Application of GIScience in Land use/cover dynamics over the 28 years-A case study of Haldwani town area, district Nainital, Uttarakhand, India

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DOI: 10.29322/IJSRP.10.05.2020.p10117
http://dx.doi.org/10.29322/IJSRP.10.05.2020.p10117

Abstract- Utilizing multi-worldly satellite symbolism, the present investigation represents spatio-temporal elements of Land use/cover of Haldwani Town of area Nainital, Uttarakhand, India. Landsat satellite symbolisms of two distinctive timespans, i.e., Landsat TM for 1990, Landsat 5 for both 2008 & 2010 and Landsat 8 for 2018 were procured and measured changes in the Haldwani town from 1990 to 2018 over a time of 28 years. Supervised Classification approach has been utilizing Maximum Likelihood Technique. The pictures of the examination territory were sorted into five unique classes, viz., built-up area, vegetation, agriculture lands, sand bar and water bodies . The outcomes show that during the most recent three decades, built-up and sand bar of the Haldwani town region has been expanded about 26.57% (i.e., 55.89 km^2) and 2.15% (i.e., 4.09 km^2) individually, while zone under other land classifications vegetation, agricultural and water body have diminished about 16.57% (34.87 km^2), 10.98% (23.11 km^2) and 1.20% (2.53 km^2), respectively. The investigation uncovers that the Haldwani town is expanding towards southern course along the National Highway-87. The consequences of the paper on computerized change identification strategies will be useful in appropriate land use making arrangements for a reasonable and uniform urban development of the Haldwani town zone.

Index Terms- - Land use/cover, Spatio-Temporal, Multi-Temporal Satellite Imagery, Remote Sensing.

I. INTRODUCTION

The Land use/cover pattern of a region is a result of natural and socio-economic factors and their utilization by man in time and space(J.S. Rawat et al., 2015). Data about land use/cover is very necessary to help in urban management and planning, managing the natural resources sustainably and socio-economic development (Kontes et al., 2000). Land cover is a basic parameter, which describes the surface of Earth. Land cover is a considerably variable parameter that helps in linking various parts of human to its physical environments. (Foody, 2002). While, land use refers to man's activities, which are directly related to the land (Clawson et al.1965, James R. Anderson et al. 1976). Land use refers to the process of managing and modifying the natural environment into built environment such as fields, pastures, and settlements. Land use Land cover changes has gotton a very important and point of focus in current strategies, which are being made for managing natural resources and monitoring the changes that are occurring in the environment. Although Land use/cover changes are widespread and accelerating phenomenon, which are driven because of human actions but it also results in those changes that inversely influence the human race (Agarwal et al., 2002). Land cover changes has become one of the central points in debate of sustainable development as along with other factors it also drives the process of environmental change. Although it is not very much true that land cover change only occurs under human influence as this change also occurs when the human activities are not present, under or through natural processes but land use change is totally the manipulation of land cover under human influences for multiple purposes such as foods, fuel wood, timber, fodder, leaf, litter, medicine, raw materials and recreation. Land use/cover changes have been reviewed numerous times and from different perspectives in order to identify the drivers of land use/cover change, their process and consequences.The advent of high spatial resolution satellite imagery and more advanced image processing and GIS technologies, has resulted in a switch to more routine and consistent monitoring and modeling of land use/land cover patterns (J.S. Rawat et al., 2015). Using space science technologies such as remote sensing to develop land use classification mapping is a useful and detailed way to improve the selection of areas designed to agricultural, urban and/or industrial areas of a region (Selcuk 2003, J.S. Rawat et al. 2013). Remote-sensing has been widely used in updating land use/cover maps and land use/cover mapping has

become one of the most important applications of remote sensing (Lo, 2004 &). The mapping of land use/cover can be performed in a cost-effective manner using Earth observation remote sensing technologies in conjunction with geographical information systems (Weng, 2002) and GI Science (Wilson and For the ringham, 2008). The present study shows application of GIS using multi-temporal satellite data in analysing land use/cover dynamics of a Himalayan foothill town, viz., Haldwani located in Nainital district of the Uttarakhand State.

II. STUDY AREA

The study area i.e. Haldwani town (Figure 1) of nainital district Uttarakhand, India extends between 29°05'16"N to 29°17'28"N latitudes and 79°24'07"E to 79°37'05"E longitudes and encompasses an area of 210.36 km². Out of the present total town area only about 10.65 km^2 area falls under the Haldwani Municipal area which shows that the sprawl of town is happening quickly. The elevation of the town above mean sea level varies between 268m in the extreme south to 584m at the extreme north. Physiographically, Haldwani is settled at foothill region of Kumaun himalaya (also called as Bhabhar locally) made-up of quaternary stores, i.e., coarse alluvium where the mountain streams debase and reappear in the nearby Indo-Gangetic plain. Climatically, the study area has sub-tropic climate conditions. Haldwani is the gate way of the geographic entity of one of the two divisions of the Uttarakhand state, viz., the Kumaun region.

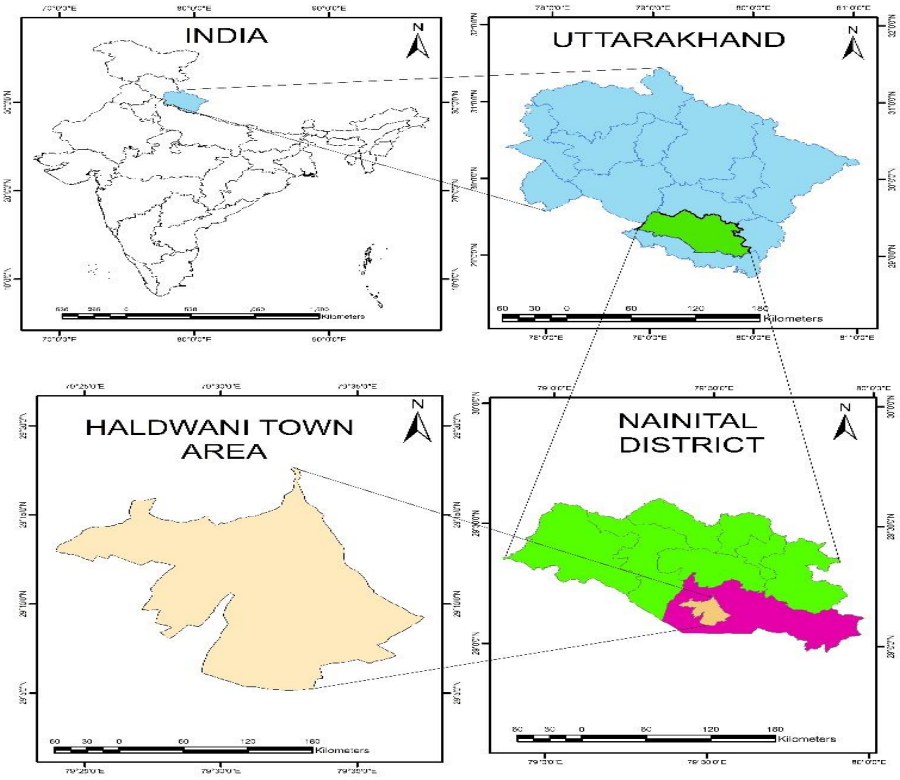

Figure 1 -Study Area Map

III. METHODOLOGY

One of the prerequisite for understanding land use/cover dynamics is successful land use/cover classification. In order do the land use/cover classification and change detection, multi-temporal satellite of Landsat Thematic Mapper of 15th November 1990 and Landsat 8 of 15th November 2018 were obtained by USGS Earth Explorer at 30m resolution. The imageries of 1990 to 2018 helped in understanding the process of land use/cover change over the last two decades using change detection images and matrix (Weng, 2001). With the help of these multi-temporal imageries, the directional rate and magnitude of change were analysed in the ERDAS Imagine 9.3, ENVI 4.3 and ArcGIS 9.0 software. Firstly, different bands of the imagery were stacked to produce a false color composite. The area of interest was extracted by sub-setting of the image. To detect and analyse the land use/cover change, digital classification through supervised maximum likelihood classification technique, based on the field knowledge and image characteristics was employed to perform the classification. The extracted land use/cover categories include built-up area, vegetation cover, agricultural land, water body and sand bar. GPS points were collected during field survey for the accuracy of the classification.

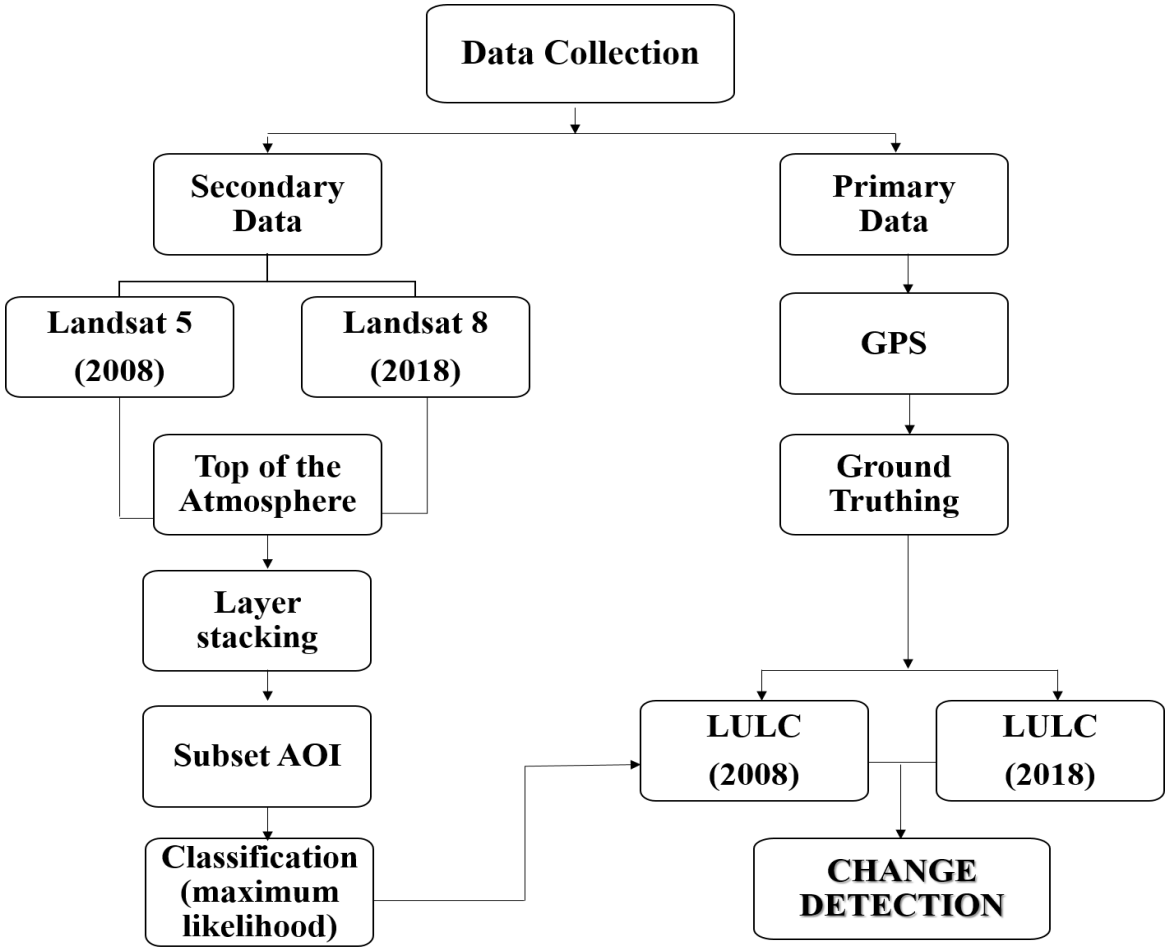

Figure 2- Methodology chart

IV. RESULTS AND DISCUSSION

The outcomes acquired through the analysis of multi-temporal satellite imageries were diagrammatically represented in figure and data are registered in table. Figure and Table depicts land use/cover status. A brief account of these outcomes is discussed in the following paragraphs.

A. Land use/cover Status

Table 1 depicts spatial distributional pattern of land use/cover of the Haldwani town area for the year 1990and 2010, from the Source of Data from **Rawat el. al. 2014**. Data reveal that in 1990; about 3.36% (7.07 km^2) area of Haldwani town was under built-up land, 41.23% (86.73 km^2) under vegetation, 49.14% (103.37 km^2) under agricultural land, 2.17% (4.56 km^2) under water and 4.09 % (8.61 km^2) was covered by sand bar.During 2010 the area under these land categories was found 15.24% (32.06 km^2) under built-up land, 36.57% (76.93 km^2) under vegetation, 41.44% (87.16 km^2) under agricultural land, 3.03 % (1.44 km^2) under water and 5.31 % (11.16 km^2) under sand bar (Table 1) using the Source of Data from **Rawat el. al. 2014**.Now spatial distributional pattern of land use/cover of the Haldwani town area for the year 2008 and 2018, During 2008 the area under these land categories was found 12.76% (26.84 km^2) under built-up land, 37.44% (78.75 km^2) under vegetation, 43.51% (91.51 km^2) under agricultural land, 1.85 % (3.89 km^2) under water and 4.45 % (9.35 km^2) under sand bar. During 2018, the area under these land categories was found 29.93 % (62.96 km^2) under built-up land, 24.66 % (51.86 km^2) under vegetation, 38.21 % (80.37 km^2) under agricultural land, 0.97 % (2.03 km^2) under water and 6.24 % (13.12 km^2) under sand bar.

Table 1- LULC of Haldwani Town (1990-2018)

LULC	Area in Sq. Km (values in parenthesis are in percentage)				Area Change in (Sq. Km)
	1990*	2008**	2010*	2018***	1990-2018
Agriculture	103.37 (49.14%)	91.51 (43.51%)	87.16 (41.44%)	80.37 (38.21%)	-23.11
Built-up	7.07 (3.36%)	26.84 (12.76%)	32.06 (15.24%)	62.96 (29.93%)	55.89
Vegetation	86.73 (41.23%)	78.75 (37.44%)	76.93 (36.57%)	51.86 (24.66%)	-34.87
Water	4.56 (2.17%)	3.89 (1.85%)	3.03 (1.44%)	2.03 (0.97%)	-2.53
Sand Bar	8.61 (4.09%)	9.35 (4.45%)	11.16 (5.31%)	13.12 (6.24%)	4.51

* Source of Data from Rawat el. al. 2014. ** Based on Landsat Data, *** Based on Landsat 8 Data.

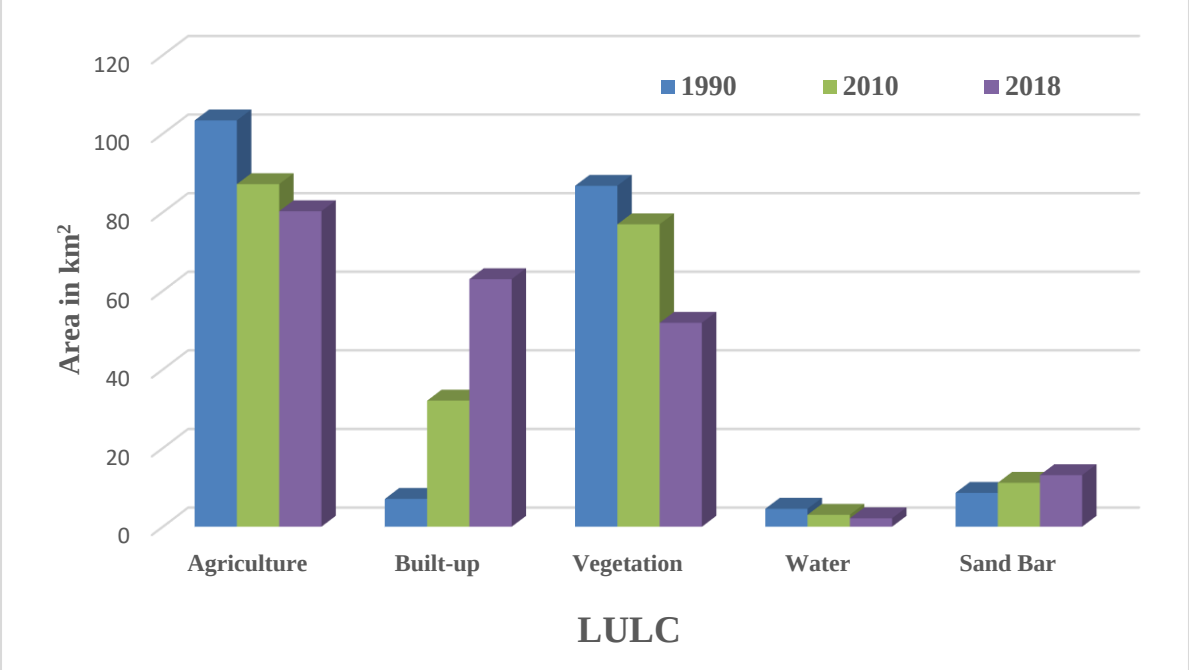

Figure 3- Change in Land Use/Cover classes, Haldwani town (1990-2018)

Table 2- LULCC Change Rate

LULC	Change Rate per year		
	1990-2010	**2010-2018**	**1990-2018**
Agriculture	-0.81	-0.86	-0.80
Built-up	1.25	3.86	1.93
Vegetation	-0.49	-3.13	-1.20
Water Body	-0.08	-0.11	-0.08
Sand Bar	0.13	0.25	0.16

The Haldwani town area has witnessed different change rates over the years for different land use land cover classes . Change rate for built-up area has been highest from 1990 onwards being 1.25 from 1990-2010, and 3.86 from 2010-2018. The average change rate from 1990-2018 was 1.93. Agriculture, Vegetation and water body saw a negative change rate in the time period of 1990-2018. Highest negative change rate for agriculture was experienced in time period of 2010-2018 which was -0.81, water body and vegetation also experienced the highest negative fall in the same time period which was -0.11 for water body and -3.13 for vegetation. Expansion in built-up area can be taken as the main reason behind the declination of agricultural as well as vegetation area. Whereas the declination of water body can be attributed to increase in area or proportion of sand bar.

B. Land use/cover change

The data enrolled in Table 1 delineates that both positive and negative changes happened in the land use/cover pattern in the Haldwani town area. During the last 28 years, the built-up area has expanded from 7.07km^2 in 1990 to 62.96 km^2 in 2018, which represents 26.91% of the absolute spread region. The vegetation cover has decreased significantly from 86.73 km^2 in 1990 to 51.86 km^2 in 2018. This decrease in vegetation accounts for 15.19% of the increased total town area. The agricultural land has diminished slightly from 103.37 km^2 in 1990 to 80.37 km^2 in 2018, which accounts for 9.93% of the increased total town area. The water body has slightly decreased from 4.56 km^2 in 1990 to 2.03 km^2 in 2018, which accounts for 1.56 % of the total town area. Due to depletion in water bodies area under sand bar has increased from 8.61 km^2 in 1990 to 13.12 km^2 in 2018 which accounts 1.79% in area of increased town area.

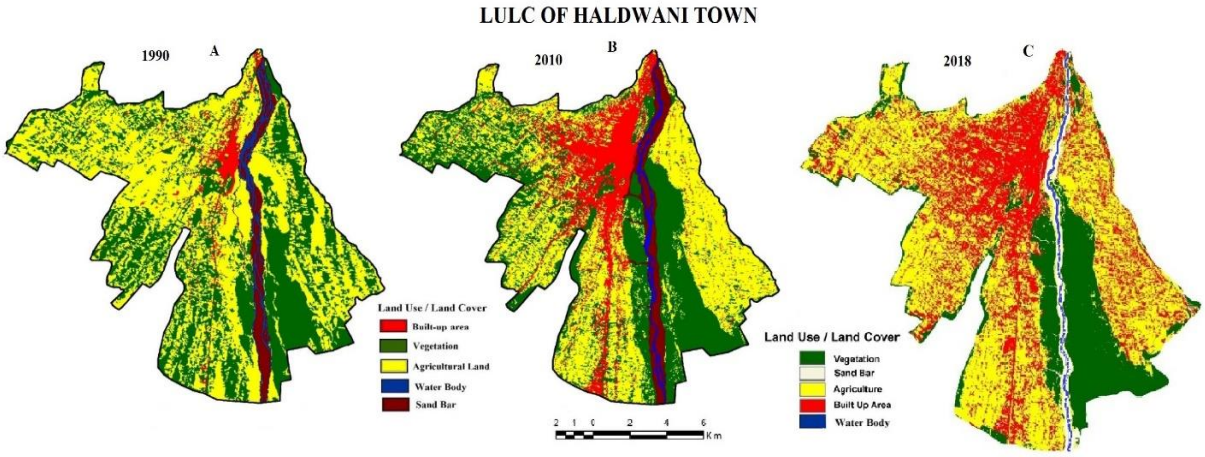

Figure 4- Changing scenario of Haldwani town from 1990-2018

V. CONCLUSION

The study led in one of the towns of the Uttarakhand state situated in the lower region zones of the Kumaun Lesser Himalaya advocates that multi temporal satellite imagery is helpful to distinguish the adjustments in land use rapidly and precisely. The study uncovers that the most of land use in the Haldwani town zone is the built-up area. During the most recent three decades, the zone under built-up has

been expanded 11.86% (55.89 km^2) because of the development of new structures & buildings on vegetation land and agriculture land while the area under vegetation, agricultural land water body and sand bar have decrease by 4.68% (34.87 km^2), 7.71% (23.11 km^2) and 0.7% (2.42 km^2), 1.02 % (4.51 km^2) respectively. The study also reveals that the Haldwani town is extending most extreme towards southern heading along the National Highway at the rate of 0.34 km^2/year. The methodology adopted in this study clearly exhibited the potential of Remote Sensing & GIS technology in estimating change pattern of land use/cover in town area. This type of studies can be very helpful in development planning for the future .

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