Pleione 9(1): 193 - 200. 2015. **ISSN: 0973-9467**

Landuse and Landcover mapping of East District of Sikkim using IRS P6 satellite imagery

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[Received 01.11.2014; Revised 12.06.2015; Accepted 15.06.2015; Published 30.06.2015]

Abstract

Satellite based remote sensing technology is the best methods to estimate the forest cover/ Landuse and land cover mapping in the hilly areas. East Sikkim, having the total geographical area of 954 sq km, ranging over the altitude 300 m (Rangpo) to 4500 m (Nathula), is having tropical to alpine forests. Based on altitude, these forests can be divided into three types *viz*. Lower Hill forest, Middle Hill forest and Upper Hill forest. Present work used clouds free IRS P6 Jan 26, 2006 satellite imagery was used. The imagery was geo- referenced to Survey of India (SOI) topomaps with less RMS error and knowledge based classified using the slandered vegetation classification legend. A ground based vegetation classes were used during the image classification. The vegetation types when compared with the altitudinal zones of the area shows good relationship. The LISS III image was classified using the ERDAS Imagine (9.1) software by applying two different method of classification in a GIS environment viz. visual interpretation technique and supervised classification. These classification showed 83.72 % overall accuracy**.**

Key words: Landuse and Landcover, East Sikkim, Satellite Imagery

INTRODUCTION

Land use is influenced by economic, cultural, political, environmental, historical and many other factors at multiple scales. On the other hand, land cover is one of the many biophysical attributes of the land that affect how ecosystems functions (Turner *et al*. 1995).

The accurate, meaningful, current data on land use are essential for planning and management of critical concern area such as flood plains and wetlands, energy resource development and production areas, wildlife habitat, recreational lands, and areas such as major residential and industrial development sites etc. (Anderson 1976)

The forest vegetation is largely disturbed because of the increasing rate of deforestation due to unsustainable extraction of timber, fuel wood and fodder as well as encroachment for settlements (SER 2013; ISE 2001).

Land use deals to man’s activities and the various use which are carried on land, and on the other hand, land cover deals to natural vegetation, water bodies, rocks, soils etc. The land use information is an important element in forming policies regarding economic, demographic and environmental issues; but a very good skill is required to classify the different land use and land cover using the satellite imagery. An individual land use and land cover categories are formed from collection of diverse objects, features, and structures that are often not individually resolved and the image. The Remote Sensing technology along with GIS is a perfect device to identify, locate and map various types of lands associated with different landform units (Sharma *et al.* 2009).

The visual interpretation using the satellite imagery provides the idea of the basic distribution of vegetation dynamics (Ravan *et al*. 1995). Identification of changed area in landuse and landcover is possible with less time, at low cost and with better accuracy using Satellite based Remote Sensing Technology (Roy& Giriraj 2008).

Study Area:

East district of Sikkim, India, lies between the coordinates 27º 08' 08.39" N to 27º 25' 26.86" N and 88º 26' 26.02" E to 88º 55' 22.81" E and covers an area of 954 sq km. The elevation of study area is ranging from 300 m in the foot hills (at Rangpo) to 4500 m (at Nathula - the trade route with China). The study area bounded in the west River Teesta, River Dikchu/ Rateychu in the north, in south River Rangpo and in east Bhutan and Tibet/china.

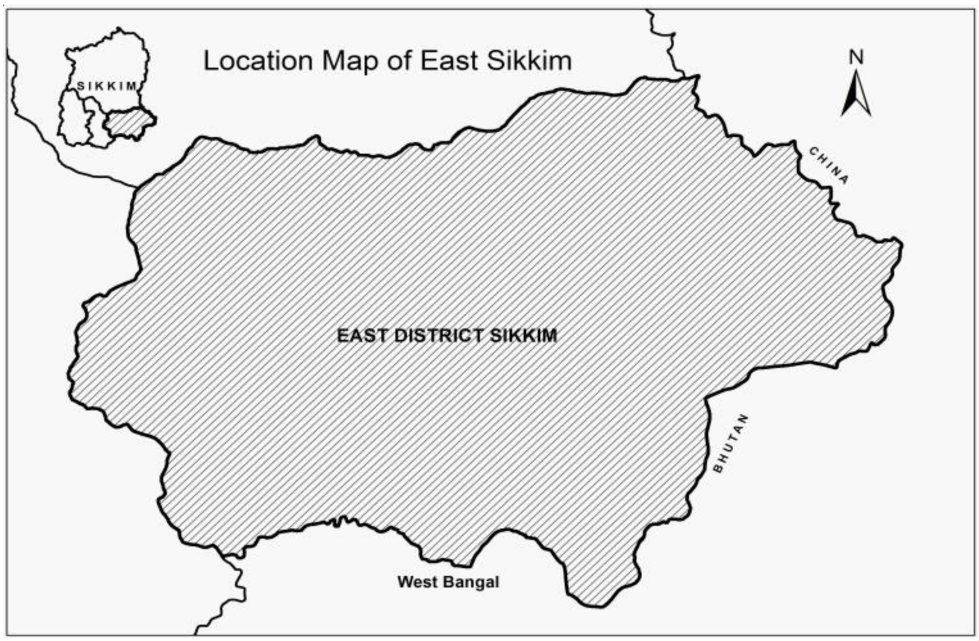

Fig. 1. Location of East Sikkim district of Sikkim, India

METHODOLOGY

The IRS P6 January 26, 2006 imagery was used in the classification of LULCs through ERDAS Imagine software (9.1). The images were geometrically corrected and geo-coded to the Universal Transverse Mercator (UTM) Co-ordinate system, using 1:50000 scale, approximately 20 evenly distributed ground control points were selected from the image. These were used to spatially resample the images using a nearest neighbor algorithm, which takes the value of pixels in the input image that is closest to the computed co-ordinate. This method is fast and does not alter the original pixel values. The transformation had a root mean square (RMS) error of between 0.4 and 0.7 pixel, indicating that the image rectification was accurate to within one pixel. After registration, the TIFF imagery was converted into Image format imagery which describes all the information of the image like scale, resolution, projection etc. checking the image with the help of projected topomap.

The boundary of East district of Sikkim was generated with the help of Toposheet and Satellite imagery. The western boundary of the study area was bounded by River Teesta which is clearly seen in the satellite imagery, the northern boundary is bounded by River Dikchu/ Rateychu, the half of the southern boundary is bounded with River Rangpo Chu and the other half boundary is shared with Bhutan and the eastern boundary is shared with Tibet Autonomous Region (TAR) boarder.

The imagery was subset by using the AOI (Area of Interest) of the study area boundary. The acquired images were classified based on onscreen/ head's up interpretation using image interpretation keys. Semi-automated approach was also considered while analyzing few categories at local level.

In onscreen visual interpretation, the imagery is displayed onto computer screen (normally as FCC) and intended classes are delineated based on image interpretation elements, ancillary and legacy data. (Anderson 1976) Resultant output from this will be vector format, which supports complex GIS analysis and has smaller file size. Advantages of visual/ manual interpretation approaches are as follows (NRSA 2012)

1. Context/ texture/ pattern based classes can be delineated
2. Various enhancement options are possible to exploit the capability of multiband/ multi-season data
3. Minimizes issue of sensor radiometry and date of pass
4. Polygons of change only to be updated on T1 output using T2 data
5. Temporal assessment is time effective
6. Adoptability and operational feasibility is high.

Visual interpretation

Much interpretation and identification of targets in remote sensing is performed manually or visually, i.e. by a human interpreter. In many cases, this is done using imagery displayed in a pictorial or photograph-type format, independent of what type of sensor was used to collect the data and how the data were collected. In this case we refer to the data as being in analog format. Visual interpretation may also be performed by examining digital imagery displayed on a computer screen. Both analogue and digital imagery can be displayed as black and white (i.e. monochromes) images, or as colour images by combining different channels or bands representing the different wavelengths. Visual interpretation requires little, if any specialized equipment, whereas digital analysis requires specialized and often expensive equipment (Anderson 1976).

Manual interpretation is often limited to analyzing only a single channel of data or a single image at a time due to difficulty in performing visual interpretation with multiple images. This Visual interpretation is a subjective process, meaning that the results will vary with different interpreters (NRSA 2012). The supervised classification technique is also use to cross-check the visual interpretation layer, for shadow and snow cover areas.

RESULT AND DISCUSSION

Through onscreen interpretation (visual interpretation), the different class polygons were digitized based on terrain knowledge acquired during fieldwork and distributed throughout the study area. The interpretation elements like tone (light, medium, dark, very light, very dark), texture (course, medium, fine, even, uneven, mottled, uniform), colour (brighter, gray, light blue, grayish white, dull white, light pink, yellowish white), patterns (discrete-contiguous

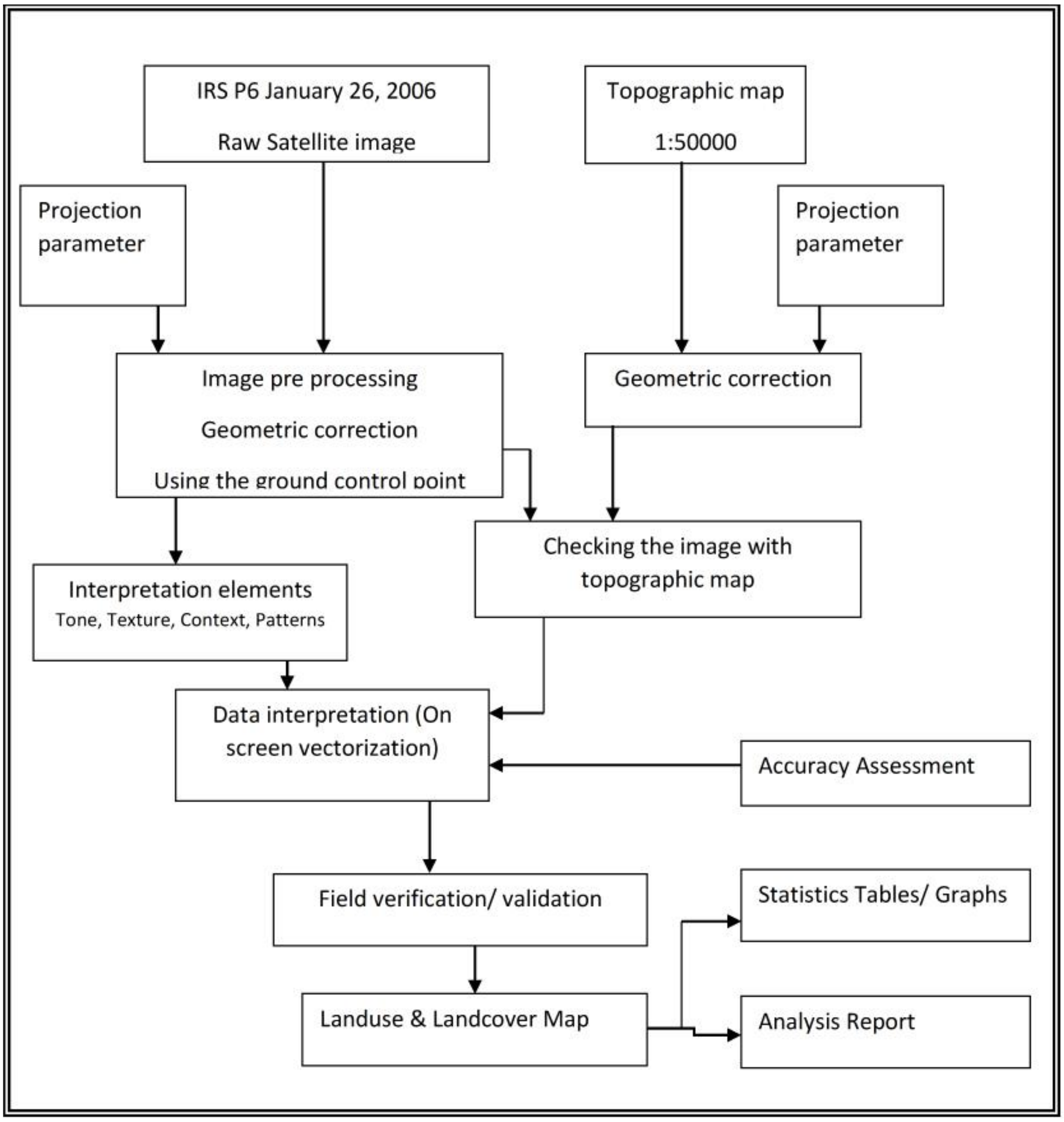

Fig. 2: Flow-chart of detail methodology

patches), size (small, medium, large, uniform or varied), shape (compact, regular, elongate, square, irregular, rectangular), association etc, were kept in mind during visual interpretation of the image.

On the basis of IRS P6 images, LULCs of the study region was classified into six categories in level I viz.: built-up, agricultural land, forest, barren rocky, water-bodies, snow-glacial area and in level II the six classes of level I were further classified into 13 different categories these are shown in Table 1. During the classification of the satellite imagery, some elements of the image interpretation were keeping in mind like (small, medium, large, uniform or varied), shape (compact, regular, elongate, square, irregular, rectangular), tone (light, medium, dark, very light, very dark) texture (course, medium, fine, even, uneven, mottled, uniform), association, shadow, site, pattern etc.

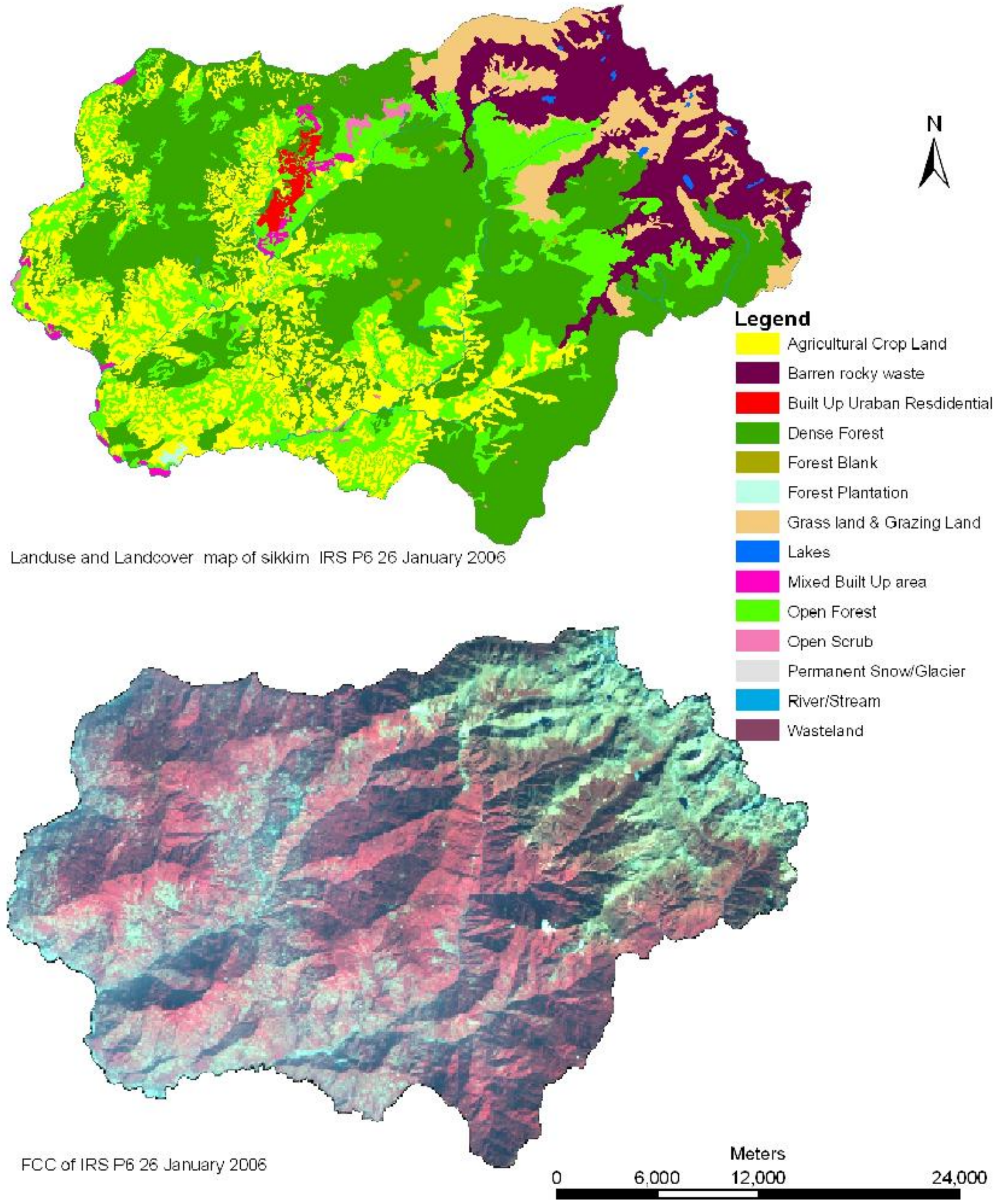

Fig. 3. A. False Color Composite of IRS P6 January 2006 of East Sikkim;**B.** Landuse and Landcover Map of East Sikkim

The total study area was mapped and classified into 13 land use types using IRS P6 Raw Satellite Image. The total geographical area of East district of Sikkim is 95400 ha, of which 40124 ha is under Dense Forest, which is slightly over 42 % of total area of East district; 17160 ha land is under Agricultural cropland, which is nearly 18% of the district's area. Similarly, 18509 ha of land was classified as Open Scrub land which is over 19 % of the total area. This is followed by 10874 ha (i.e. 11 %) area under Barren Rocky wasteland.

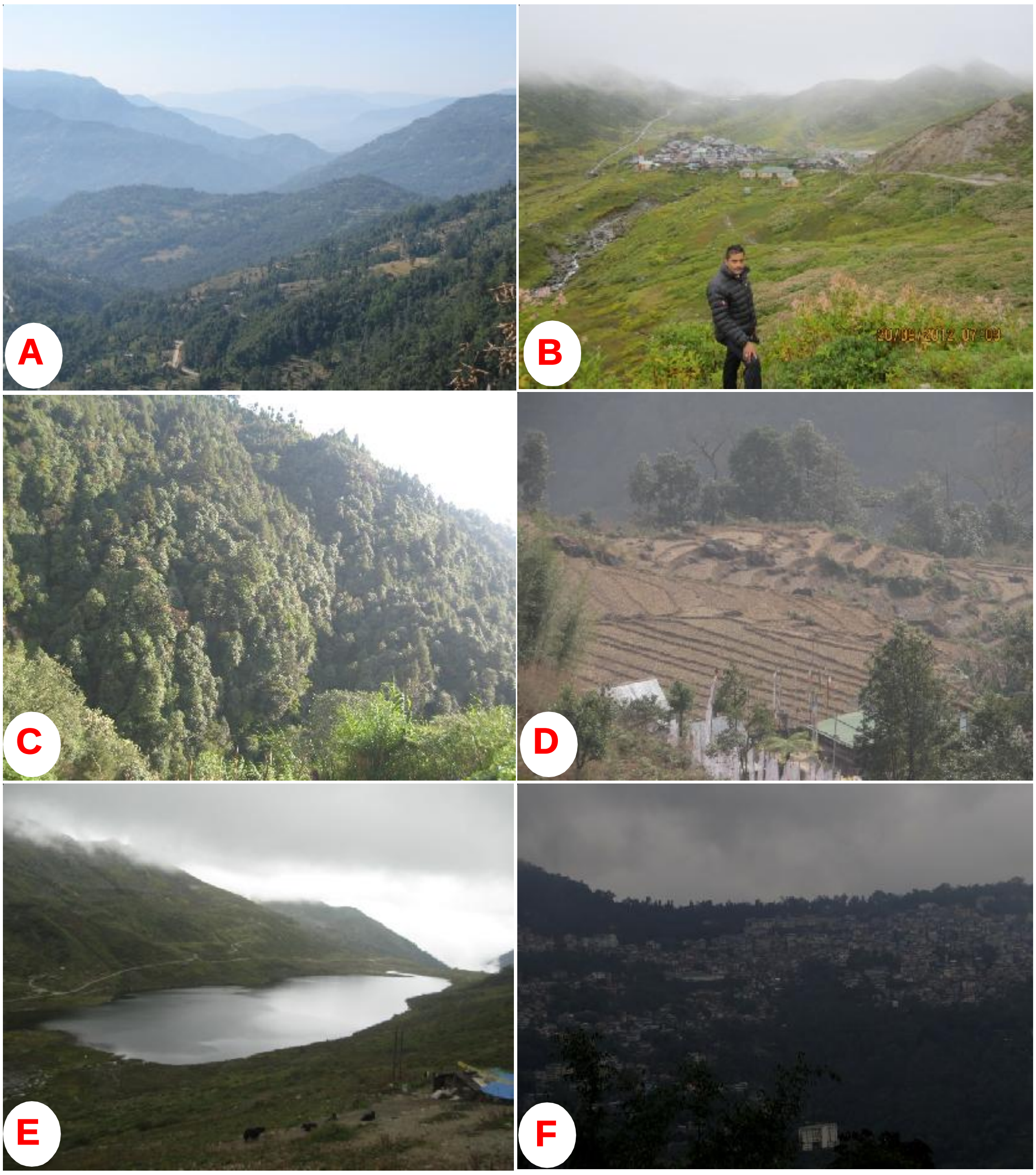

PLATE - I. Snaps on different land features of East District of Sikkim: A. Open Forest with Agricultural land; **B.** Alpine Grass Land and Grazing Land; **C.** Dense Forest; **D.** Agriciltural Land; **E.** Kupup Lake of East Sikkim; **F.** Built up urban Residential area

Also, 6226 ha or 6 % area was classified as Grassland and Rangeland. Other land use types were classified as Built up Urban Residential, Forest Blank, Forest Plantation, Lakes, Mixed Built up area, Permanent Snow/Glacier, River/Stream and Wasteland and each of them contribute less than 1% of total geographical area of East Sikkim (Table 1).

Precision, as it pertains to agreement between observers (interobserver agreement), is often reported as a kappa statistic (Cohen 1960). Kappa is intended to give the reader a quantitative measure of the magnitude of agreement between observers. Accuracy assessment was done following Kappa Statistics method (Table 2).

Table 1. Land use and Land cover type of East Sikkim with area

Sl. No.	Land use Type	Area in Ha.	% of Area
1.	Agricultural Crop Land	17160	17.99
2.	Barren rocky waste	10874	11.40
3.	Built Up Urban Residential	701	0.73
4.	Dense Forest	40124	42.06
5.	Forest Blank	233	0.24
6.	Forest Plantation	98	0.10
7.	Grassland & Grazing Land	6226	6.53
8.	Lakes	165	0.17
9.	Mixed Built Up area	641	0.67
10.	Open Scrub	18509	19.40
11.	Permanent Snow/Glacier	20	0.02
12.	River/Stream	642	0.67
13.	Wasteland	7	0.01
	Total	**95400**	**100.00**

Table 2. Accuracy assessment table using Kappa statistics

	Agricu-lture	Built up	Forest	Alpine	Waste-land	Snow & glacier	Water bodies	**TOTAL**
Agriculture	**22**	1	1	0	0	0	0	24
Built up	1	**17**	0	0	1	0	0	19
Forest	0	0	**19**	1	0	0	0	20
Alpine	1	1	1	**10**	1	1	0	15
Wasteland	1	1	2	1	**13**	1	1	20
Snow glacier	0	0	0	1	0	**13**	2	16
Water bodies	0	0	0	0	0	1	**14**	15
TOTAL	25	20	23	13	15	16	17	**129**

Kappa assessment Sum of the observation on which the class occur/total no. of Observation x 100

$$\frac{108}{129} \times 100 = 83.72$$

The overall accuracy assessment of vegetation classification of East Sikkim is 83.72%

[*Abbreviations*
SER -State of the environment report
ISE -Indian state of Environment
TIFF-Tagged image file format
IRS- Indian Remote Sensing]

CONCLUSION

In this study the Land-use and land-cover pattern of east Sikkim using IRS LISS III imagery was studied and showed the natural vegetation cover is restricted to 42% of the area of the East District of Sikkim as it was on January 26, 2006. On the other hand, settlements has covered 1 % area, and the total land used for cultivation is 18 %. This is little old data, but the modification of natural habitat is taking place very fast and, it is expected that the present scenario will be little different, with much more areas now urbanized and occupied for cultivation, industry, etc.

This picture is not impressive as it translate the too much of anthropogenic pressure of the survival of extremely rich biodiversity of Sikkim Himalaya, which is a part of the Himalaya Hotspot for Biodiversity Conservation. It is now important for planners and policy makers to decide wheather the Sikkim biodiversity will preserved in which way. The pictures showed the changes are not restricted only to the previous city areas, even the land-use is quite fast even in remote areas and numerous new townships are appearing.

So, the present set of generated data will be helpful for better modeling and forecasting the land-use and land-cover change over the time. This will also speak for the direct and indirect impact on environment, which are expected cause due to rampant change in land-use pattern.

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