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An Investigation into Land Use and Land Cover Change through Object Based Classification (A Case Study of South Haldwani, Uttarakhand, India)

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ABSTRACT: *This study present an approach to map land use and land cover change in Tarai region of Uttarakhand. The region comes under district Udham Singh Nagar. For higher accuracy Resourcesat 2 LISS4 image of south of Haldwani region were used to apply classification technique. The major LULC classes were extracted using object based classification in ERDAS objective. The images of the study area were classified into six classes which were further increased to eight as per land use change. The area under present study has been chosen in order to trace huge change of agricultural fields into current large scale industrial area. The main aim of the paper is to bring out the importance of remote sensing technology in LULCC detection.*
KEY WORDS: LULC, ERDAS Objective, LULCC

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I. INTRODUCTION

With rapidly increasing population the land use and land cover is also changing. The study of change in LULC is essential for the planning and monitoring by different government and private agencies. The change that takes place in land use/land cover is simultaneously the result of social and economic factor that operates in the region. In order to maintain and pace up with the ongoing development we must understand the change that are taking place in LULC, it is also important to maintain the natural resources and thus form sustainable development.

India is bestowed with variation in natural resources like forests, minerals, wetlands, rivers, vast agricultural tracts and surface water bodies. In order to see and monitor the changes of these natural resources, we aim to study LULCC from Remote sensing technology. With the invent of remote sensing and Geographical Information System (GIS) techniques, land use/cover mapping has given a useful and detailed way to improve the selection of areas designed to agricultural, urban and/or industrial areas of a region (Selcuk, 2003).

The present study has been conducted in order to see change of agricultural and industrial area in south of Haldwani city of Udham Singh Nagar district of Uttarakhand. High Resolution imagery of LISS-4 has been used as the high spatial resolution images convey more ground information and allow Earth observations with enhanced accuracy of digital information (Aksoy S., 2010).

II. STUDY AREA

Tarai region of Udham Singh Nagar district of Uttarakhand has been selected as the study region. It covers an area of 100.11 km² and located between 28°59’30”N to 29°4’30”N and 79°25’0”E to 79°30’0” E. This area is marked with vast agricultural land and industries. Tarai formation consists of clays, sandy clays, fine to medium sand and occasional gravels. In this formation there is a dominance of clayey successions over sandy horizons. This place is also known for its sub-surface water capabilities and potential. The temperature of the area reaches up to 42°C in summers and comes down to 4°C in winters with frequent foe conditions.

Rainfall conditions are no different than the country, the area receives 90% of its rainfall in monsoons and the rainfall is also unpredictable and erratic. The following figure 1 shows the location of the study region.

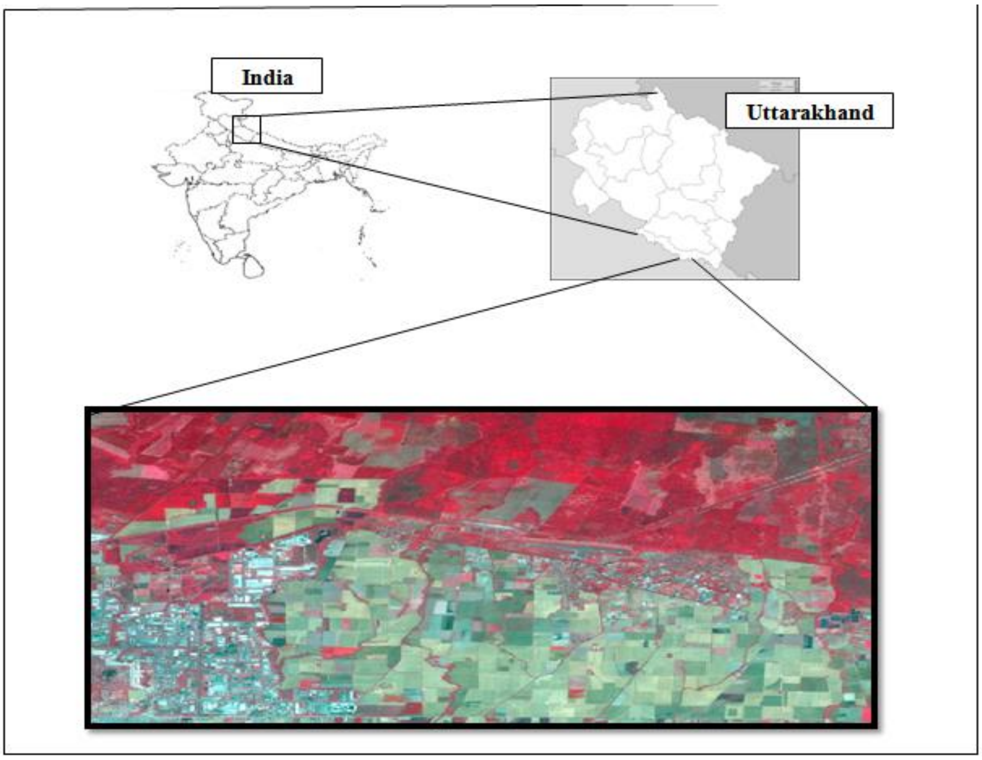


Figure1: Location of Study Area

Table 1: Satellite Specification

Satellite	Sensor	Date of Pass	Spatial Resolution	Spectral Resolution	Radiometric Resolution
IRS R-2	LISS-4	6th March 2005	5.8m	3 bands (2,3,4)	8 bit
		24th March 2015			16 bit

The above table 1 shows the specification of satellite, which includes IRS R-2 LISS 4 temporal data.

III. MATERIALS AND METHODOLOGY

Data processing: For the purpose of change detection two RESOURCESAT-2 LISS-4 (cloud free) images were taken one from 6th march 2005 and other 24th march 2015. The pixel size of the data sets was 5.8m×5.8m (WGS 84) as given in table 1.

ERDAS imagine Objective software was used for segmentation. Work including rectification, classification was done in ArcGis10.2.2. Eight classes of level 2 has been identified and worked upon for the study, following the classification scheme of NRSC (2011) given in the table (2) below.

Table 2: Land use/ Land cover classification scheme, NRSC (2011)

Level 1 classes	Level 2 classes	LUCODE	Description
Built-up	Compact	1	All places with a municipality, corporation or cantonment or notified town.
	Sparse	2	Areas where discrete uses are not distinguishable or separable.
	Vegetated/open area	3	Includes vegetation cover midst urban areas, play grounds, stadium, racecourse, golf course, gardens, parks, zoo, beaches and skiing areas
	Rural	4	Built up areas smaller in size, mainly associated with agriculture and allied sectors and non-commercial activities.
	Industrial	5	Human activity is observed in the form of manufacturing along with other supporting establishments of maintenance.

			Heavy metallurgical industry and thermal cement, petrochemical, engineering plants.
Agriculture	Crop Land	6	Areas with standing crop as on the date of satellite overpass. It appears bright red to red in color with varying shape and size in a contiguous to non-contiguous pattern.
	Fallow Land	7	Cropland areas, which are un cropped during the agricultural year under consideration as on the date of satellite overpass during all cropping seasons.
	Plantation	8	Includes tea, coffee and rubber, which are normally grown in the hilly regions and closely associated with forest cover.
	Aquaculture	9	Located mostly along the coast or in lakes, river and estuaries where fish are bred and reared for commercial purposes.
Wasteland	Scrub land	13	The land which is generally prone to deterioration due to erosion.
	Sandy	15	Areas that have stabilized accumulation of sand, in coastal, riverine or inland areas.
Wetland	Wetland	16	All submerged or water saturated lands, natural or man-made, inland or coastal, permanent or temporary, vegetated or non-vegetated, which necessarily have a land-water interface.
Water Body	Water Body	17	Surface water in the form of rivers, canals, ponds, lakes and reservoirs.

Figure 2: Process Framework for Segmentation

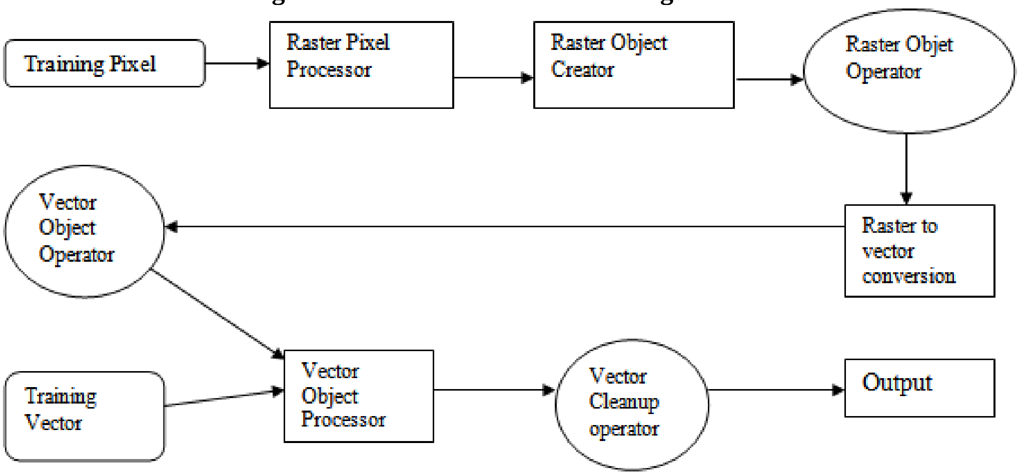


Image Classification: Classification for LULC map here includes both object based and on screen classification of LISS-4 image. This segmentation process creates image objects that reflect group of spatially homogeneous neighboring pixels are iteratively clustered until a preset threshold is exceeded. If more weight is assigned to particular spectral layers, these layers have more influence on the resulting segmentation boundaries (Ganguly, 2016). Object oriented image analysis approach combines spectral information and spatial information. The approach segments the pixel into objects according to the colour/tone, texture etc. of the image and classifies by treating each object as a whole (Chepkochei, 2011).The first step includes object based classification and segmentation into different objects. Here in this study LISS-4 image was segmented into image objects. The process framework of segmentation is been given in Figure 2. Here **Raster Pixel Processor** works which was performed with single feature probability. The extracted objects of plantation, Fallow, Built up and scrubland has been given in figure 3 and 4.

Second step includes **Raster Object creator,** here 'threshold/clump' function was applied performing threshold on pixel probability layer. Segmented image is created and the result is a thematic image.

Third step includes **Raster Object operator** probability filter and size filter allow keeping pixel objects with high probability and a certain amount of pixels only (Chepkochei, 2011).

Fourth step includes **Raster to Vector Conversion** which is basically the output of step 1 and 2, the image is vectorised into polygons, thus forming Vector layer.

Fifth step **Vector Object Operator,** elimination of those vector objects that does not meet c certain criteria, and also combining multiple vector to form single vector polygon.

Sixth step **Vector Object Processor;** here classification of vector objects is performed.

Last step includes **Vector Cleanup Operator** which finally manipulates the vector objects once they have been processed by vector object processor.

Figure 3 and 4 shows the extraction of different land use categories through Object based classification.

Figure 3: Extraction of Plantation and Fallow Land through Object based classification

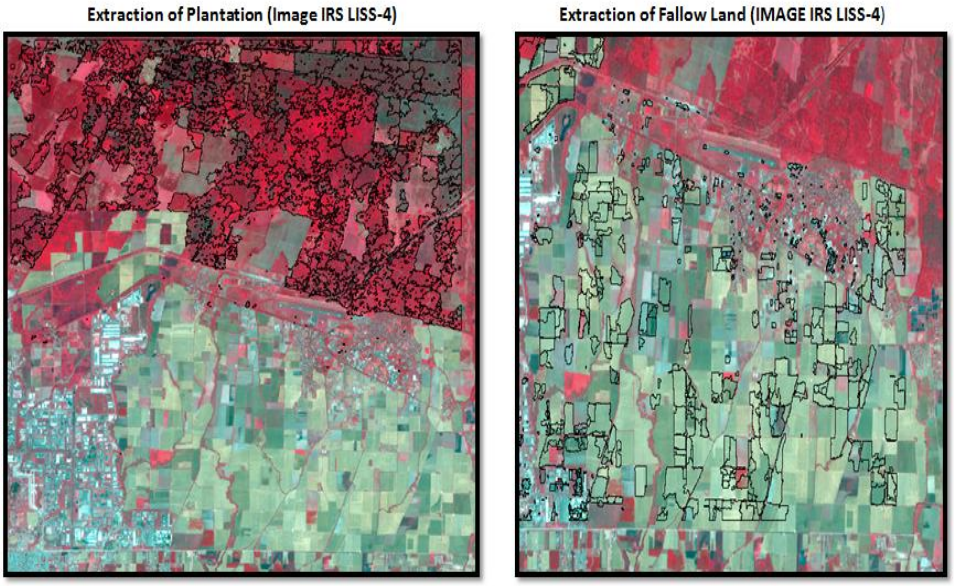


Figure 4: Extraction of Built-up Area and Scrubland

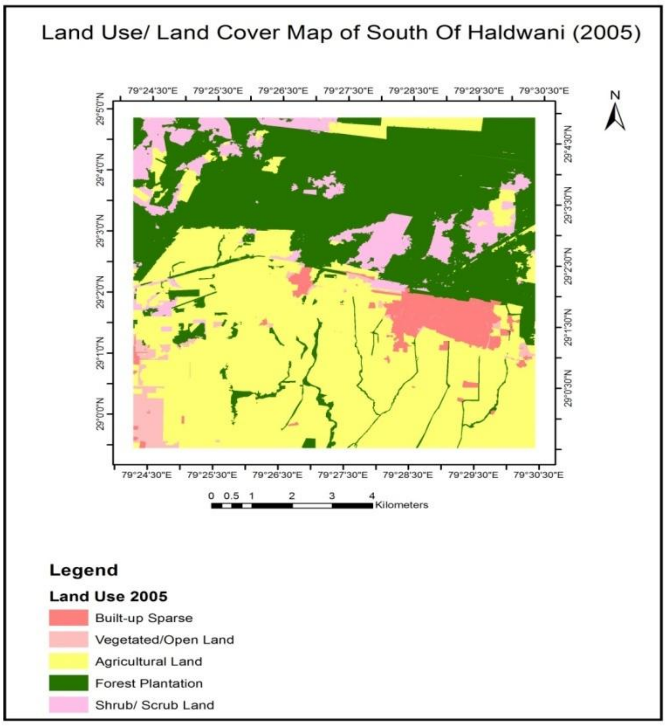
IV. SEGMENTATION AND OVERLAY

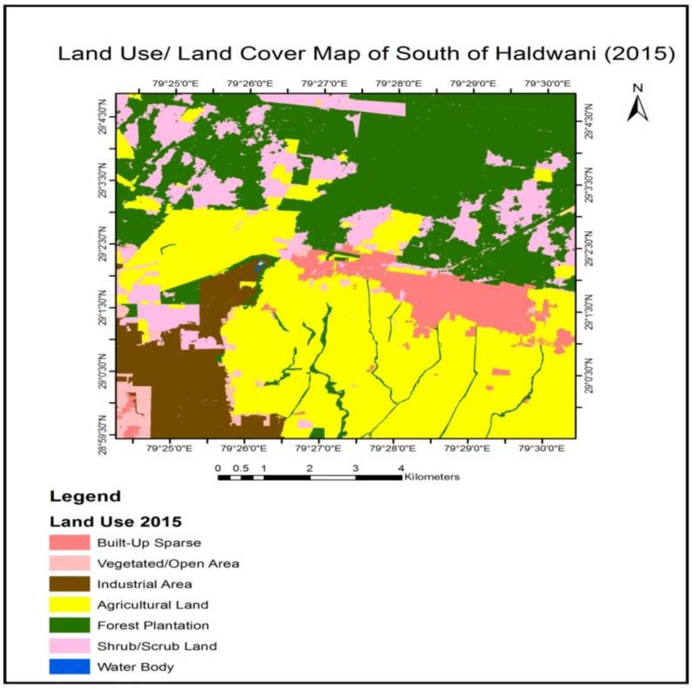
After using ERDAS objective, the onscreen modification was done in ArcGis software. One database was created using Union method. All the misclassified polygons were corrected, slivers were eliminated. For this study LISS-4 image of 2005 was classified into 6 land use classes and was updated to 8 in the LISS-4 2015 image, therefore the same data fields was updated to 2015 with addition of two new land-use classes.

V. CHANGE DETECTION

In order to detect change, multi date data (temporal data) was used. Change detection maps were prepared for the year 2005 and 2015. The study area shows the increasing trend of Industrial, Built-up sparse and scrub land and a sharp decline in agricultural area, Crop land and Agricultural fallow has been merged as Agricultural area. About 10.82 sq km area has now been converted into industrial area which has also resulted to the increase in built-up because of the increase in demand of people coming to work in this area. We also see a decline of 4.33% of the forest plantation from the year 2005 and simultaneously 5.27% of the area has increased under scrub land. The change detected has been given in the following figure 5. The change in % of area of different land use categories has been given in table 3 and with a diagrammatic representation in figure 6.

Figure 5: Land use/cover status of South Haldwani





Land Use / Land Cover Change Statistics (2005-2015)

Table 3 : Change in area in Sq. Km in individual classes

Land Use Classes	Area in Sq. km				
	LU_CODE	2005	2015	Change areas	Percentage
Built-up Sparse	2	4.40	6.32	1.93	1.93
Vegetated Open	3	2.24	1.83	-0.41	-0.41
Industrial	5	0	8.37	8.37	8.37
Agricultural land	10	47.35	36.49	-10.86	-10.85
Forest Plantation	22	38.09	33.76	-4.34	-4.33
Scrubland	35	8.03	13.31	5.28	5.27
Waterlogged	41	0.00	0.03	0.03	0.03

Figure 6: Diagrammatic illustration of land use/cover change in percent during 2005-2015

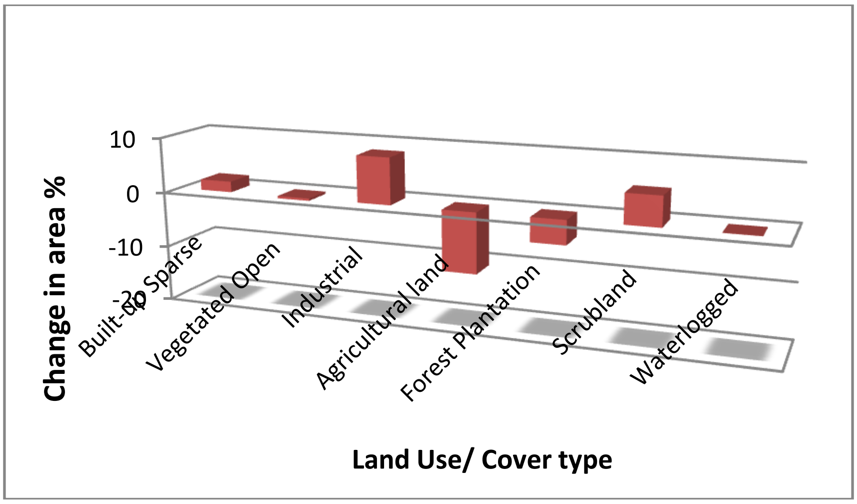


Table 4: Change Detection Matrix

LU Classes	Industries	Water body	Built-Up Sparse	Vegetated Open Land	Crop Land	Agricultural Fallow	Forest Plantation	Scrub Land	Grand Total (2005)
Industries	-	-	-	-	-	-	-	-	-
Water body	-	-	-	-	-	-	-	-	-
Built-Up Sparse	0.14	-	4.26	-	-	-	-	-	**4.40**
Vegetated Open Land	0.58	-	0.60	1.06	-	-	-	-	**2.24**
Crop Land	0.02	-	-	-	0.37	0.10	0.04	-	**0.53**
Agricultural Fallow	7.62	0.03	1.36	0.47	5.16	26.90	2.33	2.94	**46.81**
Forest Plantation	0.04	-	0.09	0.26	0.57	1.91	29.52	5.70	**38.09**
Scrub Land	-	-	0.01	0.02	0.07	1.41	1.87	4.66	**8.04**
Grand Total (2015)	**8.38**	**0.03**	**6.32**	**1.83**	**6.17**	**30.32**	**33.76**	**13.3**	**100.11**

From the above table 4 we conclude the change of agricultural fallow area from 46.81 sq.km to 30.32 sq.km and increase from 0 to 8.38 sq km in Industrial area. Increase in built up sparse from 4.40 sq. km to 6.32

sq km is result of industrial growth that has led to growth of built up environment. For study purpose the agricultural fallow and crop land was later merged as one class and it together shows a decline of 47.34 sq. km to 36.49 sq.km which has partially changed to Industrial and Built up sparse class.

Figure6: Images showing encroachment of Large scale Industries into agricultural area

VI. RESULTS AND DISCUSSION

This study was conducted in south Haldwani area of Kumaun (Uttarakhand). In order to detect change in land use/cover multi temporal data has been proved very efficient. It becomes difficult map on conventional basis as it requires a lot of man power and is time consuming. The area has a dominance of Agricultural field followed by Forest plantation which is about 36 and 34 percent respectively. Also there has been a great decline in agricultural area which has now transformed to Industrial area (SIDCUL). There has been an increase in Built-up sparse from 4.4 sq km to 6.3 sq km. This study also goes to prove the importance of remote sensing in quantifying and analyzing the change going on land use/cover. This technology brings better accuracy in less time and involves less manpower and cost. With the launch of new high resolution satellites we can further do this work with higher accuracy and in less time for better results. The images given in Figure 6 shows the encroachment of industries in agricultural area.

For further accuracy assessment ground validation can be done with the help of geo-tagging aided GPS.

VII. CONCLUSION

Object based classification is a new and unique technique to analyze remotely sensed images. The process of segmentation is less time consuming and additional on screen digitization helps in getting good accuracy. For LULC this technique is very useful as the changes taking place in land use are very quick and need time to time data which is easily available from different satellites and can be analysed by Object based classification. Through the review of many research paper using segmentation technique the accuracy has been very high, therefore for the purpose of LULC segmentation proves to be very useful.

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