Spatial changing pattern in land use/land cover using GIS: a case study of Sukhna choe watershed, India

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Abstract: The Knowledge of Spatial land cover information is essential for proper management planning and monitoring of natural resources. The objective of this study was to provide recent perspective for land use and land cover change that has taken place in the last 24 years, using Remote sensing and GIS capabilities in the Sukhna Choe (Small rivulets) watershed located in Chandigarh, partly in Punjab and Haryana. The study was carried out through GIS approach using SOI Toposheets, Satellite imageries for 1989 and 2013. Digital land use/land cover classification through unsupervised classification method based on field knowledge is employed to perform the classification. Erdas imagine 9.1 and Arc GIS 9.3 GIS software were used for data processing. The twenty four year period from 1989 to 2013 show the major type of land use change. Closed forest, scrubs and Agricultural land were decreased. Closed forest decreased from 2277.18ha in 1989 to 1834.07ha. in 2013. Scrubs reduced from 723.3ha in 1989 to 126.54ha in 2013 and agricultural land from 292.85 ha (1989) to 260.3ha in 2013. Meanwhile, water bodies Increased from 112.13ha to 292.39 ha during the corresponding year, which shows positive result for Sukhna Lake. Remote sensing and GIS data of different time periods is very useful for the detection of changes which are taking place in short time period.

Key words: Land Use, Land cover, Choe, Spatial changing Pattern, Remote sensing and GIS.

1.Introduction:

The Knowledge of Spatial land cover information is essential for proper management planning and monitoring of natural resources and considered as essential element for modeling and understanding the earth as a system (Zhu 1997, Srinivasan *et al* 2013). Land is the most important natural resources on which all activities are based. The increase in population and human activities are increasing the demand on the limited land and soil resources for agriculture, forest, pasture, urban and industrial land use. Information on the rate and kind of change in the use of land resources is essential for proper planning management and to regularize the use of such resources (Gautum and *Narayanam* 1983, Vemu Sreenivasulu and Bhaskar P.U., 2010).Knowledge about existing land use and land cover and its trend of change is essential for various reasons. Land use data are needed in the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current level (Anderson et al 1976, Sreenivasulu *et al* 2010).

Land use refers to man's activities and the varied uses which carried on over land and land cover refers to natural vegetation, water bodies ,rock/soil, artificial cover and others noticed on the land (NRSA, 1989, Gajbhiye *et al* 2012).Land cover defined as the assemblage of biotic and a biotic components on the earth's surface. Land cover is that which covers the surface of the earth and land use describes how the land cover is modified. Land cover includes: water, snow, grassland, forest, and bare soil. Land use includes agricultural land, built up land, recreation area, wildlife management area etc (Lu *et al* 2005, Ashraf and Yasushi Yamaguchi 2009, Gajbhiye et al 2012).

Land –use and land cover change (LULCC) is the change in the terrestrial surface of the earth. It is the most ancient human phenomenon induced in the biosphere (TurnerII, 2011, EOEARTH, 2010, Brar, 2013 and 2014). Human beings are the agents which brings changes in the character of the land more than any other agents. Originally the nature is dominating factor for land use and land cover change. Land change puts an impact of the environment of the area (Kostrowicki, 1983).Land use/Land cover change are the major issues of global environment change. The satellite remote sensing data with their repetitive nature have proved to be quite useful in mapping land use/land cover pattern and change with times. Quantification of such changes is possible through GIS techniques even if the spatial datasets are at different scales/resolution (Sarma *et al*., 2001, Pardian *et al* 2014)

Several studies have discussed about land use and land cover change in arid, semi-arid and agricultural productive land. Over the years remote sensing has been used for land use/land cover mapping in different parts of India (Gautuam and Narayanam 1983: Sharma *etal*, 1984: jain, 1992: Brahabhatt *etal* ,2000) as well as abroad. Civco, D.L (1989) studied Knowledge based land use and land cover mapping. (Sohl and Sohl,2012) studied on Land-use Change in the Atlantic Coastal Pine Barrens Eco region in which Land change is the primary modifier of the landscape, which leads to an Impact on socioeconomic, biological, climatic and hydrologic systems. Abbas studied mapping land use-land cover and change detection in Kafur local government Katsina, Nigeria 1995-2008 using remote sensing and GIS. Application of remotely sensed data made possible to study the change in land cover in less time at low cost and with better accuracy. Remote sensing and Geographic Information System (GIS) provide efficient methods for analysis of land use issues and tools for land use planning and modeling. This paper discuss the spatial changing pattern of land use/Land cover Using GIS for Sukhna Watershed located in Chandigarh between 1989 and 2013 in order to detect the changes that have taken place over a given period using GIS satellite data.

2. Study Area:

The study area is located in the Union Territory of Chandigarh and part of it located in Haryana and Punjab. The catchment area of 42.843 sq Km is drained by two seasonal rivulets i.e. Kansal and Nepli which originate in Haryana and are fed by number of rivulets to Sukhna Lake located in Chandigarh. It lies between Latitude $30^0$45′0″N to $30^0$49′0″N and Longitude $76^0$49′0″E to $76^0$53′0″E (Figure1).

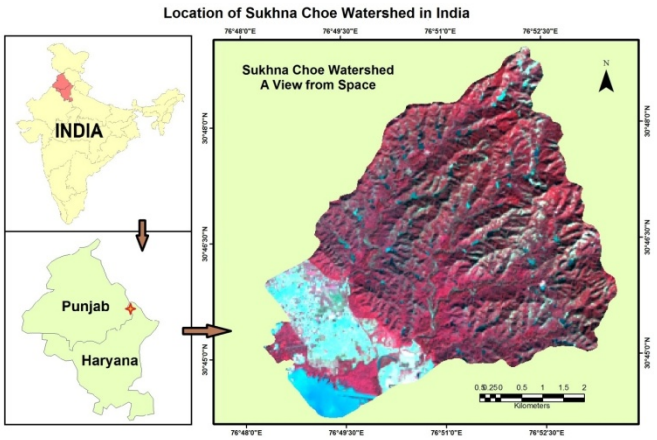

Figure1.Location of Sukhna Choe Watershed in India

The climate is semi arid with mean maximum temperature of 41.80 ^{0}C during June and minimum temperature of 5.10^{0}C during January. Average rainfall of the area is 1120mm with maximum of 2200 mm and minimum of 713mm. Out of the total rainfall received during the year, 80% is received during monsoon season from July to September (Grewal 2009). The catchment areas are highly variable within short distance. Murthy and Shankaranarayana (1977) mapped the soils and Grewal and Juneja (1984) characterizes the soil of this catchment as erosive in behavior. The natural vegetation consists of trees, shrubs, climber and grasses. Apart of the natural vegetation so many other species plantation has also been done. The forest is the predominant land use in the catchment which constitute of Shiwalik hills. The foot-hill area has agriculture, settlement and fallow land. This area falls in three villages namely Kaimbwala, (U.T. Chandigarh), Kansal (Punjab) and Saketri (Haryana). (Grewal 2009)

3. Material and Method:

3.1 Data Acquisition:

For detection of the spatial changing pattern of Land use and land cover, satellite imageries of two year i.e. 1989 and 2013 were acquired. Satellite imageries from Land sat TM (1989) and Land sat OLI (2013) imaginaries are used. Except this top sheet no. (H43K13, H43K14) which covers the whole watershed was used and ground verification is also done by using GPS.

S.No.	Data Type	Year	Scale
1.	Land sat image	1989	30m
2.	Land sat image	2013	30m

3.2 Data Processing:

For data processing visual image interpretation and digital image interpretation techniques are used. Signatures are identified from satellite imageries. Digital land use/land cover classification through unsupervised classification method based on field knowledge is employed to perform the classification. Erdas imagine 9.1 and Arc GIS 9.3 GIS software were used for data processing. Unsupervised classification was done for both image and find the eight classes of the land use and land cover are created in both time periods. The land use and land cover classes include:

Closed Forest, Open forest, Scrubs, Agricultural Land, Barren Land, Settlement, Water bodies, Choes. This classification is performed based on the classification scheme of National Remote Sensing Agency (NRSA) Department of Space, Government of India in 1995.

The comparison of the land use land cover statistics assisted in identifying the percentage Change, Trend and Annual rate of change between 1989 and 2013.

3.3 Data Analysis:

The data which were processed with GIS software was also analyzed with this software. The changes in area under each category, mapping etc. all work was done with the help of GIS software. Mainly Erdas Imagine 9.1 is used for analysis the raster data.

Table 1 and Table 2 shows land use/ land cover in hectare and percentage change over the years i.e. (1989 and 2013). To determine the trend of change it was calculated by dividing observed change by sum of change multiplied by 100.

Trend percentage Change = (Observed change/Sum of change)*100

In obtaining annual rate of change, the percentage change is divided by 100 and multiplied by the number of study year 1989-2013 = 24 years. (Gajhiye and Sharma 2012)

4. Result and Discussion:

The Significant change in land use and land cover by applying classification techniques on both satellite imaginaries was found and the details of area under each category are given in Figure 3 and Figure 4. The percentage change, trend and annual rate of change between 1989 and 2013.are shown in Table 1 and Table 2. The distributions of land use/ land cover during the two periods are shown in bar diagram (Figure 2).

Table 1: Percentage change in area in Land use and [ii]Land cover in Sukhna Catchment, 1989 and 2013

Categories	1989		2013		Change Area	
	Area (ha)	**Area (%)**	**Area (ha)**	**Area (%)**	(ha)	**(%)**
Closed Forest	**2277.18**	**53.15**	**1834.07**	**42.81**	**-443.11**	**-10.34**
Open Forest	**567.47**	**13.25**	**1327.77**	**30.99**	**760.3**	**17.75**
Agricultural Land	**292.85**	**6.84**	**260.35**	**6.08**	**-32.5**	**-0.75**
Barren Land	**242.98**	**5.7**	**299.48**	**7.00**	**56.5**	**1.32**
Scrubs	**723.3**	**16.88**	**126.54**	**2.95**	**-596.76**	**-13.92**
Choe	**0.78**	**0.018**	**53.24**	**1.24**	**52.46**	**1.22**
Settlement	**67.62**	**1.58**	**90.47**	**2.11**	**22.85**	**0.53**
Water bodies	**112.13**	**2.62**	**292.39**	**6.82**	**180.26**	**42.1**
Total	**4284.31**	**100**	**4284.31**	**100**		

Note: Negative sign: Reduction, Positive sign: Increase

In 1989, closed forest occupies the highest area with 53.15% of the total catchment; Choes occupies least area with just 0.018% of the total area. The pattern of land use /land cover distribution in 2013 also follows the pattern in 1989.Closed forest still occupied a major part of the total land. But when we compared the data for both years then closed forest decreased by 10.34% of the total area. The areas under Choes were increased by 1.22%. The open forest was increased from 13.25% to 30.99% of total area. In 1989 agricultural land was 6.84% and in 2013 it became 6.08% of total area showing decreased by 0.75% of the total area whereas, barren land increased by 1.32% from 1989 to 2013. Scrubs covered 16.88% of the total area in 2013 it became just 2.95% showing decreased by 13.92% of the total area. Water bodies in 1989 were 2.62% of the total area which increased to 6.82% in 2013. It is worth observing that in 24 years closed forest is reduced by 10.34% of the total area meanwhile open forest and water bodies were increased by 17.75% and 42.1% respectively. Settlement did not increase

much within these 24 years, which was only 0.53%. As there is not much human interference because the catchment was under restricted used by forest department as such agricultural land and settlement was not increased over the 24 years.

Table 2: The annual rate of change in Land use and Land cover in Sukhna Catchment::

Categories	1989-2013		Annual rate of change
	Area (ha)	% Change	
Closed Forest	-443.11	-10.34	-2.48
Open Forest	760.3	17.75	4.26
Agricultural Land	-32.5	-0.75	-0.18
Barren Land	56.5	1.32	0.32
Scrubs	-596.76	-13.92	-3.34
Choe	52.46	1.22	0.29
Settlement	22.85	0.53	0.13
Water bodies	180.26	42.1	10.10
otal	4284.31		

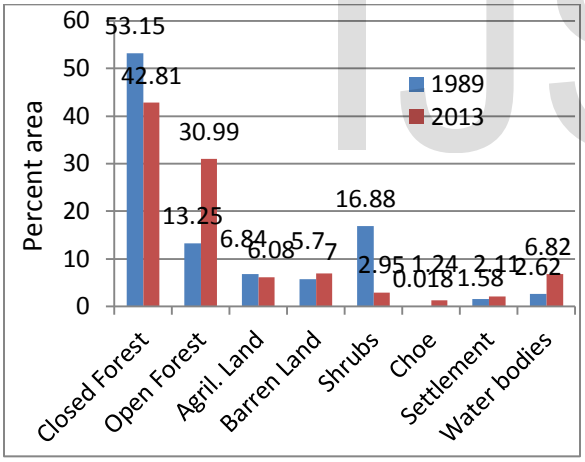

Figure 2: Distribution of land use and land cover during the two periods in Sukhna Catchment percentage area 1989 and 2013.

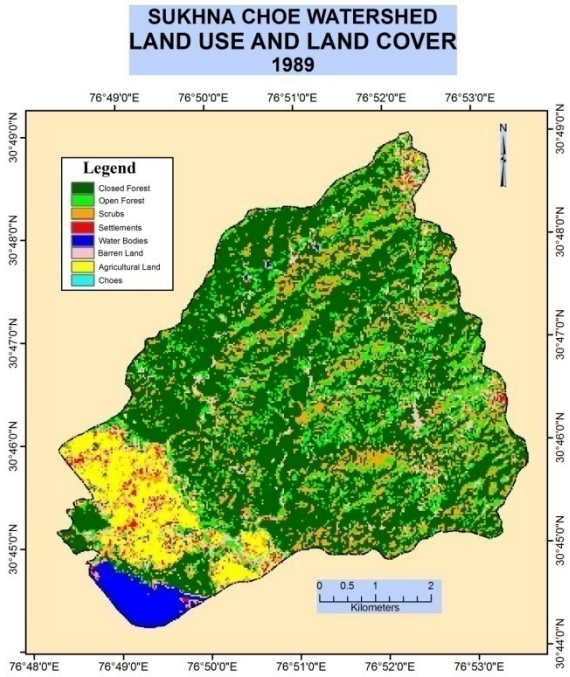

Figure3: Change in Land Use and land Cover in Sukhna Choe Watershed in 1989

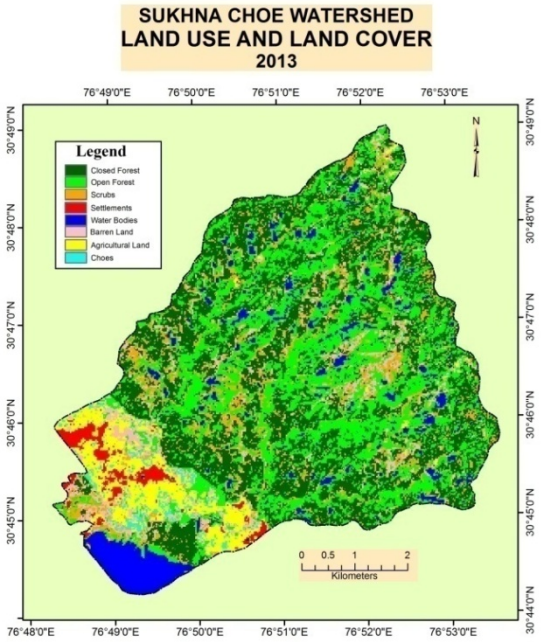

Figure 4: Change in Land Use and land Cover in Sukhna Choe Watershed in 2013

5. Conclusion:

The objective of this study were to provide recent perspective for land cover type and land cover change that has taken place in the last 24 years, using GIS capabilities by studying the spatial changing pattern in land cover and land use. The area under closed forest, scrubs and Agricultural land were decreased from 2277.18 ha in 1989 to 1834.07ha. in 2013. The scrubs reduced from 723.3ha in 1989 and 126.54ha in 2013.People who lived in surrounding villages of this catchment come to collect the scrubs for fuel purpose. There was no biotic interference in the catchment so the changes observed in settlement and agricultural land was not much. As water bodies were increased by using different techniques of soil and water conservation measures by forest department which shows positive result for Sukhna Lake

The application of geospatial techniques are also examined in this study. Remote sensing and GIS data of different time periods is very useful for the detection of changes which are taking place in short time period. Finally one can say that geospatial technology has made it very easy to identify the change over the surface of the earth

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