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Land Use / Land Cover Changes and Urban Expansion in Jammu city, India and its surroundings

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Abstract

Rapid, unplanned urbanization affects the existing land use patterns at a fast rate, which generally leads to changes that are unsustainable. Jammu, one of the two capital cities of the state of Jammu and Kashmir has experienced an rapid expansion of urban area during the last three decades. This paper seeksto detect, quantify and analyze these land use changes using Remote Sensing (RS) and Geographical Information Systems (GIS). This was done by conducting a multi-temporal study for Jammu city and its surrounding areas for the years 1989, 2000 and 2014 using Landsat data. Visual interpretation of satellite imagery was used to produce three maps of land use categories and the corresponding statistics. The changes occurring during the last 25 years were estimated using GIS tools. The over-all changes show that the built-up area has increased significantly at the cost of agricultural and other land use classes like scrub. Importantly, the study shows that the unplanned urbanisation has had an alarming impact on the seasonal stream beds that have been engulfed in the expanding built-up class. In conclusion, RS and GIS technologies can be used to assist decision makers to monitor implementation of plans and prepare future plans in accordance with the principles of sustainability and environmental conservation.

Keywords: Urbanization, Land Use/Land Cover, Visual Interpretation, Remote Sensing and GIS, Change detection.

Introduction

The world saw a tremendous increase in population in the last century, especially after the 1960s. At the end of the century, world population stood at 6.1 billion of which, India accounted for 1 billion. It is now expected that almost all of the future population growth shall occur in the developing countries, and most of this growth shall be absorbed by the urban areas[1]. According to the United Nations, in 2014, 54% of the world population was residing in urban areas, and is projected to rise to 66% by 2050. Despite the low levels of urbanization, Asia accounts for 53% of world's urban population. Between 2014 and 2050, India alone is projected to add 404 million inhabitants in urban areas[2].

Urbanization has been referred to as a "process of spatial diffusion"[3]. It is a process whereby urban land use encroaches upon the surrounding, usually rural landscape. Urban land use is an offshoot of the market economy, which is the driving force in the process of urbanization. Urbanization starts and proceeds in many different ways according to the geographical, economic and geopolitical position of the region[4]. In this process, an increasing part of a region's land becomes urban and so do the people. Rural land use, lifestyles and means of livelihood give way to urbanized ones[5]. Urbanization also refers to the process of cultural and sociological change caused by the transformation of rural life styles into urban. For cities experiencing rapid urbanization, the conflict between development and environmental protection is particularly likely. In most cases, governments of developing countries have always associated modernization with industrialization and urbanization, thus promoting policies of industrialization and urbanization over those of environmental conservation[6].

Land cover patterns evolve over time under the varying influences of natural and human factors. Land is the basic resource of the people of an area. The stage of urbanization determines the land use to a large extent, as a reflection of the use of this resource. Information on the rate and kind of change in the use of land resources is essential for proper management, planning and regularizing the use of such resources[7]. Land cover may change through the process of expansion of one type into the neighbouring types depending upon topography and the resistance of the neighbouring types. Alternatively, a new land cover type may be introduced into an otherwise homogenous area. This type of change is more unpredictable. However, in both this and the former processes, the change is perpetuated once it has occurred, enabling transformation of the neighbouring land use types under the influence of the change[8].This change is more important to understand when it is occurring rapidly, so that appropriate decisions can be taken in time to channelize the transition forces for more sustainable development.

In this context, remote sensing and GIS are very useful technologies to assist decision-makers in monitoring land use/cover change as well as its subsequent analysis for better understanding of the process of urbanisation. Remote sensing through satellite imagery provides a synoptic view of the land in

which correlations can be derived which may not be as apparent at the ground level view. There is a wide range of techniques used for land use change detection of urban areas. However, it must be recognized that remote sensing is only a tool and not an end in itself. The GIS environment allows the creation of thematic datasets, as well as synthesis and analysis of virtually all sorts of data from any source—as long as they can be geographically referenced[9].

With the advances in technologies dealing with remote sensing data and GIS software, there has been a shift in the techniques followed for synthesis and analysis of remotely sensed data from various sources. There is a general perception that automated classification techniques using high resolution satellite imagery give the best results in land use/cover change studies. However, before taking any decision, there are several trade-offs that must not be overlooked, depending on the objective and scale of the study. Visual interpretation is more useful in studies conducted using medium to low resolution imagery. Processing times and software/ hardware requirements for conducting both automated and visually interpreted classification are similar. For studies up to level 2 classification using medium resolution satellite imagery, visual interpretation is as accurate and reliable as automated classification[10].

Belaid[11] undertook an extensive review of land use change detection techniques for comparative studies at Morocco and Saudi Arabia. The methodology adopted was visual interpretation using Landsat-TM data in Saudi Arabia and visual interpretation using SPOT-HRV data in Morocco. Overall, the results obtained were found to be very informative as all significant areas of change could be studied. An "evolution matrix" was generated which supplied information on overall regression, extension or neat evolution in the various land use classes. This was used to carry out impact assessment of urbanization on the existing land use and land cover, notably agriculture.

The current study was undertaken to analyse the changes in land use/cover that have occurred over a period of 25 years in the city of Jammu, from 1989 to 2014. Jammu is one of the two capitals of Jammu and Kashmir, and is an important centre of education, commerce and industry of the state. In recent years, the city experienced an accelerated process of migration of people, which included political refugees, people displaced from border areas between due to border firing, as well as people looking for better education, employment opportunities and urban facilities.

The rapid development of the city over this period has also been attributed in part, to its location as a transit point for the large numbers of tourists and pilgrims bound for Vaishno Devi Shrine, which is just about 60 km from the city, and also for the annual Amarnath Yatra in Kashmir. Jammu is the terminus of Northern Railway, and has direct train services to all four metropolitan cities and most other major cities in the country. It is also well connected by road and air network[12].

Jammu city is located on both the banks of the river Tawi between 32°38'15"and 32°48'00" North latitude and 74°47'18"and 74°50'05" East longitude. The city lies on the southern lower slopes of the Siwaliks. The urban area is not flat, as the old city is situated on a hillock, and the north-eastern parts of the city are sloping up towards the hills. The river Tawi crosses the area in a north-east to south-west direction. The average elevation of the plains is 280-320m which are traversed by numerous hill torrents locally called as *khad*. These torrents remain dry over the greater parts of winter and summer seasons and attain enormous size during the rains.

The city lies in zone of sub tropical vegetation, and experiences sub-tropical monsoon type of climate with three significant seasons. Summer, from April to June, remains almost dry with average temperature of 35° C and low relative humidity. The onset of the South-West Monsoon is in the first week of July and it ends by mid-September. Relative humidity and temperature remain high and rainfall ranges from 100 to 200 cm. The winter extends from late October to March with average temperature ranging from 10°C to 25°C although the minimum temperature can go as low as 4°C. Fog is common during extremely chilly days and about 150 mm of rainfall is received during the season.

Materials and Methods

To achieve the objective of mapping and quantifying land use/cover, the study focused on the following areas: i. Land use / Land cover classification by visual interpretation and monitoring of the urbanization process in the city in 1989, 2000and 2014. ii. Land use/ Land cover change detection by post-classification method on the basis of Land use/ Land cover classification results drawn by visual interpretation.

The steps involved in land use mapping and change detection are shown in Table 1. The boundary of the study area was delineated on the basis of latitudinal and longitudinal extent, on the topographic sheet. This boundary map was then used to define the study area on the satellite images as well.

Table-1
Steps involved in image interpretation and change detection

Survey of India Topographic Sheets (Year 1968) Landsat TM Image in Raster Format (Year 1989) Landsat ETM+ Image in Raster Format (Year 2000) Landsat 8 Image in Raster Format (Year 2014)
Georeference images to one coordinate system
Land use/ Land cover classification
Define boundary of the study area
Polygonisation using visual interpretation and onscreen digitisation
Land use/ Land cover maps (1989, 2000, 2014)
Post-classification change detection (1989-2000, 2000-2014)

To identify the physical changes in and around Jammu city, land cover classification was first done. Land use/ land cover for different years was mapped from Landsat 5 TM satellite image of 1989, Landsat 5 TM image of 2000 and Landsat 8 image of 2014 by on-screen digitisation using visual interpretation technique.

For visual interpretation of the images, an interpretation key was prepared on the basis of photo elements like shape, size, tone, texture, pattern, association and location etc and ground information collected during the reconnaissance survey. The LU/LC maps were then classified into a total of 13 land use classes going in to level 2 classification as well, as per classification scheme given in Table-2.

Post-classification technique was used for detecting and studying land cover changes, where two images from different dates are independently classified and labelled[13]. The area statistics under various land use/cover categories in all the images were worked out (Table-5) and the land use statistics for the years 1989, 2000 and 2014 were compared to study the land use dynamics (Figure-1). The maps for the years 1989 and 2000, and 2000 and 2014 respectively, were crossed to obtain information about the conversions in the land uses among the various land use/ land cover classes.

An "evolution matrix" was created using this crossed data showing the reduction, extension and evolution of the land use categories over the two periods- 1989-2000 and 2000-2014 (Tables-6 and 7 respectively).

Table-2
Land use/cover Classification System

LEVEL 1	LEVEL 2	LEVEL 1	LEVEL 2
Built-up	Settlement	Vegetation	Moderately dense forest
	Facility		Open forest
	Industry		Tree cover
Water Bodies	River	Open	Open Vacant
	Canal		Stream bed
Scrub			River Bed
Agriculture			

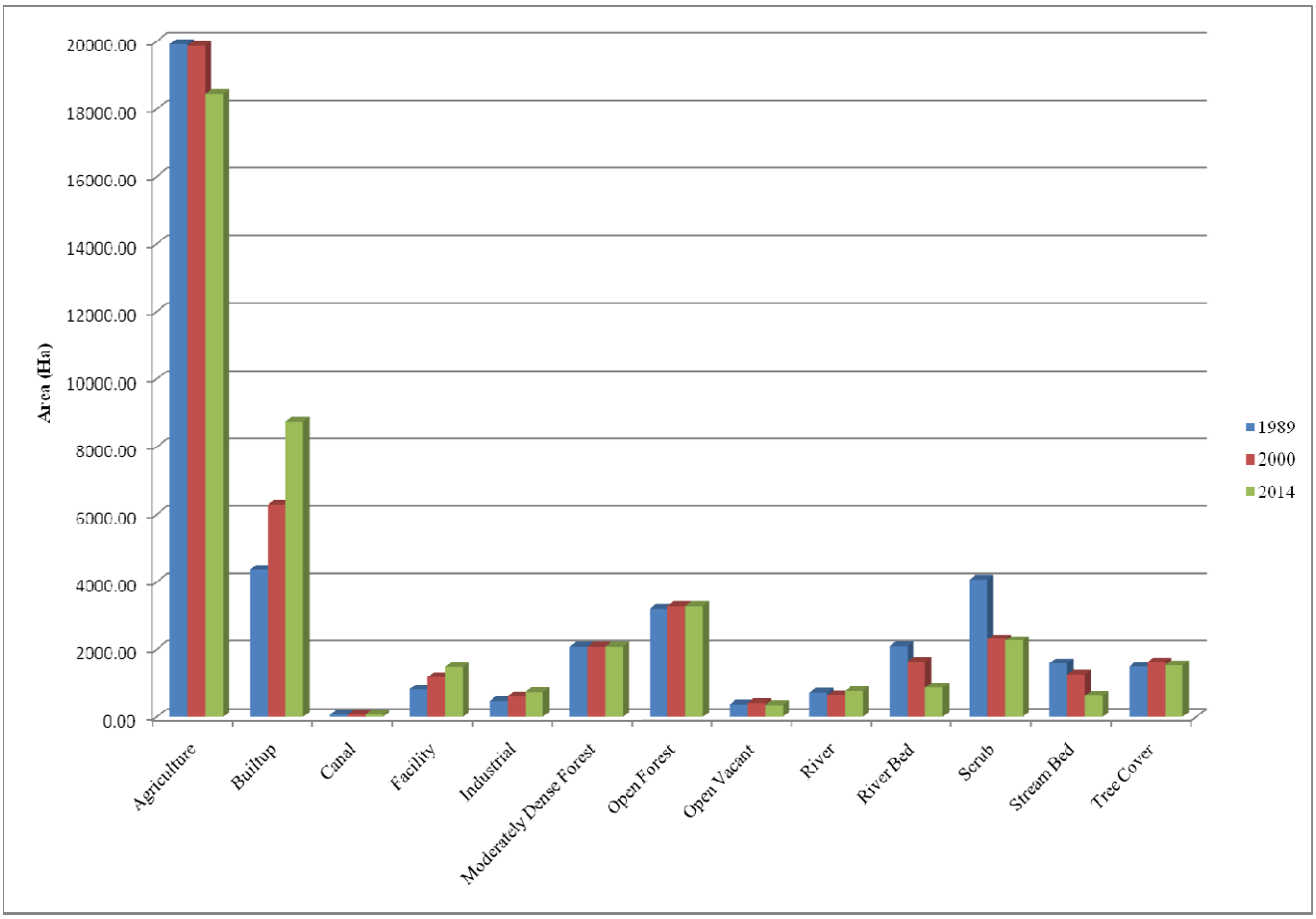

Figure-1
Comparison of Land Use/ Cover of Jammu City in 1989, 2000 and 2014

Results and Discussion

Table-5 shows the area in hectares under different land cover classes for the years 1989, 2000 and 2014. Agriculture remains the most dominant class, occupying 45% of the total study area in 2014. This figure is down from 48% it occupied in both 1989 and 2000. Forest area has remained more or less constant at 13%, while tree cover outside forest registered an overall increase from 1492.16 ha in 1989 to 1525.67 ha in 2014.

The built-up class has emerged as the most rapidly growing land use class, increasing from 11% to 21% of the total land cover from 1989 to 2014. This expansion has been relentless, from 4356.28 ha in 1989 to 6283.54 ha in 2000 and increasing to 8750.81 ha in 2014. A perusal of Table 6 shows that the from 1989 to 2000, more than a thousand hectares each was contributed by agriculture and scrub classes to the built-up class. However, Table-7 shows that from 2000 to 2014, agriculture class lost the most to built-up area, a figure of 1756.39 ha. Hence, from 1989 to 2000, the areas generally remaining uncultivated under scrub cover contributed as much too urban expansion as agricultural lands. Since then, urbanisation has been exerting pressure on the remaining agricultural land which is showing decreased resistance. Spatially, most of this land is from small un-irrigated land holdings which were abandoned and sold and became engulfed within the expanding settlement. However, an increasing share is being contributed from the extensively irrigated prime agricultural lands south of the Ranbir canal. With increasing urbanisation, more and more of these lands may get converted into settlements or other built-up land uses.

Another important aspect is the alarming loss of stream beds and river bed. The area under stream beds, which serve as natural drainage channels so important to a city situated in the region of monsoon type of climate, has shown a continuous decline of 951.28 ha from 1581.22 ha in 1989 to 629.94 ha in 2014, an overall decrease of 2%. Although the statistics show a loss of around a hundred ha from stream beds to built-up class from 1989 to 2000 and another 266 ha from 2000 to 2014, the situation is more grim when the spatial aspect is noticed in the land use maps of the three years. Evidently, the built-up class has subsumed the stream beds in the process of expansion. These broad stream beds are now present only in the shape of channelized drains which are sorely incapable of acting as effective storm water drains. This was apparent during the September 2014 rains which threatened to inundate the entire city, as happened in Srinagar, the other capital of J and K during that particular month.

Interestingly, the river bed and stream beds have contributed a total of 579.64 ha to the agriculture class over the 25 years. This is a significant fraction of the total change experienced by the contributing classes towards agricultural land use during the period under study. Overall a net regression can be seen in the agricultural land use amounting to -1493.09 ha from 1989 to 2014. During the same period, the built-up class showed a net extension of 5052.92 ha.

According to the Centre for Science and Environment, planners in cities of the country have not paid adequate attention to conservation of the water bodies existing in these cities. In a pattern common to all cities across the country, natural flood discharge channels have been built over, blocking the flow of water and inundating the urban areas[14].

In India, urbanization occurred in all states irrespective of the level of development. The developed states attracted population in urban areas due to industrialization and infrastructural investment but the backward states too experienced rapid urban growth. During the nineties a significant shift occurred, since many developed states registered urban growth above the national average, while the backward states experienced growth either below that of the country, or at the most, equal to it. However, Jammu and Kashmir showed an annual urban growth rate of 3.44% which was higher than the all India growth rate of 2.73%, for the period 1991-2001. In terms of population growth also, J and K has remained above the national decadal growth rate since 1961-71, as shown in Table-3. An immediate consequence of such rapid population growth has been the decrease in per capita arable land in India from 0.17 ha to just 0.1 ha, which has inevitably forced large scale migration of rural people into urban areas in search of gainful employment[15]. In J and K, this has decreased from 0.14 Ha in 1981 to just 0.06 ha in 2012[16].

Table-3
Percent decadal growth rate of population in India and JandK

Decade	India	JandK	Decade	India	JandK
1951-61	21.64	9.44	1961-71	24.8	29.65
1971-81	24.66	29.69	1981-91	23.87	30.34
1991-01	21.54	29.43	2001-11	17.64	23.71

The total population of Jammu city and its outgrowths, according to the 2011 Census of India provisional data was 5.7 lakhs (Table-4). The literacy rate was 90.14% and sex ratio was 908 females per thousand males[1]. The annual rate of intra-regional migration has been estimated between 29% and 35%. The city also faced unprecedented migration of about 2 lakh persons from the Kashmir valley from 1989 to 1994. The religious tourism circuit associated with the Vaishno Devi Shrine has seen a continuous increase with 105.95 lakh pilgrims visiting in 2012[17]. Around 18000 families move from Srinagar to Jammu every year for six months during the month of October when the seat of state government shifts to the winter capital.

This increase in urban population has been accompanied with problems of inadequate public transportation, scarcity of safe drinking water, congestion and poor sanitation. This has led to construction of settlements in the more vulnerable areas, encroaching on the stream beds. Agricultural lands have also faced unrelenting pressure, as observed in the study. In these circumstances, the situation of Jammu is not very different from other urban centres of India, which have gradually been turning into sources of concentrated hazard instead of being engines of growth[18].Most of the land considered ecologically important like scrublands have already been converted to built-up and assimilated in the sprawl thus increasing the overall impervious footprint of the urban area. Of the 4071.77 ha under scrub in 1981, 1070.57 ha was lost to built-up class till 2000 and another 830.38 ha to agriculture. In 2014, only 2260.72 ha remain which can be classified as scrub, a decrease of 5% from the figure in 1989.

Table-4
Population of Jammu and its outgrowths in 2011

Population	Total	Males	Females
Jammu MC and outgrowths	576198	303689	272509
Jammu MC	502197	263141	239056
Literate	411558	222438	189120
Children(0-6 yrs)	45642	24931	20711
Average literacy %	90.14	93.38	86.62
Sex ratio	908		
Child sex ratio	831		

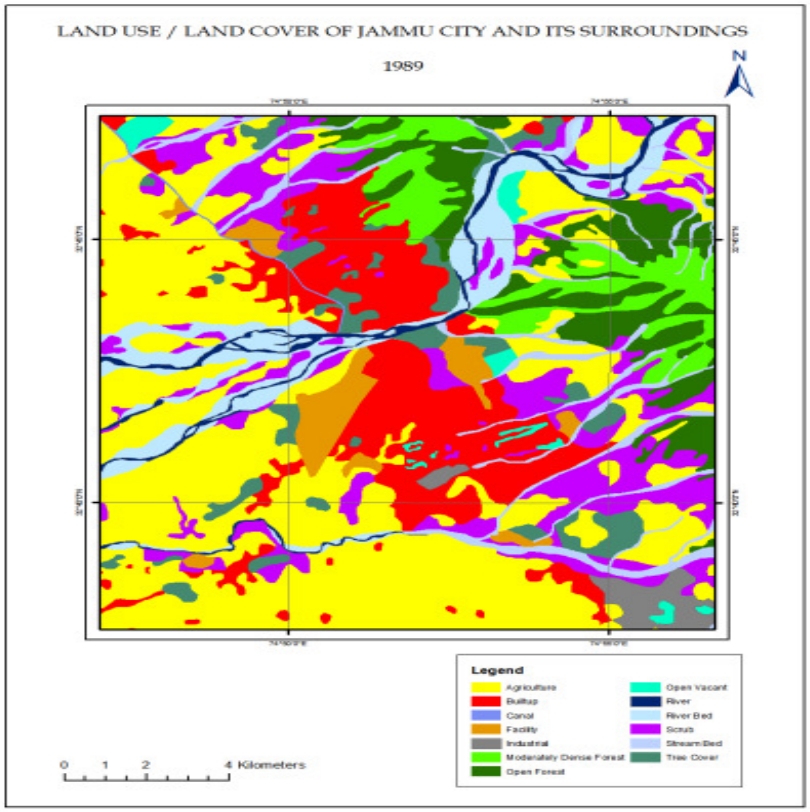

Figure-2
Land use/ Land Cover of Jammu city in 1989

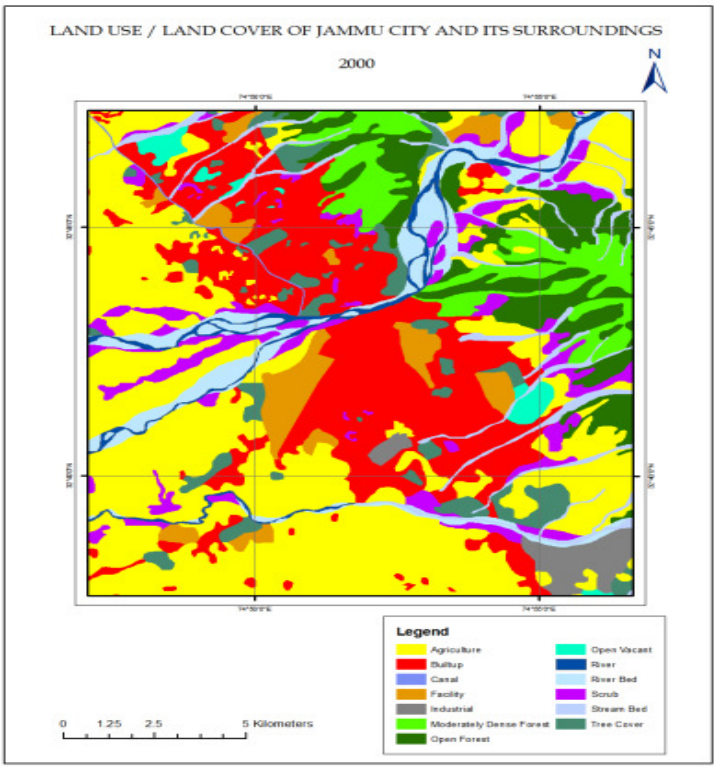

Figure-3
Land use/ Land Cover of Jammu city in 2000

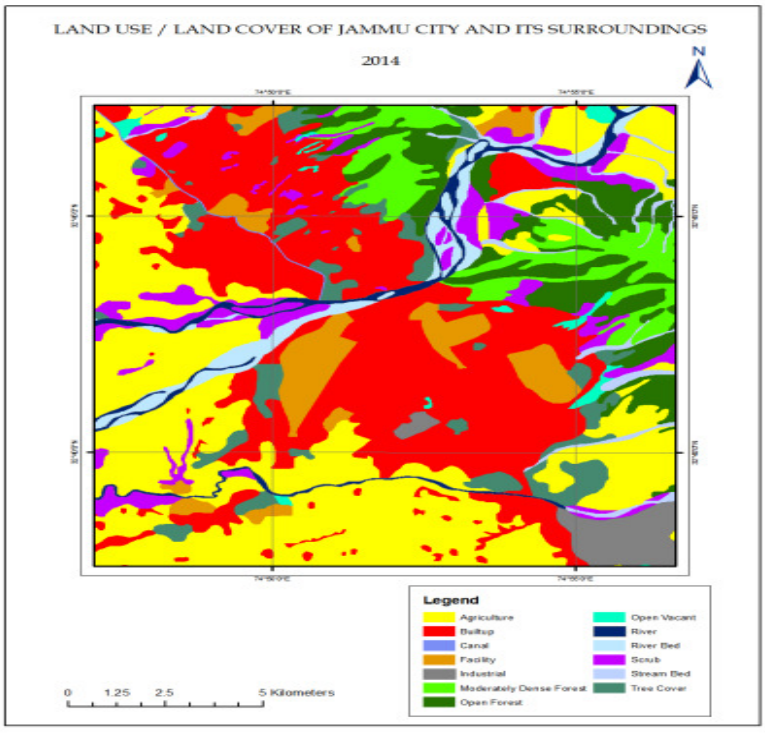

Figure-4
Land use/ Land Cover of Jammu city in 2014

Table-5
Land Use/Cover (in Ha) for years 1989, 2000 and 2014 in Jammu city, India

#	Land Use/Cover Class	1989 (Ha)	1989 (%)	2000 (Ha)	2000 (%)	2014 (Ha)	2014 (%)
1	Agriculture	19921.83	48%	19877.59	48%	18427.44	45%
2	Builtup	4356.28	11%	6283.54	15%	8750.81	21%
3	Canal	68.40	0%	68.40	0%	68.40	0%
4	Facility	822.47	2%	1184.15	3%	1483.53	4%
5	Industrial	471.56	1%	609.28	1%	741.33	2%
6	Moderately Dense Forest	2076.99	5%	2076.99	5%	2076.99	5%
7	Open Forest	3202.06	8%	3281.79	8%	3281.79	8%
8	Open Vacant	376.42	1%	415.06	1%	355.92	1%
9	River	725.36	2%	644.57	2%	775.10	2%
10	River Bed	2086.29	5%	1630.23	4%	875.19	2%
11	Scrub	4071.77	10%	2307.17	6%	2260.72	5%
12	Stream Bed	1581.22	4%	1264.85	3%	629.94	2%
13	Tree Cover	1492.16	4%	1609.20	4%	1525.67	4%
	TOTAL	41252.82	100%	41252.82	100%	41252.82	100%

Table-6
Land Use/Cover Change Matrix for Jammu city from 1989 to 2000 (Figures in Ha)

2000 / 1989	Agriculture	Builtup	Industry	Forest	Open Vacant	River	River Bed	Scrub	Stream Bed	Tree Cover	Change	Evolution
Agriculture	0.00	1173.95	58.38	0.00	0.00	22.86	17.97	139.17	8.61	78.39	1499.31	-43.23
Builtup	134.52	0.00	24.96	0.00	5.98	0.00	0.00	88.94	1.32	207.47	463.18	2286.26
Industrial	0.60	3.01	0.00	0.00	42.18	0.00	0.00	0.00	0.00	57.52	103.31	137.72
Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	79.73
Open Vacant	135.64	109.09	0.54	79.73	0.00	0.00	0.00	0.00	0.00	0.52	325.52	38.71
River	46.68	0.17	0.00	0.00	0.00	0.00	305.93	45.61	4.11	0.00	402.51	-80.79
River Bed	186.58	3.35	0.00	0.00	0.00	282.32	0.00	480.48	1.22	5.70	959.66	-456.06
Scrub	830.38	1070.57	120.14	0.00	206.32	16.54	60.47	0.00	19.72	255.30	2579.46	-1764.44
Stream Bed	65.02	110.14	0.00	0.00	20.48	0.00	119.23	29.93	0.00	5.22	350.02	-315.05
Tree Cover	56.66	279.16	37.00	0.00	89.27	0.00	0.00	30.88	0.00	0.00	492.98	117.15
Total	1456.08	2749.44	241.03	79.73	364.23	321.72	503.61	815.01	34.97	610.13	7175.96	

Table-7
Land Use/Cover Change Matrix for Jammu city from 2000 to 2014 (Figures in Ha)

2014 / 2000	Agriculture	Builtup	Industry	Forest	Open Vacant	River	River Bed	Scrub	Stream Bed	Tree Cover	Change	Evolution
Agriculture	0.00	1756.39	62.80	0.00	85.94	29.91	0.00	292.25	0.00	209.64	2436.92	-1449.86
Builtup	35.02	0.00	3.11	0.00	67.39	0.00	0.00	39.29	0.00	50.10	194.90	2766.66
Industrial	10.15	14.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24.61	132.05
Forest	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open Vacant	0.01	213.03	14.76	0.00	0.00	0.00	0.00	28.69	0.00	40.79	297.28	-59.14
River	14.92	0.00	0.00	0.00	2.72	0.00	182.85	42.56	0.00	1.08	244.13	130.53
River Bed	155.04	78.70	11.07	0.00	0.00	301.02	0.00	431.18	0.00	5.24	982.25	-755.04
Scrub	589.04	183.95	0.00	0.00	11.00	4.33	44.36	0.00	0.00	200.03	1032.71	-46.45
Stream Bed	173.20	265.77	7.41	0.00	50.00	39.39	0.00	75.91	0.00	23.22	634.91	-634.91
Tree Cover	9.68	449.26	57.51	0.00	21.09	0.00	0.00	76.39	0.00	0.00	613.92	-83.82
Total	987.06	2961.55	156.66	0.00	238.14	374.65	227.20	986.26	0.00	530.10		

Conclusion

Land use changes in Jammu have continued in the direction of increasing urbanisation over the last 25 years. This shift has not been entirely unexpected, but the relative pace at which these changes have occurred and the direction these changes are taking, are a cause for concern. Especially since the pressure momentum of urbanisation has carried its spread into conventionally no-go areas from the planning perspective, viz., irrigated agricultural lands and natural drainage channels. This study is a pointer to the issues that should be kept in perspective whilst taking decisions regarding land-use policy and planning.

To conclude, remote sensing and GIS remain the tools of choice in rapid assessment of land use / land cover changes**.** For most agencies involved in management of natural resources or urban amenities, the constraints of technological shortcomings and budget constraints can be mitigated to a large extent by using the visual interpretation technique on freely available data like that provided by Landsat, which provides a high degree of homogeneity in the quality of its data products. These data products can be used for assessment of current situations as well as comparison with those existing decades ago. The method of visual interpretation is not very technology intensive, and can be learnt and used by planners and decision makers easily. These tools should be used in earnest by the agencies and departments associated with all aspects of urban planning.

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