# GEO-SCIENCE IS A TOOL FOR URBAN ANALYSIS: A CASE STUDY OF INDIAN CITY.

**Rupesh Gupta,** ***M.Tech.*** **®** ***& Rupali Mathur,M.Tech.*** **® ®**

***Key Words:*** *Urban encroachment, Built-up land, Multi-Temporal, Spatio-Tempo., RS,GIS*

## Introduction

Problems related to rapid transformations of landuse have reached a level of significant impact, this unabated trend is increasing pressure on the limited land available in the city and its environs. It is, therefore, desirable to plan for the city and its peripheral areas in an integrated manner, so that, in due course, as the city grows, the periphery can merge into the whole. This kind of planning needs knowledge of the composition of the urban land use patterns and the quantitative analysis of the space devoted to each type of landuse. JAIPUR is the oldest planned city of India experienced a phenomenal growth during the post independence period due to the heavy influx of displaced persons. This, resulted in the change of the original city structure, many new residential areas were developed. The expansion of the city towards the north and the east was restricted because of physical constraints, development therefore, continued towards the south, manifold in the last few decades both in terms of population and in the extent of area. Keeping in view of the above, the present study has been performed to assess the land transformation patterns by change detection in landuse of different time periods during 1975 to 2003 of the Jaipur city.

## Objectives

- To analyse the status of existing landuse/landcover patterns and urban environment of the Jaipur city
- To find out the trends of the urban expansion during 1975 to 2003.

## Study Area

Entire Jaipur city (area covered by old JDA boundary) is considered for the purpose of land transformation and change detection studies. The whole region has experienced an emergence of environmental crises in terms of depletion of ground water, forests, soil erosion, flora and fauna and climatological 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. Stalinization is prominent in west and the south west of Jaipur Region. All the above phenomena have put heavy pressure on the environment, which in turn has created environmental changes in the ecosystem and their subsystems.

**®*Research Scholar,*** Dept. of Geography, Delhi School of Economics, University of Delhi-07, India. Email:rupesh_indian@rediffmail.com
***®®GIS Engg. SAR Softech.New Delhi, India***

**Location, Topography and Climate**

Jaipur is the capital of Rajasthan, the largest state of India. It is located at 26°4' North Latitude and 75°45' East longitude. It is surrounded by Aravalli hills to the north and east. The elevation varies from 462 m to 382 m above mean sea level.

Jaipur experiences a semiarid climatic condition with hot and dry summers and cold winters. The mean maximum temperature is 41°C, and the mean minimum temperature is 6.5°C. The average annual rainfall in the area is 620 mm. The month of July experiences highest relative humidity (74%). The predominant wind direction is from northwest and west.

**Data Input**

Details of data used in the present study are outlined below:

- IRS 1C LISS III (FCC) data of February 2003, of Path 96, Row 53.
- IRS 1C LISS II (FCC) data of 1991, of Path .29, Row 49, scale - 1:50,000.
- LANDSAT-TM (FCC) data of April 7, 1986 of path 147, row 41, scale - 1:1000,000.
- LANDSAT-MSS (FCC) data of March 2, 1975 of path 158, row 41, scale - 1:1000,000.
- SOI Toposheets, bearing no.– 45N/13, 45N/14, 45N/9, 45N/10, 45N/8, 45M/12, 45M/16, 54A/4 & 54B/1 of 1:50000 scales.
- Guide map of Jaipur city on the scale of 1:20,000

**Softwares Used**

- ARC/INFO (ArcGIS) version-8.02
- Geomatica version- 8.2
- ArcView version- 3.2a
- Image Analyst

**Methodology**

In the present study mainly two aspects, landuse/landcover and change detection have been demonstrated and mainly remote sensing techniques were used for the purpose.

**Landuse Classification**

**Data Requirements and Collection**

For the purpose of land use classification of different time periods, the regional scale maps have been prepared using remote sensing data as well as other ancillary data, published maps and field data.

**Classification System Adopted**

In the present study, a detailed classification system is developed for mapping. The landuse/landcover classes developed are: first order, second order and third order classification according to NRSA manual.

**Methodology For Preparing Landuse/Landcover Maps**

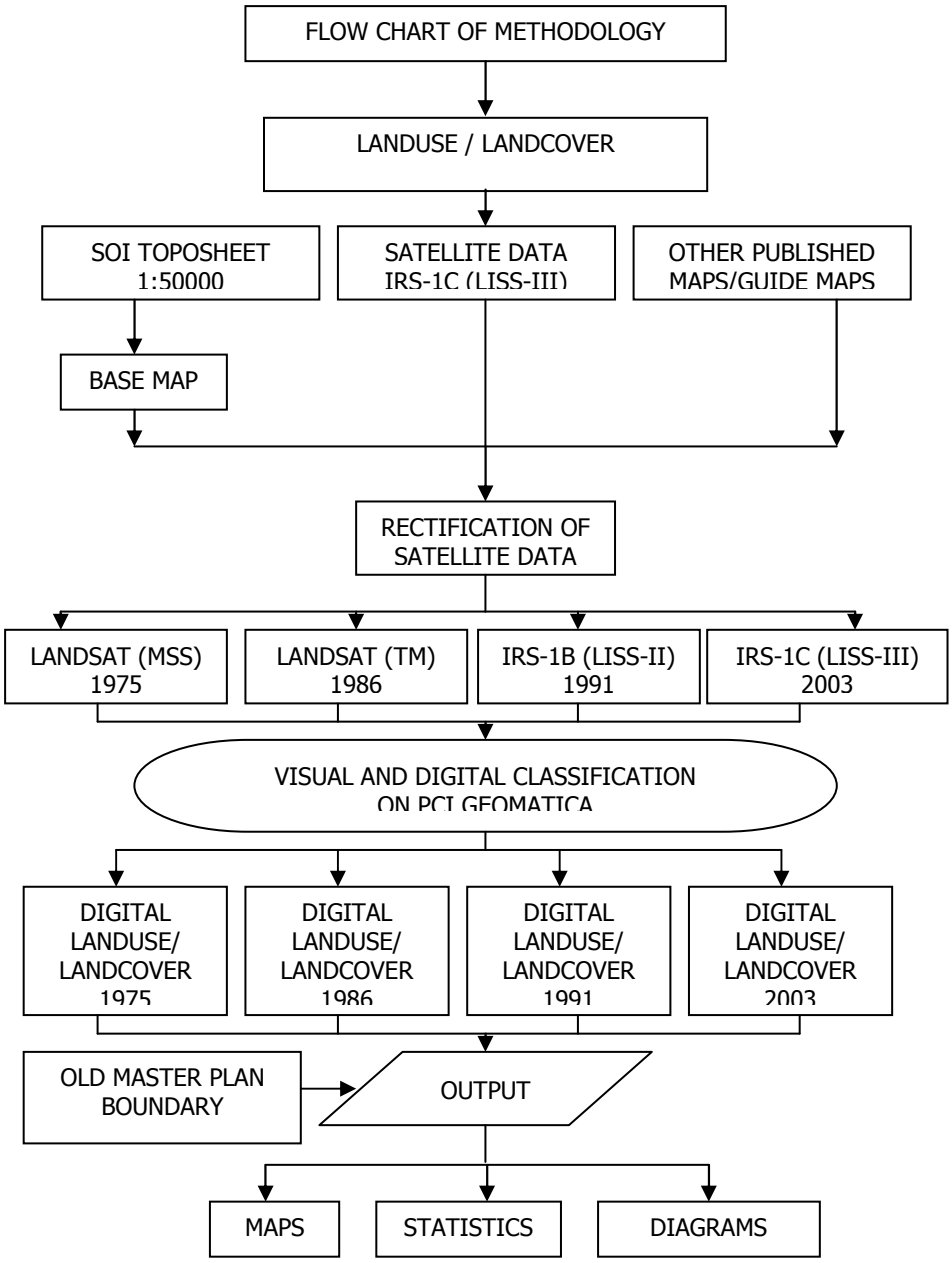
The broad methodology followed for the preparation of landuse/landcover maps, involves the following main steps.

**Preparation of Base Map**

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 1:20000 and by IRS 1C LISS III satellite data. The features such as water bodies, national highways, metalled and unmetalled roads, railways, settlement have been included in the base map.

**Preparation Of Landuse/Landcover Maps For The Years 1975, 1986 & 1991, Based On Visual/ On Screen Visual Interpretation.**

Landuse map of 1975, 1986 were obtained by the LANDSAT MSS & TM respectively, IRS 1B data was used for the preparation of landuse/cover map of 1990 of entire Jaipur region and map for 2003 was prepared by digital cum on screen visual interpretation of IRS 1C LISS (III) data.



**Landuse/Landcover of 1975**

For the preparation of Landuse/Landcover map, old JDA (Jaipur Development Authority) boundary had been considered. This boundary covered almost 44472.27 hectares of land.

**Area Under Landuse/ Land Cover in 1975**

| Category(LU/LC) | Area (in hectares.) | Area (in %) |
|---|---|---|
| High density built-up land | 1001.66 | 2.25 |
| Medium density built-up land | 1523 | 3.42 |
| Low density built-up land | 2113.69 | 4.75 |
| Croped area | 16385.65 | 38.22 |
| Fallow land | 12308.26 | 27.68 |
| Degraded Forest | 2911.33 | 6.55 |
| Mining area | 48.61 | 0.11 |
| Gullied area | 249.52 | 0.56 |
| Sandy area | 4823.54 | 10.85 |
| Saline area | 334.08 | 0.75 |
| Industrial area | 302.92 | 0.68 |
| Land under transformation | 1427.1 | 3.21 |
| Rocky wastelands | 789.75 | 1.78 |
| River beds | 253.15 | 0.57 |
| TOTAL | **44472.27** | **100** |

**Landuse/Landcover of 1986**

After the gap of eleven years since 1975, following observations are made, 41.20% of the total study area was cropland, which has increased to 2.98% As a result fallow land was highly decreased. Degraded forest was increased, while due to afforestation 2.53% of area converted to forest class. Areal extent of Built up land clearly indicates the development of the city during this period.

**Area Under Landuse/ Land Cover in 1986**

| **Category(LU/LC)** | **Area (in hectares.)** | **Area (in %)** |
|---|---|---|
| High density built-up land | 1268.12 | 2.85 |
| Medium density built-up land | 4216.78 | 9.48 |
| Low density built-up land | 3086.38 | 6.94 |
| Croped area | 18252.98 | 41.2 |
| Fallow land | 3942.14 | 8.86 |
| Degraded Forest | 4147.72 | 9.33 |
| Actual Forest | 1124.58 | 2.53 |
| Mining area | 167.56 | 0.38 |
| Gullied area | 415.35 | 0.93 |
| Sandy area | 1301.88 | 2.93 |
| Saline area | 194.8 | 0.44 |
| Industrial area | 807.67 | 1.82 |
| Land Under Transformation | 4426.73 | 9.95 |
| Park/Playground | 80.81 | 0.18 |
| Rocky wasteland | 785.61 | 1.77 |
| River beds | 253.15 | 0.57 |
| **Total** | **44472.27** | **100** |

**Landuse/Landcover of 1991**

During 1991 the built up land has grown from 19.27% to 25.47% registering an increase of 6.20% area of built up land. During this period croped area and land under transformation categories cover 35.54% and 13.49% of total geographical area. Which indicates that city is in growing stage.

**Area Under Landuse/ Land Cover in 1991**

| Category(LU/LC) | Area(in hectares.) | Area(in %) |
|---|---|---|
| High density built-up land | 2988.92 | 6.72 |
| Medium density built-up land | 4131.99 | 9.29 |
| Low density built-up land | 4209 | 9.46 |
| Croped area | 15803.2 | 35.54 |
| Fallow land | 2960.52 | 6.66 |
| Degraded Forest | 5489.28 | 12.34 |
| Actual Forest | 230.92 | 0.52 |
| Mining area | 65.78 | 0.15 |
| Gullied area | 436.9 | 0.98 |
| Sandy area | 475.55 | 1.07 |
| Saline area | 180.75 | 0.41 |
| Industrial area | 376.19 | 0.85 |
| Land Under Transformation | 6000.88 | 13.49 |
| Park/Playground | 81.73 | 0.18 |
| Rocky wasteland | 789.75 | 1.78 |
| River beds | 250.91 | 0.56 |
| **TOTAL** | **44472.27** | **100** |

**Land Use/ Land Cover of 2003**

A remarkable change has been observed in landuse during this period. Area statistics shows that city is developing at very fast rate, as built land has increased by 33.98%(map 4.4). Crop area has covered 26.62%. 3.47% and 4.36% was under gullied and saline lands respectively.

**Area Under Landuse/ Land Cover in 2003**

| Category(LU/LC) | Area (in hectares.) | Area (in%) |
|---|---|---|
| High density built-up land | 2444.2 | 5.5 |
| Medium density built-up land | 12665.09 | 28.48 |
| Crop area | 11837.84 | 26.62 |
| Fallow land | 2909.38 | 6.54 |
| Degraded Forest | 233.05 | 0.52 |
| Actual Forest | 5289.06 | 11.89 |
| Mining area | 82.37 | 0.19 |
| Gullied area | 1543.39 | 3.47 |
| Saline area | 1937.84 | 4.36 |
| Park/Playground | 153.16 | 0.34 |
| Rocky wasteland | 12.38 | 0.03 |
| Plantation | 157.88 | 0.36 |
| Scrub | 2653.92 | 5.97 |
| River beds | 250.5 | 0.56 |
| Water body | 5.82 | 0.01 |
| Rail | 143.08 | 0.32 |
| Road | 2153.32 | 4.84 |
| TOTAL | 44472.27 | 100 |

**Landuse/Landcover of 2003 within New JDA Boundary**

The new master development plan for the development of Jaipur was prepared and approved in 1995, which came into force from 1/09/98. Landuse/Landcover map of the new area has been prepared by digital image processing techniques of the IRS-LISS III data of the year 2003.

The computations show that out of 149438 hectare land, 18180.75 hectare land is under high and medium density built up lands, which is 11.72% of the total study area. Computations also show that 36.55% area is under cropland, 17.16% area is under fallow land (map 4.5). 9.48% area is under Scrubland .

Within the new JDA boundary some small townships like Bagru, Sanganer, Chaksu, Kukas were also been considered. The regional appearance of the area is urban and of sub urban categories.

**Area Under Landuse/ Land Cover In 2003 (New Boundary)**

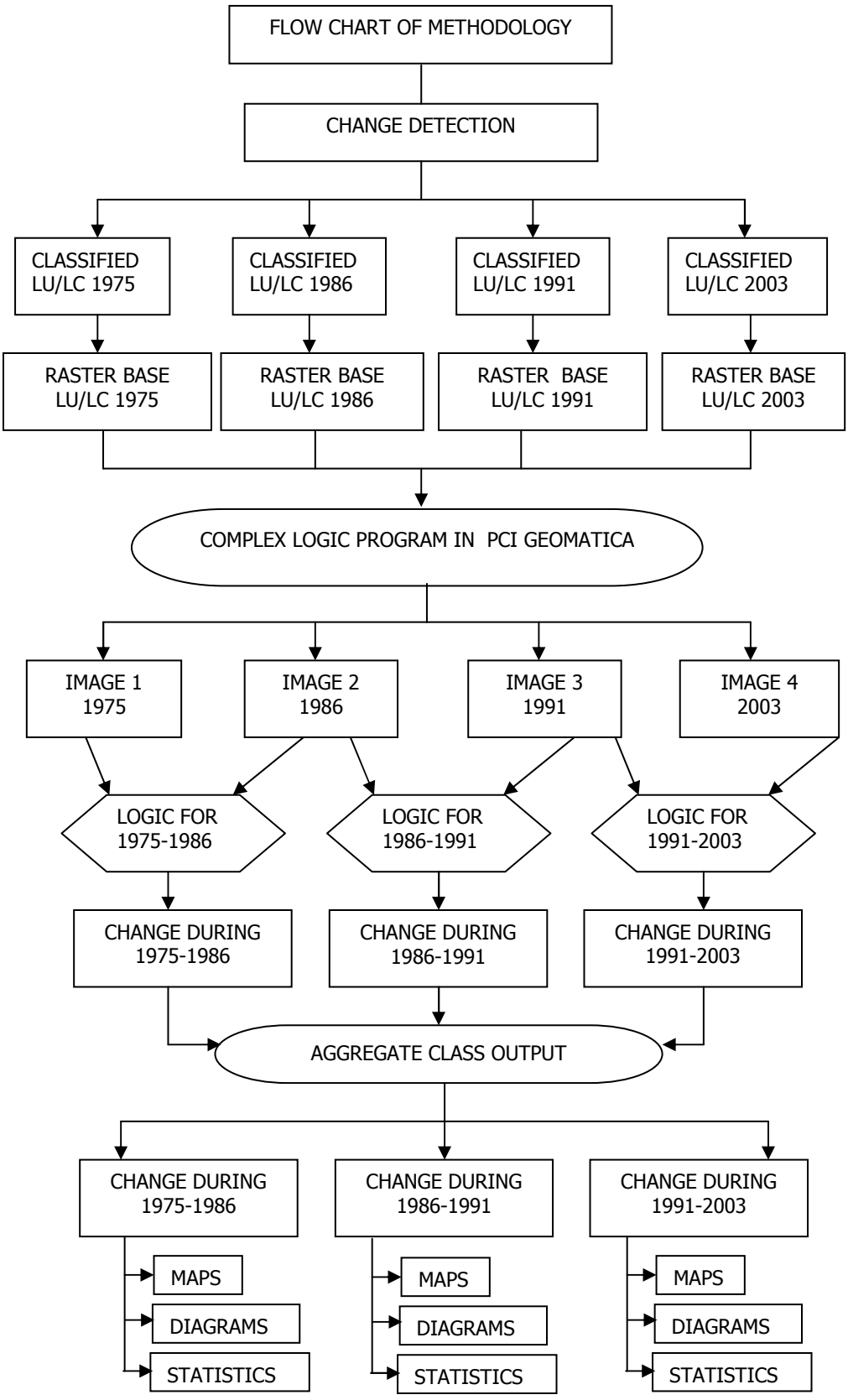
| Name | Area (in hectares.) | Area (in%) |
|---|---|---|
| High density built-up land | 2494.83 | 1.67 |
| Medium density built-up land | 15685.92 | 10.5 |
| Crop area | 54616.66 | 36.55 |
| Fallow land | 26323.31 | 17.61 |
| Degraded Forest | 1104.48 | 0.74 |
| Actual Forest | 12131.08 | 8.12 |
| Mining area | 82.37 | 0.06 |
| Gullied area | 7675.55 | 5.14 |
| Saline area | 9902.76 | 6.63 |
| Park/Playground | 153.16 | 0.1 |
| Rocky wastelands | 852.54 | 0.57 |
| Plantation | 157.88 | 0.11 |
| Scrub | 14168.74 | 9.48 |
| River beds | 900.69 | 0.6 |
| Water body | 73.84 | 0.05 |
| Rail | 280.97 | 0.19 |
| Road | 2834.15 | 1.9 |
| **TOTAL** | **149438.94** | **100** |

**Trends of Urban Development**

The urban sprawl maps of Jaipur city have been prepared on the basis of multi-date data of Landsat (MSS), Landsat (TM), IRS – IB (LISS – II), IRS–IC (LISS – III) data in conjunction with SOI topographical Maps. These maps depict, growth of the city as well as the direction of the growth.After analyzing these maps, the following observations are made on the basis of their Landuse / Land cover classification.

**Change Detection During 1975 T0 2003.**

LANDSAT (MSS) sensor used for finding the change for the period of 1975 and after 11 years the same study area covered by LANDSAT(TM) in 1986. Again same study area was covered with the help of IRS 1B LISS (II) data in 1991 to find out the change during the gap of 5 years. Likewise again IRS LISS (III) data been taken for the year 2003, to find the change since 1991.
To get the changes at periodical interval one cross matrix has been generated with the help of Complex Logic Program in PCI Geomatica, which gives the direction and dimensions of change in landuse and landcover during two time periods.(Annexure-I)


FLOW CHART OF METHODOLOGY
CHANGE DETECTION
CLASSIFIED LU/LC 1975
CLASSIFIED LU/LC 1986
CLASSIFIED LU/LC 1991
CLASSIFIED LU/LC 2003
RASTER BASE LU/LC 1975
RASTER BASE LU/LC 1986
RASTER BASE LU/LC 1991
RASTER BASE LU/LC 2003
COMPLEX LOGIC PROGRAM IN PCI GEOMATICA
IMAGE 1 1975
IMAGE 2 1986
IMAGE 3 1991
IMAGE 4 2003
LOGIC FOR 1975-1986
LOGIC FOR 1986-1991
LOGIC FOR 1991-2003
CHANGE DURING 1975-1986
CHANGE DURING 1986-1991
CHANGE DURING 1991-2003
AGGREGATE CLASS OUTPUT
CHANGE DURING 1975-1986
CHANGE DURING 1986-1991
CHANGE DURING 1991-2003
MAPS
DIAGRAMS
STATISTICS
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**Change Detection Studies**

**Change during 1975-1986**

Total built up land in 1975 was 10.4% of total study area, which has become almost double and covered 19% land of the study area. The major changes are observed in southern and western parts where density of houses has increased to high density and open areas have been converted into built up lands. The Mining area in the study area is mainly stone quarrying found near foothills of Jhalana and Nahargarh hill ranges. During 1975-86 period it has increased from 48.61 hectares to 167.56 hectares, showing three-fold increase.Land under transformation category mainly showing the transition phase. 6979.9 hectares land of this category has remain as open land. This shows that the city is developing outwards and encroaching agricultural lands.

Category wise changes are shown in the following table.

**Change During 1975 to 1986 (Aggregate classes)**

| S.No. | Class Name | Area (in Hectares.) | Area (in %) |
|---|---|---|---|
| 1 | High density | 1002.41 | 2.25 |
| 2 | Moderate density | 1377.04 | 3.1 |
| 3 | Low density | 1038.64 | 2.34 |
| 4 | Built up development | 1221.98 | 2.75 |
| 5 | Crop to settlement | 1901.55 | 4.28 |
| 6 | Open area to settlement | 3330.89 | 7.49 |
| 7 | Land trans to settlement | 913.88 | 2.05 |
| 8 | New settlement | 42.57 | 0.1 |
| 9 | Crop area | 16435.7 | 36.96 |
| 10 | New crop area | 390.01 | 0.88 |
| 11 | Land under transformation | 6979.85 | 15.69 |
| 12 | Fallow land | 2212.07 | 4.97 |
| 13 | New plantation | 317.43 | 0.71 |
| 14 | New park | 11.4 | 0.03 |
| 15 | Degraded forest to open area | 126.6 | 0.28 |
| 16 | Degraded forest | 3645.56 | 8.2 |
| 17 | Dense forest | 53.68 | 0.12 |
| 18 | Industrial area | 302.8 | 0.68 |
| 19 | New industrial area | 608.95 | 1.37 |
| 20 | Mining area | 48.5 | 0.11 |
| 21 | New mining area | 150.62 | 0.34 |
| 22 | Wasteland | 1161.45 | 2.61 |
| 23 | New wasteland | 152.76 | 0.34 |
| 24 | Barren rocky | 790.96 | 1.78 |
| 25 | River | 249.64 | 0.56 |
| 26 | Null | 5.3 | 0.01 |
| | **Total** | **44472.27** | **100** |

**Change During 1986-1991**

During 1986-91 period major changes have been observed in two landuse classes agricultural and built up land. Crop area has been decreased considerably, whereas built up land is increasing to, accommodate the increasing population of the city. New colonies are being developed on the agricultural lands, open lands.
New Plantation areas have been developed in various land use areas, like Degraded forest, Gullied area & sandy area in 1991 Most of the dense forest areas have been changed to degraded forest and only 112.32 hectares of land has remains unchanged due to droughts or decline in vegetative cover.

A considerably large part of land under transformation has been utilized for residential purpose (2500.76 hectares) and industrial purpose (74.30 hectares). This shows that the Jaipur city has expanded at the faster rates especially in southern and western directions.

**Change During 1986to 1991 (Aggregate classes)**

| S. No | Class Name | Area ( in Hec.) | Area ( in %) |
|---|---|---|---|
| 1 | High density | 1268.12 | 2.85 |
| 2 | Moderate density | 2372.26 | 5.33 |
| 3 | Low density | 1766.42 | 3.97 |
| 4 | Built up development | 3161.72 | 7.11 |
| 5 | Crop to settlement | 703.53 | 1.58 |
| 6 | Open area to settlement | 630.89 | 1.42 |
| 7 | Land trans to settlement | 2500.76 | 5.62 |
| 8 | New settlement | 56.68 | 0.13 |
| 9 | Crop area | 13727.63 | 30.87 |
| 10 | New crop area | 1068.88 | 2.4 |
| 11 | Land under transformation | 8846.67 | 19.89 |
| 12 | Fallow land | 700.19 | 1.57 |
| 13 | New plantation | 295.49 | 0.66 |
| 14 | Park/playground | 51.84 | 0.12 |
| 15 | Degraded forest to open area | 32.2 | 0.07 |
| 16 | Degraded forest | 4318.68 | 9.71 |
| 17 | Dense forest | 112.32 | 0.25 |
| 18 | Industrial area | 808.24 | 1.82 |
| 19 | New industrial area | 87.26 | 0.2 |
| 20 | Mining area | 167.27 | 0.38 |
| 21 | New mining area | 50.8 | 0.11 |
| 22 | Wasteland | 583.03 | 1.31 |
| 23 | New wasteland | 119.35 | 0.27 |
| 24 | Barren rocky | 786.36 | 1.77 |
| 25 | River | 249.35 | 0.56 |
| 26 | Null | 6.34 | 0.01 |
| | **Total** | **44472.27** | **100** |

**Change during 1991-2003**

During 1991-2003 time periods major change has found within / between two landuse classes agricultural and built up land. Crop area has been decreased considerably, whereas built up land is increasing very fast, as population of the city is increasing at fast rate. A major positive transformation occurred in this time period, 4222.77hectares of land of this class changed to plantation, this is because of afforestation programs, and this is further reclassified as new plantation category.

**Change During 1991 to 2003 (Aggregate classes)**

| S. No. | Class Name | Hectares | %Image |
|---|---|---|---|
| 1 | High density | 2367.42 | 5.32 |
| 2 | Moderate density | 3639.92 | 8.18 |
| 3 | Low density | 3808.92 | 8.56 |
| 4 | Built up development | 61.98 | 0.14 |
| 5 | Crop to settlement | 1750.87 | 3.94 |
| 6 | Open area to settlement | 490.69 | 1.1 |
| 7 | Land trans to settlement | 2978.84 | 6.7 |
| 8 | New settlement | 599.67 | 1.35 |
| 9 | Crop area | 10340.01 | 23.25 |
| 10 | New crop area | 1185.29 | 2.67 |
| 11 | Land under transformation | 7003.12 | 15.75 |
| 12 | Fallow land | 435.05 | 0.98 |
| 13 | New plantation | 4304.22 | 9.68 |
| 14 | Park/playground | 26.78 | 0.06 |
| 15 | New park | 99.53 | 0.22 |
| 16 | Degraded forest to open area | 354.99 | 0.8 |
| 17 | Degraded forest | 38.13 | 0.09 |
| 18 | Dense forest | 523.64 | 1.18 |
| 19 | Industrial area | 322.79 | 0.73 |
| 20 | Mining area | 65.43 | 0.15 |
| 21 | New mining area | 28.97 | 0.07 |
| 22 | Wasteland | 355.28 | 0.8 |
| 23 | New wasteland | 305.45 | 0.69 |
| 24 | Barren rocky | 767.92 | 1.73 |
| 25 | River | 255.86 | 0.58 |
| 26 | Road network | 2153.32 | 4.84 |
| 27 | Rail network | 143.08 | 0.32 |
| 28 | Null | 65.09 | 0.15 |
| | **Total** | **44472.27** | **100** |

**Results and Discussion**

Jaipur city was bounded by a strong wall for living 2.5 lac people. The city has shown the higher rate of expansion after 1973 and has covered 151.1 km. area under the residential category. The major expansion is observed in the western, southern and south-eastern parts and along the national highways no. 8, 11 and 12. Towards south it has expanded about 20 km. from Ajmeri gate covering Sanganer town and even along the Tonk road. Towards western direction it has almost reached to Bagru town, which is about 35 km. away from the city.

**Main Findings**

- Jaipur city has expanded towards south and western directions in uncontrolled manner, engulfing used productive cropped areas.
- The urban area has cover over the surroundings towns, which are developing as the satellite towns like Sanganer, Bagru, Chomu, Achrol, Kanota etc.
- Jaipur city is putting heavy pressure on the ecological sensitive areas, due to deforestation and mining in Nahargarh and Jhalana reserve forest areas.
- The Remote Sensing Technology has proved its importance for Urban landuse analysis, Change detection and Planning.

**Suggestions**

- The planning authorities should prepare the future development in advance to avoid unplanned expansion of the city.
- The planner should use Remote Sensing technology for identification of suitable lands for establishment of new colonies, industrial and institutional areas without harming ecology and productive areas.
- The planners can utilize Remote Sensing tools for route planning, circuitry route (Byepass routes), requirement of flyovers, treatment plants and various facilities. It can also be use for identification of unplanned and slum area, so that they can be taken up on priority of plan.
- The authorities responsible for the supply of various facilities & amenities should prepare of comprehensive database for the entire of the city, so that they may know the status of the facilities available in different parts / colonies of the city. It would help in identifying the area where the facilities are lacking or needs immediate measures.
- Various types of simulation modelling can be possible by combination of Remote Sensing and GIS techniques to facilitate the planners for effective planning.

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## ANNEXURE-I

## CROSS MATRIX CHART DURING DIFFERENT TIME PERIODS:

**MATRIX: 1975 to 1986**

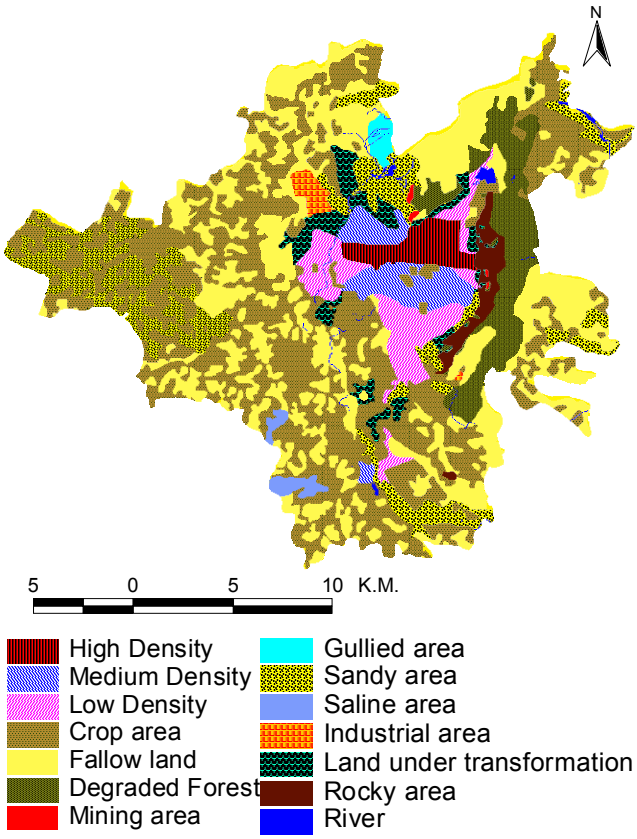
| | Code | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | 1975 \ 1986 | High Density | Med Density | Low Density | Crop | Fallow | Deg Forest | Plantation | Actl.Forest | Mining | Gullied | Sandy | Saline | LUT | Industrial | Park/Playgrd | Rocky | Scrub | River |
| 1 | High Density | 1002.41 | - | | | | | | | | | | | | | | | | |
| 2 | Med Density | 146.53 | 1377.04 | | | | | | | | | | | | | | | | |
| 3 | LowDensity | 149.24 | 926.21 | 1038.64 | | | | | | | | | | | | | | | |
| 4 | Crop | 26.55 | 815.5 | 1059.49 | 16741 | | | | | 35.71 | | | | | 94.98 | | | | |
| 5 | Fallow | 4.03 | 188.7 | 378.26 | | 1557.6 | 1370.53 | | | 73.09 | | | 5.59 | | 367.32 | | | | |
| 6 | Deg. Forest | | 8.76 | 33.81 | 248.74 | 8.81 | 2275.03 | 317.43 | | 18.72 | | | | | | | | | |
| 7 | Plantation | | | | | | | | | | | | | | | | | | |
| 8 | Actl. Forest | | | | | | | | 53.68 | | | | | | | | | | |
| 9 | Mining | | | | | | | | | 48.5 | 249.4 | | | | | | | | |
| 10 | Gullied | | | | | | | | | | | | | | | | | | |
| 11 | Sandy | 431.42 | | 235.76 | 2092.7 | 654.51 | | 117.79 | | 23.1 | 147.2 | 681.2 | | | 138.82 | | | | |
| 12 | Saline | | | | 103.28 | | | | | | | | 230.8 | | | | | | |
| 13 | Land Trans. | 61.63 | 437.24 | 415.01 | 38.02 | | | 11.4 | | | | | | 6979.9 | | | | | |
| 14 | Industrial | | | | | | | | | | | | | | 302.8 | | | | |
| 15 | Park/Playgrd | | | | | | | | | | | | | | | | | | |
| 16 | Rocky | | | | | | | | | | | | | | | | 791 | | |
| 17 | Scrub | | | | | | | | | | | | | | | | | | |
| 18 | River | | | | | | | | | | | | | | | | | | 249.6 |

MATRIX: 1986 to 1991

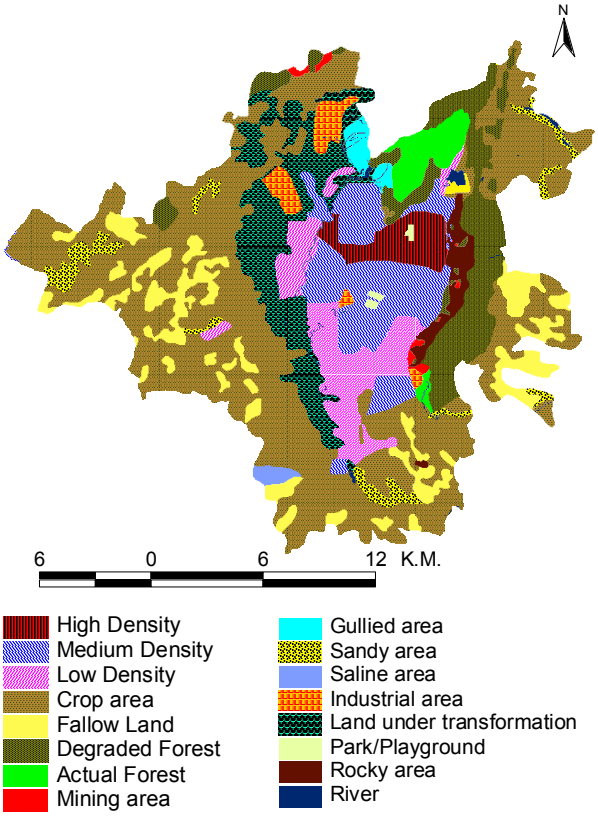
| | Code | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | 1986 \ 1991 | High Density | Med Density | Low Density | Crop | Fallow | Deg.Forest | Plantation | Actl.Forest | Mining | Gullied | Sandy | Saline | LUT | Industrial | Park/Playgrd | Rocky | Scrb | River |
| 1 | High Density | 1268.12 | - | | | | | | | | | | | | | | | | |
| 2 | Med Density | 1841.64 | 2372.26 | | | | | | | | | | | | | | | | |
| 3 | Low Density | 48.38 | 1271.69 | 1766.42 | | | | | | | | | | | | | | | |
| 4 | Crop | | 213.58 | 489.95 | 13733.87 | | | | | 2.48 | | | | | 12.96 | | | | |
| 5 | Fallow | | | 25.86 | | 583.14 | 161.11 | | | | | | 96.83 | | | | | | |
| 6 | Deg. Forest | 0.35 | 22.87 | | 461.2 | 25.17 | 3132.12 | 189.16 | | 48.33 | | | | | | | | | |
| 7 | Plantation | | | | | | | | | | | | | | | | | | |
| 8 | Actl. Forest | | | | | | 1025.45 | | 112.32 | | | | | | | | | | |
| 9 | Mining | | | | | | | | | 167.27 | | | | | | | | | |
| 10 | Gullied | | | 4.67 | 77.18 | | | 106.33 | | | 227.92 | | | | | | | | |
| 11 | Sandy | 24.31 | | 0.4 | 580.32 | 117.04 | | 7.03 | | | 22.52 | 280.4 | | | | | | | |
| 12 | Saline | | | | 120.1 | | | | | | | | 74.71 | | | | | | |
| 13 | Land Trans. | | 555.49 | 1945.27 | 410.4 | | | | | | | | | 8846.67 | 74.3 | | | | |
| 14 | Industrial | | | | | | | | | | | | | | 808.24 | | | | |
| 15 | Park/Playgrd | 28.8 | | | | | | | | | | | | | | 51.84 | | | |
| 16 | Rocky | | | | | | | | | | | | | | | | 786.36 | | |
| 17 | Scrub | | | | | | | | | | | | | | | | | | |
| 18 | River | | | | | | | | | | | | | | | | | | 249.35 |

***Rupesh Gupta,M.Tech.,****Research Scholar,Delhi School of Economics,University of Delhi-110007,India.Email:gisrs@sify.com*

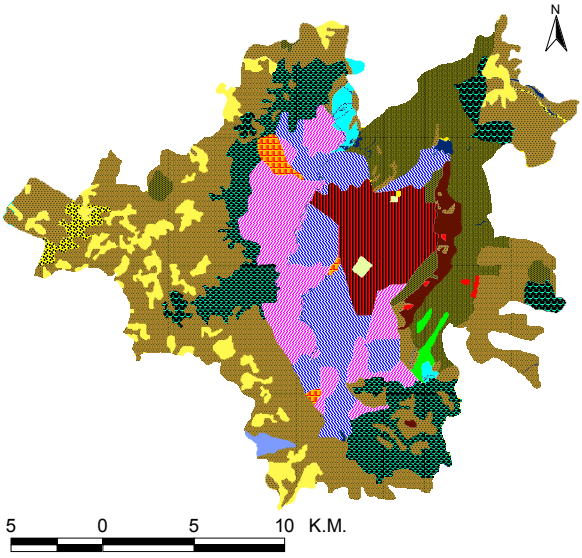
**LANDUSE /LANDCOVER MAP (1975)**



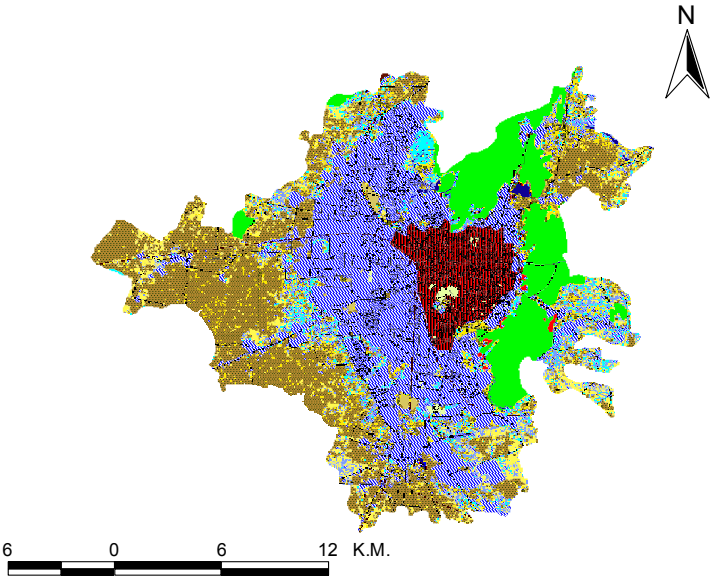

**LANDUSE /LANDCOVER MAP (1986)**



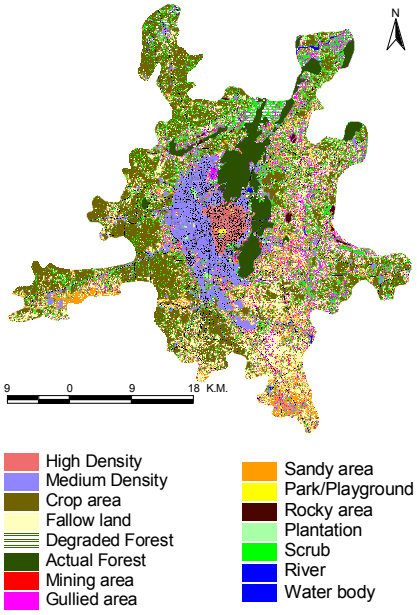
## LANDUSE /LANDCOVER MAP (1991)



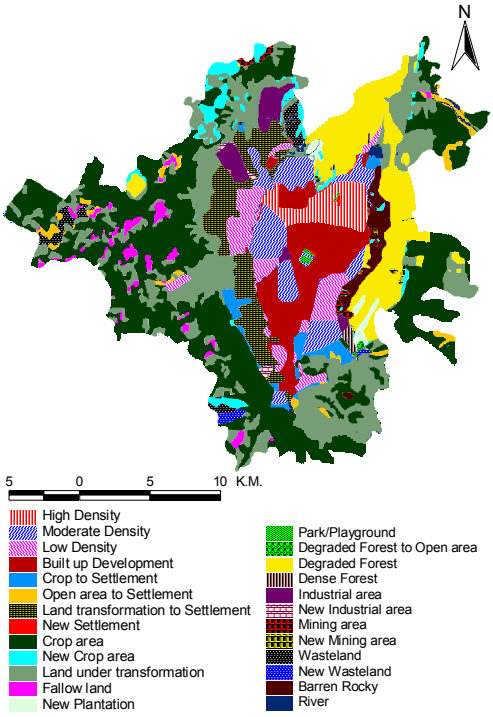

## LANDUSE /LANDCOVER MAP (2003)



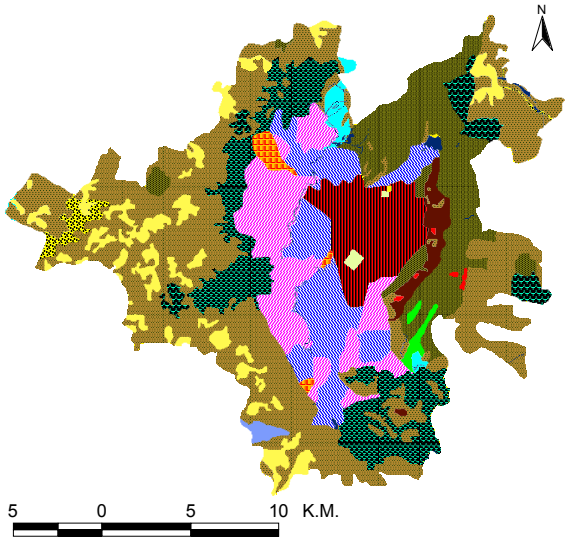
## LANDUSE/ LANDCOVER MAP (2003)
## New JDA Boundary




## LAND TRANSFORMATION
## DURING 1986 TO 1991



**LAND TRANSFORMATION**
**DURING 1975 TO 1986**




**LAND TRANSFORMATION**
**DURING 1991 TO 2003**