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Mapping and Analysis of Land-Use/Land Cover of Kanpur City Using Remote Sensing and GIS Technique, 2006

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Abstract

The present research paper is focused on a comprehensive analysis of existing land-use/ land cover and population characteristics of Kanpur city based on Municipal Corporation boundary using Remote Sensing data. Land is one of the critical natural resource on which most developmental activities are based. For success of any planning activity, detailed and accurate information regarding the land cover and the associated land use is of paramount importance. The study is based on both primary and secondary data. Primary data includes the ground truth and GPS field survey whereas secondary sources of data include Cartosat-1, LISS-IV, Toposheets at scale of 1:50,000, Guide map of Kanpur city 2005-06, Primary Census Abstract-2001 and Kanpur City Development Plan, 2006. The satellite data have been used for the land-use/land cover classification of Kanpur city which is based on NUIS Manual, 2008. The present status of land-use/ land cover of Kanpur city is evaluated by visual interpretation of satellite data. Analysis shows that the existing land-use/land cover of Kanpur city present a diversified and scattered distribution of land-use throughout the city space which is the result of historical legacy and contemporary forces such as industrialization, growth of population and transport activity etc.

Background

The land-use/land cover change information is very important for decision making of sustainable land-use planning in both national and regional levels. Identifying, delineating and mapping land cover is important for global monitoring studies, resource management, and planning activities. Identification of land cover establishes the baseline from which monitoring activities can be performed, and provides the ground cover information for baseline thematic maps.

The change of land-use/land cover is a matter of concern among India's urban and town planners. For efficient urban planning land-use/land cover study is prerequisite for any kind of planning and development activities. Most of the urban studies in India are undertaken to assess the functioning of municipalities. The municipalities are confronted with a number of problems, such as non-availability of data, ineffective participation in the decision-making process (despite adoption of the policy of reservation), delays in the transfer of funds to the municipalities 'despite constitution of State Finance Commissions', poor recovery from various tax and non-tax sources (despite devolution of power) etc. The success of planning for developmental activities depends on the quality and quantity of information available on both natural and socio-economic resources. (http://www.csre.iitb.ac.in/~csre/conf/wpcontent/uploads/fullpapers/OS4/OS4_13.pdf). Remote sensing provides land resource

data in the form of digital magnetic tapes and in different bands of the electromagnetic spectrum. Availability of such a data in different bands makes it very useful for delineation of land-use/land cover classes distinctly. Land-use/land cover mapping both by visual interpretation and digital analysis is possible by satellite remote sensing techniques. The land-use/land cover categories can be expanded or reduced to any degree and be made more responsive to the information the user needs (Rai and Rai, 2009). Remote sensing with its multi-spectral, multi-temporal and synoptic view has the potential to provide accurate spatial and temporal information on land-use/land cover of a region in a time and cost effective manner (Pandey and Nathawat, 2009).

In India, unprecedented population growth of city with unplanned developmental activities has led to urbanization, which lacks of infrastructure facilities in the city. The urbanization takes place either in radial direction around a well-established urban area or linearly along the highways. This dispersed development change the land-use/ land cover pattern of the city.

Knowledge of the present distribution and area of such agricultural, recreational, and urban lands, as well as information on their changing proportions, is needed by legislators, planners, and State and local governmental officials to determine better land use policy, to project transportation and utility demand, to identify future development pressure points and areas, and to implement effective plans for regional development.

Objectives of the Study

The study is undertaken with the following objectives

1. Mapping and analysis of land-use/land cover of Kanpur City
2. To present a picture of population characteristics of Kanpur city

Material and Method

Methodology is central part of any research work which helps in scientific description and explanation of reality. The data for this study have been taken from both primary and secondary sources. Primary data includes the ground truth and GPS field survey whereas secondary sources of data include Cartosat-1 (PAN image) with 2.5 m resolution, LISS-IV (5.8 m) and Fused image (PAN+LISS-IV image) with 2.5 m resolution, Toposheets Guide map, Primary Census Abstract-2001 and Kanpur City Development Plan, 2006. ERDAS 9.0 and Arc GIS 9.3 software have been used for the present study. Geo-referenced satellite data have been used for the land-use/land cover classification at third level which is based on National Urban Information System (NUIS) Manual, 2008. Ground truth and GPS field survey have been used to relate image data to real features on the ground for the better results and verification of doubtful points.

Study Area

Kanpur million city which is better known as industrial capital of North India is the 8th largest city of India with population of 2.71 million as per 2001 Census and

Table 1: Kanpur Urban Agglomeration Population Distribution, 2001

Towns	Population	Percent
Kanpur Municipal Corporation	2551337	93.95
Rawatpur Station Yard	3017	0.11
Central Railway Colony	1457	0.05
Kanpur Cantonment	100796	3.71
Armapur Estate	20584	0.76
Northern Railway Colony	29783	1.10
Chakeri	8581	0.32
Total	2715555	100

Source: Computed from Primary Census Abstract-2001, Series-1, India (UAs/Towns)

has an area of 260.21 sq.km. and it is administratively divided into 6 zones and 110 wards. Geographically, it is located at 26^0 27'31" N latitude to 80^{0}19'14"E longitude and it is also the largest city of Uttar Pradesh which holds 7.86 percent of the total urban population of the state. City nestled on the banks of the river Ganga and stands for one of the major industrial centers of North India, also known as Manchester of the country for their industrial importance and now also called the commercial capital of Uttar Pradesh. Kanpur city is surrounded by two main rivers of India, Ganges in the north-east and Yamuna in the south. Kanpur city is surrounded by the district of Hamirpur in south, Unnao in north-east, Farrukkhabad in the north and Etawah in the west. Topographically, it is a flat land

Table 2: Population Growth of Kanpur City: 1901-2001

Census Year	Population	Growth Rate in Percent
1901	202797	-
1911	178557	-11.95
1921	216436	21.21
1931	243755	12.62
1941	487324	99.92
1951	705383	44.75
1961	971062	37.66
1971	1275242	31.32
1981	1639064	28.53
1991	2111284	28.81
2001	2715555	28.62

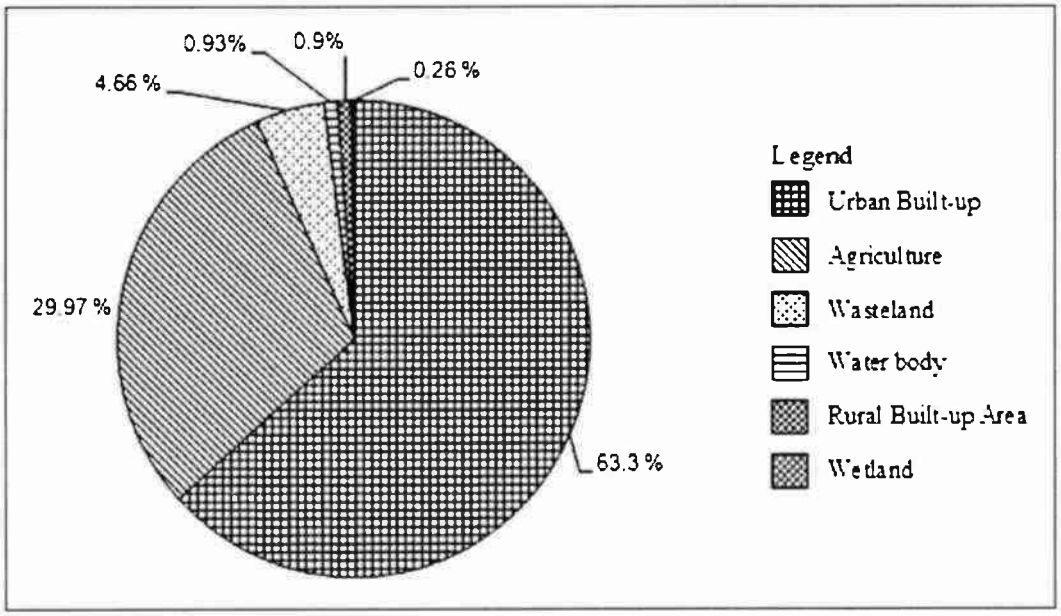
Source: Singh, 1998, p. 458 and PCA-2001, Series-1, India (UAs/Towns)

and located mainly on an alluvial terrace, popularly known as Ganga Plain.

Population Characteristics of Kanpur City

The demographic characteristic of million cities in India is changing rapidly. In 1951 there were only five, million cities in India with a total population of 11.75 million.By 2009 the number of cities with population exceeding a million has reached 38 as the total population of these cities to 108 millions. The growth of population is the direct consequence of rural-urban migration and also migration from smallest towns/ cities. Kanpur which is a million city came to an existence in 1971.

Fig 1: Kanpur City - Land Use/Land Cover Pattern 2006



Source: Based on Table 5

Growth and Distribution of Population

The constituent units of the Urban Agglomeration according to the Census 2001 are: Kanpur Municipal Corporation, Rawatpur Station Yard, Central Railway Colony, Kanpur Cantonment, Armapur Estate, Northern Railway Colony and Chakehri. These units or towns together account for a population of 2.71 million. (Table 1)

Table 2 shows that the population of Kanpur city increased significantly from 1931 onwards. The decade 1931-1941 recorded an unprecedented increase in population i.e. 99.92 percent which is the highest growth of population in any other decade till 2001. However, a decline in population growth is noticed after the 1931-1941 decade. A slight increase during 1981-1991 has been noted by 1991 that is 0.28 percent.

Density of population is one of the important indicators to study population concentration and it is defined as number of persons living in per sq. kilometer. According to Census 2001, the density of population of Kanpur Municipal Corporation is 9805 persons per sq. km.

Kanpur City: Pattern of Land-use/land cover (Fig. 1 and Fig. 3, see page 53)

Analysis of land-use/land cover is a key component in town planning and provides the better understanding and spatial relationship between land use classes. Land-use/land cover of Kanpur City determines the city space and indicates the extent of facilities, infrastructure and layout of the cities in the present time provides in right and for future development and management of different aspects of the city. The existing land-use

in Kanpur city is the result of historical legacy and contemporary forces such as technological changes in transport, growth of population and industrialization etc. Land-use /land cover of Kanpur city present a diversified and scattered distribution of land use category throughout the city space. The past and contemporary developments have given rise to complex picture of land-use in Kanpur city.

On the basis of the analysis carried out with the help of satellite images six major classes 80% Land use have been identified. The area under each of these classes is given in table 3 the class built up area is further divided into a number of sub classes on the basis of the activities carried out in the given built up area. In all 11 such sub classes could be identified through the analysis of images. These are lighted in table 4 alongwith their properties in built up area class as well as the city area as a whole.

Table 3: Land Use/Land Cover Statistics of Kanpur City

Category	Area in sq. km	Percent of total Area
Urban Built-up	164.62	63.30
Agriculture	78.00	29.97
Wasteland	12.14	4.66
Water body	2.43	0.93
Rural Built-up Area	2.35	0.90
Wetland	0.68	0.26
Total	260.21	100.00

Source: Computed from Cartosat-1 (PAN image), LISS-IV and Fused image (PAN+LISS-IV), 2006

Urban Built-up

The built-up space in Kanpur will continue to increase as long as the city can accommodate it within itself and natural growth of the city cannot be ignored but unplanned construction of high rise buildings may give rise to various problems. It includes settlement areas and buildings for the purposes such as industrial, commercial, institutional, recreational, public and semi-public, public utilities and facilities area etc. It also incorporates those areas where the above activities were initiated. The total area of Kanpur municipal is 260.21 sq km, out of which 164.62 sq km (63.26 percent) is urban built-up whereas rest of 95.59 sq. km (36.74 percent) area is used for agricultural and other purposes. Table 6 shows the extent of the different uses of built up area in the Kanpur city.

Residential Area

This is the major land use activity in the study area which occupies an area of 91.80 sq km i.e. 55.77 percent of the total built-up area and 35.28 percent of the study area of Kanpur city. Acute shortages of housing and unhygienic living condition are permanent features of Kanpur metropolis. The increase in the population of Kanpur over the decades and slow rate of housing building up of residential structures has resulted in overcrowding and congestion. It is estimated that about 80,000 to 1,00,000 new households are being added to Kanpur every year out of which 67 percent belong to economically weaker section (Singh, 1998). The seriousness of housing problem in Kanpur city has forced a number of

Table 4: Urban Built-up Area of Kanpur City

Category	Area in sq. km	Percent of Built-up Area	Percent of total Area
Residential Area	91.80	55.77	35.28
Industrial Area	19.61	11.91	7.54
Vacant Land	17.96	10.91	6.90
Public and Semi Public	12.66	7.69	4.87
Transport Activity	10.53	6.39	4.05
Vegetated Area	5.13	3.12	1.97
Recreational Area	3.65	2.22	1.40
Mixed Built-up	1.27	0.77	0.49
Public Utilities & Facilities Area	1.26	0.76	0.48
Commercial Use	0.51	0.31	0.20
Communication Area	0.23	0.14	0.09
Total	164.62	100	63.26

Source: Computed from Cartosat-1 (PAN image), LISS-IV and Fused image (PAN+LISS-IV), 2006

households to live in slums and overcrowded places in the old residential area.

The physical setting of the residential area is based on street pattern. All major roads become the principal arteries for movement as well as commercial activity. The main commercial centre of the city developed along these routes.

Industrial Use

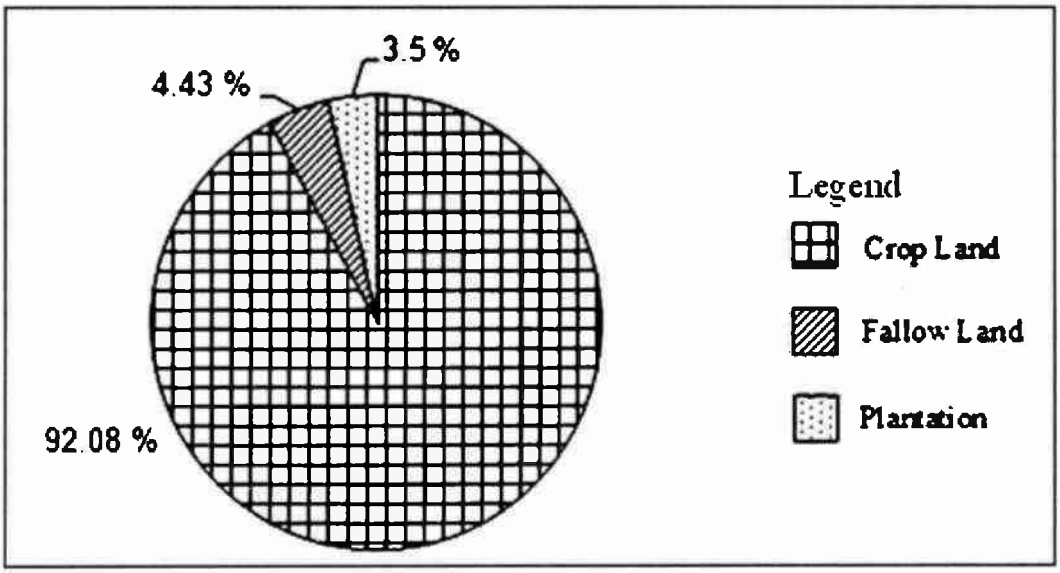
Table 4 shows that industrial activity covers the 11.91 percent of the built-up area and 7.54 percent of the study area. It is a major function of the city that is why the city is also known as the Manchester of India and industrial capital of Uttar Pradesh. The current pattern of land use depicts a concentration of commercial and household industries in the city. Industrial set-up in the city played an important role in the development of Kanpur city.

According to Kanpur City Development Plan, 2006 ten main industrial areas exist in the city. They are (i) Panki Industrial Area (ii) Dada Nagar Co-operative Industrial Estate (iii) Govt. industrial Estate, Fazalganj, (iv) Shikshit Berojgar Industrial Asthan Panki, (v) Uptron industrial Estate, Panki, (vi) Industrial Area, Rooma, (vii) Kanpur Mahayojna (viii) Jajmau, (ix) Saresh Bagh, (x) Fazalganj.

Mixed Built-up

The land which is used for the multiple functions such as residential, commercial, hotels and restaurants, workshops, clothe markets etc. are included under this category. These type of land-use found in Kanpur city

Fig. 2: Kanpur City - Area Under Agricultural Activity 2006



Source: Based on Table 8

along the road network and in residential areas. It covers only 0.77 percent (Table 4) of the built-up space.

Recreational Area

Table 4 shows that recreational land use in the Kanpur city covers an area of 3.65 sq km accounting for 1.40 percent of the city space. This is remarkably low from the proposed master plan 2021 made by the Kanpur Development Authority. The KDA proposes to increase it to i.e. 9.56 percent. This category of land use comprises of parks and gardens, playground and stadium, Golf course, zoo/museum, historical monuments etc.

Public and Semi-Public

The area which is used for the place of work, education, religious activities, health and medical, cantonment, social-cultural centre's and commercial establishments are out the public and semi-public category. It covers 7.69 percent of the built-up area. Indian Institute of Technology, Central Labour Institute, National Sugar Institute, Government Leather Institute, Indian Agricultural Institute and Kanpur University Kalianpur and Chhatrapati Shahu Ji University Kanpur are the important educational institutes in the city.

Communications Use

Communication area covers 0.14 percent (Table 6) of the built-up space. The category belongs to the facilities related to radio, telephone, television, cell phone and other transmission services. Such types of facilities are available near the residential, commercial, recreational, public and semi-public areas of Kanpur city.

Public Utilities and Facilities Area

Land under public utilities and facilities services extends over 1.26 sq. Km, i.e. 0.76 percent (Table 4) of the built-up area of Kanpur city. Public utilities and facility area scattered all over the city and it include; water supply, sewerage, electric power, inland gas supply, water pumping and treatment plants; gas and oil storage tanks and pipelines, and power plant, transmission lines etc.

Commercial Use

The area which is used for the sale of products and services like; retail and wholesale business, hospitality outlets, shopping malls, warehouse market yards etc. are included in this category. Kanpur city is very much known for the commercial activity. The setting of commercial areas are near the residential area, public and semi-public areas and also along the main road network of the city. It covers only 0.51 sq. km which is 0.31 percent of the built-up area.

Transport Activity

Transport is one of the most important elements of infrastructure needed for balanced development of any region (Gupta, 1998). Table 4 shows that 4.05 percent area is covered by the transport activity of Kanpur city. The location of the Kanpur city plays very important role in transport network of the state. The city is well connected by roads and railways with the important cities of India. National and State highways radiate in all direction and provide a better services. There are four National Highways which pass through the Kanpur city.

Vacant Land

Land which is not used for any activity is included in this category. Such type of land used with the growth of the city. Table 6 shows that the 6.90 percent vacant land of total area is available in Kanpur city which can be utilized for future development in a planned way.

Vegetated Area

Tables 6 indicate that vegetated area covers 5.13 sq. km which is 3.12 percent of the built-up area and 1.97 percent of the study area.

Rural Built-up area

It includes settlement areas like village and dhani, which are smaller in size. The rural built up area occupy 2.35 sq km which is 0.90 percent (Table 3) of the study area.

Agriculture Use

The land which is put to agriculture practice and comprises of both food crop and cash crop are under this category. This is the major land use activity in the study area which occupies an area of 78 sq km i.e. 29.97 percent (Table 3) of the total geographical area of the Kanpur city.

Agricultural land is found mainly in the peripheral part of the urban built-up land. Indicates that much of the area covered by the crop land. It is mainly found in the north-west and south-east parts of Kanpur

city. Plantation and fallow land covers less than five percent of the agricultural land.

Wasteland Area

It occupies an area of about 4.66 percent (Table 3) of Kanpur city which is mainly consists of land with or without scrub, salt-affected and sandy area. It is the result of increasing human activity on land for the production of vegetation for food and other purpose. Thus, land has been transformed into soil salinity, waterlogged and diversification in Kanpur city.

Wetland

Wetland area includes marshy/swampy, mudflats, waterlogged and salt pans. It covers only 0.26 percent (Table 3) of the study area.

Water bodies

Natural lakes, tanks, ponds (both perennial and non-perennial) etc. are considered in this category and they are identified on the satellite image by their black and dark blue tones. The area under water bodies is 2.43 sq km which is 0.93 percent (Table 3) of the study area.

Conclusion

Although an industrial city, the decadal growth of population has decline since 1951 and particularly after 1981 it shows a sign of stagnancy. In absolute terms the population has grown from 7 lakhs to 27 lakhs depicting more than three fold increase. In million cities the decadal growth rate has noticed more than 50 percent till 2001 after the 1951 and population has grown 117.5 lakhs to 1078.8 lakhs depicting more than nine fold increase.

The present status of land-use/ land cover of Kanpur city is evaluated by visual interpretation of satellite data. Analysis indicates that majority of area in Kanpur city is used for urban built-up (63.30 percent) and agricultural activities (29.97 percent). In urban built-up, residential and industrial activities are dominated which covers 35.28 and 7.34 percent respectively. Study highlights that city has a mixed pattern of land use. Central core areas comprise not only residential but also commercial, public and semi-public activities. The inner most areas are characterized by high population of density and facing the problem of water supply, sewage disposal, transportation, housing, electricity, health and sanitation.

So, Kanpur city faces different types of planning problem due to mix land use, immigration and rising residential densities, rapid growth of population, slums and mismanagement, which require immediate attention for better planning purposes.

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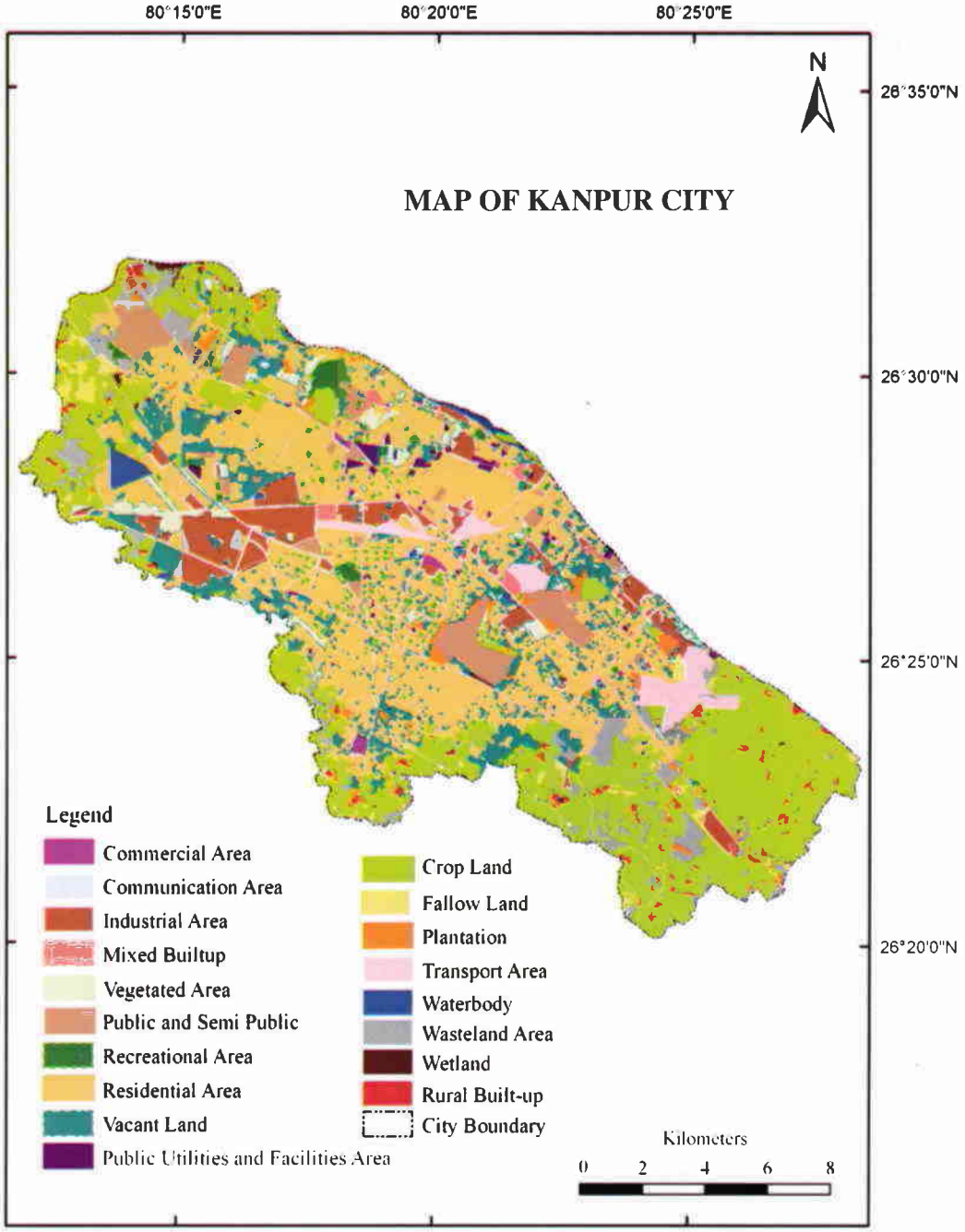

Source: Based on Cartosat-1 (PAN image), LISS-IV and Fused image (PAN-LISS-IV) 2006