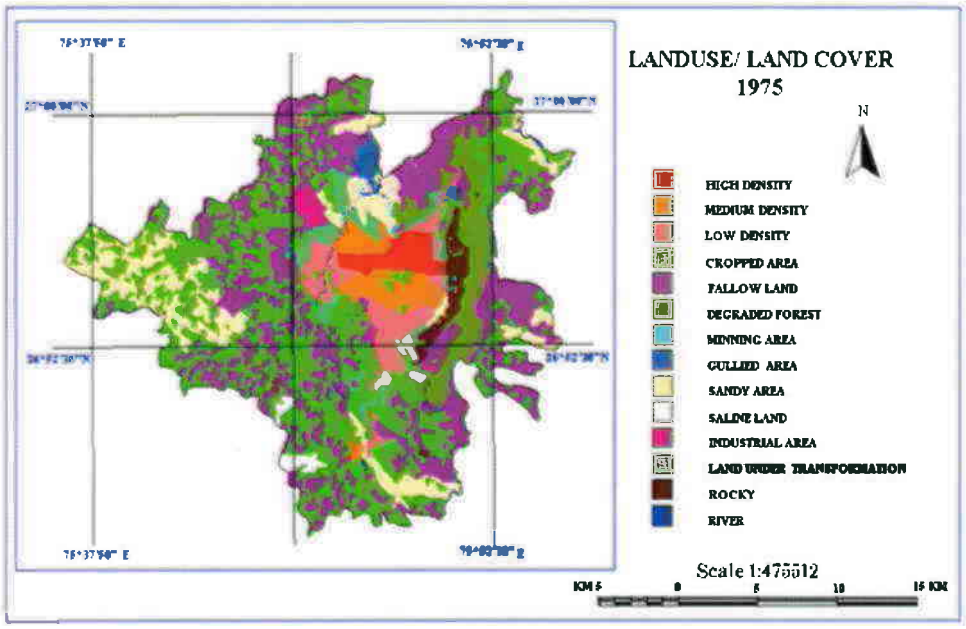
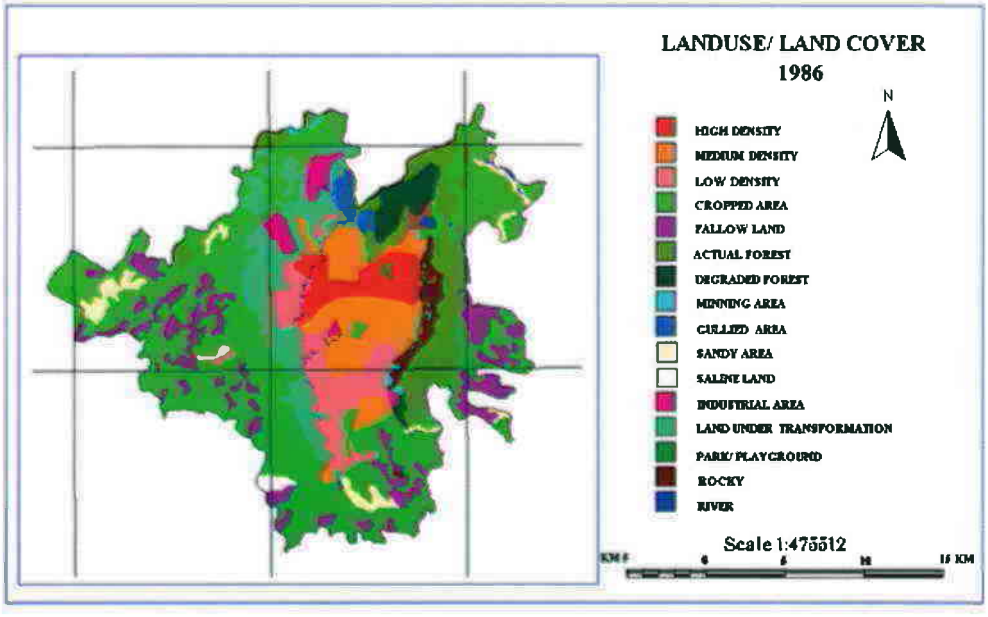


Fig. 2 See page 79 for text



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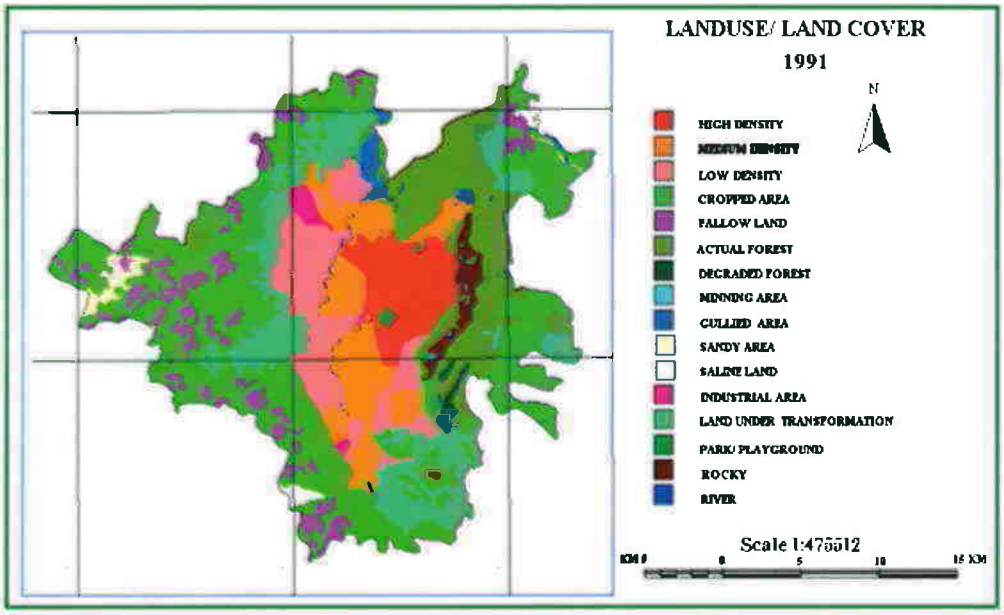

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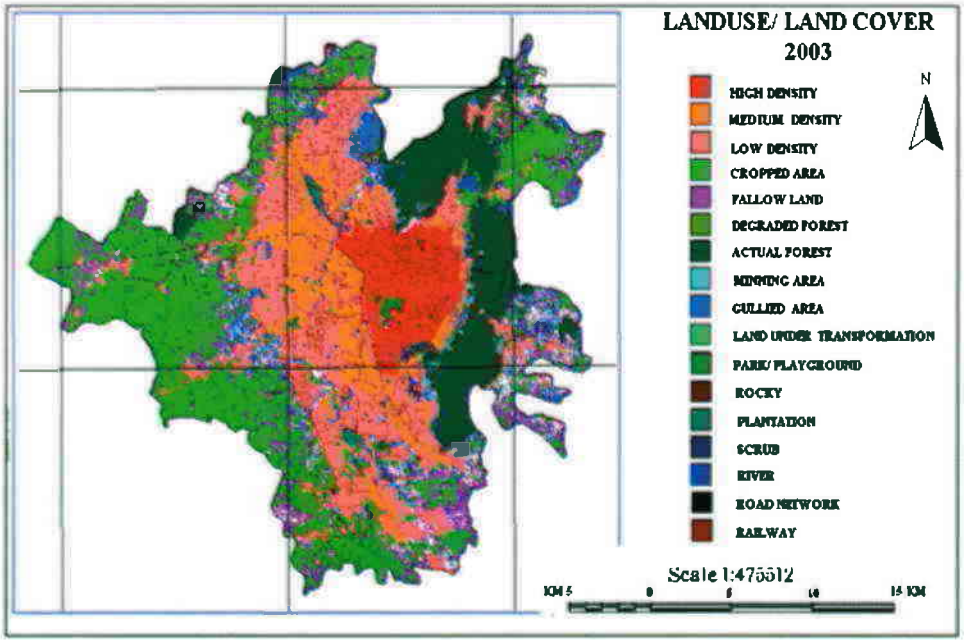

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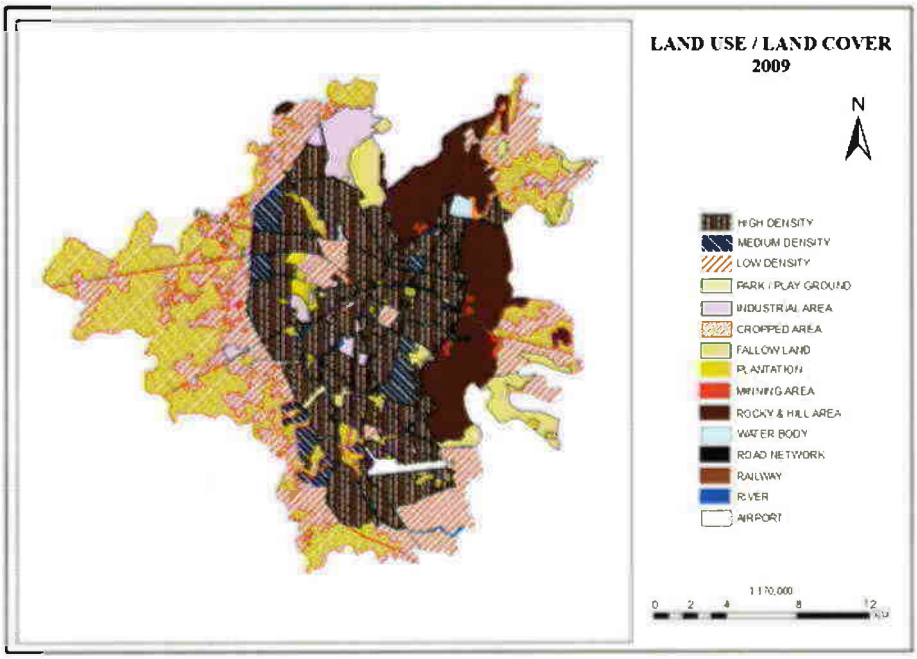

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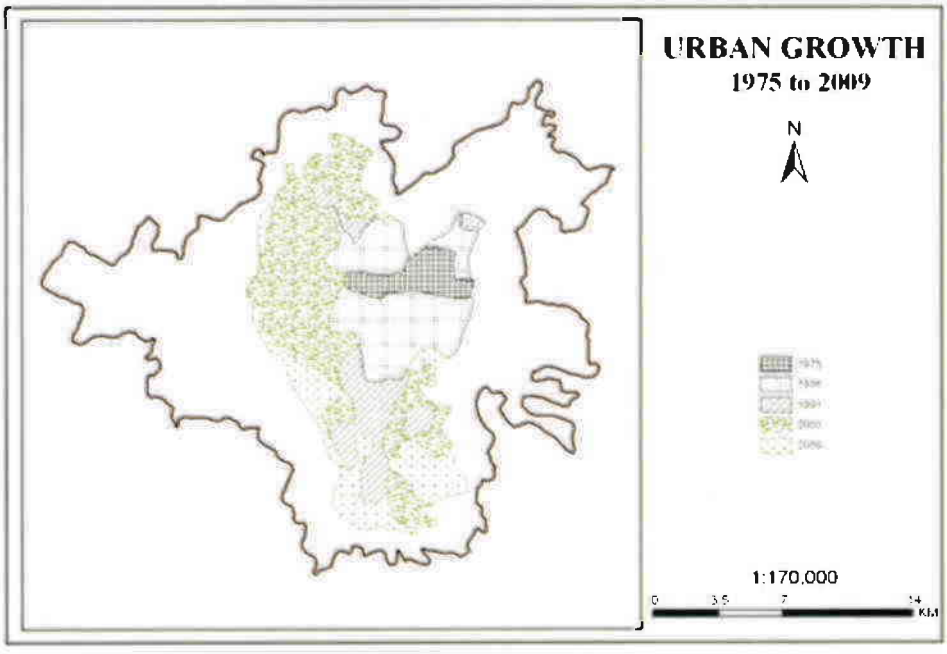

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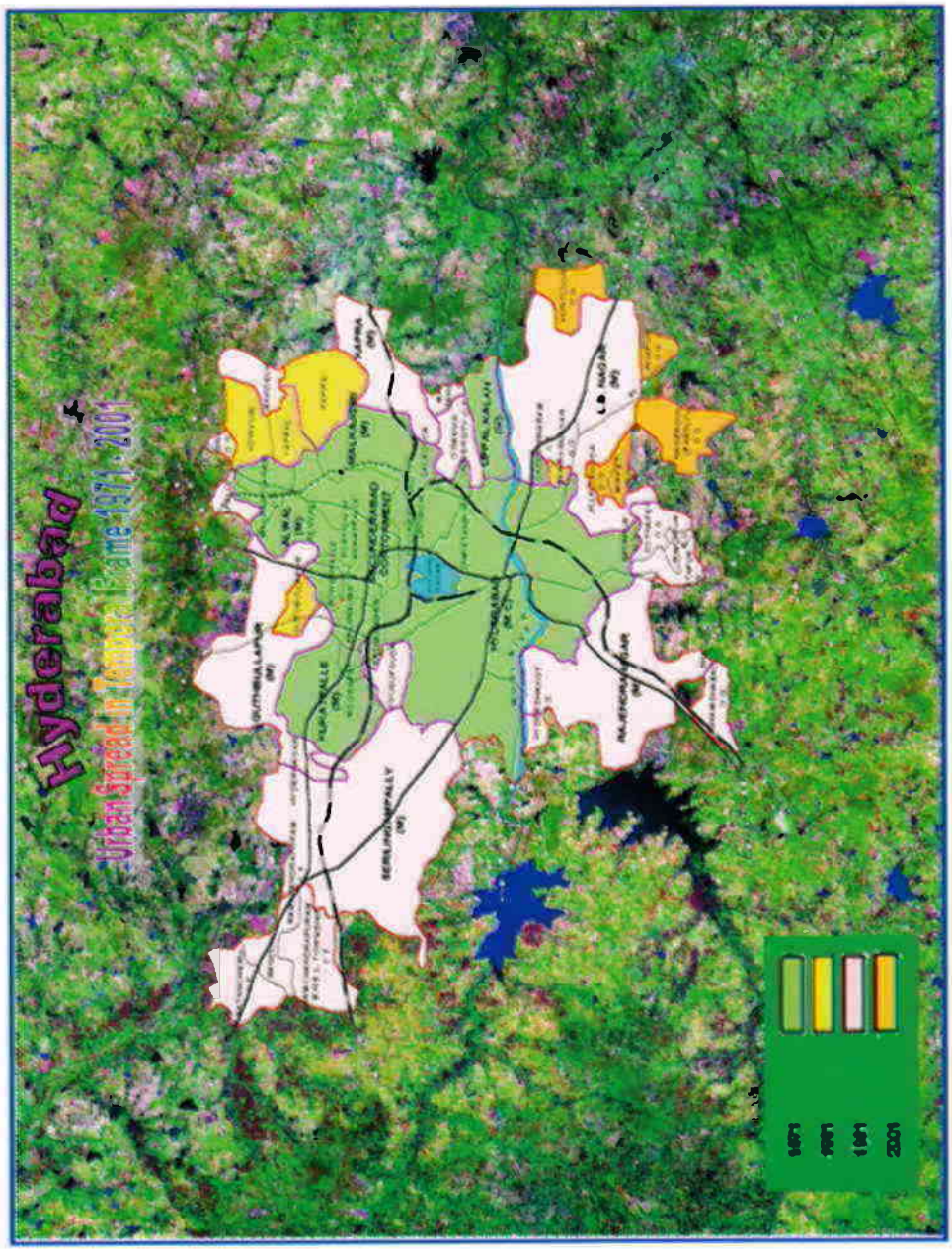

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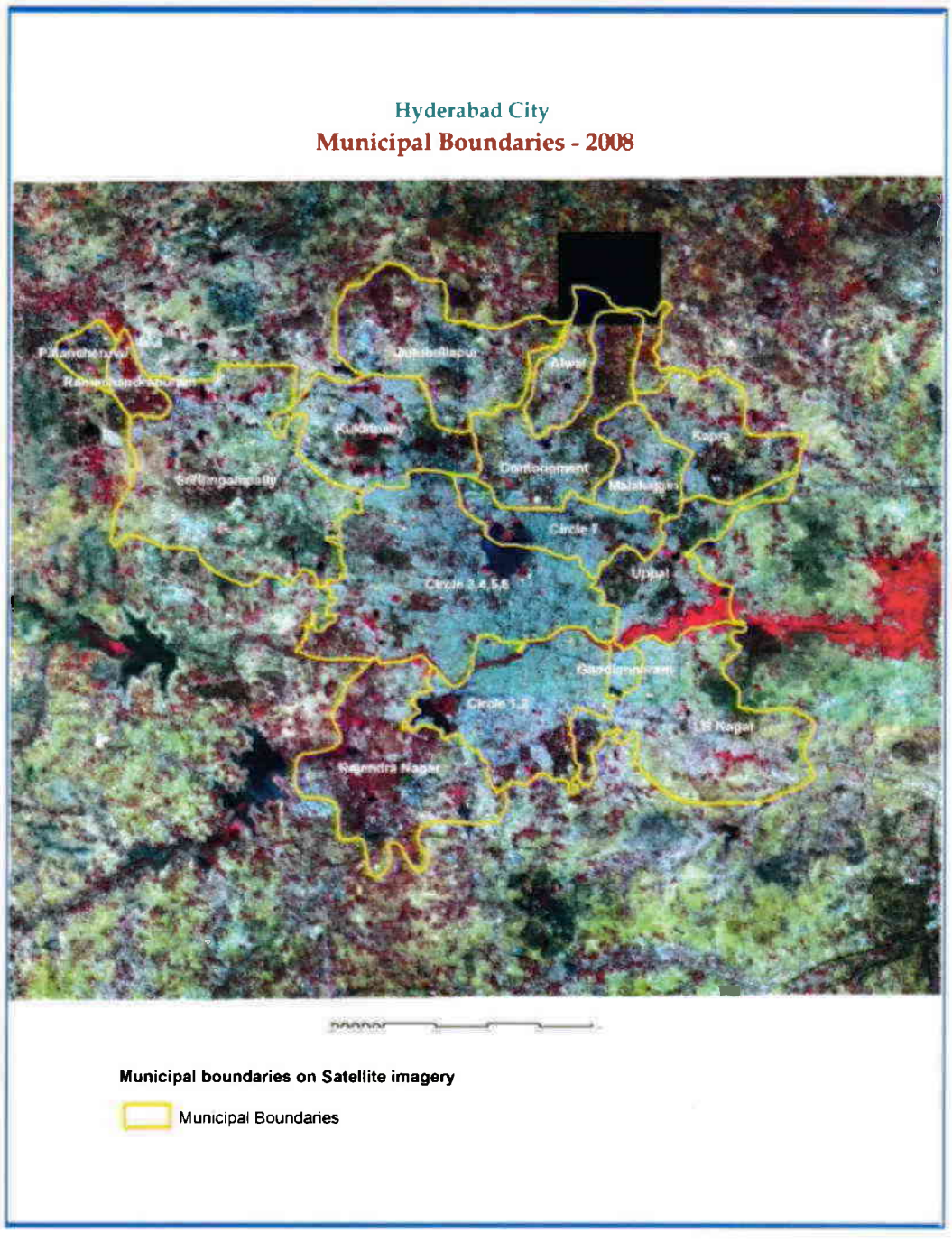

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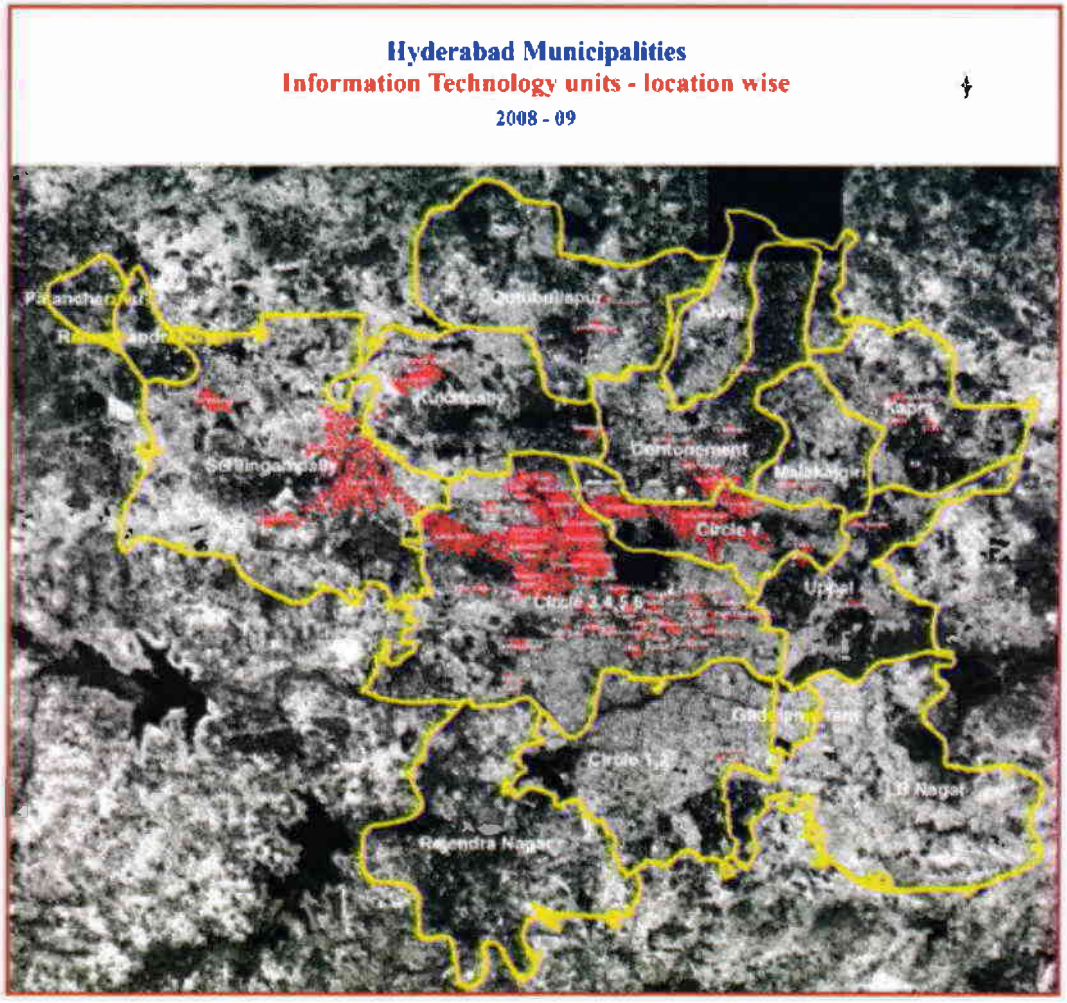

Fig. 4 See page 64 for text