

# The Study of the Land Use/Land Cover in Varanasi District Using Remote Sensing and GIS

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## Abstract

*Land use and Land cover change, is one of the main driving forces of global environmental changes, and central to the sustainable development debate. Understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for proper land management and decision improvement. Land use gives an overview of how different parcels of land are being utilized under various activities. Varanasi district, in recent years, has been witnessing significant land use changes. On the one hand while there is a progressive decline in area under agriculture, built up area has witnessed a prolific growth. Similarly area under wasteland, forests and fallow land too has witnessed a decline. Space technology through Remote Sensing has provided us with viable tool to assess such changes. The present paper highlights the changing trends and pattern of land use in Varanasi District using two time frame dataset (IRS P-6 LISS III, Standard FCC) of three cropping seasons. The study is based on standard digital classification techniques and its accuracy assessment.*

**Key Words:** Change detection, Land Use, LISS III, Remote Sensing.

## Introduction

Land use and Land cover change, is one of the main driving forces of global environmental changes, and central to the sustainable development debate. (Balchander D. et.al. 2011). Understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for proper land management and decision improvement. Land use/cover change detection is very essential for better understanding of landscape dynamic during a known period of time having sustainable management. Land use and land cover change has been recognized as an important driver of environmental change on all spatial and temporal scales (Turner *et al.*,

1994), Changes may involve the nature or intensity of change but may also include spatial (forest abatement at village level, or for a large-scale agro industrial plant), and time aspects. Land use/ Land cover changes also involve the modification, either direct or indirect, of natural habitats and their impact on the ecology of the area.

Land use gives an overview of how different parcel of land is being utilized under various activities. The pattern of land use in an area and the temporal changes therein are an important indicator of the type and pattern of development taking place in a given region. Knowledge about land use and land cover has become increasingly important to overcome the problems of

haphazard, uncontrolled development, deteriorating environmental quality, loss of prime agricultural lands, destruction of important wetlands, and loss of fish and wildlife habitat. (Anderson 1976). Land use and land cover changes have impacts on a wide ranges of environmental and landscape attributes including the quality of water, land and air resources, ecosystem processes and functions, the climate system itself through greenhouse gas fluxes and surface

albedo effects. (Balchander D. *et.al.* 2011). Land use data are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current levels (Anderson 1976).

Land use mapping has always been a time consuming and expensive process. Space technology in recent years has emerged as a powerful tool for land use /land cover studies, particularly change detection.

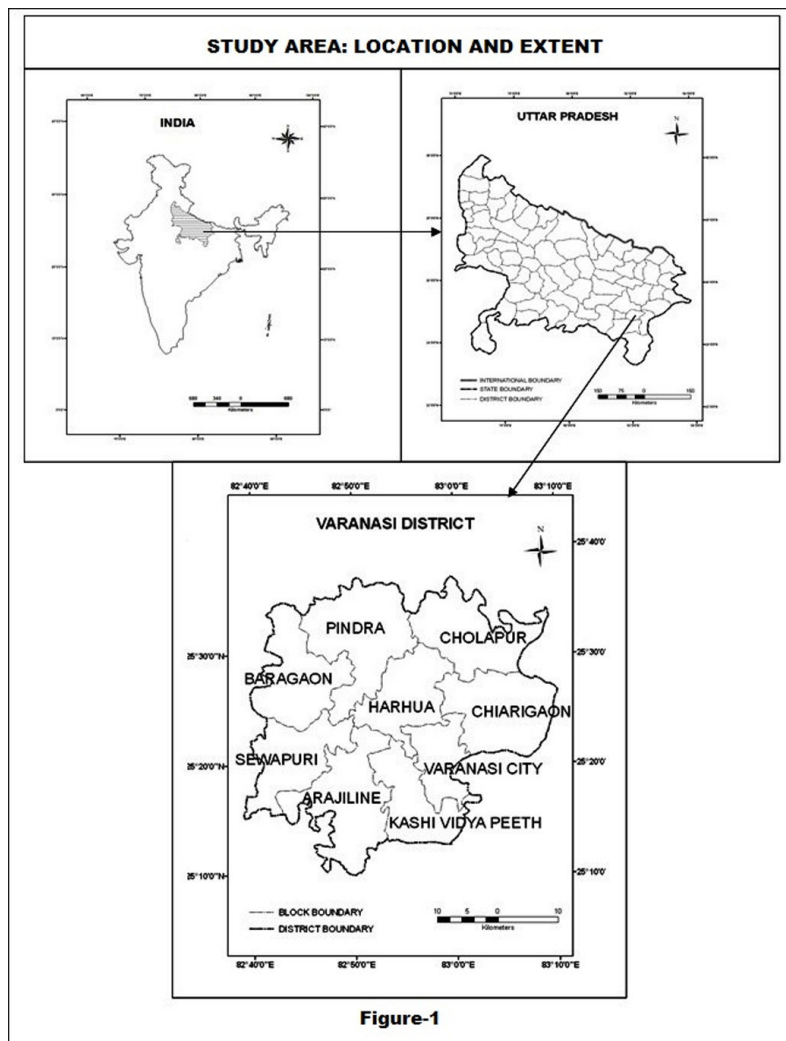


Fig. 1 :

Contrary to the traditional methods of field survey in which it took several years for the preparation and final mapping of land use/ land cover of an area, remote sensing technology, due to synoptic view, map like format and repetitive coverage, is a viable source of gathering quality land cover information at local, regional and global scales (Csaplovics, 1998; Foody, 2002). Land use is a matter of continuous growth and change in pattern. For economic development of a region, planners need up-to date information which can only be obtained quickly, economically and accurately through remote sensing techniques (Gautam N. C. and Narayan L.R.A. 1983)<sup>7</sup>. In the present paper an attempt is made to study the land use/ land cover change of Varanasi district using remote sensing and GIS.

### **Study Area**

Varanasi District, extending between 25°10'30''N and 25°35'15''N and 82°40'50''E and 83°12'18''E lies in eastern Uttar Pradesh (Figure-1). Physiographically it lies in the Middle Ganga Plains. The district is bounded by river Gomati and Jaunpur district in the north, by Sant Ravidas Nagar Bhadohi in the west and Chandauli district in the east. The total geographical area of the district is around 1526 sq km. Topographically the study area is a featureless alluvial plain with local prominences whose elevation varies from 70 meters in the east to 90 meters in the west. River Ganga is the principal river of the district. It meanders along the eastern part of the district forming its eastern boundary. It is joined by River Varuna, its left bank tributary from the west and by River Gomati in the north. Geologically the district is

composed of Gangetic alluvium formed by the deposition of the sediments brought by River Ganga and its tributaries. It consists mainly of sand, silt and clay interspersed by kankar at a few places. Climatically the region has sub tropical monsoonal climate characterized by seasonal extremities. January is the coldest month with mean maximum temperature of 23°C. Occasionally, though, the minimum temperature may drop down to around 5° C during mid December and January coupled with occurrence of dense fog. June is the hottest month with mean maximum temperature around 35°C. However temperatures' soaring above 40° C is not uncommon with occasional rise in mercury above 45°C under the impact of heat wave. The average annual rainfall of the district is around 110 cms bulk of which is received from the south west monsoons during June to September, August being the rainiest month.

### **Objective of the Study**

The main objective of the present study is to prepare the land use/Land Cover map of the study area and detect changes in the pattern of landuse/land cover for two years i.e. 2005-06 & 2011-12 using multi temporal satellite data.

### **Materials and Method**

In the present study geocoded ortho-rectified IRS P6 LISS-III(Resourcesat-I) satellite image Row 54 and path 102 (Fig-2 see page 209) having a resolution of 23.5 meters acquired from NRSA, Hyderabad of three cropping seasons viz. Rabi, Kharif and Zaid of two different years 2005-06 and 2011-12 and Survey of India Toposheets Nos.63K and 63O on 1: 250,000 scale have been used.

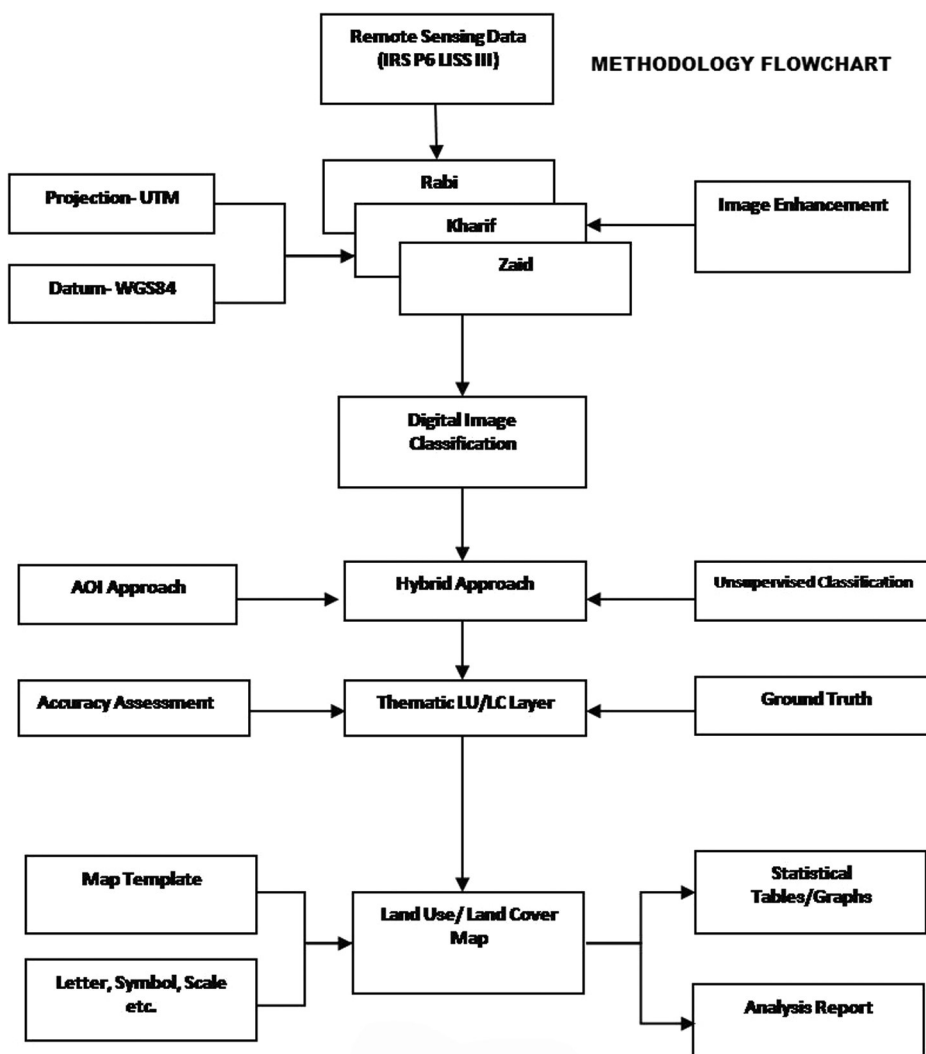


Fig. 3 :

The time frame selected viz. 2005-06 and 2011-12 for the purpose, because it shows the considerable changes in land utilization and, availability of cloud free satellite data of different cropping season. A number of steps are involved in the preparation of land use/Land cover Map as shown in Figure-3. All the processing has been done on ERDAS Imagine and Arc GIS software. A hybrid classification approach has been adopted for

the purpose. Unsupervised classification has been performed on the rabi season imagery to delineate land use/land cover classes. A total of 20 classes were taken initially and later merged into six major land use/land cover classes. Agricultural land has further been sub-classified into single, double and multiple cropped areas by intersecting the AOI (area of interest) of agricultural land of all three cropping seasons viz. Kharif, Rabi

and Zaid. Field checks have been performed for ascertaining the ground truth. Error Matrix for accuracy assessment has been generated and finally the land use map and reports have been prepared.

## Result and Discussion

Table-1 and Fig.4 (see page 209) shows the pattern of land utilization and the changes under each category of land use in Varanasi district during 2005-06 and 2011-12 taking 2005-06 as base year. Following the Land Use/Land cover classification scheme as developed by NRSA six land use/land cover classes viz. water bodies, built up area, fallow land, area under agriculture, waste land and area under vegetation have been delineated for Varanasi District. Area under agriculture has been further sub-classified into single, double and multiple cropped areas.

Agriculture constitutes the major economic activity in the study area as 65 percent of the total area was under agriculture in 2005-06. Area under single cropping in which cultivation takes place only once in an year, basically during Kharif

season, accounted for 14.81 percent to total area, area under double cropping, wherein cropping takes place twice in an year during Kharif and Rabi seasons constituted 11.41 percent area whereas area under multiple cropping in which cultivation takes place throughout the year accounted for 21.48 percent of the total area. The corresponding figures for 2011-12 are 52.36 percent (total cropped area), 18.88 percent (single cropped), 28.58 percent (double cropped) and 4.90 percent (multiple cropped area). If we analyze change in the different categories of cropped area then it can be seen that while there is a phenomenal increase in area under double cropping, 150 percent in 2011-12 over 2005-06, area under single cropping too has substantially increased by 27.46 percent during this period, this is mainly because of timely rainfall in khariff season and better irrigation and infrastructural availability in rabi season. However, area under multiple cropping has significantly declined by 77.18 percent (Table-1) because zaid season dedicated vegetables only which totally depends of irrigation and demand.

**Table 1:** Land Utilization in Varanasi District in 2005-06 and 2011-12

Land Use/Land Cover Class	2005-06 Area		2011-12 Area		Change in Area	
	In Hect.	In %	In Hect.	In %	in Hect	in %
Single Crop	22953.02	14.81	29256.02	18.88	6303.00	27.46
Double Crop	17687.23	11.41	44291.98	28.58	26604.75	150.42
Multiple Crop	33295.45	21.48	7597.44	4.90	-25698.01	-77.18
Fallow Land	44900.70	28.97	31305.43	20.20	-13595.27	-30.28
Vegetation Cover	8130.47	5.25	6455.40	4.17	-1675.07	-20.60
Built Up Land	18175.62	11.73	27855.99	17.97	9680.37	53.26
Waste Land	6519.86	4.21	4676.37	3.02	-1843.49	-28.27
Water Bodies	3321.68	2.14	3689.57	2.38	367.89	11.08
Total Area	154984	100	155128	100		

**Source:** Computed by the authors from IRS P6 LISS III Satellite Image

Fallow land, described as agricultural area devoid of cropping at the time of the recording of the data covered 44900.70 hectares area in 2005-06 and declined to 31305.43 hectares in 2011-12 so as declined by 30.28 percent over the period. This is attributed by better agricultural practices over the period.

Vegetation cover includes the area under the tree canopy. Unfortunately the study area is devoid of significant forest cover as in 2005-06, it constitutes only 8130.47 hectares or 5.25 percent of the total area and it further declined to 6455.40 hectares thereby showing a decline by 20.60 percent in 2011-12. This is because of harvesting of trees for agricultural and housing purposes.

Built-up Land, defined as an area of human habitation developed due to non agricultural land use and that has a cover of buildings, transport and communication, utilities in association with water vegetation and vacant lands (NRSA 2006) constituted 11.73 percent of the total area in 2005-06. It increased to 17.97 percent in 2011-12 which shows the growth 53.26 percent over the period, signifying a construction spree owing to expansion of settlements and urbanization mainly in and around Varanasi city by virtue of excessive growth of population and rapid urbanization. According to the Master Plan 2011 prepared by Varanasi Development Authority the total area of the city is proposed to increase from 14494.40 hectares in 1991 to 17927.22 hectares in 2011, an increase by 23.68 percent.

Area under wasteland has declined by 28.27 percent in 2011-12 over 2005-06 since it has been reclaimed for varied utilization viz. agriculture, pasture land, housing etc.

Water bodies includes the surface water bodies i.e. ponds, rivers, streams, canals etc. It accounted roughly 2 percent of the total area both in 2005-06 and 2011-12. In terms of change it has recorded an 11 percent increase in 2011-12 over 2005-06. It is mainly because of availability of water in surface water bodies due to better rain in the 2011-12 over the period.

### **Accuracy Assessment**

No image classification is said to be complete unless its accuracy has been assessed. To determine the accuracy of classification, a sample of testing pixels is selected on the classified image and their class identity is compared with the reference data (ground truth). The choice of a suitable sampling scheme and the determination of an appropriate sample size for testing data play a key role in the assessment of classification accuracy (Arora and Agarwal, 2002)<sup>2</sup>. In the present study, in order to assess the classification accuracy of classified images, 40 sample points for 2005-06 and 50 points for 2011-12 was selected using stratified random sampling in ERDAS. Sample points assigned to each class of classified images were verified with reference image (ground truth) to derive producer & user accuracy for each class and overall classification accuracy as depicted in Table-2 (Error Matrix) (Congalton, 1991)<sup>4</sup>. The overall classification accuracy stands at 72.5% and 92% for the year 2005-06 and 2011-12 respectively which shows the rationality of the study and found to be useful.

**Table-2:** Accuracy Assessment of Classified Map

Class	Reference Totals		Classified Total Number		Correct		Producer Accuracy (in %)		Users Accuracy (in %)	
	2005-06	2011-12	2005-06	2011-12	2005-06	2011-12	2005-06	2011-12	2005-06	2011-12
Single Crop	7	11	6	9	6	9	85.71	81.82	100	100
Double Crop	5	14	4	14	4	13	80.00	92.86	100	92.86
Multiple Crop	7	2	9	3	7	2	100.00	100	77.78	66.67
Fallow	10	9	11	10	6	9	60.00	100	54.55	90.00
Vegetation Cover	0	1	2	2	0	1	---	100	---	50.00
Built Up	7	10	5	9	3	9	42.86	90	60	100
Water Bodies	2	1	1	1	1	1	50.00	100	100	100
Waste Land	2	2	2	2	2	2	100.00	100	100	100
Total	40	50	40	50	29	46				
Overall Classification Accuracy: 2005-06 = 72.50 % 2011-12 = 92.00%										

**Source:** Computed by authors in ERDAS Imagine

### Summary and Conclusions

The present study aptly brings to light the changing trend in the pattern of land utilization in the study area. Among different categories of land use, area under agriculture is predominant accounting for more than 50 percent area in both 2005-06 and 2011-12 followed by fallow land and built up area. Area under forests is abysmally low accounting for not more than 5 percent of the total area. Change analysis shows a phenomenal rise in the built up area which has grown by 53 percent signifying a spree in construction activity mainly on account of rising demand for residential accommodation, and expansion of business activities in the district. Industrial use has however not contributed much to the building activity as there has not been very significant development of industries in the

district. This however has had a negative impact on area under agriculture which has shown a decline by 5.3 percent including fallow land. Like-wise area under vegetation cover and wasteland too has declined by 20 percent and 28 percent respectively in the period under study.

Thus, while reduction in the area under wasteland is encouraging increase in the agricultural land in some parts, while increase in built up land encourage the reduction in agricultural land in and around urban centers, and reduction in vegetation cover is a cause of concern. This is because reduction in agricultural area means loss of fertile land and additional pressure will exist upon the existing agricultural land to meet the additional food demand of the growing population in future, ecological sustainability and development.



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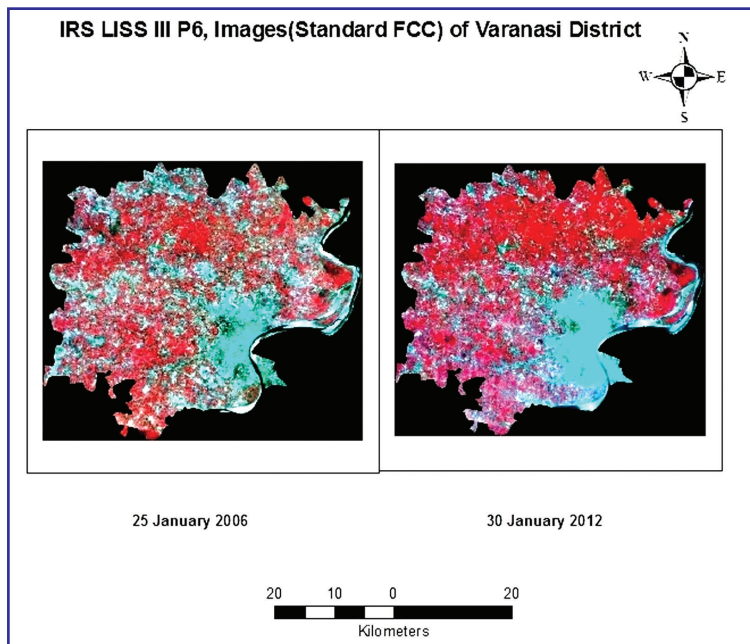


Fig.2 See page 203 for text

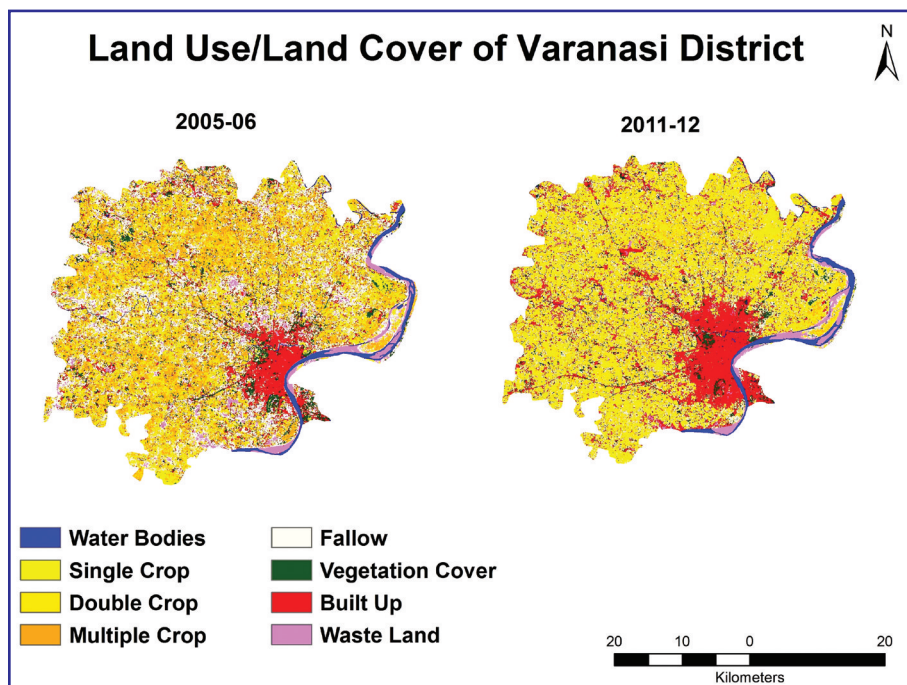


Fig.4 See page 205 for text

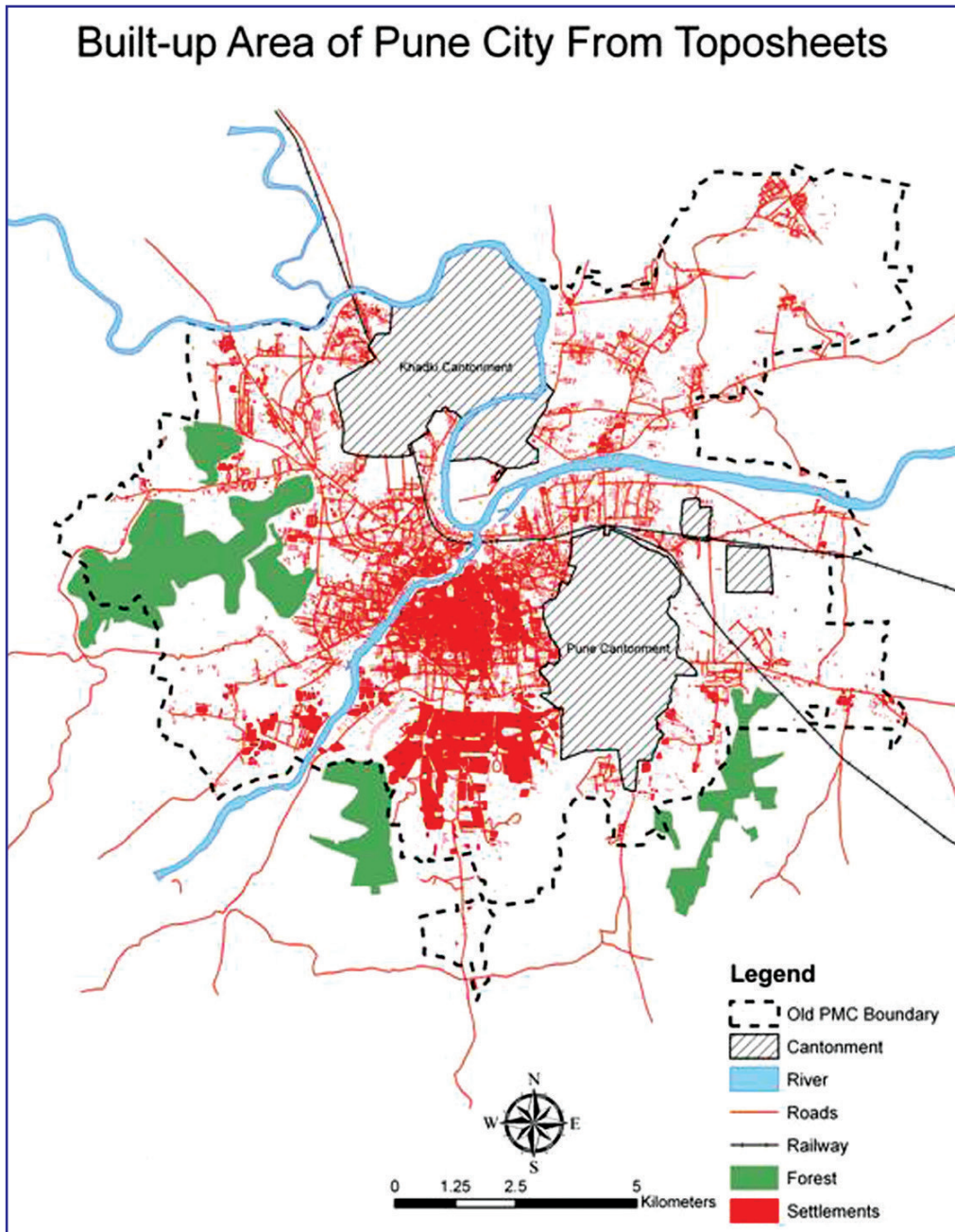


Fig.4 - See page 217 for text

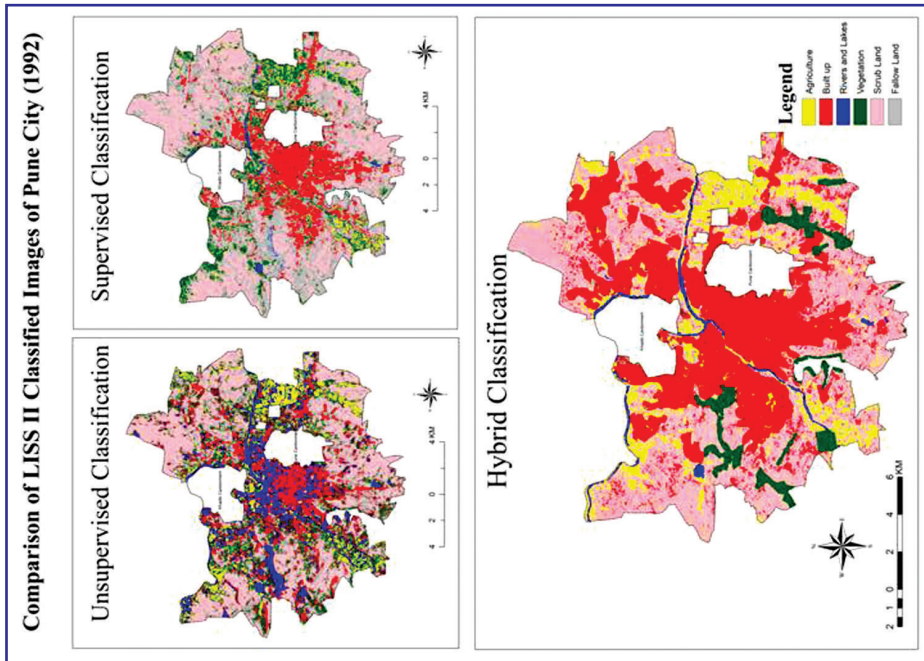


Fig.5 - See page 218 for text

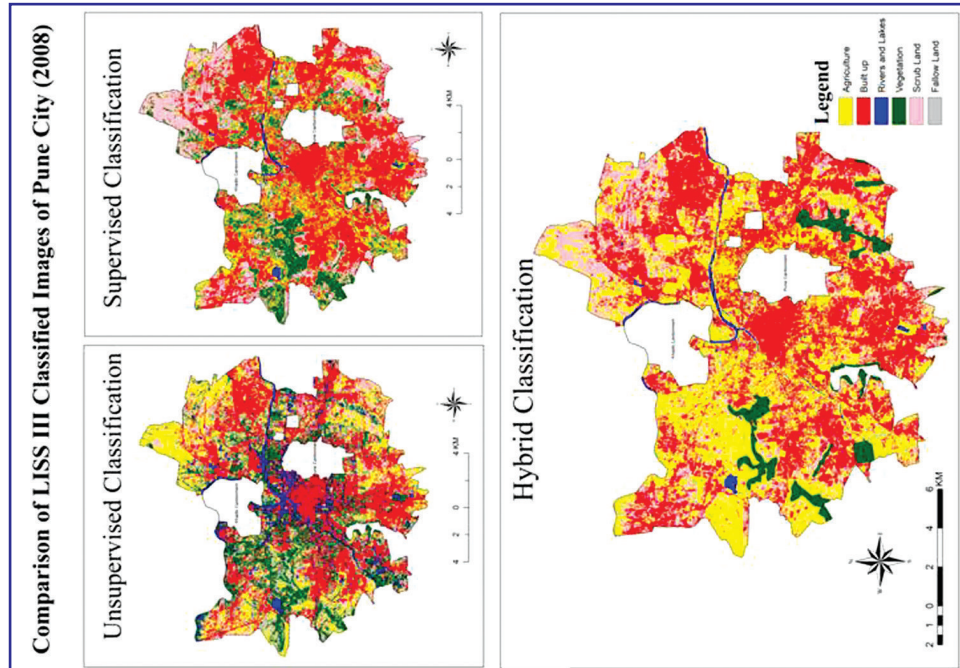


Fig. 6 - See page 218 for text



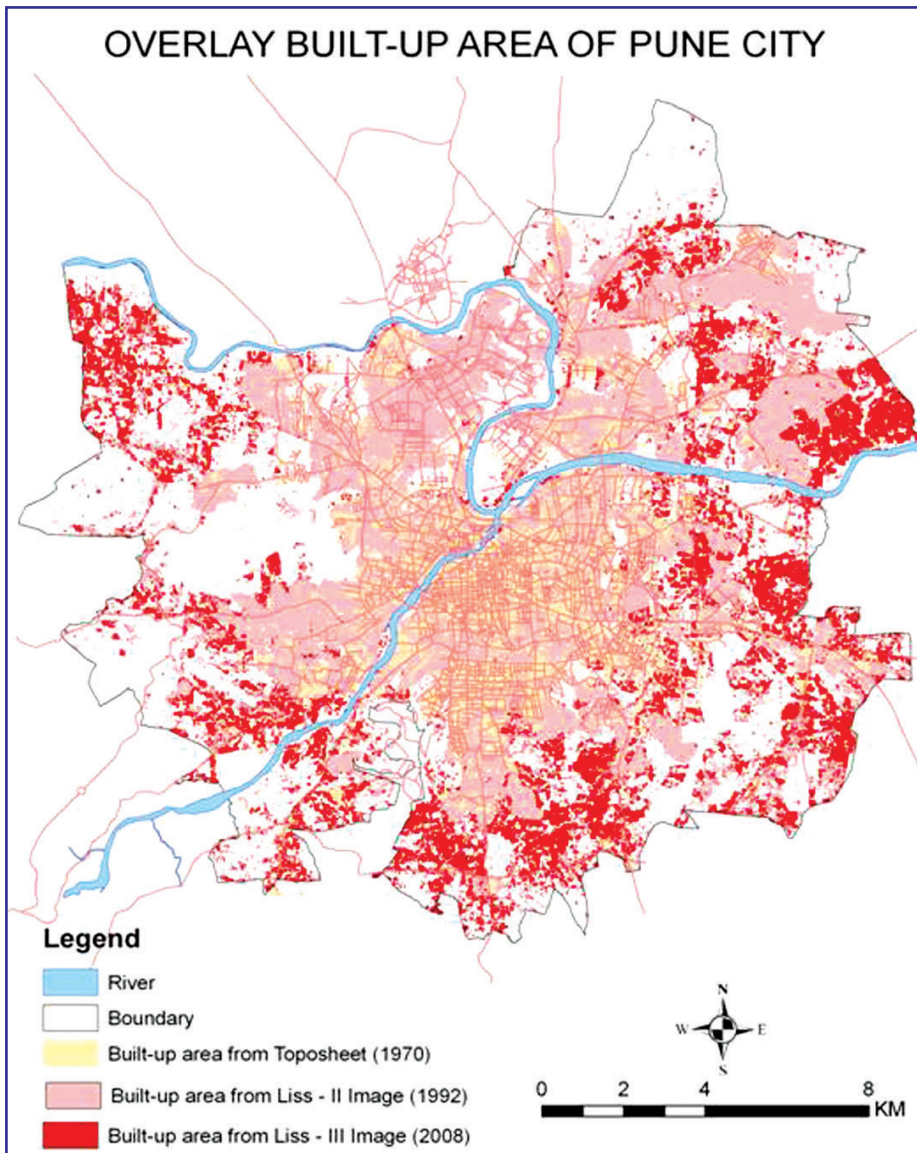


Fig. 8 - See page 221 for text