Monitoring land Use/cover Change using Remote Sensing and GIS Techniques: A Case Study of hill Station Pithoragarh Town, Uttarakhand, India

Arvind Pandey, Jiwan Singh Rawat, Sarita Palni, Charu Pundir, Snehal Mohite, Pankaj Kumar Bhatt

Abstract: Technique of Change Detection using LANDSAT satellite imagery helps in understanding the dynamics of landscape. This study depicts the spatio-temporal dynamics of land use/cover of Pithoragarh town area situated in Uttarakhand district of India. To quantify the changes in land use and land cover in Pithoragarh town over a period of 23 years. LANDSAT satellite imageries of two different time period i.e. LANDSAT Thematic Mapper (TM) of 1990 & LANDSAT OLI of 2013 were obtained with the help of USGS Earth Explorer. To fulfil the classification, purpose unsupervised Classification methodology has been used using the K-means technique. Study area was categorized into four different classes. i) Vegetation, ii) Agriculture, iii) Built-up, and vi) Barren land. Results of this study indicates that built-up land have been increased by 38.73% (3.55km^2) and while vegetation, agriculture, and barren land, have decreased by -17.20% (-1.57 km^2), 10.58% (-0.96km^2), -10.94% (-1.01km^2), respectively in past 23 years. This study is being conducted first time for this study area. Thus, this paper determine application of GIScience in change detection of land use pattern.

Keywords: Land use/ Land cover, Remote Sensing, GIS, Change Detection Technique, Pithoragarh Town.

I. INTRODUCTION

The process of identifying differences in the state of an object or phenomenon by observing it at different times is named as Change Detection (Singh 1989). A variety of change detection techniques have been developed and many have been summarized and reviewed by many scholars (Singh 1989, Mouat et al. 1993, Sohn, H et al. 2003, Coppin et al 2004, Jensen et al. 1999). Due to the importance of monitoring the change of Earth's surface features, research of change detection techniques is an active topic, and new techniques are constantly being developed. Good change detection research should provide the following information: (1) Change in area and change rate; (2) Spatial distribution of changed types; (3) Change trajectories of land-cover types; and (4) Accuracy Assessment of change detection results. Remote sensing data of better resolution at different time interval helps in analysing the rate of changes as well as the causal factors or drivers of changes (Mertens et al. 2000). Land Use Land Cover Changes (LULCC) is urbanization induced, which has led to dramatic changes in land use practices (Mirkatouli et al 2015).

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Quantifying rate of land cover changes at Himalayan terrain is challenging due to major constraints of undulating, sloppy terrain and hill shade effect. Recent advancement of remote sensing can help and explain demographics of population expansion and rate of its changes in major cities at Himalayan landscape (Zhang et al. 2009). For the analysis of environmental processes and problems that must be understood if living conditions and standards are to be improved or maintained at current levels, land use & land cover data is a necessity. The variety of land use and land cover data needs is exceedingly broad. Current land use and land cover data are needed for equalization of tax assessments in many States. Land use and land cover data also are needed by Federal, State, and local agencies for water- resource inventory, flood control, water-supply planning, and waste-water treatment (Anderson, 1977). Federal agencies need land use data to assess the environmental impact resulting from the development of energy resources, to manage wildlife resources and minimize man-wildlife ecosystem conflicts, to make national summaries of land use patterns and changes for national policy formulation, and to prepare environmental impact statements and assess future impacts on environmental quality (Roth, 1997). Land cover implies to the physical condition of the ground surface, For example- forest, Grassland, etc. while Land use reflects human activities such as the use of the land, For example- industrial zones, residential zones, etc. Land cover refers to features of land surface, which may be natural, semi-natural, managed, and man-made. They are directly observable by remote sensors. Land use and land cover research needs to deal with the identification, qualitative description and parameterization of factors which drive changes in land use and land cover, as well as the integration of their consequences and feedbacks (Baulies and Szejwach, 1998). However, one of the major challenges in land use and land cover analysis is to link behaviour of people to biophysical information in the appropriate spatial and temporal scales (Codjoe, 2007). Land use and land cover changes has become a central component in current strategies for managing natural resources and monitoring environmental changes (Kauland Sopan, 2012).Changes in land use affects land cover and vice versa. Changes in land cover by land use do not necessarily imply degradation of the land.

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However, many shifting land use patterns driven by a variety of social causes, result in land cover changes that affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere (Riebsame et al., 1994). Land use/cover change detection is very essential for better understanding of landscape dynamic during a known time period having sustainable management. Land use/cover changes is a widespread and accelerating process, mainly driven by natural phenomena and anthropogenic activities, which in turn drives changes that would impact natural ecosystem (Ruiz-Luna and Berlanga-Robles, 2003; Turner and Ruscher, 2004). Understanding landscape patterns, changes and interactions between human activities and natural phenomenon are essential for proper land management and decision improvement. Today, earth resources satellites data are very applicable and useful for land use/cover change detection studies (Yuan et al., 2005; Brondizio et al., 1994). The aim of this study is to assess the land cover and land use changes in Pithoragarh Town in last 23 years. In this regard the study objective is, i) to identify land cover and land use., ii) to prepare the land use and land cover change map and transition matrix of Pithoragarh town and iii) To prepare the landscape dynamics of Pithoragarh Town.

II. STUDY AREA:

The study area, the town area of District Pithoragarh of the Uttarakhand state lies in the Higher to middle Himalayan extent in India. It extends between Latitude 29.5829°N to 80.2182°E Longitude and encompasses an area of 1687.8 km² (Census, 2001). Pithoragarh is the easternmost Himalayan district situated in the state of Uttarakhand, India. It is naturally landscaped with high Himalayan mountains, snow-capped peaks, passes, valleys, alpine meadows, forests, waterfalls, perennial rivers, glaciers and springs. The area is very rich in ecological diversity as it has a large variety of flora and fauna. Pithoragarh town, being in a valley, is relatively warm during summer and cool during winter. During the coldest months of December and January, the tropical and temperate mountain ridges and high locations receive snowfall and have an average temperature of 5.5–8.0°C. Pithoragarh town has extreme variation in temperature due to the large variations in altitude. The temperature rises from mid-March through mid-June. The areas above 3,500 metres remain in a permanent snow cover. Regions lying at 3,000–3,500 metres become snow bound for four to six months. At places like the river gorges at Dharchula, Jhulaghat and Seraghat, temperatures reaches 40 °C. The annual average rainfall received by this area is 36.7cm, After June the district receives monsoon showers. According to the 2011 census Pithoragarh district has a population of 4, 85,993. This gives it a ranking of 546th district among the 640 other districts of India (Census 2011). The district has a population density of 69 person/ Km2. Its population growth rate over the decade 2001–2011 is 5.13%. Pithoragarh has sex ratio of 1021 females for every 1000 males, and a literacy rate of 82.93%.

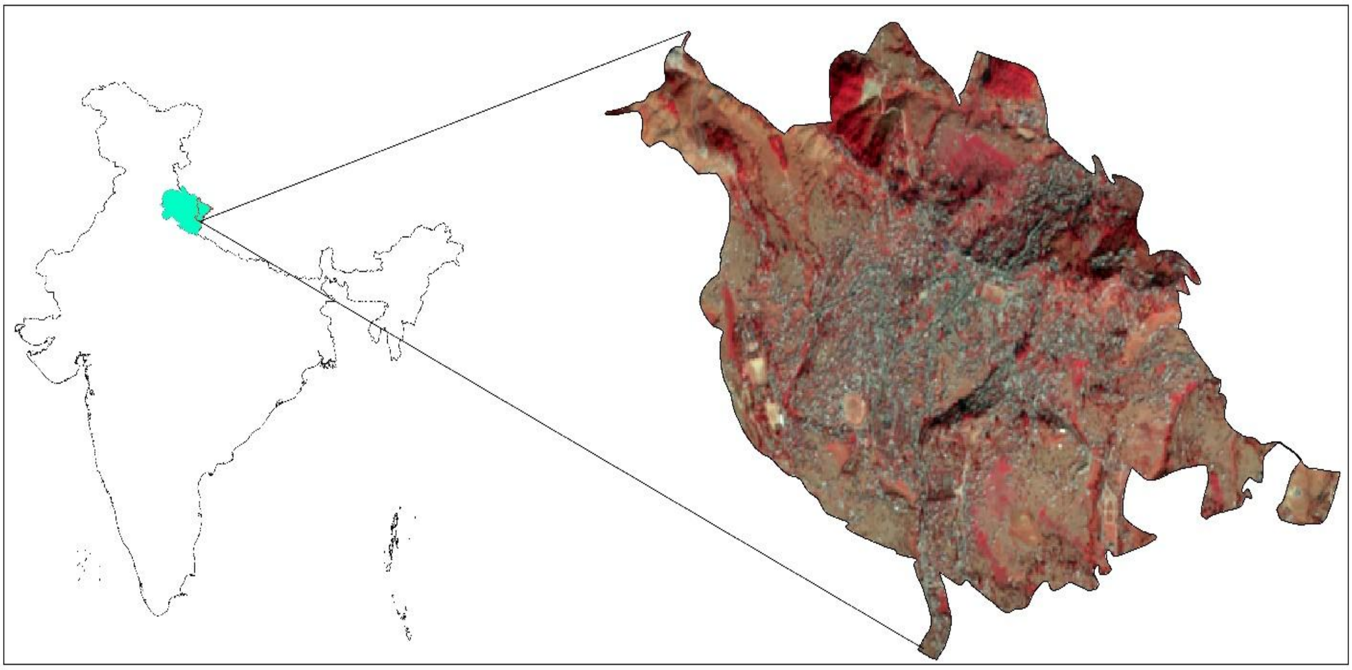

Fig.1: Location map of the study area.

III. DATABASE AND METHODOLOGY:

LANDSAT satellite having resolution of 30m of 1990 (Landsat TM) and 2013 (Landsat OLI) were used for land use/cover classification. The satellite data covering study area were obtained from earth explorer site (http://earthexplorer.usgs.gov/). These data sets were imported in ERDAS Imagine (Leica Geosystems, Atlanta, U.S.A.), satellite image processing software to create a false colour composite (FCC).

IV. METHODOLOGY:

The topo-sheet on scale 1:50000 which is obtained from Survey of India (SOI), Dehradun are scanned using plotter on 400 dpi and imported in tiff format. Scanned topographical-sheets are imported in ArcGIS and geo-referencing has been carried out with well distributed Ground Control Points with 1st polynomial order. RMS error was kept below 0.4. Further, it was resampled with bucolic convolution method and assigned UTM projection and WGS 84 Datum with 44 North Zone.

Generation of Layers:

Further, topographical-sheet was geo-referenced and various vector layers have been generated with the help of point, line and polygon features. Rivers were digitized with the help of topographical-sheet using line feature where polygon feature used for boundary.

Methodology in land use and land cover Chat

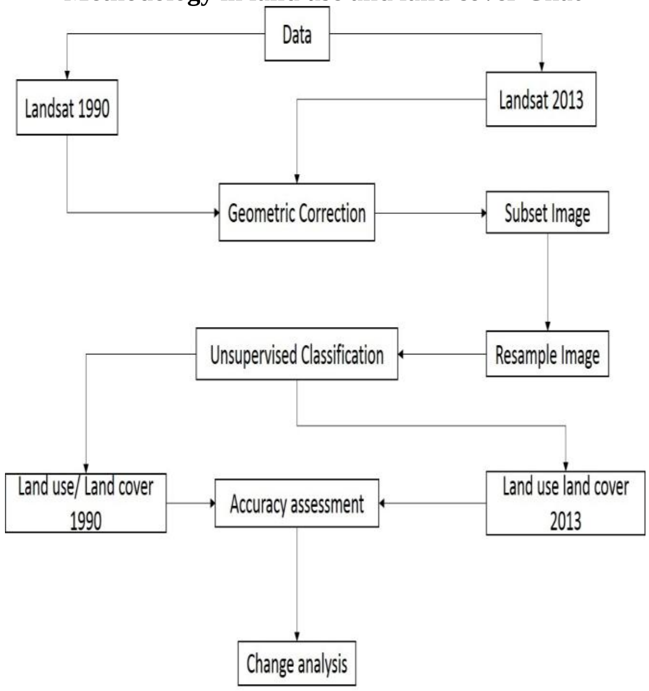

Fig: 2- Methodology

Temporal land use/land cover and change detection

Satellite image of 1990 and 2013 respectively have been used for generation of land use/ land cover map. The satellite data was enhanced before classification using histogram equalization for the better quality of the image and to achieve better classification accuracy. Further, both satellite data were rectified to a common Universal Traverse Mercator (UTM) projection/coordinate system on 1:50,000 scale. The data was resampled to a common spatial resolution of 30m. Then unsupervised classification was performed using K-means algorithm of the classified data and then it was recoded. After this the ground trothing was done and thereafter accuracy assessment matrix was performed. Two land use/land cover maps were prepared from, i) Landsat TM 1990 and ii) Landsat OLI 2013 satellite data of 2013 thereafter changes in different land use/land cover was observed (Fig. 3).

V. ANALYSIS AND RESULTS:

The analysis of multi-temporal satellite imageries is diagrammatically illustrated in fig. 3 to 7 and data is registered in table 1 and 2. Fig. 3 is used to show the land use/cover status of year 1990, fig. 4 depicts the major class of Land use /land cover change & fig. 5 illustrates the land use/cover status of year 2013, with the help of fig. 6 help we can compare the land use and cover change since 1990 to 2013. Fig. 7 shows us the total change from year 1990 to 2013. A brief description of these results is discussed in the following paragraphs.

Land use/land cover in 1990 and 2013 of Pithoragarh town –

Figure 3 depicts location wise distributional pattern of land use/cover of the Pithoragarh town for the year 1990 where the vegetation cover was 40.03% agriculture land cover was 35.74% built up land cover was 9.22% and barren land cover was 14.99% of the total land proportion of Pithoragarh town. Figure 5 illustrates the spatial distributional pattern of land use/cover of the Pithoragarh town for the year 2013. In year 2013 the proportion of vegetation cover was 22.83%, agriculture land was 25.16%, built up land was 47.96% and barren land was 4.042% of total land of Pithoragarh town.

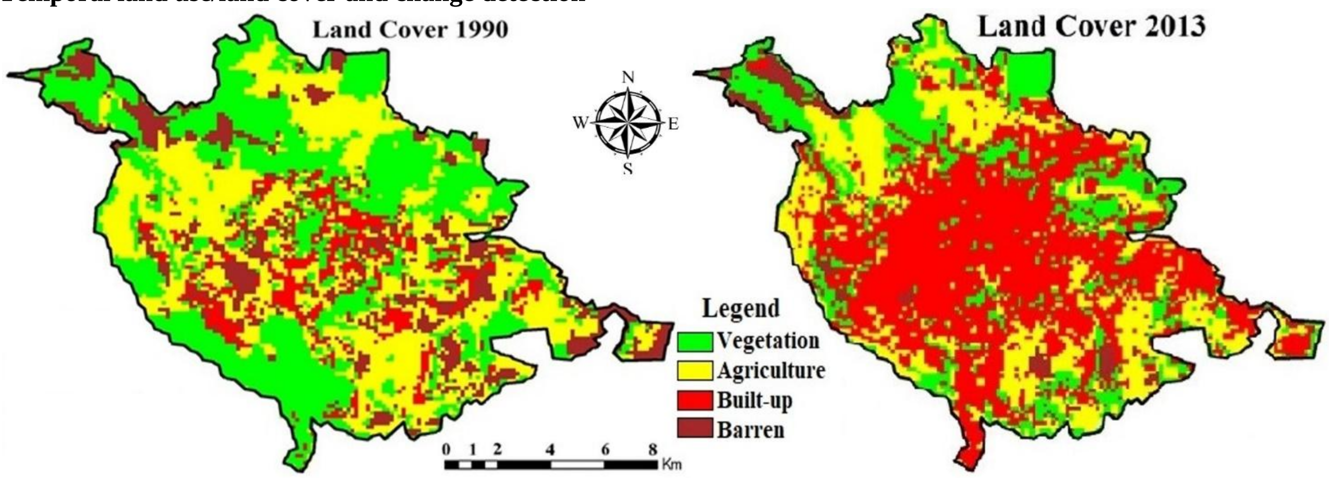

Fig. 3- Land Use/Cover map in 1990 and 2013 of Pithoragarh Town.

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Change in Land use /land cover-

In year 1990 the agriculture land was 35.74% while it changed to 25.16% in year 2013. It shows the change of -10.58% in agricultural land. This depicts that the agricultural land has decreased in last two decades. In year 1990 the proportion of barren land was 14.99% while in the year 2013 it changed to 4.042%. This shows a change of -10.94% in barren land depicting that barren land has also decreased in last two decades. In case of vegetation land, its proportion in year 1990 was 40.03% while in the year 2013 it became 22.83%. This also shows the declination of -17.20% in vegetation land in last two decades. In year 1990 the built-up land was 9.22% while in the year 2013 it changed to 47.96% this depicts the 38.73% change in built-up land showing that built-up land has increased dramatically in last two decades in Pithoragarh town. Fig. 4 assists to understand the magnitude of change that took place in various categories of land cover and land use like agriculture, vegetation, built-up land and barren land of Pithoragarh town and with the help of fig.4, we can compare the overall changes in a glance altogether since 1990 to 2013.

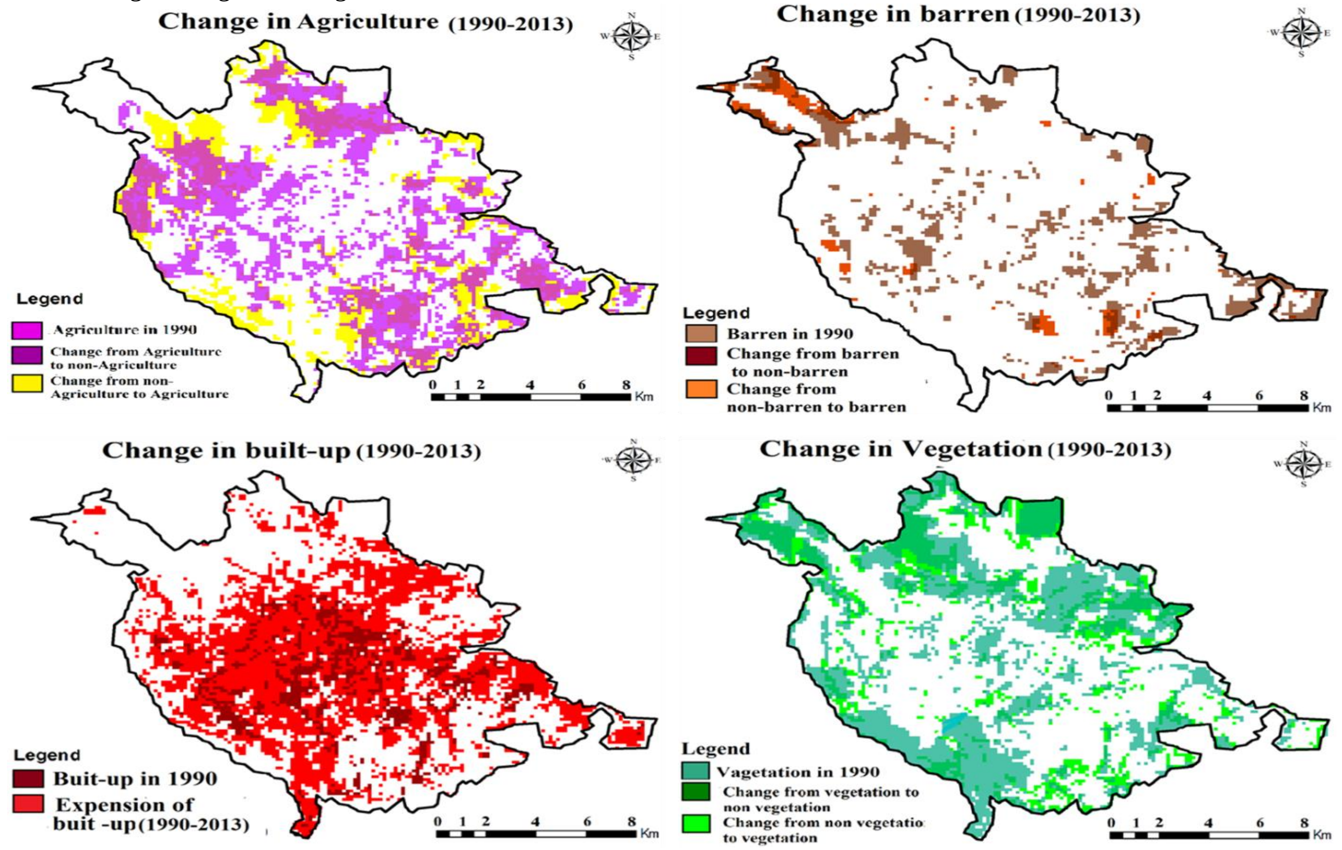

Fig. 4: Magnitude of change in various categories of land of the town area of district Pithoragarh during 1990-2013

VI. DISCUSSION

Change in various categories of land use/cover during 1990 to 2013 has been present in table 1. There data revent that during the last two decades the vegetation cover has decreased by -17.20 as it was 40.03% (3.66 km2) in year 1990 while in 2013 it reduced to 22.83% (2.0889 km2). Agriculture land has also decreased by 10.94% as it was estimated at 35.74 (3.27 km2) in year 1990 while in year 2013 it was calculated just 25.16% (2.31 km2) along with barren land which has also reduced by -10.94% as it was 14.99% (1.37 km2) in year 1990 while in 2013 it was recorded just 4.2 (0.37 km2). In case of built up land positive changes can be seen. In year 1990 it was 9.22 % (0.84 km2) while in 2013 it is 47.96% (4.38 km2), the increase of 38.73% can be seen in this case.

Table-1: Area and amount of change in different land use/cover categories in the land of the town area of Pithoragarh town during 1990 to 2013.

Land use categories	Area in 1990		Area in 2013		Change in area	
	Km^2	%	Km^2	%	Km^2	%
Vegetation	3.66	40.03	2.09	22.83	-1.57	-17.2
Agriculture	3.27	35.75	2.31	25.16	-0.96	-10.58
Built-up Land	0.84	9.23	4.37	47.96	3.54	38.73
Barren Land	1.37	14.99	0.37	4.05	-1.01	-10.95
Total	**9.14**	**100**	**9.14**	**100**	**0**	**0**

Land Encroachment- According to the study land use and land cover in Pithoragarh town has changed dramatically where agricultural land, barren land and vegetation land has decreased in last two decades but the build-up area has kept on increasing continuously in these past two decades. This shows that the increase in population has directly or indirectly affected all kinds of land use & land cover. This study also depicts that the urbanisation is also increasing very haphazardly.

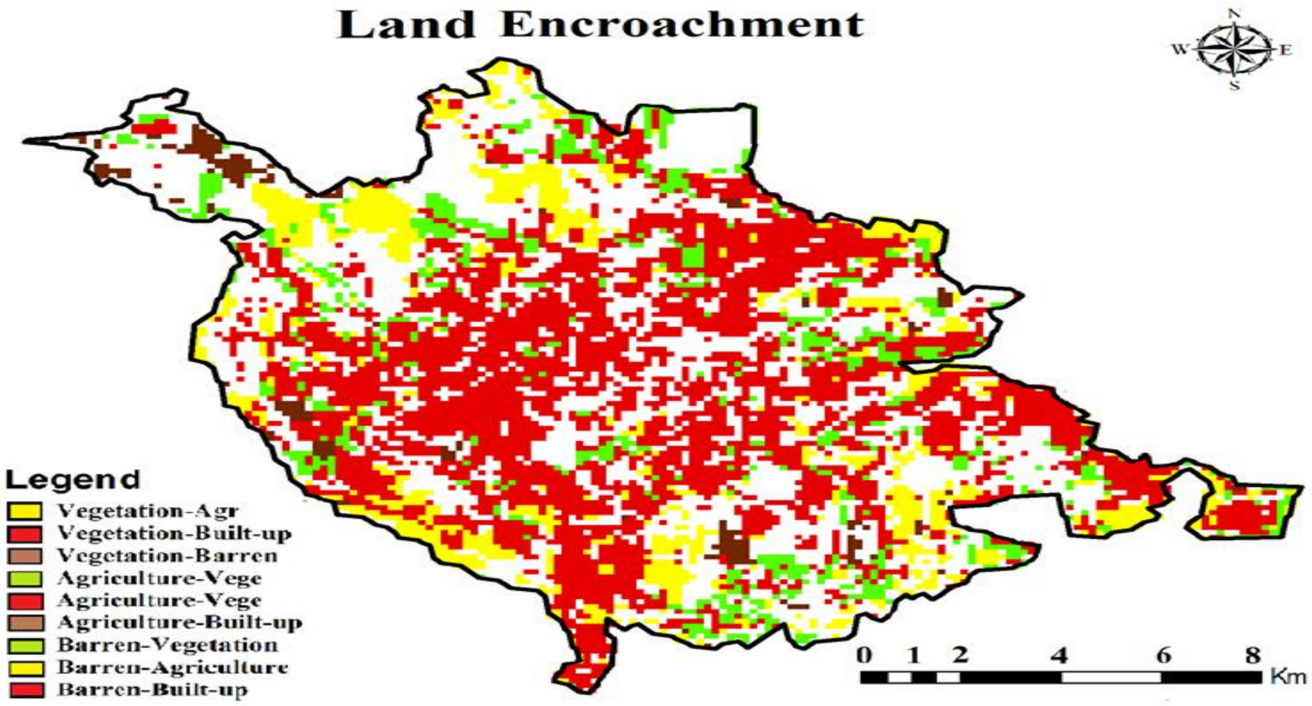

Fig: 5- Land encroachments for different land categories during the last two decades (1990-2013) in the pattern of the area.

To understand land encroachment for different land categories during the last two decades, a change detection matrix (Table 2) was prepared which reveals that:

i. about 79.2% area of vegetation covered has been converted into agriculture, 146.07% area under built-up area and 11.43% area under barren land;
ii. about 49.95% area of agriculture has been converted into vegetation, 8.1% into barren, 145.89% in built-up
iii. about 32.49% of area of barren has been converted into agriculture, 26.73% area under vegetation, 61.29% area under built-up land

Table-2: Area and amount of change in different land use/cover categories in the land of Pithoragarh town during 1990 to 2013.

Land use/cover categories		1990				
		Vegetation (Km^2)	Agriculture (Km^2)	Built-up Land (Km^2)	Barren Land (Km^2)	Total (Km^2)
2013	**Vegetation**	128.79	49.95	0	26.73	**205.47**
	Agriculture	79.2	118.17	0	32.49	**229.86**
	Built-up Land	146.07	145.89	84.42	61.29	**437.67**
	Barren Land	11.43	8.1	0	16.56	**36.09**
	Total	**365.49**	**322.11**	**84.42**	**137.07**	**909.09**

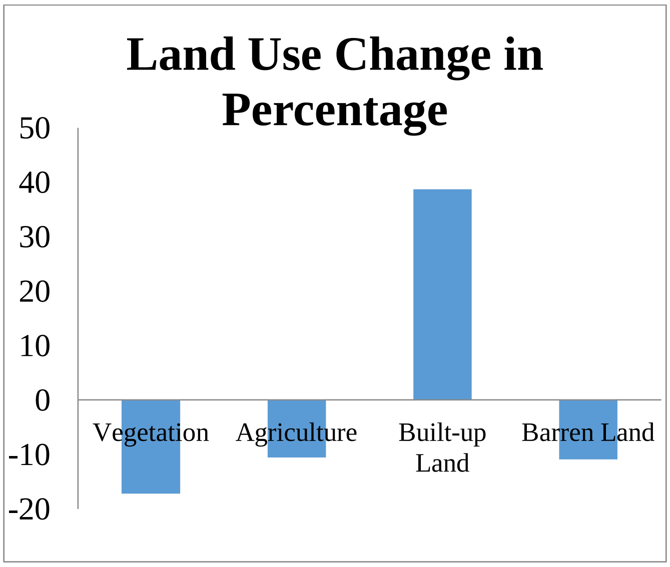

Fig: 6 Land use/cover change in percent during the last two decades (1990-2013) in Pithoragarh town area.

VII. CONCLUSION

This study conducted in one of the developing town area of Pithoragarh district in Uttarakhand state advocates that multi temporal satellite imagery is very much important in quantifying spatial and temporal phenomena which is otherwise not possible to attempt through conventional mapping. The study also reveals that most of the area in the study area falls under built-up area. The area under built-up has increased 47.96% (9.22 km^2) due to rapid urbanisation during 1990 to 2013. The second major category of land use in the study area is agriculture which decreased by -10.94%. Proportion of agricultural land in the study area was 35.74 (3.27km^2) in year 1990 while in 2013 it became only 25.16% (2.31 km^2) due to conversion from agricultural to vegetation, barren land and built-up land. The third major category of land in the study area is Barren Land which has also shown the trends of delineation. During the study period (i.e., 1990-2013), Barren Land was 14.99% (1.37 km^2) in year 1990 while in 2013 it was 4.042% (0.37 km^2) by decreasing approximately 10.94% because of converting into agricultural land, vegetation and built-up land. Thus, the present study illustrates that Remote Sensing and GIS are very important technologies for temporal analysis and quantification of spatial phenomena which is otherwise not possible to attempt through conventional mapping techniques. Change detection is possible by using these technologies in less time, at low cost and with better accuracy.

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