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Assessment of Land Use and Land Cover Change (1974-2018) Using Geospatial Techniques In Western Haryana Plains of Northern India

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ABSTRACT

Changing land use and land cover pattern in the plains of Western Haryana was assessed for the last four decades during 1974 to 2018. The change detection studies are proved to be significant in the planning and management of developmental activities. This study hypothesized that the changing patterns in the Western Haryana Plains of Northern India are related to its human population dynamics. The multispectral temporal data of MSS, TM, and ETM+ sensors of LANDSAT and LISS IV sensor of IRS P6 was used for identifying various categories such as built-up, agriculture, forest, scrub land, barren/rocky, waterlogged area, sandy area, and water bodies. These categories have been delineated by using the supervised image classification technique. It is observed that marginal changes have occurred in all land-use categories except the sandy area which is drastically declined. On the other hand, agricultural land has been increased more with 27% of total land area during the study period.

Key words: *Land use and land cover (LULC), Western Haryana Plain, Supervised classification, Remote sensing and GIS.*

Introduction

Mapping and identification of land use and land cover (LULC) of an area is very much needed for the development activities of a region. In recent years, the high resolution imageries are being classified by utilizing digital classification procedures for studying LULC changes across the globe. Land use changes are efficiently captured by satellite sensors with various resolutions. Satellite imageries are very useful and reliable sources of data for conducting spatial and temporal research related to change dynamics of land use. Sustainability of natural resources particularly LULC is essential to understand the process of change in the landscape as it is a crucial component in understanding the interrelationship between human activities and their impact on environment (Mas, 1999; Swarna Latha and Nageswara Rao, 2020). Roy and Giriraj (2008) analyzed the remote sensing data as it provides accurate and reliable information regarding the spatial variables of the land surface for sustainable management of natural resources. The conversion of the large-scale wastelands in general and barren lands in particular are being converted into croplands, which is now tremendously increased in several parts of the country (Jayakumar and Arockiasamy, 2003). Zang *et al.* (2014) discussed that the information on LULC can be acquired from various band combinations of satellite sensors by using digital image processing and classification techniques. Geospatial information techniques including geographic information system and remote sensing have been proved as an efficient approach for map-

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ping LULC changes over space and time. The changes in LULC is analytically linked to the natural and human influences on environmental changes. For mapping and monitoring of broad LULC categories and their spatial distribution, the image classification techniques could be used with limited ground truth. Digital image classification techniques like supervised and unsupervised can be used to classify pixels in an image to acquire a given set of labels or land cover themes. The LULC classification provides data that can be used for modeling specifically for the protection of the environment and planning of natural resources (Disperati *et al.* 2015). Moran *et al.* (2004) opined that LULC permits an overall view to understand the interface, behavior, and interaction of geophysical as well as socioeconomic systems. When paired together, remote sensing and GIS techniques provide more reliable and useful information in identifying LULC dynamics (Rwanga and Ndambuki, 2017). The utilization of land use of any arer varies according to the variation in the spatial distribution of physical factors as well as human activities in the developed and unused land (Mandal, 1982). Conventional methods used for generating information on LULC are laborious, subjective, expensive, and also impracticable for its monitoring over a short period of time. On the other hand, remote sensing with multispectral viewing, repetitive coverage, and synoptic vision has been provided a great opportunity in mapping changes of LULC. The remote sensing applications with techniques related to geospatial technologies are well recognized on this ground (Toleti and Rao 1995; Clevers *et al.,* 1999; Chaudhary *et al.,* 1999).

The objective of the present study was to identify changes in the Western Haryana Plains of Haryana for the period of 44 years during 1974-2018. In this study, we have been attempted in mapping land use and land cover changes using digital image classification techniques along with the fieldwork data.

Study Area

The study area, Western Haryana Plains (WHP) of Northern India, covering an area of about 15,546 km² which contributes around 2.83% of total geographical area of Haryana State. The research area extends between 28°47′ N to 28°53′ North latitudes and 75°01′ to 76°13′ East longitudes covering in four districts namely Sirsa, Fatehabad, Hisar, and Bhiwani (Fig. 1). The area is characterized by the semi-arid nature of climate and receives average annual rainfall anywhere between 280 and 500 mm. The WHP is bounded with Rajasthan in the West, Punjab in the North and other districts of Haryana in the East and South. The existence of sand dunes made this region characteristically different from other plains of Haryana. Geographically, the Western Haryana Plain is known as "*Bhiwani Bagar*". Due to low rainfall and scarcity of water, the area has been faced severe drought conditions in many times. The total population accounts for 1.3 million,

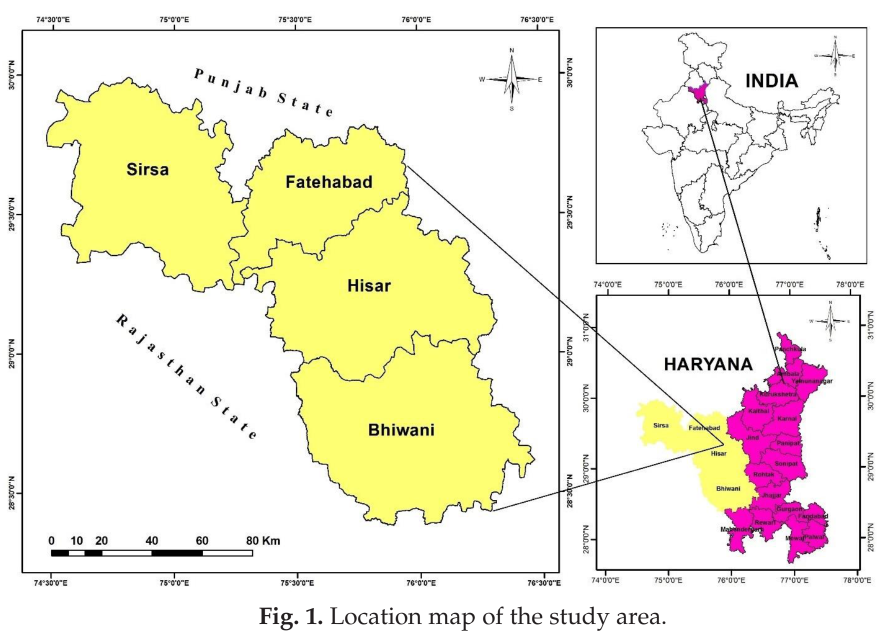

Fig. 1. Location map of the study area.

out of which 0.8 million is the rural population.

Data Source

It is necessary to have at least two different periods of data for evaluation and comparison of LULC changes. Landsat 2 MSS (1974), Landsat 5 TM (1988 and 1998) and Landsat 7 ETM+ (2008) datasets in Geotiff format were taken from USGS Earth Explorer (http://earthexplorer.usgs.gov/) and IRS-P6 LISS IV data for 2018 collected from HARSAC, Hisar for the present purpose of study (Table 1).

Methodology

The software ArcGIS 10.4 for statistical spatial analysis and ERDAS Imagine 2014 for image processing were used. Supervised classification is more precise than unsupervised classification. It needs familiarity by the user about the area and more input, but it can yield better results than unsupervised classification. In supervised classification, pixels are associated with a particular training site signature allocated to the maximum probable class. So, on the basis of the highest likelihood, the pixels of unidentified classes are assigned (Foody *et al.* 1992; Lillesand and Kiefer, 2000; Joseph, 2007). The overall methodology used in this study is shown in Fig. 2.

To prepare LULC map from satellite imageries, the NRSC (2012) classification scheme was adopted. A total of eight major LULC classes namely built-up, agricultural land, forest land, scrub land, barren/rocky, waterlogged area, sandy area and water bodies (Table 2) have been selected for mapping the entire plain area.

Supervised Classification

To determine various LULC classes on digital image, the supervised classification is considered to be very important. This technique is used to categorize the LULC classes into a specific segment based on the spectral signature classes taken from the remote sensing data (Saha *et al.*, 2005). Supervised classification is based on selecting sample pixels in an image that represents specific classes. Image processing

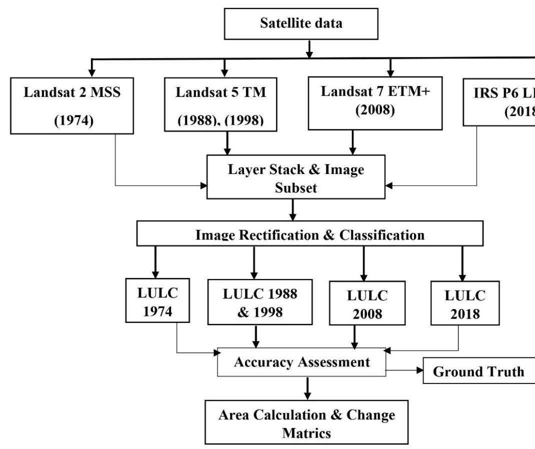

Fig. 2. Flow chart showing methodology adopted in the present study.

Table 1. Data collected from different sources used in the study.

Year	1974	1988	1998	2008	2018
Source	earthexplorer.usgs.gov	HARSAC			
Satellite	LANDSAT 2 MSS	LANDSAT 5TM	LANDSAT 5TM	LANDSAT 7ETM+	IRSP6 LISS IV
Date of Acquisition	04/03/1974	13/02/1988	20/02/1998	02/02/2008	05/02/2018

Table 2. Land use and land cover categories (NRSC 2012).

Category	Level	Description
Built-up	I	Rural and urban areas
Agricultural land	I	Crop land, agriculture plantation and fallow land
Forest Land	I	Includes agroforestry and land with tree cover
Scrub land	II	Open, dense, and lands covered with small bushes and scrubs
Barren/rocky area	II	Areas having no vegetation i.e. sediments, bare rocks, degraded forest area
Waterlogged area	II	Rising of the water table due to very poor drainage.
Sandy area or	II	Lands, characterized by accumulation of sand development in situ transported by the Aeolian process.
Water bodies	I	Reservoir/tanks/canals (human-made channels for irrigation).

software uses testing sites as references for the classification of other pixels by the user. By selecting training sites based on knowledge, the user designates the total classes that the image is classified into. The following steps are involved in the supervised classification procedure. The field work was conducted for the confirmation of training sites.

Results and Discussion

The classified maps of LULC showing built-up, agricultural land, forest land, scrub land, barren land, waterlogged area, sandy area and water bodies for the years 1974, 1988, 1998, 2008, and 2018 are shown in Fig. 3. The statistical results are given in Table 3. In 1974, the total area in each category was 1.36% in built-up, 73.81% in agricultural land, 0.13% in forest land, 0.64% in water bodies, 0.25% in scrub land, 0.25% in barren/rocky area, 0.07% in waterlogged area and 23.49% in sandy area, respectively. The scenario of the LULC classes started changing in the next decade as in 1988 about 77.58% of the area comes under agricultural land indicating an increase of cropping through the implications of the green revolution.

Sandy area was covered by 23.49%, the built-up area covered 1.36%, pond/lake area covered 0.37%, forest and scrubland occupied about 0.13% and 0.25% area, respectively. The classified images of 1998 and 2008 illustrate that the largest area was covered by agricultural land accounting 84.82% and 92.94%, sandy area was covered by 12.09% and 3.19%, forest occupied by 0.12% and 0.12 %, barren area 0.13% and 0.13 %, water bodies 0.81% and 0.86%, scrubland 0.19% and 0.18 %, built-up 2.09 % and 2.55% and waterlogged area 0.07 % and 0.04% respectively. In 2018, the area under agricultural land was 93.04% followed by sandy area (2.13%), forest (0.21%), barren area (0.12%), waterbodies (0.88%), scrub land (0.16 %), built-up (3.45%) and waterlogged area (0.03%). It shows an increase of 26.74% in agricultural land and ten times decrease in the area of waste lands. The conversion of wastelands into agricultural land is mainly due to application of fertilizers, high yielding variety of seeds, irrigation facilities and mechanization of agriculture helped them to conversion of cropping lands. Some of the field photographs are given which was sandy

Table 3. LULC categories and their distribution during 1974-2018.

Class	1974	1988	1998	2008	2018	LULC Change (1974-2018)	
			Area (Hectares)			Area	%
Built-up	21229	27675	32774	39834	53931	32702	153
Agricultural land	1154909	1213874	1320924	1454172	1455713	300804	26
Forest land	2081	2150	1950	1886	3258	1177	61
Scrub land	3983	4348	3749	2767	2489	-1494	-36
Barren/rocky	3889	2268	2068	1958	1824	-2065	-52
Waterlogged	1036	1142	1138	617	414	-622	-57
Sandy	367549	301246	189198	49902	33279	-334270	-1104
Water bodies	9937	11910	12812	13477	13705	3768	72

Table 4. Accuracy assessment of classified images (1974-2018).

Year Category	User Accuracy (%) 1974	User Accuracy (%) 1988	User Accuracy (%) 1998	User Accuracy (%) 2008	User Accuracy (%) 2018	Reference Total	User Accuracy %
Built-up	81	84	86	90	96	150	87
Agricultural land	85	91	90	94	98	150	92
Forest land	78	81	83	85	89	100	83
Scrub land	79	81	83	86	88	100	83
Barren/rocky	91	92	93	95	95	75	93
Waterlogged	74	74	76	81	85	75	78
Sandy	80	83	87	88	92	150	86
Water bodies	90	90	92	93	93	100	92
Overall Accuracy	82	85	86	89	92		87

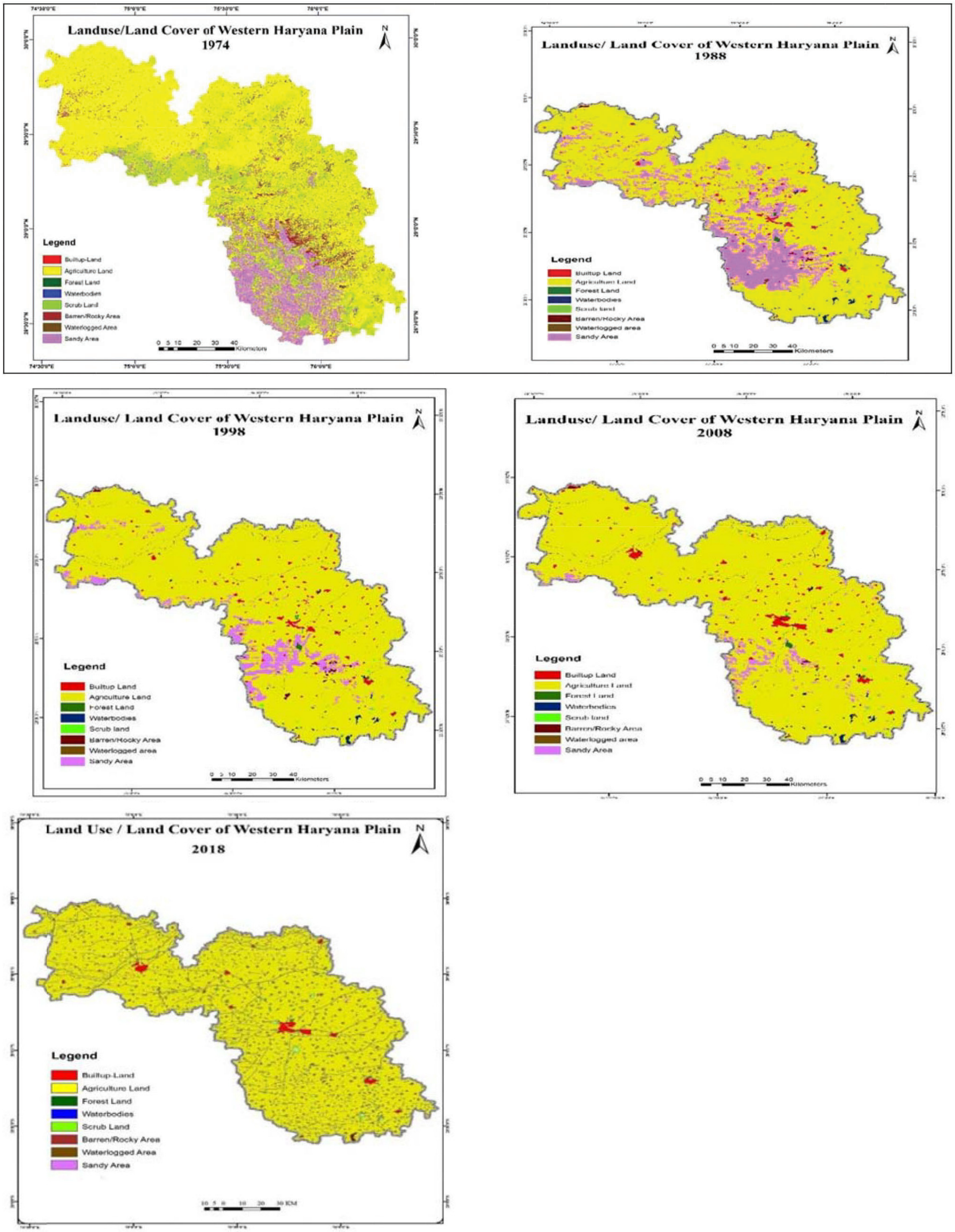

Fig. 3. LULC maps for the years 1974, 1988, 1998, 2008 and 2018.

Fig. 4. Field photo-graph shows the sprinkler irrigation practices adopted in conversion of sandy area into agricultural land.

region converted into agricultural land by adopting sprinkler irrigation techniques, etc. (Fig. 4).

Accuracy Assessment of Classified Images

Accuracy assessment of the classified image is the most important aspect that has been performed by testing the sampling area pixels. The error matrix is used for the testing sites of image with the ground truth data (Table 4). Handheld Garmin eTrex 30x and Google Earth tools were used in the collection of ground truth information.

Conclusion

The monitoring of LULC changes is very much needed in the assessment of depletion and degradation of natural resources. In the present study, the change matrix studies are carried out by utilizing the classification procedures. The changes in land-use have efficiently been captured by satellite sensors with various resolutions. The study is related to identifying the pattern of LULC changes from 1974 to 2018 in Western Haryana plains of Northern India. The result of comparison between these four decades showing a tremendous declining trend in the proportion of sandy area. The area under agricultural land use has been increased with the increase of intensity of Green Revolution. Barren/rocky area, scrub land, waterlogged area were decreased significantly over the study period from 1974 to 2018. On the other hand, other classes including settlements of built-up, water bodies and forest/natural vegetation showed an increasing trend with change of 153%, 72%, and 61% respectively. Green Revolution in India came with its universal profits and changed significantly the land use and land cover. The development in agriculture, irrigation, new machinery, and change in built-up areas have caused alterations as well as modifications in LULC status. The change in LULC mainly emerged from the new irrigation techniques like sprinkle irrigation, drip irrigation, and an increase in the consumption of fertilizers. On one hand increase in the agricultural area increased the crop production, increases the income of the farmers but on the other hand, it led to groundwater depletion. Remote sensing and GIS is one of the most eminent technologies used for the spatial as well as temporal LULC analyses. The findings of this study may help to formulate policies in Western Haryana Plain regions in the renewable LULC exercises.

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