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Research Article

GEOSPATIAL APPROACH FOR ANALYSING LAND USE LAND COVER CHANGE IN TOURIST TOWN OF LEH (LADAKH)

Sajad Nabi Dar., Shamim Ahmad Shah., Safiya Skinder and Muzafar Ahmad wani

Department of Geography and Regional Development University of Kashmir

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ABSTRACT

Tourism is one of the major driving forces behind land use and landscape changes in the mountainous areas. Land use land cover change is an important component in understanding the interaction of human activity with the environment and thus it is necessary to be able to simulate changes. Empirical observation revealed a change in land use land cover classification in the tourist town of Leh of Ladakh region in Jammu and Kashmir State. In this paper, an attempt is made to study the change in land use land cover in Leh town over the period of last ten years (2001-2011) due to increase in the tourist activities. The study has been done through remote approach using Survey of India Toposheet of Leh Town (1977), and Land set imageries of June 2001 and July 2011. GIS software used to prepare the thematic maps. These maps were taken into the field of study for ground truth. Ground truth observations performed to check the accuracy of the classification. The present study has brought to light that during the last ten years (2001-2011) the barren or wasteland reduced from 283 hectares to 196 hectares. The agriculture land during the year 2001 was 184 hectare it has reduced up to 152 hectares from the last ten years. The land under plantation (willow and popular) has also been reduced from 265 hectares to 258 hectares. The overall increase has been in the land under built up class as it has increased from 168 hectares to 294 hectares at the same time the growth rate of only accommodation observed as 74% during the 2001 -2011. The increase in accommodation sector is the biggest cause of land use land cover.

INTRODUCTION

Mountainous landscape is as fragile, if not more so than other terrains. Recent trends of uncovering more natural sites, stressing tourism and human exploitation of natural resources in mountain sides are increasing tremendously (Stone, 1992). Land use/cover change analysis is an important tool to assess global change at various spatial-temporal scales (Lambin 1997). In addition, it also reflects the dimension of human activities on a given environment (Lopez *et al*. 2001). As global population increases rapidly, pressure exerts on the land resulting flimsy cohesion among environmental variables (Green *et al*. 1994). The rapid changes of land use/ cover than ever before, particularly in developing nations, are often characterized by rampant urban sprawling (Jat *et al*. 2008; Mundia and Aniya 2006). Land degradation by agricultural development and tourism industry (Shalaby and Tateishi 2007), or the transformation of agricultural land to shrimp farming (Ali 2006) ensuring enormous cost to the environment (Abduallah and Nakagoshi 2005). This kind of changes profoundly affects local and/or regional environment, which would eventually affect the global environmental conditions. Human-induced changes in land cover, for instance, influence the global carbon cycle and contribute to the increase in atmospheric CO2 (Alves and Skole 1996). It is therefore indispensable to examine the changes in land use/cover so that its effect on the terrestrial ecosystem can be discerned, and sustainable land use planning can be formulated (Muttitanon and Tripathi 2005). Scientific research community called for a substantive study of land use changes during the 1972 Stockholm conference on human environment and again 20 years later, at the 1992 United Nations conference on environment and development. At the same time, international geosphere and biosphere program and international human dimension program co-organized a working group to set up research agenda and promote research activity for land use land cover changes. Land use/land cover mapping is an essential component wherein other parameters integrated on the requirement bases to derive various developmental indexes for land use and water resource.

Land use refers to man's activity and the varied use which are carried on over land and land cover refers to natural vegetation,

Corresponding author:* **Sajad Nabi Dar
Department of Geography and Regional Development University of Kashmir

water bodies, rock /soil, artificial cover and others noticed on the land (NRSA, 1989). Land cover, defined as the assemblage biotic and abiotic component on the earth's surface is one of the most crucial properties of the earth's system. 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, grasslands, forest and bare soil. Land use includes agricultural land, built-up land, recreational areas, wildlife management areas etc. The land cover reflects the biophysical state of the earth's surface and immediate subsurface, thus embracing the soil material, vegetation, and water. Land use refers to man's activities on land, which were directly related to the land. Land use and land cover are dynamic. Changes may involve the nature or intensity of change but also includes spatial and time aspect. Land use /land cover changes also involve the modification, either direct or indirect, of natural habitats and their impact on the ecology of the area. Land degradation results mainly due to population pressure, which leads to intense land use without proper management practices. Overpopulation makes people move towards sensitive areas like Highlands. In such areas, land use without considering the slope and erodibility leads to severe erosion and related problems. The influence of road construction and other comparable disturbances of the landscape on erosion and on landslides and mass movement on hilly areas are well known. Application of remotely sensed data (imageries) made possible to study the changes in land cover in less time at low cost and with better accuracy (Kachhwaha 1985) in association with Geographical information system that provides suitable platform for data analysis updating and retrieval (Star *et al*.1997; McCracker *et al*. 1998; Chilar 2000).

Study Area

Leh town is situated between 34°08′50″ to 34°12′30″ North latitude and 77°33′00″ to 77°36′30″ (Figure 1) East longitude and altitude ranging from 3100 meters to 3600 meters above sea level. The Leh town situates in Indus valley and is on right side of the river Indus. This region situates between Ladakh range in the north and Zanskar range on the south. The town having a population of 30870 (Census 2011), covers an area of 9 Square Kilometres (Municipal Commute Leh 2011) The town divided into 13 wards managed by the municipal committee, Leh.

The climate of Leh (Ladakh) is not only arid due to lack of precipitation but it is very cold in winter. The summers are very hot. In Leh the average monthly minimum temperature for the year, 2012 was minus 15.39°C recorded in January while as the average maximum monthly temperature was 25.08°C recorded in the month of August (meteorological department 2012). According to the census 2011, the total number of the households in the Leh town was 4377, having the total population of 30870 in which 21669 are males and 9201 are females. According to the census report 2001, the total population of the Leh town was 28639 persons in which the male population was 17772 while as the females was 10867. In the census report 2011, it has mentioned that the Leh town is having 26341 literate populations in which 19751 are males and 6590 are females. The total working population of the Leh town calculates as 19538 of which 16686 are a male while, as 2852 are females. Ward Tukcha is having the highest population of 7500 of which 6238 are males and 1262 are females. The least populated ward was Gompa Gangles in which total population is 1346 with 808 males and 538 females.

Growth of Tourist Flow

The history of tourism in Ladakh was not more than the five decades older. This region was restricted for the tourists until 1974. As this region was opened for the foreign tourists the number of the tourists increased at snail speed initially and with rapid pace from the last five-six years. In the year 1974, only 527 tourists visited this place and the number increased over the period and reached up to 179491 tourists in 2011 with 55685 domestic tourists and 22115 international tourists. The below (Table 1) shows tourist flow from 2001 to 2011, It has witnessed up and the downs during the period. There is negative growth rate in tourist flow in 2002 because of 11 September 2001 parliament attack in India. As figure 2 shows from 2002 onwards, the rate of increase in tourist inflows rises significantly, in the case of both foreign as well as domestic tourists. From 2006 onwards, the number of the domestic tourist shows the tremendous increase. The sudden increase in Indian tourists could be due to a number of factors. There could be an increase in services consumption by the rising Indian middle class, increase the number of flights to Leh, the introduction of tour packages by online travel companies such

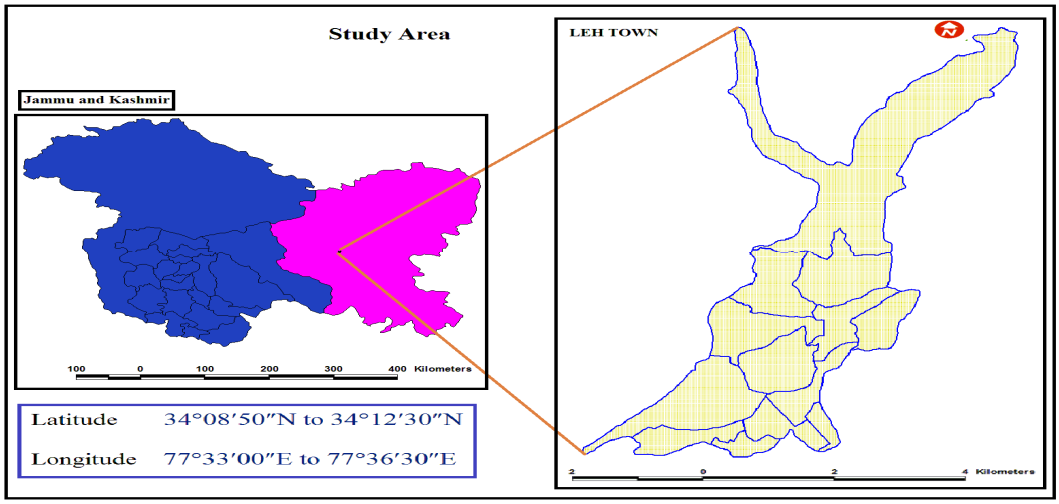

Figure 1 Study Area

as *Makemytrip.com* or perhaps most visibly due to the increasing number of Indian films being shot in the different touristic locations in Ladakh. The more than two-fold increase in tourist flows from a total flow of 77, 800 tourists in 2010 to 179,491 tourists in 2011 were attribute by many to the extremely successful 2009 Bollywood film *3 Idiots*, parts of which shot in Ladakh this was confirmed during the field survey. In addition, the flash floods of August 2010 in Ladakh led to a slight fall in tourist inflows in that year but could also have played an important part in garnering an increased number of tourists the following year in support of the local economy. The second downward trend in the foreign tourist arrivals during 2008-10, was because of global financial crisis in 2008. However, Indian tourist arrivals continued to increase during this period as the Indian economy was still able to grow since it is not as dependent on global flows of trade and capital as most other countries

Table 1 Growth Rate of Tourist flow from 2001 to 2011

Years	Foreign Tourists	Growth Rate of Foreign Tourists	Domestic Tourists	Growth Rate of Domestic Tourists	Total	Growth Rate of Tourists
2001	15439		4260		19699	
2002	5120	(-)66.83	2959	(-)30.53	8079	(-)58.98
2003	15371	200.21	13031	340.38	28402	251.55
2004	13483	(-) 12.28	21608	65.81	35091	23.55
2005	24665	82.93	13781	(-)36.22	38446	9.56
2006	26078	5.72	17822	29.32	43900	14.18
2007	28178	8.05	22007	23.48	50185	14.31
2008	35311	25.31	39023	77.32	74334	48.11
2009	30570	(-)13.42	48517	24.32	79087	6.39
2010	22115	(-)27.65	55685	14.77	77800	(-)1.62
2011	36662	56.77	142829	156.49	179491	130.70

Source: -Department of Tourism Leh.

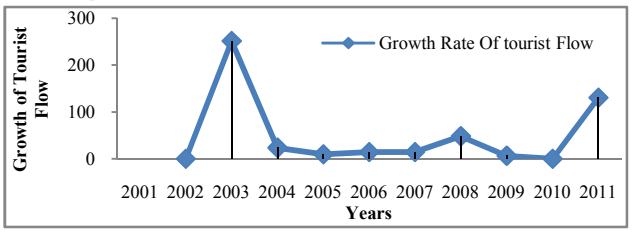

Figure 2 Growth Rate of Tourist flow from 2001 to 2011

Source: -Department of Tourism Leh.

Growth of Accommodation Sector

The accommodation sector is an important component of the tourism industry. We cannot think about the tourism without the accommodation sector. The accommodation sector is a combination of the different units having different names in different regions according to the facilities available there. The hotels, motels, rotels, flotels, the Guesthouses, the Bungalows etc it is the case with the Ladakh, the growth of the accommodation started from that day when this area opened for the tourists. The accommodation shows considerable increase mostly in the form of hotels and guesthouses. The growth of the accommodation sector related to the growth of tourist, as the tourist increase the number of accommodation units also increases. The growth of accommodation during the time of 2001 to 2011 is shown in the below table 2. In the year 2001, the 31 accommodation units have increased in the already existing accommodation sector and it reached up to 261 units in 2011 to accommodate the increasing number of the tourists. The up and downs in the growth of accommodation were analyzed in figure 3. The increase in the tourist accommodation, on one hand, solves the problem of the accommodating the increasing tourists, but at the same time, they create the great pressure on the existing natural resources of the area. The Ladakh is a cold desert and having the lack of the fertile soil and the availability of the water. These important resources has lost their place in this environment because of the changing nature of the land use, at first the land was used for the agriculture purposes and the land was covered with agriculture products like the wheat, barley, fodder and the water was also used for the raising of these crops and for domestic purposes. Now the land use has changed and which effects on the land cover also, the same land use now used for the construction purposes, like hotels, guesthouses, restaurants, and the water is now used in these accommodation units for the washing purposes, the increase in the accommodation units means decrease in the land and the water resources.

Table 2 Growth Rate of Accommodation Units from 2001 to 2011

Year	Number of Accommodation Units	Cumulative Frequency	Growth Rate
2001	31	31	
2002	15	46	48.38
2003	15	61	32.60
2004	16	77	26.22
2005	16	93	20.77
2006	18	111	19.35
2007	24	135	21.62
2008	22	157	16.29
2009	22	179	14.01
2010	49	228	27.37
2011	33	261	14.47

Source: - Department of Tourism Leh

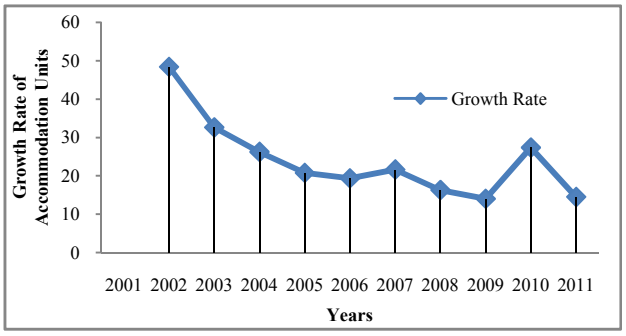

Figure 3 Growth Rate of Accommodation Units from 2001 to 2011

Source: - Department of Tourism Leh

Distribution of the Hotel Accommodation

The distribution of the hotels is depending on the topography of the land and the market. The present distribution of the hotels in Leh town seems to be concentrated in the centre of the town because of the nearness to the market. As we come out from the city centre the number of the hotel's decrease. The distribution of the hotels is uneven which can be analyzed from the figure 4. The centre of the town is highly dense in terms of the hotel accommodation. Among the 13 wards in the town only a few wards are having good concentration of hotels accommodation, these wards are Tukcha, Karzu, Gompa, Sheynam, Chanspa and Skara

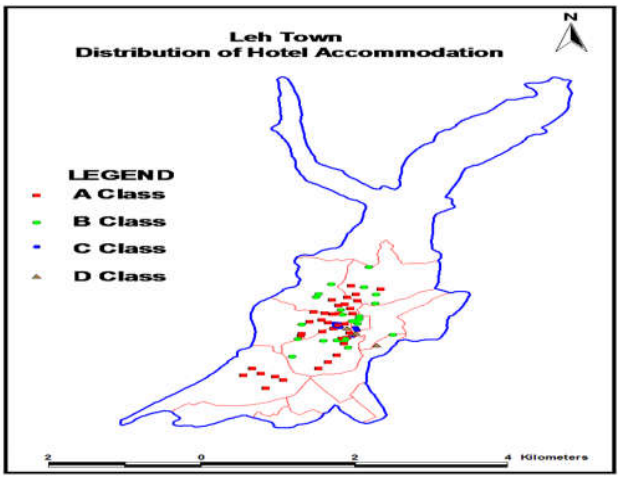

Figure 4 Distribution of Hotel Accommodation

Source: - Field Survey (2012)

Distribution of Guest Houses

The distribution of guesthouses is also unevenly distributed. However, the maximum concentration of the guesthouses is towards the centre of the Leh town. The hotels and the shopping malls are already concentrated in the centre of the town. As we move away from the centre of the town, the concentration of the guesthouses also decreases. The northern portion of the town is without the tourist accommodation (figure 5). However, in the southern portion, the accommodation sector is developing especially in terms of the guesthouse accommodation.

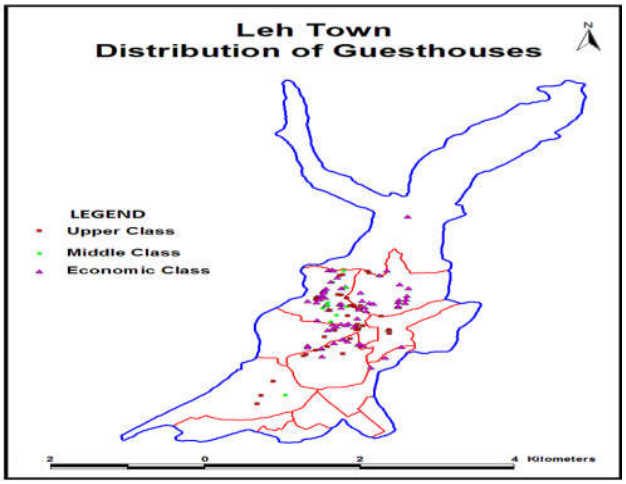

Figure 5 Distribution of the Guest Houses in Leh

Source: -Field Survey (2012)

Objectives

The main objective of the present paper is to analyze the nature and extent land use/land cover changes in the tourist town of Leh from the past 10 years (2001-2011) and to identify the main forces behind the changes.

METHODOLOGY

Multi-temporal satellite data set of LISS III (2001) and LISS (2011) were used for the land use, land cover change detection in the study area. Second, digital topographic maps digitized from the hardcopy of Survey of India topographic maps with a scale of 1:50,000 used mainly for geometric correction of the satellite images and for some ground truth information. Finally, ground information was collect between 2010 and 2011 for the purpose of supervised classification and classification accuracy assessment. The summary of the dataset used in the present study was giving below table 3.

Table 3 Methodology

Data	Month of Observation	Spatial Resolution/scale
LISS III	June 2001	23.5m
LISS III	July 2011	23.5m
SOI Topo Sheet	1977	1:50000

Geometric Correction

The accurate per-pixel registration of multi-temporal remote sensing data was essential for change detection since the potential exists for registration errors to be interpreted as land cover and land-use change, leading to an overestimation of actual change (Stow, 1999).

Change detection analysis was performed on a pixel-by-pixel basis; therefore, any mis-registration greater than one pixel will provide an anomalous result of that pixel. To overcome this problem, the root-mean-square error (RMSE) between any two dates should not exceed 0.5 pixels (Lunetta & Elvidge, 1998). In this study geometric correction were carried out using ground control points from topographic maps with a scale of 1:50000 produced in 1971 to Geo-code the image of 2011 then, this image was used to register the image of 2001. The RMSE between the two images was less that 0.4 pixel which is acceptable. The RMSE was defined as the deviations between GCP and GP location as predicted by the fitted polynomial and their actual locations.

Image enhancement and visual interpretation

The goal of image enhancement is to improve the visual interpretability of an image by increasing the apparent distinction between the features. The process of visually interpreting digitally enhanced imagery attempts to optimize the complementary abilities of the human mind and the computer. The mind is excellent at interpreting spatial attributes on an image and is capable of identifying obscure or subtle features (Lillesand & Kiefer, 1994).

Contrast stretching was applied on the two images and two false color composites (FCC) were produced. These FCC were visually interpreted using on-screen digitizing in order to delineate land cover classes. The process of visually interpreting digitally enhanced imagery attempts to optimize the complementary abilities of the human mind and the computer. The mind is excellent at interpreting spatial attributes on an image and is capable of identifying obscure or subtle features (Lillesand & Kiefer, 1994). Some classes were spectrally confused and it was not able to separate them well by supervised classification and hence visual interpretation was required to separate them.

Image classification

Land cover classes were typically mapped from digital remotely sensed data through the process of a supervised digital image classification (Campbell, 1987; Thomas, Benning, & Ching, 1987). The overall objective of the image

classification procedure automatically categorizes all pixels in an image into land cover classes or themes (Lillesand & Kiefer, 1994). The maximum likelihood classifier quantitatively evaluates both the variance and covariance of the category spectral response patterns when classifying an unknown pixel so that it was considered one of the most accurate classifiers since it was based on statistical parameters.

Supervised classification was done using ground checkpoints and digital topographic maps of the study area. The area was a classified wasteland, agriculture, built-up and plantation. Then accuracy assessment was carried out using 200 points, 150 points from field data and 50 points existing topographic maps dated 1971 and land cover map dated 2011. The location of the 200 points was chosen using the random stratified method to represent different land cover classes of the area. In order to increase the accuracy of land cover mapping of the two images, ancillary data and the result of visual interpretation was integrated with the classification result using GIS in order to improve the classification accuracy of the classified image.

Digital land use/land cover classifications of the said area were done through supervised classification method; the field knowledge was also employed during the classification. LISS III 2001 and the LISS III imagery of the year 2011 were used for classification and the change detection. After classification, both the imageries of these two times periods (2001 and 2011) were superimposed for the analyses of change in land use land cover. During the process of the classification, the ground truth was done simultaneously. The Arc GIS 9.2 and Erdas Imagine 9.2 where used for this purposes. The land use land cover classes include agriculture land, wasteland, built-up (settlement, road), plantation. This classification was performed based on the classification scheme of National Remote Sensing Centre (NRSC), Department of Space, and Govt of India with a modification.

Land cover/use change detection

Regardless of the technique used, the success of change detection from imagery will depend on both the nature of the change involved and the success of the image preprocessing and classification procedures. If the nature of change within a particular scene is either abrupt or at a scale appropriate to the imagery collected then change should be relatively easy to detect; problems occur only if the spatial change is subtly distributed and hence not obvious within any image pixel (Milne, 1988). In the case of the study area chosen, Field observation and measurements have shown that the change between the image collection dates was both marked and abrupt.

In this study, post-classification change detection technique was applied. Post classification is the most obvious method of change detection, which requires the comparison of independently produced classified images. Post-classification comparison proved to be the most effective technique because data from two dates are separately classified, thereby minimizing the problem of normalizing for atmospheric and sensor differences between two dates. The cross-tabulation analysis was carried out to analyze the spatial distribution of different land cover classes and land cover changes.

RESULTS AND DISCUSSION

Land cover change has been described as the most significant regional anthropogenic disturbance to the environment (Roberts *et al*, 1998). The land use system is highly dynamic which undergoes significant changes according to the changing socio-economic and natural environment setting. The change in any form of land use was largely related to either the external forces or the pressure within the system. Agriculture is the backbone of the Ladakh economy as it engages bulk of the workforce mostly as cultivators, agricultural laborers and livestock rearers (Bisht, *et. al*, 2008), yet the land devoted to agriculture in the Leh town during 2001 was 184 hectares has decreased to 152 hectares in 2011. Though plantation in Ladakh is very rare due to arid climatic condition traditionally people of the areas are serious about the conservations of vegetal and plantation owing its importance to the area But in the Leh town, the land under plantation (willow and popular) has also been reduced from 265 hectare to 258 hectare. Similarly, wasteland has reduced from 283 hectares in 2001 to 196 hectare in 2011. On the other hand, under built-up area has increased from 168 hectares to 294 at the cost of a decrease in agriculture, plantation, and wasteland.

The most dominant driving force for this aggravated transformation and shifts in the land use of the town is its ever-increasing tourism industry, which has grown up exponentially over the period. The number of the tourists visited the place during the year 2001 was 19699 it has increased and reached up to 179491 in the year 2011. Lambin *et al*. (2000) underlined that past land use changes can act as descriptive models for future development. Traditionally Leh town has been serving as a fertile land for growing various crops like barley, wheat, fodder, pulses, cereals, mustard and vegetables of all kinds. People of Leh Town used to be self-sufficient at times but now they mostly depend on imports, because large patches of agricultural have just reduced to small kitchen garden because of the construction of the accommodation units. As the area devoted to tourism development the number of accommodation rises. During the period of 2001-2011, the 261 accommodations units were constructed, these are only accommodations there is other tourism related constructions like shopping complexes, culture centers, restaurants, fitness centers etc that result in the decrease in agricultural land gradually (Atik, *et.al.* 2010). The process of rapid land transformation has not only brought food security crises in the region but also environmental destruction by soil erosion, deforestation, and reduction in ground water recharge. In fact, large-scale mass tourism is one of the main forces, particularly in Himalayan Mountain, which aggravates the pressure on the environment, during the last 10 years, (2001-2011) 261-accommodation units were added in the existing tourist infrastructure and it reached up to 456 in 2011 in the area of 9 square kilometer area of town. In order to cater demands of huge tourist arrival, a large number of accommodation units, restaurants, shopping complex etc. has constructed haphazardly over the space, without proper planning

To draw a comparative picture and quantify the magnitude of change in various land use land cover categories of the Leh town a change detection analysis of time series land use land cover maps were carried out Land use land cover change information can be obtained by either image-to-image

comparison or map-to-map comparison (Green *et al*., 1994). The image-to-image comparison involves subtracting two images. It does not give detailed information of the how a change in particular land use land cover category is taking place. In map-to-map comparison, first images are classified and maps were generated to compare. These types of classifications generally work well for spectrally homogeneous areas. The land use, land cover change detection analysis was done in terms of the calculation of the area in hectares of all the land use, land cover categories for the area. The comparison of the land use, land cover statistics assisted in identifying the percentage change between different times. Figure 6 depicts the land use, land cover of the Leh town during the year the year 2001. Out of 900 hectares, the land under waste, agriculture, plantation, and under built-up classes was 283,184,265 and 168 hectares respectively. While as the figure 7 depicts the land user/ land cover of the year 2011 in which the land use land cover changes from one class to another. Out of 900 hectares, the land under waste, agriculture, plantation, and under built-up classes was 196,152,258 and 294 hectares respectively. While as the figure 9 shows the net change in different classes which was carried out by subtracting the image of 2011 from 2001 after classification with the help of GIS.

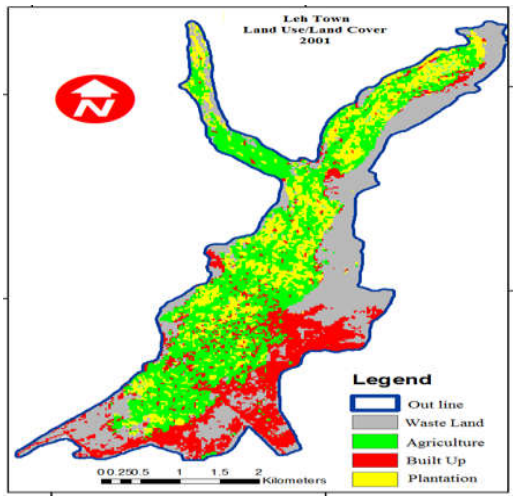

Fig 6 Land Use Land Cover Map of 2001

Source: - LISS III (2001)

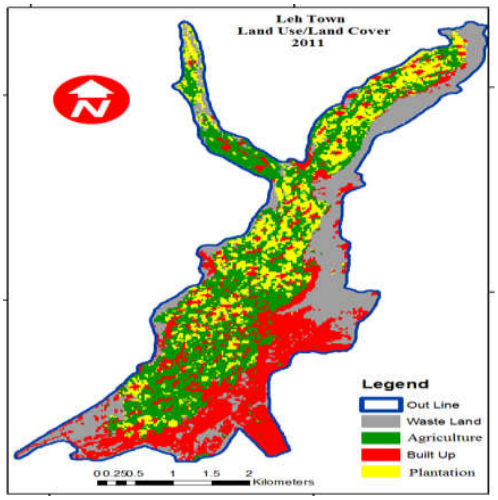

Fig 7 Land Use Land Cover Map of 2011

Source: - LISS III (2011)

The degree of success depends upon the reliability of the maps made by image classification. The comparison of the land use, land cover statistics assisted in identifying the percentage change, trend and rate of change between 2001 and 2011. In achieving this goal, the first task was to develop the figures showing the area in hectares determining the percentage change for each year (2001 and 2011) measured against each land use, land type for the area as mention below Table 4. The figure 8 shows what was the actual position of the land use land cover during the period of 2001-2011

Table 4 Land Use Land Covers Change Detection in Hectares

Land Use/Land Cover Class	Land Area (Hectares)		Percentage Change
	2001	2011	2001-2011
Waste Land	283	196	-31
Agriculture	184	152	-17
Plantation	265	258	-3
Built-Up	168	294	75

Source: Generated from LISS III images of 2001 and 2011

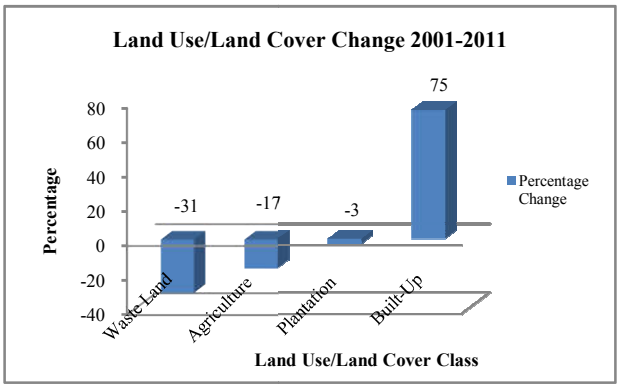

Fig 8 Land Use Land Covers Change Detection in Hectares

Source: Generated from LISS III image 2001 and 2011

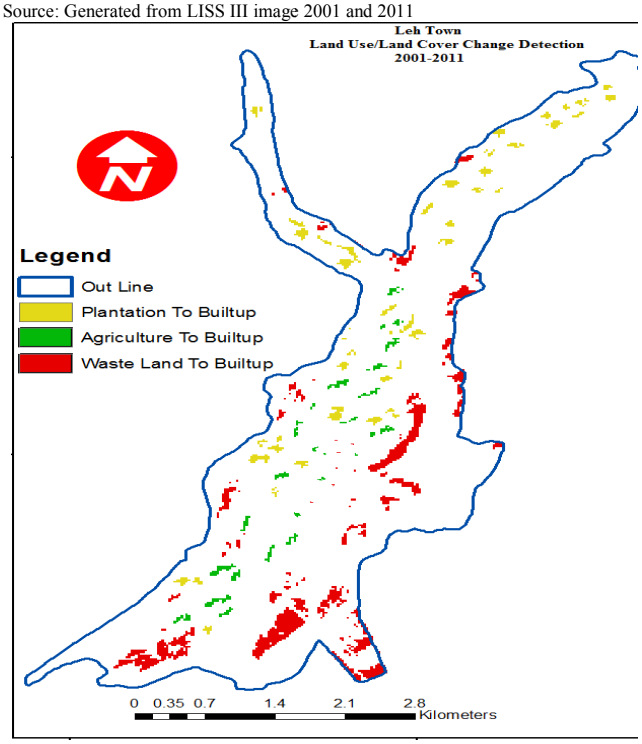

Fig 9 Land Use Land Cover Change Detection Map of 2001-2011

Source: Generated from ISRO LISS III image 2001 and 2011

CONCLUSION

The presence of a huge number of Visitors usually concentrated in small urban areas that too during the short span of peak season contribute significantly to natural resource depletion and environmental deterioration. In addition the phenomenal growth of Tourism, activities often involve haphazard urban development and intense resources exploitation. The tranquil Himalayan environment has been a source of attraction since the time immemorial, they are also reserves of rich biodiversity and scenic beauty and magnets for recreation, adventure, and expeditions for visitors from all over the world. Consequently, because of mass tourism, destinations like Leh are turning into the commercial centers and a load of human-induced pollution being deposited into ecologically sensitive and topographically fragile areas. The tourism industry of the town is rapidly expanding because of increasing international and domestic tourist traffic. The fragile natural environmental characteristics are being a ected under the threat by poor environmental planning, particularly land use management. Usually, tourist during peak season outnumbers the local residents of the town, which poses a severe challenge, for planners, administrators and local population as well. The valuable agricultural and plantation land in midst of desert is getting converted into buildup landscape at a very alarming rate. The sustainable tourism management in Leh with new innovative methods of planning for overall developmental process is the need of the hour.

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