



Assessment of Land use/land cover Change in the North-West District of Delhi Using Remote Sensing and GIS Techniques

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Abstract Land is one of the prime natural resources. A city grows not only by population but also by changes in spatial dimensions. Urban population growth and urban sprawl induced land use changes and land transformation. The land transformation is a natural process and cannot be stopped but it can be regulated. Many geographical changes at the urban periphery are associated with the transfer of land from rural to urban purpose. There is an urgent need for fast growing areas like Delhi, which can be easily done by high-resolution remote sensing data. Land use/land cover of North West of Delhi has been analyzed for the time period of 1972–2003. The remote sensing data used in study is Aster image of 2003 with a spatial resolution of 15 m and other data of 1972 Survey of India (SOI) toposheet at the scale of 1:50,000. Supervised digital classification using maximum

likelihood classifier was applied for preparing land use/land cover. A change detection model was applied in ERDAS Imagine to find out the land use/land cover during 1972 to 2003. Eight land use classes was identified but main dominated classes were built up and agricultural land. A drastic change has been recorded during 30 years of time i. e. (1972–2003). In 1972, 92.06% of the land was under agricultural practice, which reduced to 64.71% in 2003. This shows 27.35% decrease in agricultural land in three decades. On the other hand built up area was 6.31% in 1972, which increased to 34% in 2003. One of the main cause of this land use change is the population growth due to the migration in the district from small cities and rural areas of Delhi.

Keywords Population growth · Land use/land cover · N-W Delhi · Remote sensing & GIS

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Introduction

Land is one of the prime natural resources of a country. Any city grows not only by population but also by changes in spatial dimensions. Land use change, including land conversion from one type to another and land cover modification through land use management, has greatly altered a large proportion of the earth's land surface to satisfy mankind's immediate demands for natural resources (Meyer and Turner 1992; Vitousek et al. 1997; Foley et al. 2005). Human population growth

represents the primary driving force in land use change (Vitousek et al. 1997). Asia is the home to nearly 3.5 billion people among a worldwide population of more than 6 billion, and the world's two most populous countries (China and India), each with more than 1 billion people (Hillstrom and Hillstrom 2003), so with this huge population the changes in the earth surface features and its ecological consequences have been becoming a critical issue and of great interest in Asian countries.

Urban population growth and urban-sprawl induced land use changes coupled with industrial development are taking place in unplanned way as well as misuse of land leading to conversion of productive agricultural land into impervious land. Urban fringe development is the resultant of natural increase of population of the Delhi and the migration of rural population in search of better living. Land use change has taken place all around Delhi in the fringe areas especially in East, South-West and North districts of Delhi where the medium and low dense residential areas have decreased at the cost of high dense residential areas (Netzband and Rahman 2009). Remote sensing data and GIS are the best available techniques with which timely information generation is possible (Ramesh and Krishnan 1991) in order to map and monitor the land use change and urban growth. The changes in land use/land cover pattern over a time period is mainly because of the pressure of population on the land (Venkatachalam et al. 1991). Change detection is the measure of the distinct data framework and thematic change information that can guide to more tangible insights into underlying process involving land use and land cover changes than the information obtained from continuous change (Ramachandra and Kumar 2004). Detecting change in urban areas is not only of academic interest, because it serves as the major data source for strategic planning and analysis in urban areas (Donnay et al. 2001).

In order to understand the dynamics of an urban area, it is very important to take into consideration the historic aspects as well. Changing land use and population at or close to the city center have been long-standing geographical features, stimulated by the high value of land and the resulting need for constant readjustments in building and land use, as associated human activities attempt to extract the maximum benefit out of extensive central locations. Many

geographical changes at the urban periphery are associated with the transfer of land from rural to urban activities, which may be a more fundamental alteration than many other land use changes, which take place in city centre. Certainly, it is accompanied by a much sharper increase in land value than produced by any other urban land use change.

There are studies that have been taken up for assessing land use/land cover change for NCT of Delhi but no study has been taken up at the district level. Decision tree approach has been adopted for classifying land use/land cover for the metropolitan area of Delhi, using IRS-P6 AWiFS data (Punia et al. 2010). Expert system classification system approach has been adopted for the study of land use/cover for Delhi, using ASTER data (Wentz et al. 2008). The National Capital Region Planning Board (NCRB) used IRS IC PAN and LISS III merged satellite data for comparative analysis of the land use of Delhi for the 1986 and 1999. It showed that the built-up area of NCT-Delhi increased from 56,727 ha in 1986 to 70,162 ha in 1999, which is more than 47% of the total area of NCT-Delhi (NCRPB 1988, 1999). The rapid urbanization and consequent haphazard growth of cities is resulting loss of agricultural lands, open spaces, loss of water bodies, air pollution, water contamination, health hazards and many micro-climatic changes (Goyal 2003). Joshi and Suthar (2002) explained temporal change of urban land use and its impact on ecology and environment of Jaipur city by using remote sensing technique as well as conventional method. The urbanization process in Jaipur city resulted in the conversion of agricultural lands into non-agricultural uses. The land use/land cover change in and around Raniganj coal mining area, Bardhaman District, West Bengal shows marked difference in the areal extent from 1972 to 1998. Land covered by vegetation and settlement have decreased at the expense of mining activity which is reflected in the increase in area of overburden dump, barren land, waste land and quarry water (Sikdar et al. 2004).

Civco et al. (2002) compares the results of different land use and land cover change detection approaches: traditional post-classification cross-tabulation, cross-correlation analysis, neural networks, knowledge-based expert systems, image segmentation and object-oriented classification and concluded that there are merits to each of the four methods examined and no single approach can solve the land use change detection

problem. Timely and accurate information on the existing land use/land cover pattern and its spatial distribution and changes is a pre-requisite for planning, utilization and formulation of policies and programmes for making any micro and macro-level developmental plan. The complexity of urban development is so dynamic that it calls for an immediate perspective planning of cities and towns (Sokhi and Rashid 1999) especially where there is large scale land use/land cover change.

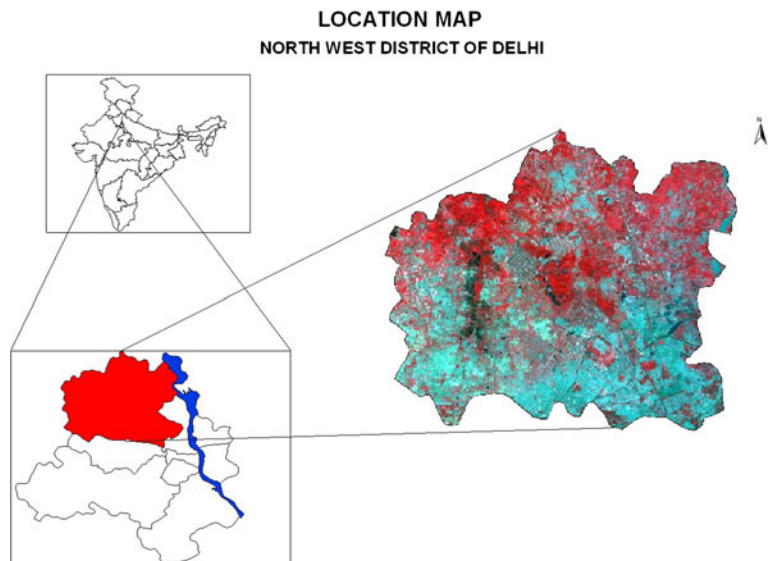
There is a need for decision making and planning for the government officials and urban planners to maintain at least some control of the city growth. Unfortunately for the developing countries, like India, this kind of data is unreliable, obsolete or just simply non-existent (Baudot 2001). This means that the secondary data taken from various Government departments is not so reliable as compared to the data sets obtained from the primary source. Usually the only ready-to-use data available for third world cities are limited to outdated topographic maps and National Census population data. Their accuracy and suitability vary greatly, however the key problem is how to cost-effectively update the datasets to meet the needs of the changing situation and a fast growing population, given the limited budgets, equipment and personnel in the local administration. In this situation when no other data is available for this kind of analysis, one solution is to use remote sensing imagery as

the primary data source, and geographic information systems (GIS) plus secondary data sources as the key for providing a framework for spatial analysis (Bähr 2001; Donnay et al. 2001). Remote sensing collects multi-spectral, multi-resolution, and multi-temporal data, and turns them into information valuable for understanding and monitoring urban land processes and for building urban land-cover data sets (Weng 2001). High-resolution satellite imageries are very helpful in urban growth and sprawl, change detection analysis. Multi-temporal remotely sensed data can provide quickly available and reliable information about land use/land cover, transformation of agricultural and other lands into developed lands, and other information essential for planning purposes (Rahman 2007). Above all satellite data is the unbiased record for detecting change at every time. So in view of above points it was thought to assess a) growth of population and b) to assess the land use/land cover change during 1972 to 2003, in NW district of Delhi (Fig. 1).

Study Area

N-W district of Delhi has been selected for this study because based on population growth; this district is the largest in terms of population (20.65%) of the total population of 2,847,395 and has the highest decadal growth rate of 60.91%. Its

Fig. 1 Location of study area



geographical extension is from 76° 55' E to 77° 15' E longitude to 28° 45' N to 28° 40' N latitudes. The total area of the district is 440.70 km sq. It is situated on the western bank of river Yamuna and is bounded by river Yamuna in the east (Fig. 1) and Jhajjar and Sonapat districts of Haryana state covered its west and north boundary, where as west district of Delhi is in the south. It is almost a plain area with gentle slope and considered the average height of 213 m. The temperature ranges from 27.5 to 30°C, the annual mean temperature is 25.3°C, but in summers the temperature attained above to 45°C and in winter season it decline up to near 2°C. The rainfall in the region is between 75 and 100 cm. The climate is semi-arid with maximum rainfall in the month of July (30 cm), October to December are dry.

Trend of Urbanization in Delhi

As the national capital Delhi has drawn migrant people from all parts of India. The estimates of migration in Delhi are based on birth and death rates and total increase in population. It is revealed from the estimates that percentage of migration was 55% whereas percentage of natural growth was 45% in 1999. The highest migration is from Uttar Pradesh 49.61% followed by Haryana 11.82% and Bihar 10.99% (Economic Survey of Delhi 2001–2002).

The total Delhi population was nearly 0.4 million in 1901, which kept on increasing slowly and it was 1.74 million in 1951 and 9.42 million in 1991. But Sharp rise in population occurred in the last decade and Delhi population reached to 13.78 million in 2001 (Table 1). As per Registrar General of India (RGI) estimates Delhi's population will be 20.78 million by 2015. The decadal population growth rate of Delhi during 1961–71 was 53.01%, in 1971–81 it was 52.83%, during 1981–91 it was 51.45% and during 1991–2001 it declined to 46.28%. In the 1901 Census, more than 47.34% of Delhi's population lived in rural areas that showed a gradual decline 17.60% in 1951 to 6.99% in 2001. The pace of urbanization was accelerated during 1941–51 when the country was divided into India and Pakistan and a large number of migrants settled in Delhi. With rapid urbanization, the rural area is shrinking; it has reduced from 1157.52 sq km in 1961 to 591.91 sq km in 2001. In 2001 the population density was 14,387 and 1,627 persons/km² in urban areas and rural areas respectively. Villages of Delhi, which have coexisted with the sprawling urban settlements, still retain a great deal of rural tradition.

The rapid urbanization has led to the development of new settlements colonies in Delhi. These settlements are categorized by Delhi Development Authority (DDA) in terms of civic infrastructure, types of houses, authorized vs. unauthorized settlement etc. *Jhuggis* and

Table 1 District-wise area and population of Delhi during 1991 to 2001

District	Area (km ²)	% Area to total area of State	1991			2001			Decadal growth 1991–2001
			Population (In lakhs)	% to Pop-ulation of State	Density (pers./km ²)	Population (In lakhs)	% to Population of State	Density (pers./km ²)	
North-West	440	29.7	1,778,268	18.88	18,088	2,847,395	20.66	29,395	60.12
South	250	16.9	1,502,878	15.95	26,261	2,258,367	16.38	25,760	50.27
West	129	8.7	1,434,008	15.22	15,986	2,119,641	15.38	22,637	47.81
North-East	60	4.05	1,085,250	11.52	11,116	1,763,712	12.8	16,431	62.52
South-West	420	28.3	1,084,705	11.51	11,471	1,749,492	12.69	12,996	61.29
East	64	4.31	1,023,078	10.86	6,012	1,448,770	10.51	9,033	41.61
North	60	4.05	688,252	7.31	4,042	779,788	5.66	6,471	13.30
Central	25	1.68	656,533	6.97	4,791	644,005	4.67	4,909	-1.91
New Delhi	35	2.36	167,672	1.78	2,583	171,806	1.25	4,165	2.47
Total NCT Delhi	1483	100.00	94,20,644	100.00	6352	137,82,976	100.00	9,294	46.31

Source: Census of India 1991 & 2001

Jhoparis (informal) resettlement colonies, Slum resettlement colonies, Refugee resettlement colonies, Approved/planned colonies, Unauthorised-regularised colonies, Urbanized colonies, Urbanized villages, Notified slum areas/Walled City and Rural villages are the various types of settlements which commonly seen in Delhi. These all above settlement constitute major chunk of the land use/land cover change in the NW district and other district of Delhi as well.

Material and Methods

Multi-temporal data is required to study the land use/land cover change over an area. Therefore, for this study Aster data of 2003, spatial resolution of 15 m and Survey of India topographical sheet at 1:50,000 scales of 1972 have been used. Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is a satellite data from NASA which is one of the high spatial resolution instrument on the Terra satellite (15, 30, 90 m) in the visible near-infrared (VNIR), shortwave-infrared (SWIR), and thermal infrared (TIR) regions of the spectrum. The VNIR

subsystem operates in three visible and near-infrared bands with 15 m resolution and a 60 km swath width. The VNIR image has a spatial resolution of 15 m, and combines ASTER bands 3, 2, and 1 in red, green, and blue (RGB).

Toposheets of Delhi were scanned into different part, and it was mosaics in Erdas Imagine 8.7. Then the area of interest (AOI) was sub-set from the mosaic toposheet. It was geo-referencing (image to map) using the ASTER data. Toposheet was resampled at 15 m resolution using nearest neighbor re-sampling method with UTM zone 43, in order to make it comparable with the ASTER data. Toposheet was then digitized for making land use map for 1972, and then this vector land use map was changed into raster form in ERDAS software. Supervised classification was done on the ASTER data of 2003 using Maximum likelihood scheme (MLC). Different land use classes were made namely urban, village, agricultural, forest, water body, waste land, industry and institution using NRSA land use classification scheme of 1995. Accuracy assessment was done for the classified map land use/land cover map of 2003. Thereafter, change detection model was run in ERDAS imagine to assess the land use/land cover change during 1972 to 2003 (Fig. 2).

Fig. 2 Flow chart of methodology

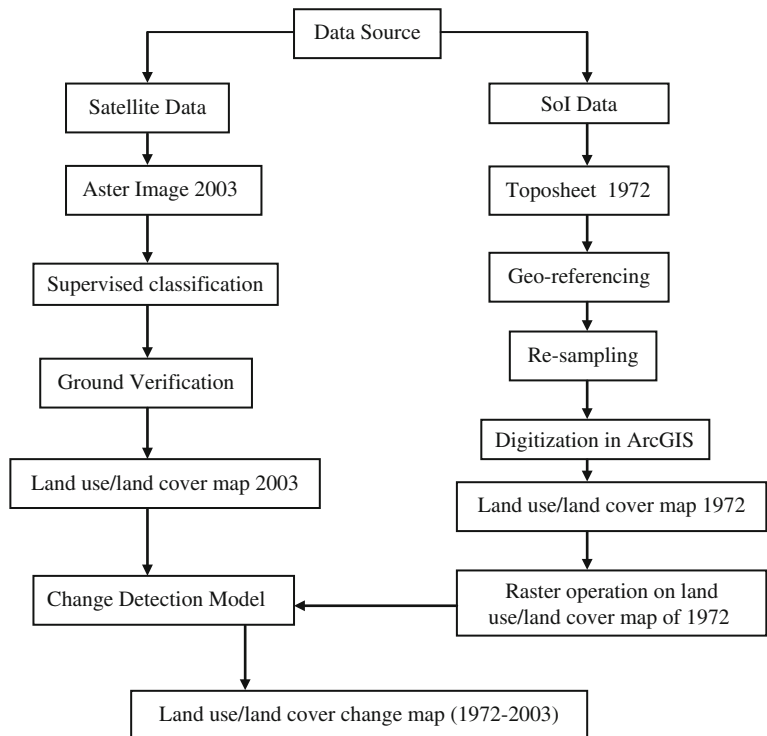


Table 2 Land Use/land cover N-W Delhi (1972)

S. No.	Land use/land cover	Area (hac.)	Area (%)
1	Urban	1374.24	3.09
2	Rural	1217.31	2.74
3	Industry	72.50	0.16
4	Institution	152.70	0.34
5	Forest	173.45	0.39
6	River	312.44	0.70
7	Pond/lake	75.80	0.17
8	Agriculture	40,940.35	92.06
9	Waste land	151.20	0.34
Total		44,470.00	100.00

Source: Survey of India toposheet 1972

Results and Discussion

Land Use/Land Cover Analysis for 1972 and 2003

The land use/land cover map of 1972 shows that the total urban area in north-west of Delhi in 1972 was only 3.09% of the total geographical area (Table 2). The dominant land use class in the North-West district of Delhi was agricultural area 40,940.35 ha i.e. 92.06% of the total area under the district. This shows that the N-W district was an agriculturally dominant i.e. rural district and the villages are well distributed all over the district (Fig. 3). Industrial and institutional classes cover an area of 72.50 and 152.70 ha respectively. The total area under water bodies (both river and

ponds and lakes) was 388.24 ha. Only 0.39% of the total area was under forest and natural vegetation cover that means it has very thin vegetative cover.

The classified land use/land cover map of 2003 shows the overall accuracy 74% and Kappa accuracy 71%. Class-wise accuracy was also assessed and it shows that urban area has an accuracy of 77.23%, and rural 74.17%, industry 68.55%, institution 70.32, forest 72.01%, River 84.34%, Pond/lake 80.06%, Agriculture 71.00% and Waste land 69.92%. The study shows a large scale change during 1972 to 2003 in NW Delhi. The urban area which was just 3% in 1972 increased to about 28% in 2003. Some of this transformation can be mainly seen along the National Highways. This urban area expanded on to the agricultural lands and hence the agricultural area reduced to 64.71% in 2003 from 92% in 1972 (Table 3 & Fig. 3). Area under institute increased to 839.20 ha from 152.70 ha during 1972 to 2003. But the forested area declined to 119.09 ha from 173.45 ha of the total area.

Land Use/Land Cover Change During 1972–2003

Land use/land cover change is a continuous process as a result of various natural and human factors. The study of land use/land cover change requires a comprehensive understanding and monitoring of all the factors which cause it. The transformation of rural land into urban land uses leads to increase in impermeable surfaces (Rahman et al. 2011). In this study it is seen that, N-W Delhi not only expanded in

Fig. 3 Land use/land cover 1972 & 2003

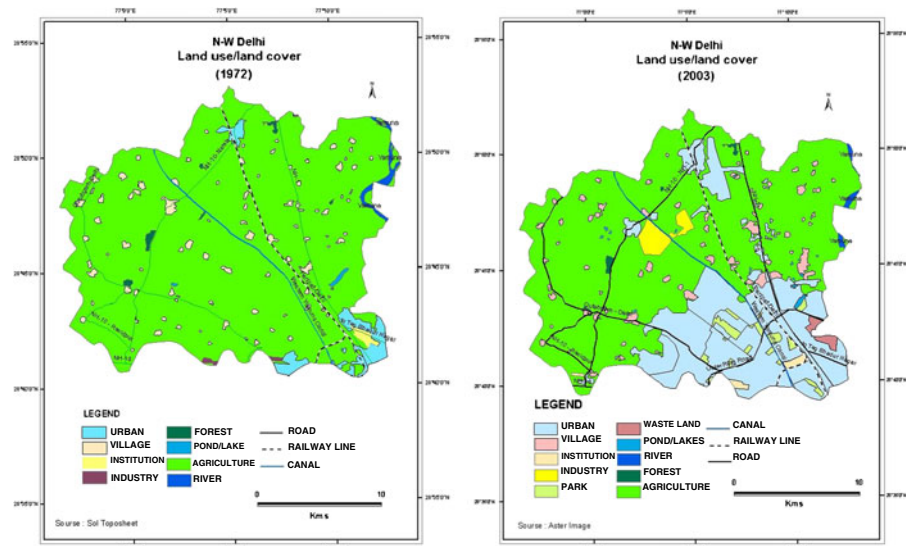


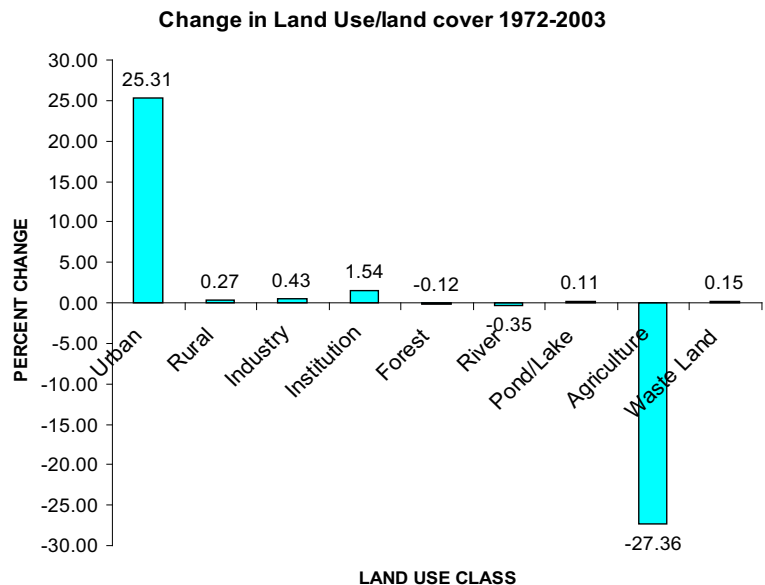
Table 3 Land use/land cover N-W Delhi 2003

S. No.	Land use/land cover	Area (hac.)	Area (%)
1	Urban	12631.23	28.40
2	Rural	1338.75	3.01
3	Industry	265.28	0.60
4	Institution	839.20	1.89
5	Forest	119.09	0.27
6	River	155.84	0.35
7	Pond/Lake	126.18	0.28
8	Agriculture	28774.80	64.71
9	Waste Land	219.64	0.49
Total		44470.00	100.00

Source: ASTER satellite data 2003

size but also there is a significant interchange of land between land use classes. Due to a number of socio-economic factors the land use pattern in Delhi as whole and also in N-W Delhi has undergone a large scale change in the last 30 years. The study shows that the urban, built-up area is coming up on the fertile agricultural land and hence it is decreasing. The increase in the built-up land can be termed as the positive increase where as the decrease in the agricultural land can be termed as the negative change (Fig. 4). In 1972 there were 40,940.35 ha of agricultural land and that has decreased to 28,774.80 ha in the 2003. The rate of decrease in the agricultural area is 0.86%/year and the total decrease recorded is 27.35% in the

Fig. 4 Area change in per cent in different land use/land cover

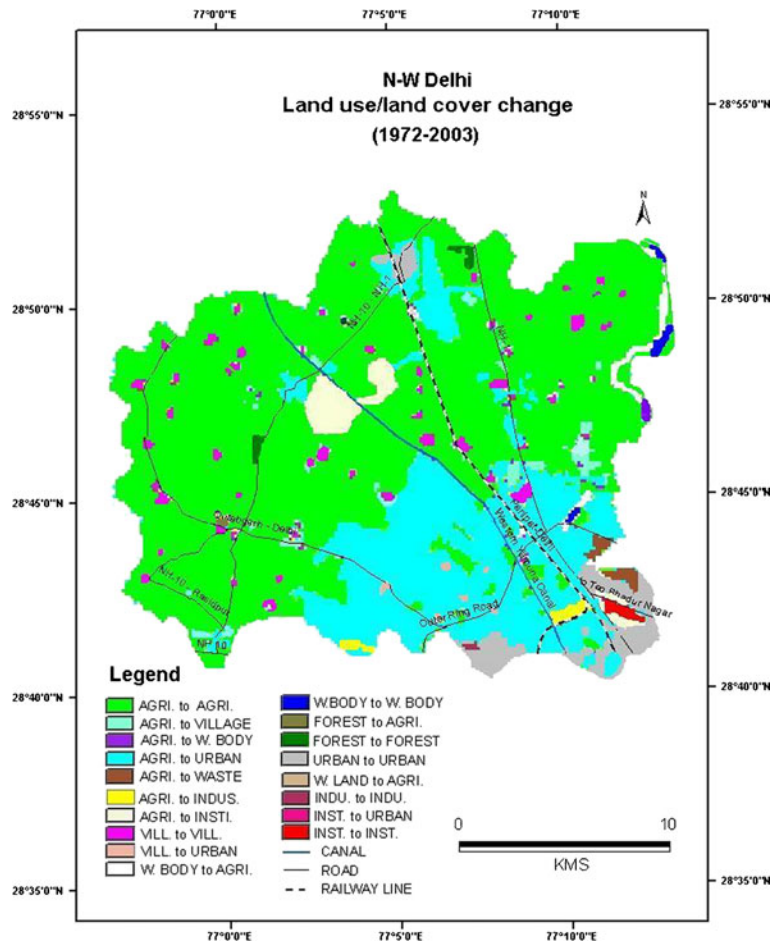


last 30 years. The major transformation was recorded from agriculture to urban (built-up) in the southern part of the District (Fig. 5). About 10,245.13 ha of agricultural land has gone to urban land (Table 4) and at the same time 694.89 ha of agricultural land has been converted into institutional area. All these figures clearly speaks about the increase in the impervious surfaces that lead to many problems and one of the most important is that of the increase in surface runoff and decrease in the ground water recharge.

Conclusions

The urban expansion and sprawl is a common phenomenon which is taking place around all urban centers in India and elsewhere, this leads to land use/land cover change. The land use/land cover changes in most of the cities are unplanned so managing and checking these issues are big task for urban planners. The current study shows that the capital city of India, Delhi has both grown and transformed too over a period of 30 years. About 60.12% decadal population growth rates have been recorded in NW district of Delhi. The total urban area in NW district was 1374.24 ha (3.09%) in 1972 which increased to 12631.23 ha (28.40%) in 2003. This shows there is a lot of land use/land cover change in the NW part of Delhi. The study further shows that 27.35% of the

Fig. 5 Land use/land cover change during (1972-2003)



fertile agricultural land has been transformed to other land use classes including urban built-up during 1972 to 2003. The highest land use/land cover change is observed in the southern part of the district which is

mainly due to its proximity to the south central part of the Delhi. The study suggests that by using medium resolution satellite data in GIS environment a spatial data base can be generated for all the urban areas to

Table 4 Land use/land cover change during (1972–2003) (in hectare)

Land use	Agriculture	Rural	Water body	Forest	Urban	Waste land	Industry	Institution	Total
Agriculture	28,784.77	701.80	121.43	13.73	10,245.13	216.92	161.69	694.89	40,940.35
Rural	30.40	774.66	0.36	0.27	361.61	0.00	20.00	30.00	1,217.31
Water body	238.68	0.00	129.46	0.00	18.72	1.40	0.00	0.00	388.24
Forest	62.96	5.99	0.00	104.51	0.00	0.00	0.00	0.00	173.45
Urban	13.19	0.00	0.00	0.00	1,305.35	4.61	20.41	30.69	1,374.24
Waste land	82.01	0.00	0.00	0.00	0.00	69.19	0.00	0.00	151.20
Industry	0.00	0.00	0.00	0.00	45.38	0.00	27.11	0.00	72.50
Institution	0.00	0.00	0.00	0.00	42.91	0.00	0.00	109.8	152.70
Total	29,212.01	1,482.45	251.25	118.51	12019.10	292.12	229.21	865.38	44,470.00

No change
Change

assess the land use/land cover change. Based on these data sets monitoring and management of the urban areas can easily be done and in a more meaningful way. Furthermore it can become a policy tool for urban planners and Government officials to control and manage unplanned land use/land cover change.

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