International Journal Of

Recent Scientific Research

ISSN: 0976-3031

Volume: 7(1) January -2016

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THE OFFICIAL PUBLICATION OF
INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH (IJRSR)
http://www.recentscientific.com/ recentscientific@gmail.com

ISSN: 0976-3031

Available Online at http://www.recentscientific.com

International Journal of Recent Scientific Research
Vol. 7, Issue, 1, pp.8467-8475, January, 2016

International Journal of Recent Scientific Research

RESEARCH ARTICLE

A HYPSOMETRIC ANALYSIS OF LAND USE/LAND COVER CHANGE IN ANANTNAG DISTRICT OF KASHMIR HIMALAYAS

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ARTICLE INFO

Article History:

Received 14th, December, 2015
Received in revised form
23th, December, 2015
Accepted 13th, January, 2016
Published online 28th,
January, 2016

Key words:

Land use, Land cover,
Horticulture,

ABSTRACT

Land Use Land Cover (LULC) change analysis assists decision makers to ensure sustainable development and to understand the dynamics of our changing environment. During the past one decade the study area has undergone many LULC changes due to rapid urban growth, poorly planned infrastructural development and attitude towards horticulture due to economic reasons. This study was proposed to detect LULC changes and to investigate the major factors that have caused these changes. For LULC change detection and analysis temporal Landsat satellite data captured by Thematic Mapper (TM) were employed. Maximum Likelihood (MLH) supervised classification algorithm was applied to classify the study area, whereas, Post Classification Comparison (PCC) approach was adopted to analyze the LULC changes. Results revealed that over a period of 10 years, a decrease has taken place in agriculture and forest at a change rate of -3.7 % and -2.26 % respectively. On the other hand, horticulture, built up have increased at a rate of 2.17 % and 1.13 % respectively.

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INTRODUCTION

Land Use (LU) and Land Cover (LC) are two fundamentals describing the terrestrial environment in connection with both natural processes and anthropogenic activities (Jansen and di Gregorio, 2002; Bender *et al*., 2005; Mendoza *et al*., 2010, 2011). Land use refers to mans activity and the varied use which are 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). 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, wild life management areas etc. The integrated term Land Use Land Cover (LULC) includes both categories of LU and LC and analysis of changes is of prime importance to understand many social, economical and environmental problems (Pelorosso *et al*., 2008). Land use land cover change analysis is an important tool to assess global change at various spatial–temporal scales (Lambin 1997). In recent years, LULC change analysis has emerged as an important research question, because LULC change has been identified as a key factor which stands responsible for environmental modification worldwide (Xiao *et al*., 2006). 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 land cover than ever before, particularly in developing nations, are often characterized by rampant urban sprawling (Jat *et al*. 2008; Mundia and Aniya 2006).

Though it is possible to monitor LULC changes by involving traditional surveys and inventories but Satellite Remote Sensing (SRS) apart from being advantageous in terms of cost and time saving for regional scale also provides large scale data on LULC changes with information about their geographic distribution (Yuan *et al*., 2005).

Geographic Information Systems (GIS) and Remote Sensing (RS) have proved to be useful tools for assessing the spatiotemporal dynamics of LULC (Hathout, 2002; Herold *et al*., 2003; Lambin *et al*., 2003; Serra *et al*., 2008). Information about change is necessary for updating LULC maps and the management of natural resources. It is very important to have continual, historical and precise information on LULC changes of the earth's surface for any kind of sustainable development program in which LULC serves as one of the major input criteria (Mei and Qing, 1999; El-Kawy *et al*., 2010). Especially such information obtained (using LULC change detection) can be useful for planning and development of the study area.

Study Area

Anantnag district is in southern sector of Jhelum Valley and is full of natural scenery. The study area is held between geographical coordinates of 74°-30' to 75°- 35' East longitude and 33°-20' to 34°-15' North latitude, at an altitude of 5,300

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feet (16,00 mts) above mean sea level, at a distance of 33 miles (53kms) from main city Srinagar.

The entire Southern sector of the study area, which is contiguous with Tehsils of Reasi, Banihal and Kishtwar of Jammu province, and Eastern sector which is contiguous with Tehsil Kargil of Ladakh division. The Northern and Western sides are bounded by Pulwama district while Kulgam district falls in its west. Of all the districts of the state, Anantnag claims the largest number of streams (Nallas) like Sandran, Brengi, Arpath and Lidder. The most important among these is Lidder which takes off from Sheshnag Lake and irrigates maximum area of the district.

The population of the study area was 1078692 (2011, Census) residing in an area of 257724.4 hectares which constitutes about 1.31percent of the total area of Jammu And Kashmir State. For in depth research analysis the study area has been delineated into five altitudinal zones that were generated from Contour DEM and are given in table 2.1 with a contour interval of 250 meters ranging from 1500 up to 5385 meters above mean sea level. Zone 'A' occupies an area of 37751.3 hacters accounting 14.6 percent of the total area of the study area while zone' E' occupies the largest area of 142892.4 hacters accounting 55.4 percent to total area.

Three meteorological stations were situated within the study area namely Pahalgam, Quazigund and Kokarnag. There was Spatio-temporal variation in temperature as well as in the rainfall quantum measured at the above mentioned meteorological stations. The mean maximum temperature (18.54^0C) and the mean minimum temperature (5.33^0C) of the study area were recorded in the month of the June and January respectively.

The monthly mean minimum rainfall measured at Pahalgam from 1971 to 2010 is 71 mm and the monthly mean maximum is 136.2 mm. Kokarnag is a high altitude meteorological station like Pahalgam, situated in the south bordering mountain chain of Pir Panjal. The monthly mean minimum rainfall recorded at this station from 1971 to 2010 is 25.8 mm while as the monthly mean maximum is 208.2 mm. Quazigund meteorological station is no exception to this variability. Monthly mean minimum and the monthly mean maximum rainfall figure recorded at this station during the above mentioned period is 73.3 mm and 234 mm respectively

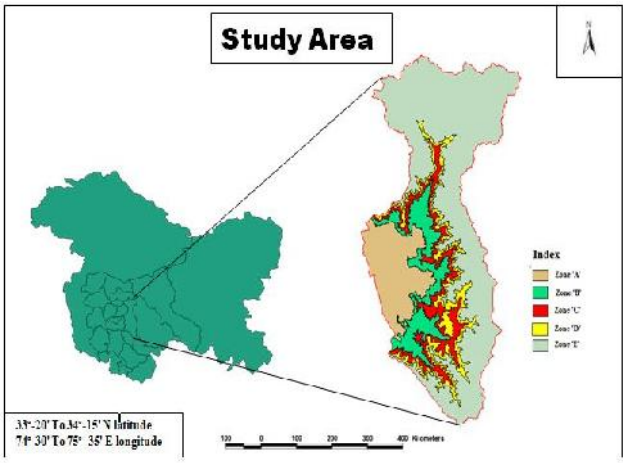


Fig 1 Study Area

Table 1 Altitudinal Zone Wise Area of Anantnag District

Altitudinal Zone (Meters)	Area in Hectares	Percentage of Total Area
'A' (1500-1750)	37751.3	14.6
'B' (1750-2000)	27944.9	10.8
'C' (2000-2250)	23811.2	9.2
'D' (2250-2500)	25324.6	9.8
'E' (Above 2500)	142892.4	55.4
Total	**257724.4**	**100.0**

Source: Computed from contour DEM

Objective

The main objective of the present study is to analyze the nature and extent of land use land cover change (Altitudinal zone wise) within the study area during the period (2001-2010) and to identify the main driving forces behind the changes**.**

METHODOLOGY

Multi temporal satellite data set of LISS III of August, 2001 and LISS III mosaic scenes of August, 2010 were use for the land use land cover change detection in the study area. Secondly, digital topographic maps digitized from hardcopy of survey of India topographic maps with scale of 1:50,000 were use mainly for geometric correction of the satellite images, for ground truth information and also for the delineation of study area. Finally, ground information was collect between 2009 and 2010 for the purpose of digital supervised classification and classification accuracy assessment. The summery of the dataset used in the present study were giving below table 2.

Table 2 Methodology

Data	Month of Observation	Spatial Resolution/scale
LISS III	August. 2001	23.5m
LISS III	August. 2010	23.5m
SOI Topo Sheet	1971	1:50000

RESULTS AND DISCUSSIONS

Land use/ Land cover Categories

In the present study area of Kashmir Himalaya as many as nine major land use/land cover classes are recognized. A brief description of each land use/land cover category class is given below:

Agriculture:-These are the croplands at the time when the imagery was taken. (LISS III, satellite data, 2001 and LISS III satellite data, 2010)

Horticulture/ plantation:- which includes orchards, fruits, herbs and shrubs etc. is included in the category of agricultural land use. Apple orchards are particularly important in study area. Plantation includes the area under Willow and Popular trees.

Dense forest:-This category includes all the forest area where the canopy cover is more than 40 percent.

Sparse forest:-This category includes the forest area where the canopy cover is 10- 40 percent.

Scrub land:-This is a land, which is generally prone to deterioration due to erosion. Such land generally occupies topographically high locations. Alpine pastures have also been included in this category

Wasteland:-These are rock exposures of varying lithology often barren and devoid of soil and vegetative cover. They are located in steep isolated hilly and around glacial lands. Highly degraded scrub is included in this category of land cover.

Built-up:-It is an area of human habitation developed due to non agricultural use and that has a cover of buildings, transport and communication lines, utilities in association with water, vegetation and vacant lands.

Water bodies:-This category comprises areas with surface water, either impounded in the form of ponds, lakes and reservoirs or flowing as streams and rivers.

Snow/Glacial cover:-These are the areas under perpetual snow cover.

Altitudinal Zone wise Land use/ Land cover of Anantnag district (2001)

The land use/land cover statistics of 2001 in the study area is given in the table 4.1. Dense forests were the dominant land use category followed by the Scrub. Dense forest consist of 63892.3 hectares comprising 24.79 percent of the study area. Scrub was the second dominant land use category with an area of 46444.8 hectare comprising 18.02 percent of the study area (fig 2).

Wastelands were the other major land cover class comprising of 16.83 percent with a total area of 43375.2 hectares, however Agriculture consists 12.54 percent with an area of 32325.3 hectares of the study area. Horticulture plantation is mainly confined in lower zones of the study area. It occupied 27931.3 hectares and constituted 10.84 percent.

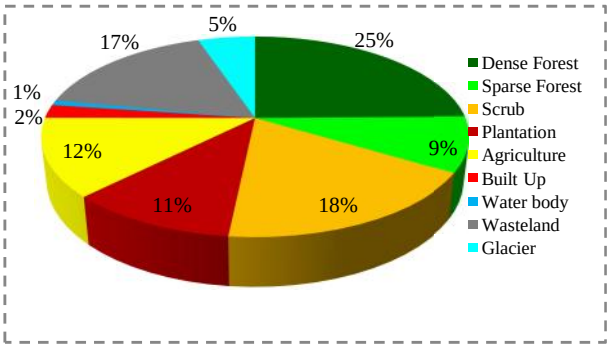


Fig 2 Land use/ Land cover statistics of Anantnag district (2001)

Sparse occupied 22785.8 hectares which constitute 8.84 percent of the study area. Glaciers are mainly found at reaches of Greater Himalayas but most of them are present in the lidder valley. Glaciers were extended over an area of 13332.0 hectares followed by built up with total area of 5567.8 hectares. Glaciers and built up constituted 5.17 percent and 2.16 percent of the study area respectively.

The area under different land use/land cover classes shows inter zonal variation in the study area (table 3). Dense forests were mostly confined in zone 'C', zone 'D' and zone 'E' with 26.77 percent,47.59 percent and 31.40 percent of the total area of zone respectively while as in zone 'A' dense forests were not present. Glaciers were only present in zone 'E' with 13332.0 hectares of the total zone area. Agriculture, Horticulture and built up were mostly found in plain areas while as forests, wasteland land were confined in higher zones (fig 3).

In zone '**A**' Horticulture were the dominant land use category fallowed by Agriculture and built up with 46 percent, 41percent and 10percent of the total area respectively while as Glaciers and Dense forests were absent. In zone '**B**' Agriculture, Horticulture and wasteland were the dominant land use classes with 46 percent, 33.04 percent and 5.9 percent. In this zone built up constitutes only 3.8 percent of the total area.

Table 3 Altitudinal Zone wise Land use/ Land cover of Anantnag district (2001)

Land Use/ Land Cover Category	zone A		zone B		zone C		zone D		zone E		Total	
	Total Area (Hac)	Percentage of Total Area	Total Area (Hac)	Percentage of Total Area	Total Area (Hac)	Percentage of Total Area	Total Area (Hac)	Percentage of Total Area	Total Area (Hac)	Percentage of Total Area	Total Area (Hac	Percentage of Total Area
Dense Forest	0	0	600.36	2.148	6373.43	26.77	12052.33	47.59	44866.21	31.40	63892.3	24.79
Sparse Forest	18.0	0.05	848.57	3.037	2414.51	10.14	2772.36	10.95	16732.33	11.71	22785.8	8.84
Scrub	20.7	0.05	1500	5.368	7641.44	32.09	8902.08	35.15	28380.53	19.86	46444.8	18.02
Horticulture/ Plantation	17410.3	46.12	9234.71	33.046	1150.11	4.83	117.81	0.47	18.32	0.01	27931.3	10.84
Agriculture	15618.6	41.37	12896.24	46.149	3383.46	14.21	383.53	1.51	43.47	0.03	32325.3	12.54
Built Up	4040.3	10.70	1081.69	3.871	330.6	1.39	115.18	0.45	0	0.00	5567.8	2.16
Water body	371.9	0.99	114.48	0.410	213.66	0.90	204.21	0.81	1166.01	0.82	2070.3	0.80
Wasteland	271.7	0.72	1668.83	5.972	2304	9.68	777.06	3.07	38353.59	26.84	43375.2	16.83
Glacier	0	0	0	0	0	0	0	0.00	13331.97	9.33	13332.0	5.17
Total	37751.3	100	27944.88	100	23811.21	100	25324.56	100.00	142892.4	100.00	257724.4	100.00

Source: computed from LISS III, satellite data, 2001

In zone '**C**' Scrub land use class consists maximum area i.e. 32.09 percent. Dense forest, Agriculture and Sparse forest consists of 26.77percent,14.21percent and 10.14percent respectively while in zone '**D**' dense forest is the leading land use category consisting 47.59 percent of the total area. Other categories include Scrub, Sparse forest and Waste land consisting of 35.15 percent,10.95 percent and 3.07 percent of the total area. In zone '**D**' Dense forest is the dominant land use category fallowed by Wasteland and Scrub up with 31 percent, 26.84percent and 19.86percent of the total area respectively. Sparse forests consists of 11.7 percent while as Glaciers constitutes 9.33percent of the total area (fig 3)

Altitudinal Zone wise Land use/ Land cover of Anantnag district (2010)

The land use/land cover map of 2010 has been generated from the satellite data and is presented in the table 4. The table reveals that Dense forest was the dominant land use with a total area of 58074.4hectares which constitutes 22.53percent of the study area followed by scrub that occupies 27301.0 hectares which is 18.44 percent of the total area (fig 4).

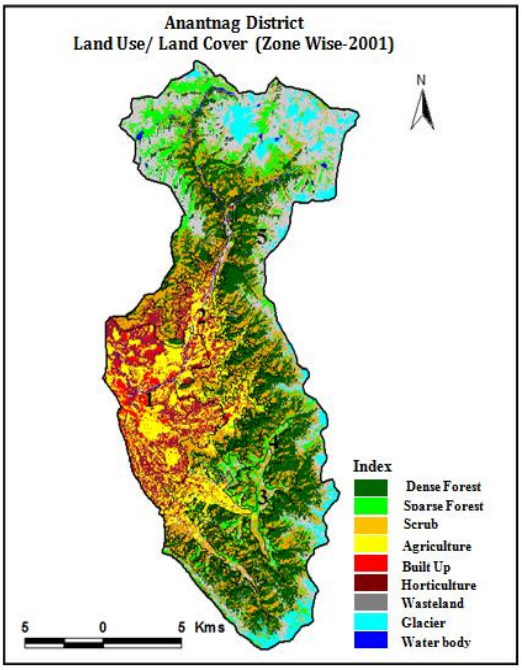


Fig 3 Land use/Land cover image (2001)

Source: LISS III, August, 2001

area. Area under agriculture in the study area has been decreased consisting of 22794.4 hectares.

Water body have least coverage of area in the study area. Total area under this category is 1922.3 hectares which is only 0.75 percent of the study area. Glacier which were mainly confined in higher reaches covers 10639.9 hectares followed by built up with an area of 8485.04 hectares constituting 4.13 and 3.29 percent of the study area respectively.

The area under different land use/land cover classes shows inter zonal variation in the study area (table 4).In zone 'A' Horticulture was the dominant land use category fallowed by Agriculture and built up with 51 percent, 31.5percent and 14.9 percent of the total area respectively.

Glaciers and Dense forests were not present in this zone of study area while as in zone 'B' Horticulture, Agriculture and built up were the dominant land use classes with 46.83 percent, 25.39 percent and 8.25 percent respectively however in zone 'C' Scrub class constitutes maximum area i.e. 32.09 percent.

Table 4 Altitudinal Zone wise Land use/ Land cover of Anantnag District (2010)

Land Use/ Land Cover Category	zone A		zone B		zone C		zone D		zone E		Total	
	Total Area (Hac)	Percentage of Total Area	Total Area (Hac)	Percentage of Total Area	Total Area (Hac)	Percentage of Total Area	Total Area (Hac)	Percentage of Total Area	Total Area (Hac)	Percentage of Total Area	Total Area (Hac)	Percentage of Total Area
Dense Forest	0.00	0.00	433.42	0.84	3948.59	16.6	10670.06	42.1	43022.42	30.11	58074.4	22.53
Sparse Forest	39.59	0.1	906.95	3.25	4539.82	19.1	3701.07	14.6	18113.65	12.68	27301.0	10.59
Scrub	30.00	0.1	1734.65	8.00	7840.97	32.9	9191.64	36.3	28715.8	20.10	47513.0	18.44
Horticulture/ Plantation	19498.6	51.7	12086.62	46.83	1750.11	7.4	161.81	0.6	31.9	0.02	33529.0	13.01
Agriculture	11902.63	31.5	8695.24	25.39	1783.86	7.5	338.25	1.3	74.47	0.05	22794.4	8.84
Built Up	5632.52	14.9	2006.07	8.25	660.41	2.8	180.46	0.7	5.58	0.00	8485.04	3.29
Water body	307.9	0.8	111.48	0.40	195.3	0.8	204.21	0.8	1103.41	0.77	1922.3	0.75
Wasteland	340.04	0.9	1970.45	7.05	3092.15	13.0	877.06	3.5	41185.24	28.82	47464.9	18.42
Glacier	0	0	0	0.00	0	0.0	0	0.0	10639.91	7.45	10639.9	4.13
Total	37751.3	100	27944.88	100	23811.21	100	25324.56	100	142892.4	100	257724.4	100

Source: Computed from IRS-1C LISS III satellite data, 2010

Wasteland is the next major land cover category spread over an area 47464.9 hectares occupying 18.42 percent of the study area.

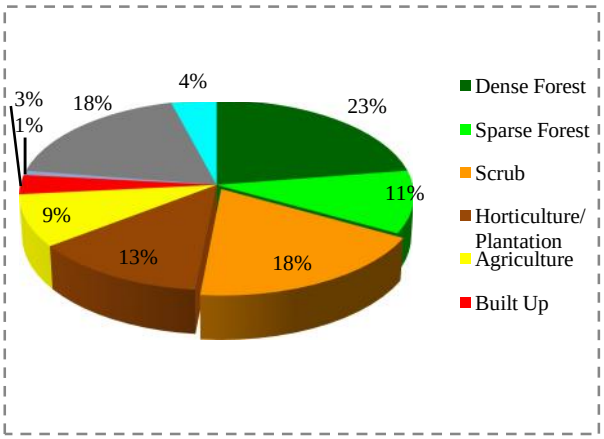


Fig 4 Land use/ Land cover statistics of Anantnag district (2010)

Horticulture plantation occupied 33529 hectares and constituted 13.01 percent area while as Sparse forest consists 27301 hectares which constitute 10.59 percent of the study

Sparse forest and Dense forest consists of 19.1percent, 16.6percent area respectively while as Agriculture and Horticulture constitutes 7.5 percent and 7.4 percent area respectively (fig 5).

However in zone 'D' dense forest is the leading land use category consisting 42.1 percent of the total area. Other categories include Scrub and Sparse forest consisting of 36.3 percent and 14.6percent of the total area respectively. In zone 'E' Dense forest were also the dominant land use category fallowed by Wasteland and Scrub up with 30.11 percent, 28.82percent and 20.10percent of the total area respectively, however built up was not present in this zone.

Altitudinal Zone wise Land use/Land cover change of Anantnag District, 2001-2010

The land use land cover change that has occurred in the study area from 2001 to 2010 is shown in the table 5. Some land use classes have depicted a positive change while others have shown a negative change

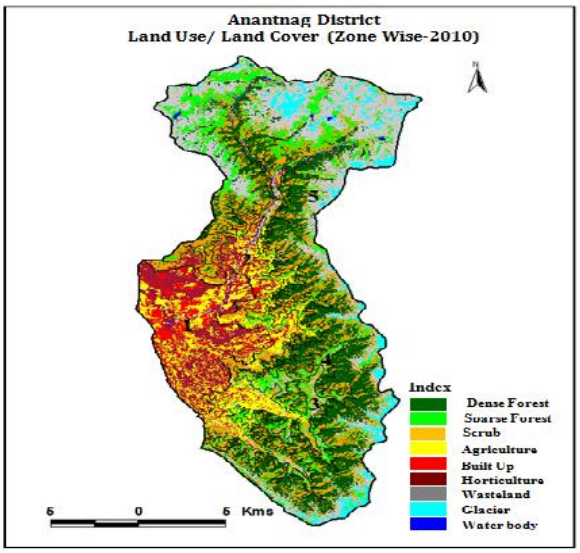
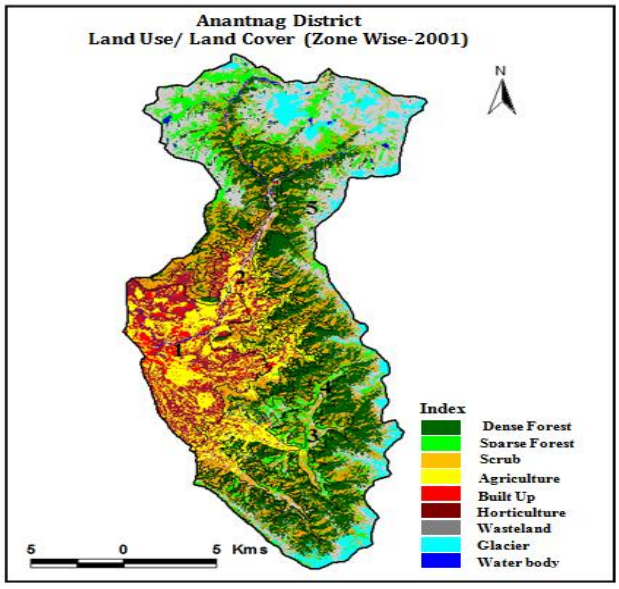
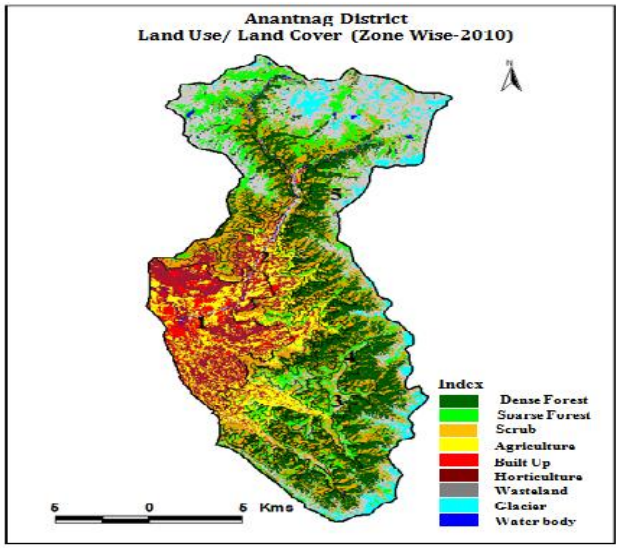


Fig 5 Land use/Land cover image (2010)

Source: LISS III August 2010



Source: LISS III, August, 2001



Source: LISS III, August, 2010

Fig 6 Change deduction of Land Use Land Cover of Anantnag District on different Altitudes (2001-2010)

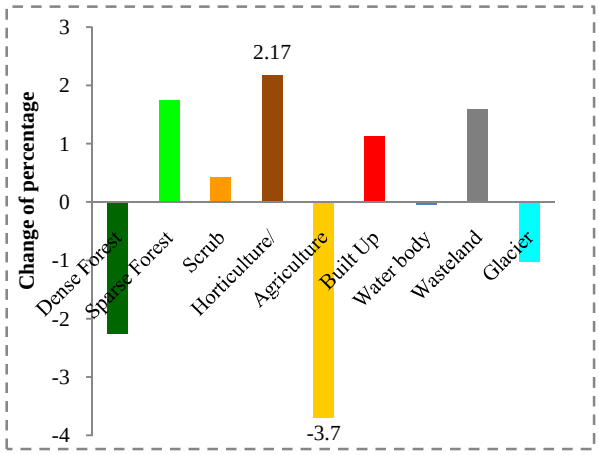


Fig 7 Altitudinal Zone wise Land use/Land cover change of Anantnag District (2001-2010)

Dense Forest

Forest cover was one of the most dominant land use class in the study area. It has been reduced from 63892.3 hectares in 2001 to 58074.4 hectares in 2010 showing a net decrease of 2.26 percent. Forest cover was decreased in all zones with maximum change in zone 'D' (5.46 percent) and zone 'C' (4.9 percent) and minimum in zone 'B' (0.60 percent). Decrease in forest cover means degradation of environment. Agricultural expansion and increasing built-up are putting tremendous pressure on the forest resources in the study area. In zone 'D' and zone 'C' wood is the most important source of energy for the rural people. Increasing demand for fuel wood and timber results in the acceleration in the process of deforestation (fig.9).

Sparse Forest

Sparse forests are mostly confined at higher zones in the study area. It has been increased from 22785.8 hectares in 2001 to 27301 hectares in 2010 registering net increase of 1.75 percent. Highest changewere observed in zone 'C' and zone 'D' with 3.89 percent and 3.67 percent respectively. Deforestation is the main cause of increasing sparse forests in these zones (fig 9).

Scrub: - scrub is one of the major land cover category in the study area and has registered a growth of 1068.2 hectares from 46444.8 hectares 2001 to 47513 hectares in 2010. The degradation of forests due to various reasons over a long period of time transforms them into scrublands (fig 8).

Horticulture

Horticulture in the study area has got maximum area under it. Anantnag district is famous for apples, pears, cherry, walnuts etc. throughout valley. It has witnessed a change of 2.17 percent. It occupied an area of 27931.3 hectares in 2001 and 33529 hectares in 2010. Horticulture is expanding towards the higher reaches of study area at the cost of forests while as in lower areas at the cost of agriculture (fig 8). Maximum change was witnessed in zone 'B' and zone 'C' with 10.20 percent and 5.7 percent respectively and minimum change was depicted in zone 'D' (0.17 percent).

Table 5 Land use/Land cover change of Anantnag District (2001-2010)

Land Use/ Land Cover Category	Zone 'A'			Zone 'B'			Zone 'C'			Zone 'D'			Zone 'E'			Total		
	Total Area (Hac) (2001)	Total Area (Hac) (2010)	Change	Total Area (Hac) (2001	Total Area (Hac) 2010	change	Total Area (Hac) (2001	Area (Hac) (2010	change	Total Area (Hac) (2001	Total Area (Hac) 2010	change	Total Area (Hac) (2001	Total Area (Hac) 2010	change	Total Area (Hac) (2001	Total Area (Hac) 2010	change
Dense Forest	0 (0)	0 (0)	0 (0)	600.36 (2.148)	433.42 (1.6)	-166.94 (-0.60)	6373.43 (26.77)	5198.59 (21.8)	-1174.84 (-4.93)	12052.33 (47.59)	10670.06 (42.13)	-1382.27 (-5.46)	44866.21 (31.4)	43022.52 (30.1)	-1843.69 (-1.3)	63892.3 (24.79)	58074.4 (22.53)	-5817.9 (-2.26)
Sparse Forest	18.0 (0.050)	39.6 (0.10)	21.6 (0.06)	848.57 (3.037)	906.95 (3.2)	58.38 (0.21)	2414.51 (10.14)	3339.82 (14.0)	925.31 (3.89)	2772.36 (10.95)	3701.07 (14.61)	928.71 (3.67)	16732.33 (11.7)	18113.75 (12.7)	1381.42 (1.0)	22785.8 (8.84)	27301.0 (10.59)	4515.2 (1.75)
Scrub	20.7 (0.050)	30.0 (0.08)	9.4 (0.02)	1500 (5.368)	1734.65 (6.2)	234.65 (0.84)	7641.44 (32.09)	7840.97 (32.9)	199.53 (0.84)	8902.08 (35.15)	9191.64 (36.30)	289.56 (1.14)	28380.53 (19.9)	28715.8 (20.1)	335.27 (0.2)	46444.8 (18.02)	47513.0 (18.44)	1068.2 (0.42)
Horticulture/ Plantation	17410.3 (46.120)	19498.6 (51.65)	2088.4 (5.53)	9234.71 (33.046)	12086.62 (43.2)	2851.91 (10.20)	1150.11 (4.83)	1350.11 (5.7)	200 (0.84)	117.81 (0.47)	161.81 (0.64)	44 (0.17)	18.32 (0.00)	31.9 (0.0)	13.58 (0.0)	27931.3 (10.84)	33529.0 (13.01)	5597.7 (2.17)
Agriculture	15618.6 (41.370)	11902.6 (31.53)	-3715.9 (-9.84)	12896.2 (46.149)	8695.24 (31.1)	-4201 -(15.03)	3383.46 (14.21)	2583.86 (10.9)	-799.6 (-3.36)	383.53 (1.51)	338.25 (1.34)	-45.28 (-0.180	43.47 (0.00)	74.47 (0.1)	31 (0.0)	32325.3 (12.54)	22794.4 (8.84)	-9530.9 (-3.7)
Built Up	4040.3 (10.70)	5632.5 (14.92)	1592.2 (4.22)	1081.69 (3.871)	2006.07 (7.2)	924.38 (3.31)	330.6 (1.39)	410.41 (1.7)	79.81 (0.34)	115.18 (0.45)	180.46 (0.71)	65.28 (0.26)	0 (0)	5.58 (0.0)	5.58 (0.0)	5567.8 (2.16)	8485.04 (3.29)	2918.1 (1.13)
Water body	371.9 (0.99)	307.9 (0.82)	-64.0 (-0.17)	114.48 (0.410)	111.48 (0.40)	-3 (-0.01)	213.66 (0.90)	195.3 (0.8)	-18.36 (-0.08)	204.21 (0.81)	204.21 (0.81)	0 (0.00)	1166.01 (0.8)	1103.4 (0.8)	-62.6 (0.0)	2070.3 (0.80)	1922.3 (0.75)	-148 (-0.05)
Wasteland	271.7 (0.72)	340.0 (0.90)	68.4 (0.18)	1668.83 (5.972)	1970.45 (7.1)	301.62 (1.08)	2304 (9.68)	2892.15 (12.1)	588.15 (2.47)	777.06 (3.07)	877.06 (3.46)	100 (0.39)	38353.59 (26.8)	41185.46 (28.8)	2831.87 (2.0)	43375.2 (16.83)	47464.9 (18.42)	4089.7 (1.59)
Glacier	0 (0)	0 (0)	0 (0)	0 (0)	0 (0.00)	0 (0.00)	0 (0.00)	0.00 (0.00)	0 (0.00)	0.00 (0.00)	0 (0.00)	0 (0.00)	13331.97 (9.3)	10639.51 (7.4)	-2692.46 (-1.9)	13332.0 (5.17)	10639.9 (4.13)	-2692.1 (-1.04)
Total	37751.3 (100)	37751.3 (100)	4559.89 (20.02)	27944.8 (100)	27944.88 (100)	8741.8 (31.28)	23811.21 (100)	23811.21 (100)	3985.6 (16.74)	25324.56 (100)	25324.56 (100)	2855.1 (11.3)	142892.4 (100)	142892.4 (100)	9197.4 (6.3)	257724.4 (100)	257724.4 (100)	0

Source: Computed from LISS III, satellite data, 2001 and LISS III satellite data, 2010.

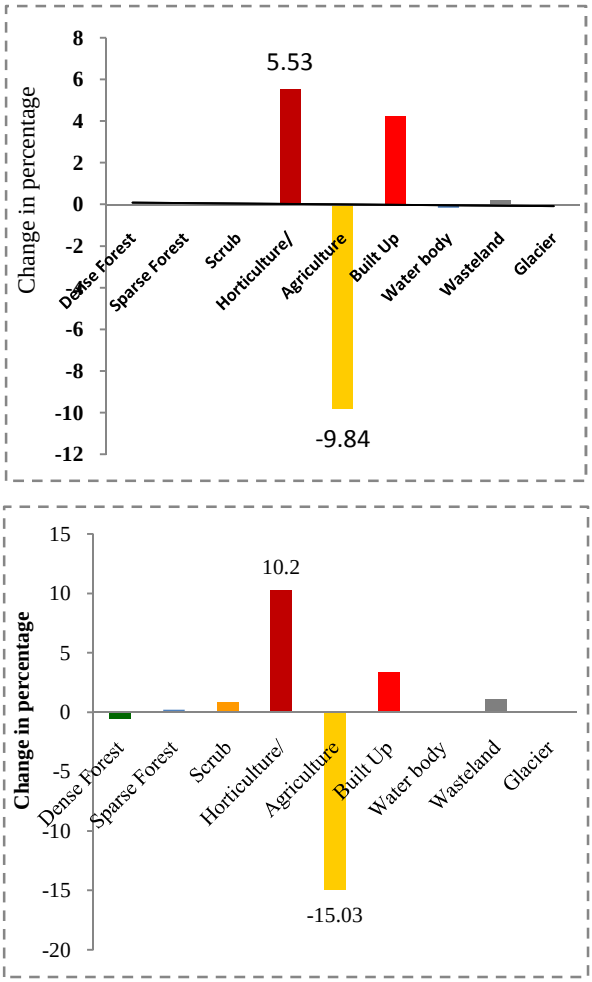


Fig 8 Land use/Land cover change of Zone 'A" and Zone 'B' 2001-2010

Agriculture

Agriculture being the dominant activity in the study area has shown declining trend of area under it. It has witnessed change of 3.7 percent. Agriculture is decreasing in the study area at the cost of expansion in horticulture and built up. The unchecked population growth and expansion of urban centers like Anantnag, Bijbehara, Dooru and Achabal towns have put more pressure on agricultural land. Laying out of railway line and extension of NH1A and NH1B in the study area is another cause. highest decrease was observed in zone 'B' and zone 'A' with15.03 percent and 9.84 percent respectively (fig 8).

Built-up

It constituted 5567.8 hectares of the study area in 2001 and 8485.04 hectares in 2010 thus, registering a growth of 2918.1 hectares (1.13 percent) from 2001 to 2010. Most of the built-up area has increased with in Anantnag, Bijbehara, Dooru and Mattan in the study area. The built-up category is still increasing on an accelerating pace to compensate the high population growth within the study area (fig 8).

Water bodies

There has been a minor decrease in the area under water bodies from 2001 to 2010.It occupied an area of 2070.3 hectares in 2001 and 1922.3 hectares in 2010. Change of -0.05 percent has occurred in this land cover category within a period of one decades. Increasing upstream erosion and sediment load has decreased the channel size of streams and other water bodies.

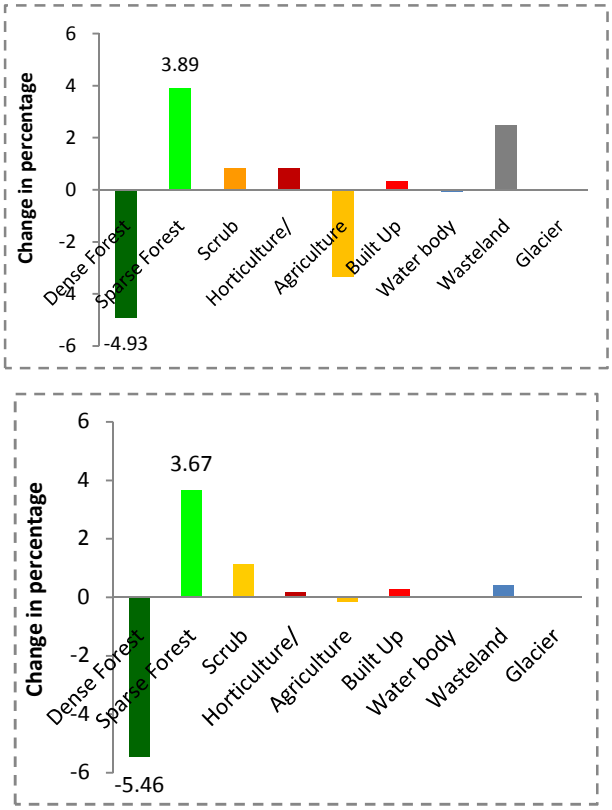


Fig 9 Land use/Land cover change of Zone 'C" and Zone 'D' 2001-2010

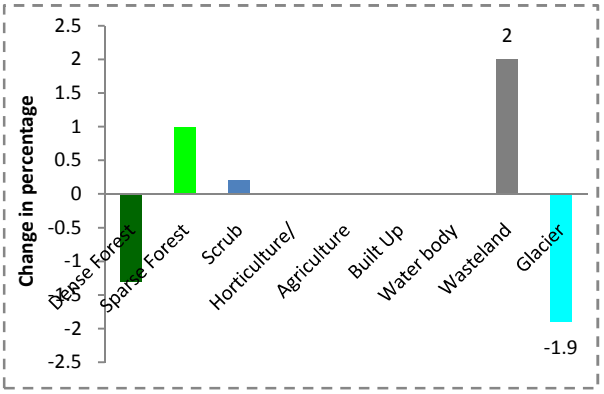


Fig10 Land use/Land cover change of Zone 'E" 2001-2010

Wasteland

The peripheral areas of the study area are mostly covered by the wastelands and are increasing at the expense of scrub land. Wastelands have witnessed a change of 1.59 percent from 2001 to 2010. It occupied 43375.2 hectares in 2001 and 47464.9 hectares in 2010 registering a growth of 4089.7 hectares. The prolonged degradation of forests and scrub has resulted in a net increase in wasteland category within the study area (fig 10).

Glaciers

Glaciers are mostly located in the eastern side of the study area within the higher reaches of Pahalgam, Kokarnag and Dooru and have substantially decreased with a total growth of -1.04 percent from2001 to 2010. There is a global trend in the decrease of glacial land covers due to the increase in global

average temperature since last few decades. Same results are evident in the study area (fig 10).

CONCLUSION

It was observed that like other Himalayan districts the study area has experienced drastic change in land use land cover in past 10 years (2001-2010). With the passage of time, agriculture, dense forests and glaciers were reduced significantly while as horticulture, sparse forest, wasteland and built-up were showing increasing trend. Agriculture were converted into horticulture and built up, due to high economic returns of horticulture, increase in population and infrastructure development respectively.

Dense forests were converted into sparse forests and scrub however increase in wasteland were observed at the cost of glacial retreat. The cause of concern lies in the rapidly squeezing agriculture and dense forests, leading environmental degradation and food insecurity in the study area. So the main motivation behind the land use transformation can be attributed to the phenomenal growth of population, the less production of the rice and the more economic benefits of the horticulture. The fragile natural environmental characteristics are being affected under the threat by poor environmental planning particularly land use management.

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How to cite this article:

Sheraz Ahmad Lone., Arif H Shah and Ishtiaq Ahmad Mayer.2016, A Hypsometric analysis of Land Use/Land Cover Change in Anantnag District of Kashmir Himalayas. *Int J Recent Sci Res.* 7(1), pp. 8467-8475.

TSSN 0976-3031