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Monitoring Land use/cover change using remote sensing and GIS techniques in upper Jhelum basin

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ABSTRACT

Land is a profitable asset and spatial distribution of land use/cover is vital for understanding landscape dynamics. The mapping of land use/cover change is fundamental for planning, management and monitoring programmes at local, regional and national levels. The present study illustrates the use of remote sensing and GIS techniques to monitor spatial distribution of land use/land cover in upper Jhelum basin between years 2008 and 2015. LANDSAT -ETM and LANDSAT-OLI satellite data for 2008 and 2015 years have been used for land use/land cover classification. Total of fourteen land use/land cover classes were delineated. The main classes include Agriculture, Forest, Horticulture, Built Up, Barren Land, Aquatic Vegetation, Plantation, Scrubs, Pastures, River Bed, Water Bodies, Exposed Rocks, Snow and Karewas. The study revealed that Agriculture has decreased by 5.02%. Similarly forest, river bed and snow has decreased by 0.41%, 0.006% and 0.57% respectively. Horticulture, built-up and plantation has increased by4.01%, 0.46% and 0.36%respectively. Barren land, exposed rocks, pastures, scrubs and karewas all have been increased by 0.10%, 0.56%, 0.32%, 0.07 and 0.01% respectively. Aquatic Vegetation and water bodies have both increased by 0.003%. The areas showing maximum changes were highlighted (hotspots) and high resolution maps of the hotspots were created via IKONOS image satellite. The change detection analyses of the three hotspots were carried out and it was analyzed that agriculture is showing depleting trend since 2008.The result of the work showed rapid growth in horticulture and built-up between years 2008 and 2015.

Key words: Land use, Land cover, Lidder, Kashmir, Kuthar, Vishaw, Watersheds.

I.INTRODUCTION

Land is one of the major critical natural resource on which most developmental activities are based. For success of any planning activity, detailed and accurate information about the land cover and associated land use is of paramount importance. The knowledge of the LULC is important for a lot of human activities. LULC is to be considered an essential element for modeling and understanding the earth (Lillesand, *et al*., 2004) [1]. Thorough understanding of gradual or sudden natural changes and factitious changes in surface of the earth provide valuable understanding of the interactions between natural environment and human activities (Bakr, *et al*., 2010) [2].

Viewing the Earth from space is crucial to understand the influence of man's activities on his natural resource base over time. With the invention of remote sensing and GIS techniques land use/cover 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 *et al.*, 2003)[3]. Application of remotely sensed data made possible to study the changes in land cover in less time, at low cost and with better accuracy (Kachhwala, 1985)[4] in association with GIS that provides suitable platform for data analysis, update and retrieval (Star *et al*., 1997[5] and Chilar, 2000[6]). Remote sensing via satellite imagery is an excellent tool to study LULC because images can cover large geographic extents and have a high temporal coverage. The U.S.Geological Survey (USGS) has a long heritage of leadership and innovation in land use and land cover (LULC) mapping that has been the model both nationally and internationally for over 20 years. The demand for large-scale LULC information has increased recently, especially in rapidly growing area. Many Federal, State, regional, and local planning agencies require up-to-date LULC information for various applications. These applications include modeling urban growth, determining land suitability for future development, monitoring how land use changes affect the environment, understanding land use patterns, and developing zoning policies concerning land use development.

The present study demonstrates the application of multi-temporal satellite imageries in defining land use/cover dynamics of upper Jhelum basin.

II.MATERIAL AND METHODS

2.1 STUDY AREA

The Kashmir valley, which forms a composite Jhelum basin, has a fairly well established drainage system headed by the Jhelum, the main channel of drainage. The river is initially formed by the junction of 3 streams, the Arapal, the Bringi and the Sandran which rise at the south-east end of the valley Jhelum drains the whole valley of Kashmir and from north-west of Anantnag where its head waters the Arapal from the north-east unit. Two to three miles north of Anantnag the Jhelum receives the Lidder which rises in the snow fields from north of the Sheshnag and do contribute a volume of water scarcely inferior to that of the Jhelum. A few miles north of Bijbehara it receives the united waters of the Vishav and Rambiara rivers, both of which flow down from the Pir Panjal Mountains. The former stream rising in the holly fount of Kounsar Nag and later in the Nandan SAR and Bhag Sar lakes. At Srinagar, it receives the Dodhganga stream which also rises in Pir Panjal range. Besides these, it is fed by numerous smaller streams and mountain torrents and its water communicate with those of the Dal, Anchar and Manasbal lakes. The river makes source of the finest meanders over this stretch and lays down a good deal of its suspended load along its bank. The Jhelum River is divided into upper Jhelum basin and lower Jhelum basin.

The upper Jhelum basin (Fig. 1) area spatially lies between 33^{0}24'54"N to 34^{0}27'52"N latitude and 74^{0}24'08"E to 75^{0}30'36"E longitude. The upper Jhelum basin consists of seven watersheds that drain their water into Jhelum at various locations in right and left side as Jhelum descends down. These watersheds are Vishav, Kuthar, Bringi, Sandran, Rambiara, Liddar and Arpal.

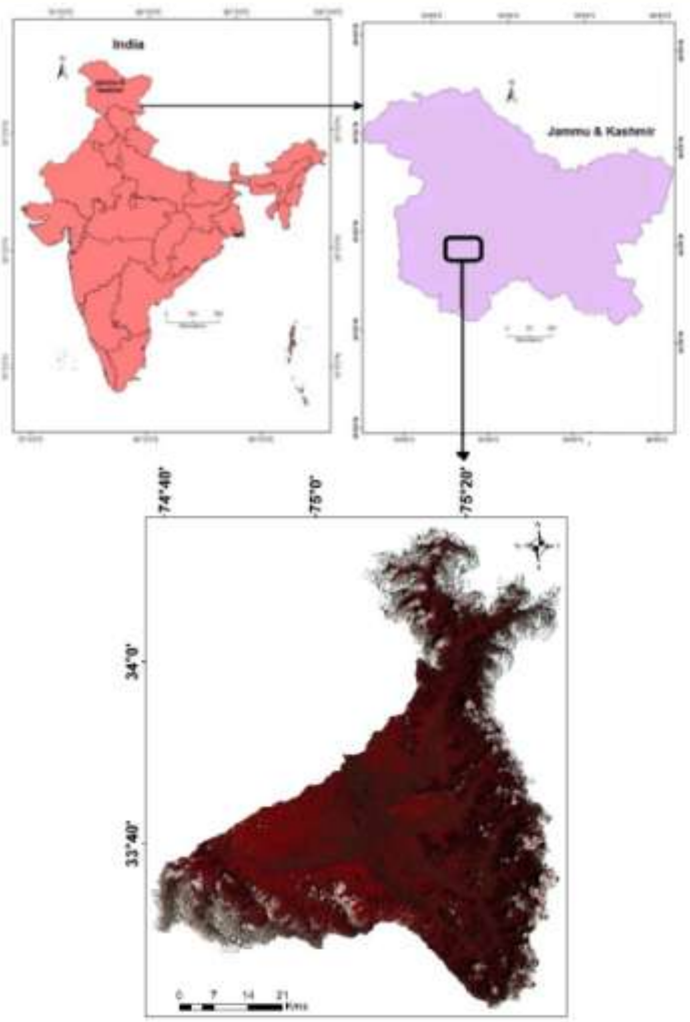


Fig. 1 Location map of Study Area

Table 1 Characteristics of watersheds draining upper Jhelum basin

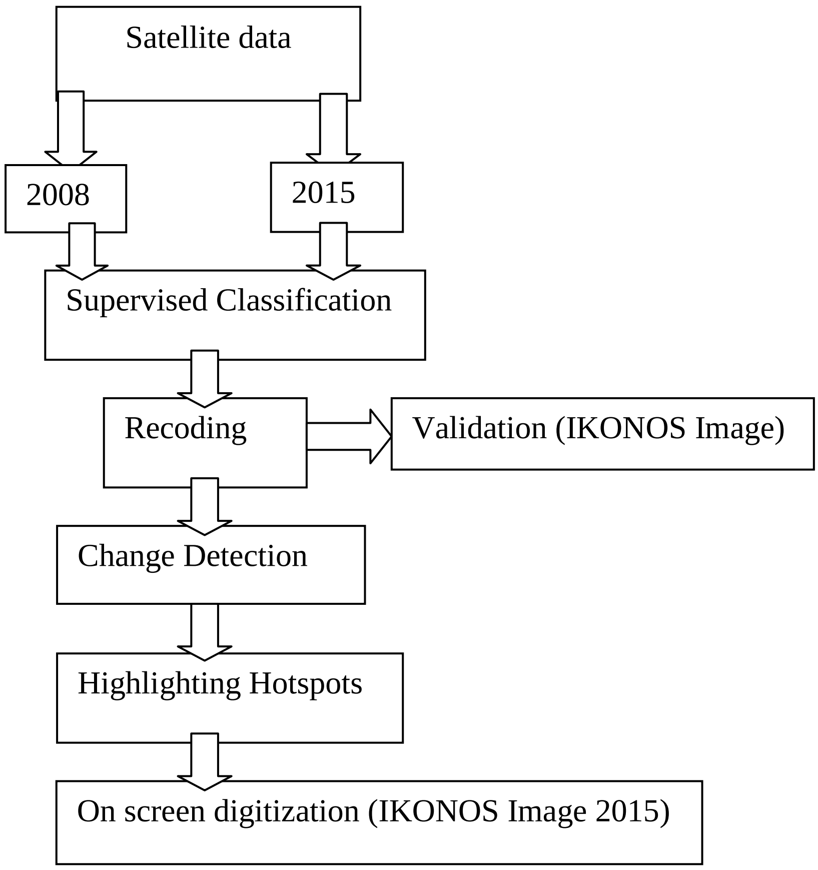
S. No.	Watershed characteristics	Vishav	Lidder	Sandran	Bringi	Kuthar	Rembiara	Arapal
1.	Max. elevation (km)	4.6	5.3	4.0	4.4	4.3	4.6	4.2
2.	Min. elevation (km)	1.5	1.4	1.5	1.5	1.5	1.5	1.3
3.	Basin relief (km)	3.1	3.9	2.5	2.9	2.8	3.2	2.9
4.	Basin area (km^2)	1188.75	1260.39	318.43	623.54	328.84	666.32	593.70
5.	Basin length (Lb; km)	63.24	71.45	50.10	53.16	35.50	65.14	34.55
6.	Length of main	78.64	82.26	53.09	53.01	39.09	76.06	38.43

	channel (km)							
7.	Basin perimeter (km)	168.49	233.36	120.67	162.1 9	89.98	165.94	111.78
8.	No. of micro-watersheds	74	98	16	49	38	41	53

2.2 DATA SETS USED

To carry out the study, geometrically corrected LANDSAT-ETM image of October 2008 and LANDSAT-OLI image of October 2015 were used for land use/cover classification. IKONOS image with 1m resolution was used for validation purpose and creating high resolution maps at 1:5000 scale of the areas showing maximum changes. The software used was ERDAS IMAGINE 9.1 and ARC GIS 10.1.

2.2.1 Flow chart of Methodology



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2.2.2 Land use/cover detection and analysis

The process is worked out by selecting optimal season data which comprises of LANDSAT-ETM digital data for year 2008 and LANDSAT-OLI for year 2015. The images were pre-processed and processed in ERDAS IMAGINE and radiometric and geometric corrections were also employed. The two year images were co-georeferenced with each other. Supervised classification with maximum likelihood algorithm was applied on the images using ERDAS IMAGINE 9.1. Post–classification detection method was employed for performing land use/cover change. The areas showing maximum changes were detected and highlighted. On screen digitization was employed to create high resolution maps of these hotspots showing maximum changes using IKONOS Image for the year 2015.

III. RESULTS AND DISCUSSION

3.1 Land use/ cover change of upper Jhelum basin

Using supervised classification, the study area was classified into 14 different classes on each image (LANDSAT_ETM 2008, LANDSAT_OLI 2015), viz agriculture, aquatic vegetation, barren land, built-up, exposed rocks, forests, horticulture, karewa, pastures, plantation, riverbeds, scrubs, snow and water. The inner change of land use is reflected by comparing the statistics of spatial data with that of quantitative change (Fig.2a,b. Table. 2) The agriculture in the study area has decreased from 667.04 km^2 in 2008 to 494.36 km^2 in 2015 which accounts for -5.02% of the total study area. The area under forest has decreased from 1136.36 km^2 in 2008 to 1122.19 km^2 in 2015 accounting -0.41%. Similar trend was observed in the case of river bed and snow. The area under river bed and snow has declined by -0.006% and -0.57% respectively from year 2008 to 2015. The most striking finding of the study was the increase in horticulture and built up. Horticulture has increased from is 239.90 km^2 in 2008 to 381.01 km^2 in 2015 accounting for 4.10%. The area under built-up has increased from 19.62 km^2 in 2008 to 35.52 km^2 in 2015 accounting 0.46%.The area under barren, exposed rock, karewa, scrubs and pastures also show increasing trend in total area change from 2008 to 2015, the percentage being 0.10, 0.56, 0.01,0.07and 0.32 respectively. The study further indicates that plantation area has increased from 198.59 km^2 in 2008 to 211.18 km^2 in 2015 showing total change of 0.36%. Similar trend has been followed by aquatic vegetation and water both registering change of 0.003% from year 2008 to 2015. The graphical representations of overall change in upper Jhelum basin from 2008 to 2015 is shown in (Fig. 3, 4)

(a)LAND COVER 2008 (b) LAND COVER 2015

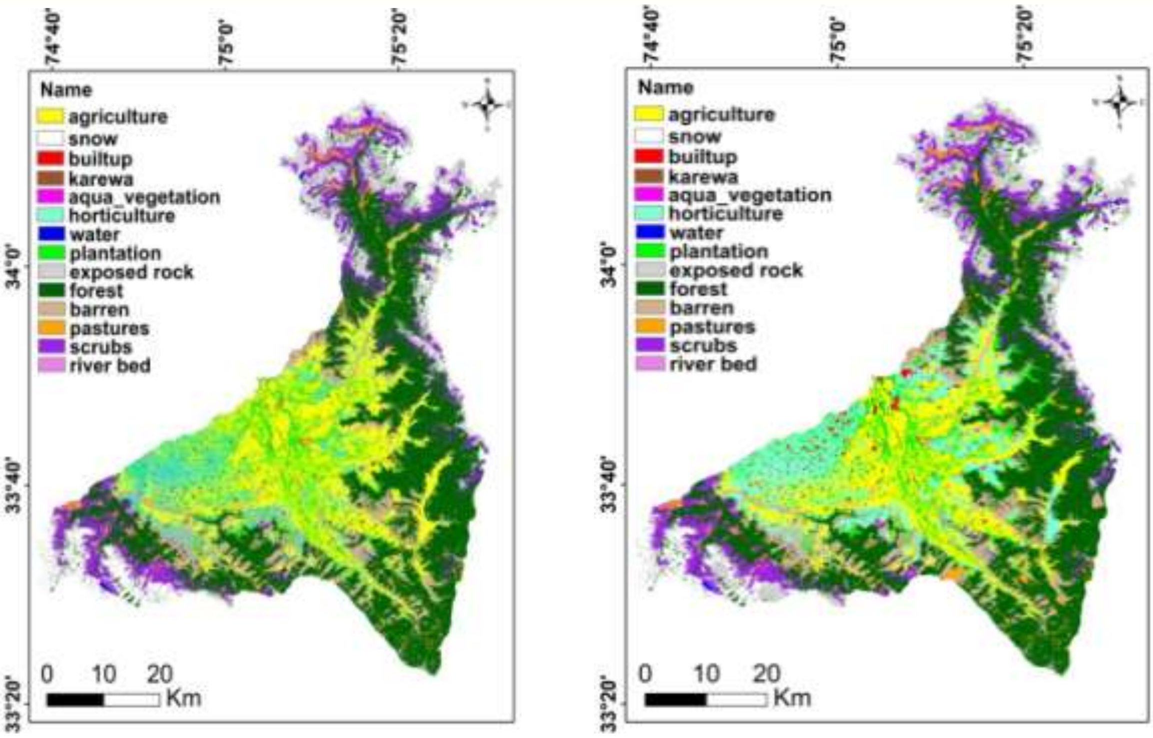

Fig. 2 land use/land cover status of Upper Jhelum basin;(a) in 2008, (b) in 2015

Table 2 Area and amount of change in land use/cover in Upper Jhelum basin from 2008 to 2015

Upper Jhelum basin						
Class Names	**2008 (km^2)**	**%**	**2015 (km^2)**	**%**	**Area Change (2008-2015)**	**Area %**
Agriculture	667.04	19.40	494.36	14.38	-172.68	-5.02
Aqua vegetation	0.03	0.001	0.14	0.004	0.11	0.003
Barren	279.04	8.11	282.72	8.23	3.68	0.10
Built-up	19.62	0.57	35.52	1.03	15.9	0.46
Exposed rock	304.16	8.85	323.63	9.42	19.47	0.56
Forest	1136.36	33.06	1122.19	32.65	-14.17	-0.41
Horticulture	239.9	6.98	381.01	11.09	141.11	4.10
Karewa	1.84	0.05	2.19	0.06	0.35	0.01
Pastures	49.22	1.43	60.29	1.75	11.07	0.32
Plantation	198.59	5.77	211.18	6.15	12.59	0.36
River bed	22.59	0.65	22.36	0.65	-0.23	-0.006
Scrubs	313.35	9.11	315.78	9.19	2.43	0.07
Snow	199.41	5.80	179.63	5.23	-19.78	-0.57
Water	5.51	0.16	5.63	0.16	0.12	0.003

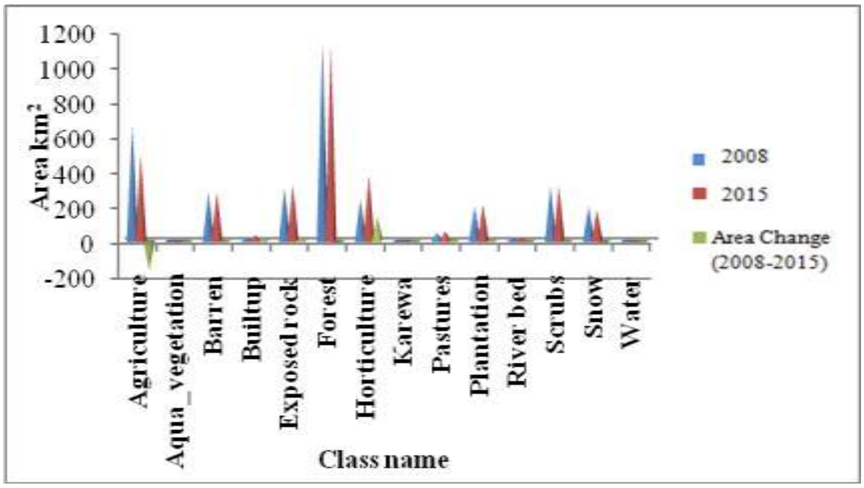

Fig. 3 Bar graph showing change in Upper Jhelum Basin from 2008 to 2015

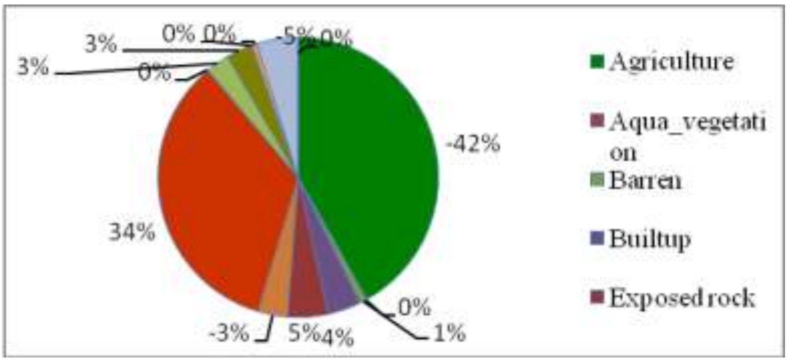

Fig. 4 Pie chart showing shows area change in Upper Jhelum basin from 2008 to 2015

There are various areas that have gone under considerable change. The maximum changes are in the class of agriculture. The area under agriculture has depleted tremendously and has been converted to horticulture and built up. This is attributed to the fact that the horticulture provides more economic benefit to the farmers than agriculture do (Yaun et al., 2005[7], Rawat 2014[8]). Horticulture utilizes less water than agriculture and water scarcity leads to the conversion. The lack of proper irrigation facilities also adds to the conversion (Adepoju et al., 2006) [9]. The built up is also increasing and the lands are used for construction purposes. This is attributed to the fact that population is increasing tremendously.

There are three hotspots in the area that show maximum changes (Fig. 5) and high resolution maps of these hotspots have been created at a scale of 1:5000 making use of IKONOS image of year 2015. The statistical data of these high resolution maps are then compared with the data of year 2008 for change detection.

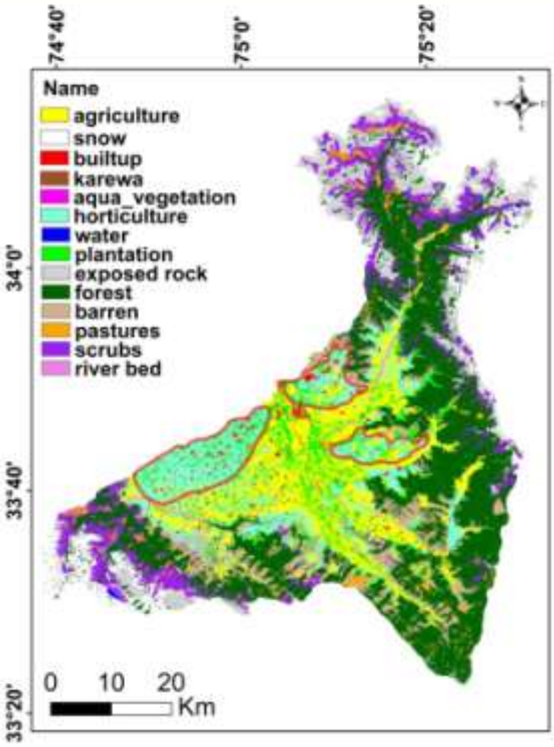

Fig. 5: Showing highlighted hotspots of Upper Jhelum basin

3.2 Description of land use/land cover maps and change detection of hotspots from 2008 to 2015

3.2.1 Hotspot 1: It is the part of Vishav watershed that includes the areas Aloora, Amshipora, Kach Dora and Gundchahal (Fig. 6). The Vishav drainage basin covering an area of 1083.48km^2 (10 % of the Jhelum drainage basin) occupies the southeastern division of the Kashmir valley and is positioned between (33^0 39' to 33^0 65' N) latitude and (74^0 35' to 75^0 11' E) longitudes with its major part (80%) in the Kulgam and Shopian districts of Jammu and Kashmir, India. The Vishav watershed is a significant left bank permanent tributary of the Jhelum stream. Having its origin from Kounsarnag (3,840 m.a.s.l.) which lies on the gentler northern countenance of the Pir Panjal range of Kashmir Himalayas, Vishav watershed appears to stem from a glacier fed stream near the base of Kounsarnag called Teri, which afterward joins the underground stream assumed to start off from Kounsarnag 2 km downstream at Mahinag, falling steeply north-northeast to arrive at the main strike valley till it amalgamate with Jhelum at Niayun (Raza *et al.*, 1978)[10].

Fig. 6 Hotspot 1part of Vishaw watershed

The change of land use is reflected by comparing the statistics of spatial data with that of quantitative change (Fig.7a,b. Table 3) The agriculture in the study area has decreased from 60.94 km^2 in 2008 to 8.49 km^2 in 2015 which accounts for -28.61% of the total study area. The area under barren field has decreased from 1.07 km^2 in 2008 to 0.31 km^2 in 2015 accounting change of about-0.42%. Similar trend was observed in case of karewa and plantation. The area under karewa and plantation has declined by -0.25% and -8.51% respectively from year 2008 to 2015. The most important finding of the study was the increase in horticulture and built up. Horticulture has increased from 87.40 km^2 in 2008 to 142.88 km^2 in 2015 accounting for 30.27%. The area under built-up has increased from 3.86 km^2 in 2008 to 17.40 km^2 in 2015 accounting change of about7.38%.The area under water also show increasing trend in total area change from 2008 to 2015, the percentage being 0.14. The graphical representation of hotspot 1 is shown in Fig. 8, 9.

(a)LAND COVER 2008 **(b)LAND COVER 2015**

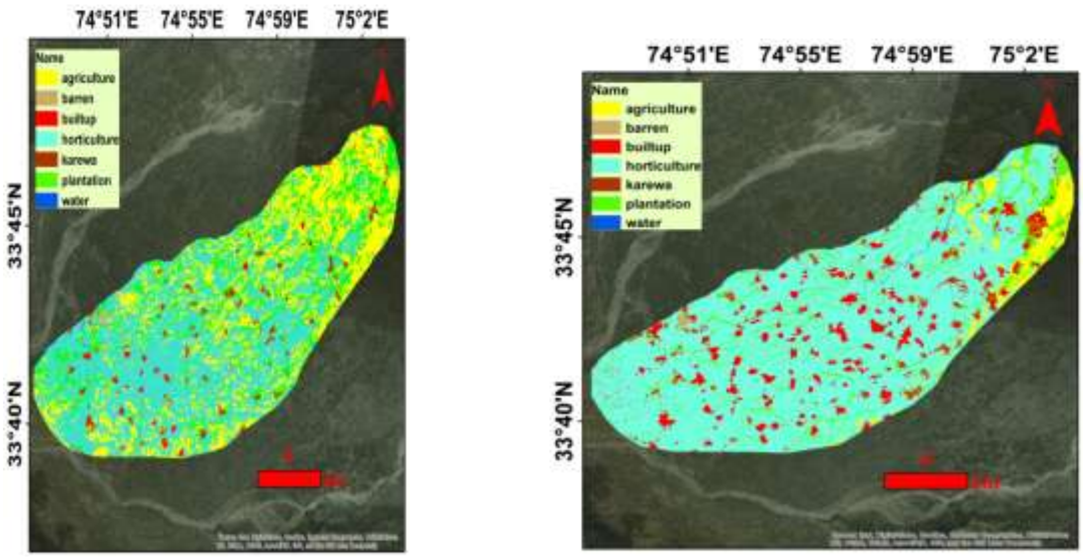

Fig. 7 Land use/cover status of hotspot1;(a) in 2008, (b) in 2015

Table 3 areas and amount of change in land use/cover in hotspot1 during year 2008 to 2015

Hotspot 1						
Class Names	**2008 (km^2)**	**Area %**	**2015 (km^2)**	**Area%**	**Area Change (2008-2015)**	**Area %**
Agriculture	60.94	33.25	8.49	4.63	-52.45	-28.61
Barren	1.07	0.59	0.31	0.17	-0.77	-0.42
Built-up	3.86	2.11	17.40	9.49	13.53	7.38

Horticulture	87.40	47.68	142.88	77.95	55.48	30.27
Karewa	0.55	0.30	0.09	0.05	-0.46	-0.25
Plantation	29.48	16.08	13.88	7.57	-15.60	-8.51
Water	0.01	0.003	0.26	0.14	0.25	0.14

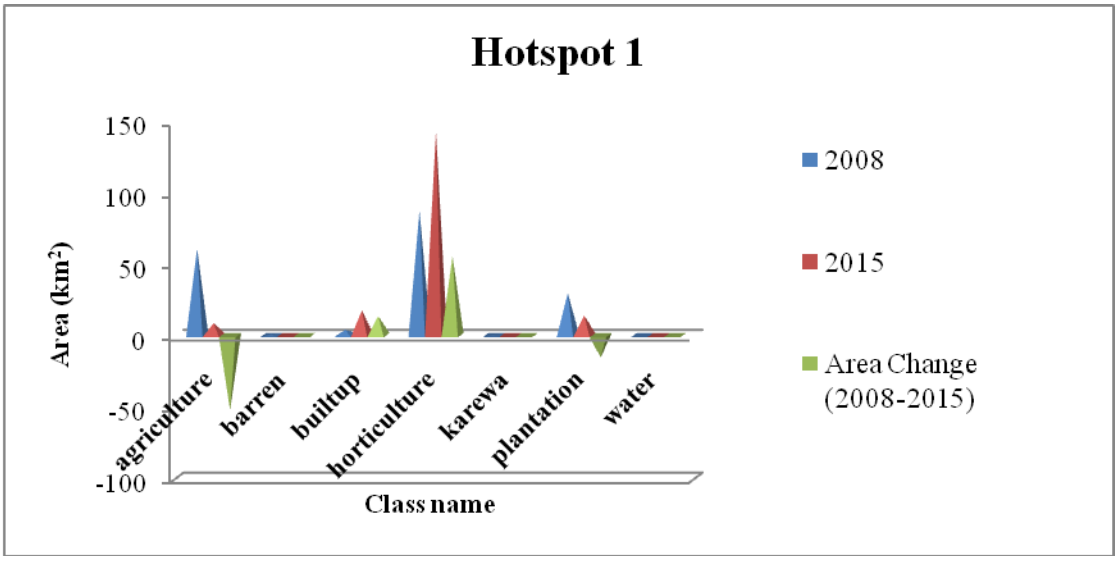

Fig. 8 Bar graph showing change of hotspot1 from 2008 to 2015

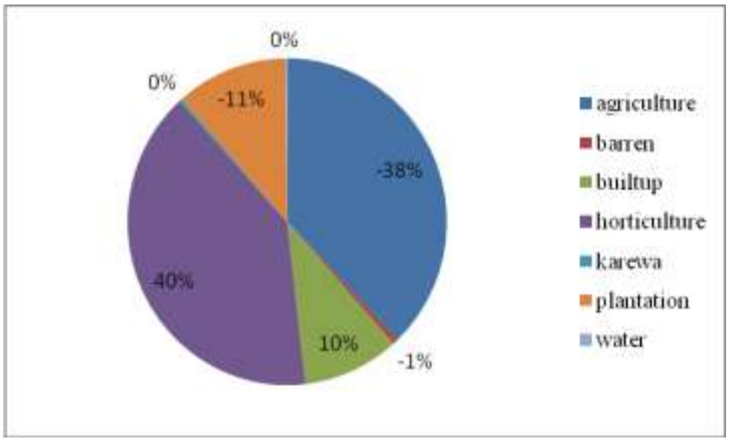

Fig. 9 Pie chart showing area change of hotspot1 from 2008 to 2015

3.2.2 Hotspot 2: It is the part of Liddar watershed that includes areas Sir Hama, Baghpora, Nowshehra, Khush Roi Kalan, and Bijbehara (Fig.. 10).The Liddar watershed in the upper Jhelum basin is a tributary of the Indus river system, located in the western Himalaya between latitudes 33° 59′ and 34° 12′ and longitudes 75° 09′ and 75° 23′ and covering an area of 653 km^2. The altitude of the watershed ranges from 2050 to ~5200 m above mean sea level. The watershed is one of a few catchments within the Jhelum basin with permanent snow, and permanent ice/glaciers occupy about 3% of the entire Liddar watershed and 6% of the upper Liddar watershed area. The Liddar watershed has 17 glaciers (*Kaul*, 1990)[11] which cover an area of about about 40 km^2 in 2008. Kolahoi and Shishram are the major glaciers with an area of about ∼10.2 and ∼8.5 km^2, respectively. The hypsometry of the watershed and the glaciers shows that maximum area of the entire watershed and the glaciers lie between 3500 and 4500 m amsl, and 4300 and 4500 m amsl, respectively.In the upper catchments (>2000 m) of the western Himalayas, precipitation generally falls as snow from late autumn to early spring. Redistribution of snow by wind and slopes is commonly observed in the Himalayas. Some of the snow tends to be deposited along the valleys, which, depending upon their orientation, normally remain under shade, particularly in E-W oriented valleys. These sites are therefore the reservoirs for the river flow for the rest of the year. The snow cover area in the Liddar watershed, although highly variable, decreases from about 90% in winter (January) to about 6% in autumn (September).

Fig. 10 Hotspot 2 part of Lidder watershed

The land use change is reflected by comparing the statistics of spatial data with that of quantitative change (Fig. 11 a,b, Table 4) The agriculture in the study area has decreased from 39.69 km^2 in 2008 13.07 km^2 in 2015 which accounts for -35.51% of the total study area. The area under barren field has decreased from 0.64 km^2 in 2008 to 0.28 km^2 in 2015 accounting change of about-0.47%. Similar trend was observed in case of karewa and plantation. The area under karewa and plantation has declined by -0.31% and -6.38% respectively from year 2008 to 2015. The most visible finding of the study was the increase in horticulture and built up. Horticulture has increased from 16.46 km^2 in 2008 to 42.90 km^2 in 2015 accounting for 35.26%. The area under built-up has increased from 2.03 km^2 in 2008 to 7.35 km^2 in 2015 accounting change of about7.09%.The area under scrubs and water also show increasing trend in total area change from 2008 to 2015, the percentage being 0.02 and0.3 respectively. The graphical representations are shown in Fig. 12, 13.

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(a) LAND COVER 2008 (b) LAND COVER 2015

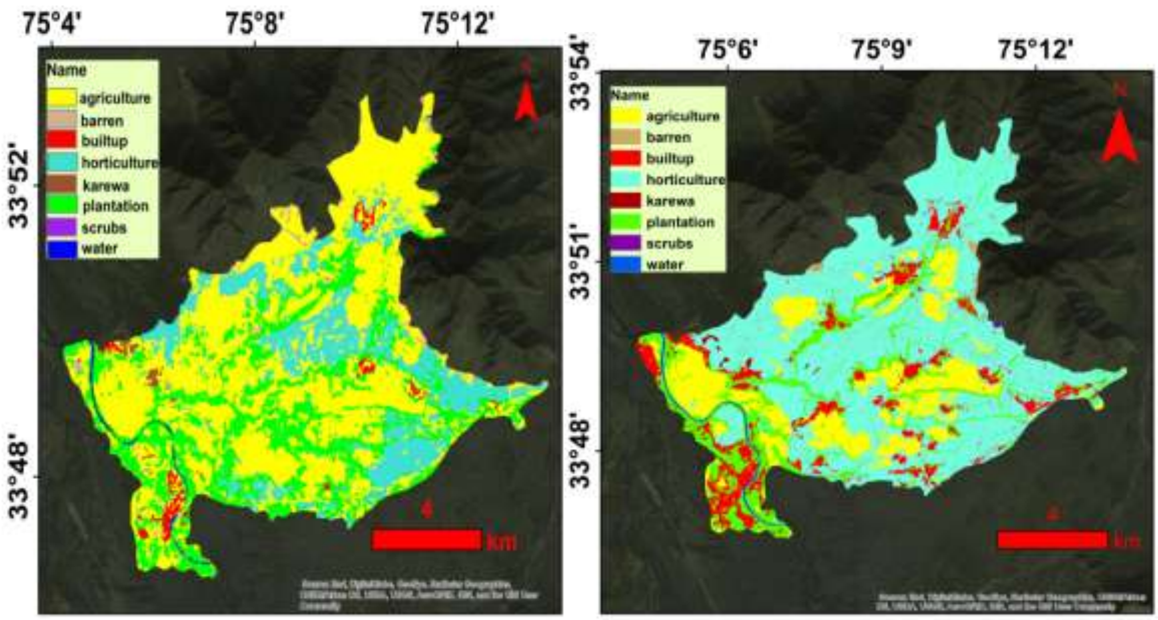

Fig. 11 Land use/cover status of hotspot2; (a) in 2008, (b) in 2015

Table 4 areas and amount of change in land use/cover in hotspot1 during year 2008 to 2015

Hotspot 2						
Class Names	**2008 (km^2)**	**Area%**	**2015 (km^2)**	**Area%**	**Area Change (2008-2015)**	**Area %**
Agriculture	39.69	52.94	13.07	17.43	-26.62	-35.51
Barren	0.64	0.85	0.28	0.38	-0.35	-0.47
Built-up	2.03	2.71	7.35	9.80	5.32	7.09
Horticulture	16.46	21.95	42.90	57.22	26.44	35.26
Karewa	0.40	0.54	0.17	0.23	-0.23	-0.31
Plantation	15.44	20.59	10.66	14.21	-4.78	-6.38
Scrubs	0.02	0.03	0.03	0.04	0.01	0.02
Water	0.29	0.39	0.51	0.69	0.22	0.30

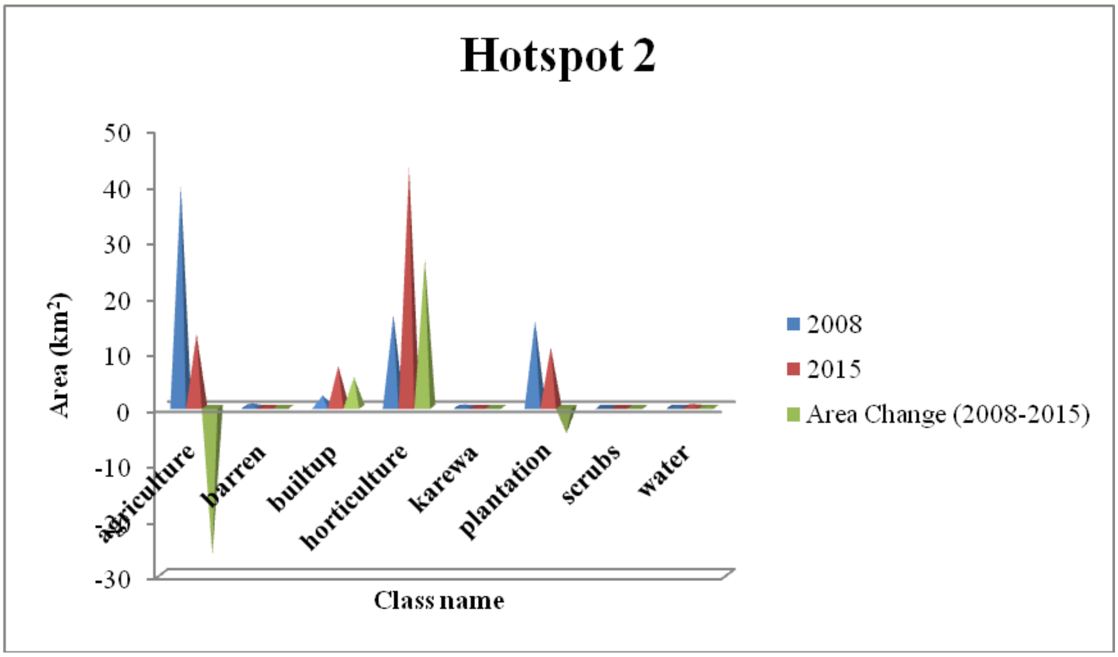

Fig. 12 Bar graph showing change of hotspot 2 from 2008 to 2015

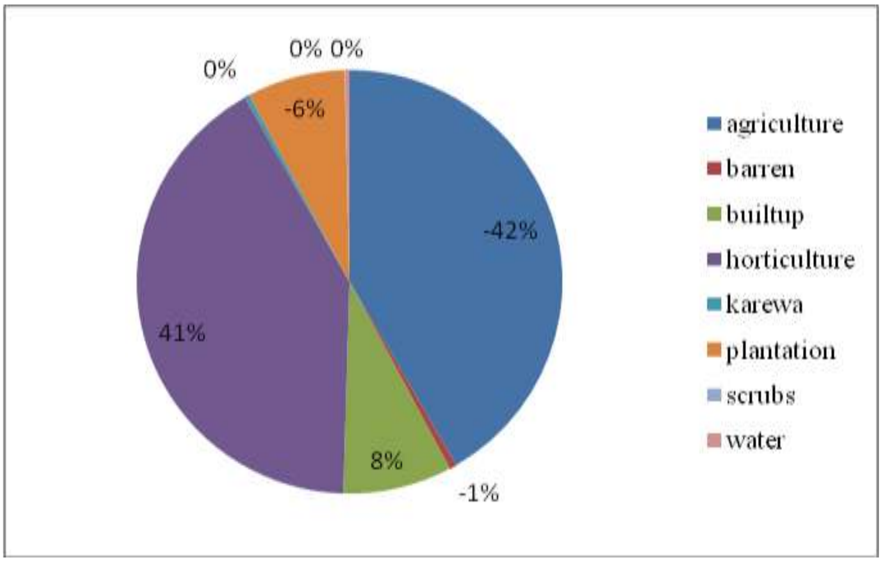

Fig. 13 Pie chart showing area change of hotspot 2 from 2008 to 2015

3.2.3 Hotspot 3 is the part which lies between the shared boundary of Liddar and Kuthar watersheds. The areas included are Deethu, Khul Chohar, Ranipora, Sheikh Gund, Arsoo andn Chithi Manzhama (Fig. 14). Kuthar watershed, one of the upland catchments of the Jhelum River in Kashmir Himalayas, lies between $33^{0}37'$–$33^{0}45'$N and $75^{0}10'$–$75^{0}16'$E. It originates from the Greater Himalayas (Zanskar range) and covers an area of approximately 329 km^2. The elevation of the mountainous catchment ranges from 1500 m above mean sea level (a.m.s.l) to more than 4000 a.m.s.l. The watershed is drained by Aripath tributary that originate within the greater Himalayan slopes. Its head stream rise below the Zajimarg pass (4041m), Niltup (4426m) and the Khalbar (4440m) peaks of the great Himalayan range in the east of the valley. The dominant drainage pattern of this catchment is dendric. Snowmelt has the major share in stream flow. It flows torrentially upto Chhaturgul and then becomes sluggish. The valley possesses distinctive climatic characteristics because of its high altitude location and its geophysical setting, being enclosed on all sides by high mountain ranges. The area has a temperate type of climate with a mean annual temperature of about 10^0C and characterized by marked seasonality with four well-defined seasons: spring (March–May), summer (June–August), autumn (September–November) and winter (December–February).

Fig. 14 Hotspot 3 part of Kuthar and Lidder watershed

The change of land use/cover is reflected by comparing the statistics of spatial data with that of quantitative change (Fig. 15 a, b, Table 5) The agriculture in the study area has decreased from 29.48 km^2 in 2008 to 11.50 km^2 in 2015 which accounts for -35.0% of the total study area. The area under forest has decreased from 0.18 km^2 in 2008 to 0.13 km^2 in 2015 accounting -0.08%. Similar trend was observed in the case of river barren land and plantation. The area under river barren land and plantation has declined by -1.08% and -10.37% respectively from year 2008 to 2015. The most striking finding of the study was the increase in horticulture and built up. Horticulture has increased from is 10.62 km^2 in 2008 to 30.70 km^2 in 2015 accounting for 39.22%. The area under built-up has increased from 0.75 km^2 in 2008 to 3.93 km^2 in 2015 accounting 6.22%.The areas under exposed rock, pastures, river bed scrubs and water also show increasing trend in total area change from 2008 to 2015, the percentage being 0.08, 0.81, 0.03,0.10and 0.7 respectively. The graphical representation is shown is Fig. 16,17.

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(a)LAND COVER 2008 (b) LAND COVER 2015

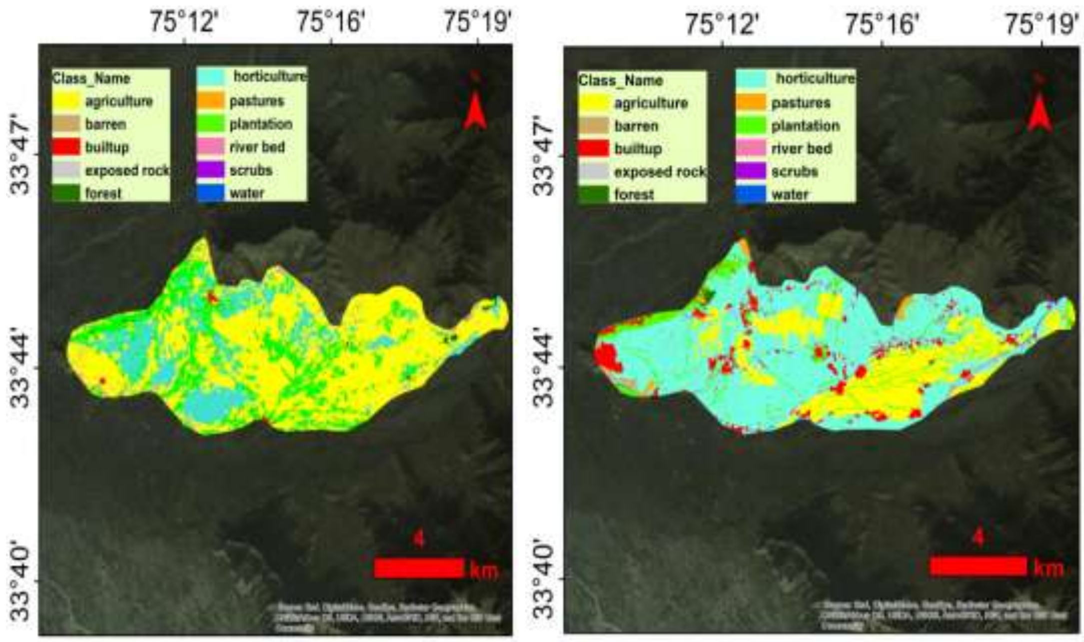

Fig. 15 Land use/cover status of hotspot3; (a) in 2008, (b) in 2015

Table 5 areas and amount of change in land use/cover in hotspot3 during year 2008 to 2015

Hotspot 3						
Class Names	**2008 (km^2)**	**Area%**	**2015 (km^2)**	**Area%**	**Area Change (2008-2015)**	**Area %**
Agriculture	29.48	57.56	11.50	22.45	-17.98	-35.10
Barren	0.86	1.68	0.31	0.60	-0.55	-1.08
Built-up	0.75	1.45	3.93	7.67	3.19	6.22
Exposed rock		0.00	0.04	0.08	0.04	0.08
Forest	0.18	0.35	0.13	0.26	-0.04	-0.08
Horticulture	10.62	20.72	30.70	59.94	20.09	39.22
Pastures		0.00	0.41	0.80	0.41	0.81
Plantation	9.20	17.96	3.88	7.58	-5.31	-10.37
River bed	0.14	0.28	0.15	0.30	0.01	0.03
Scrubs		0.00	0.05	0.10	0.05	0.10
Water	0.01	0.01	0.09	0.18	0.09	0.17

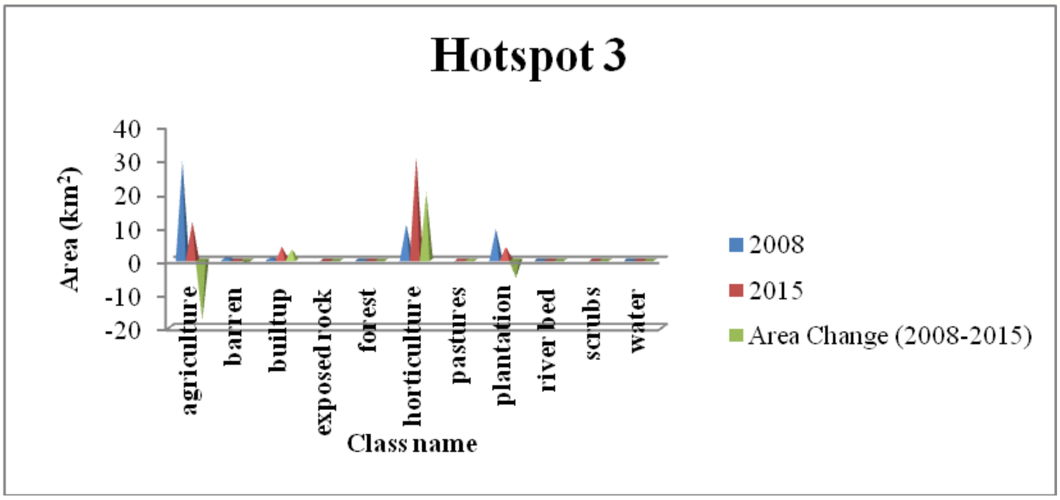

Fig. 16 Bar graph showing change of hotspot3 from 2008 to 2015

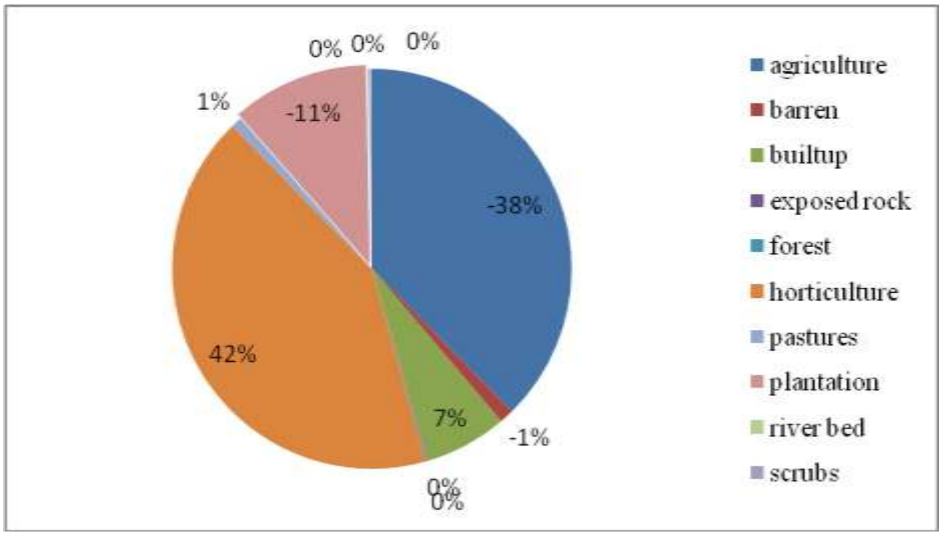

Fig.. 17 Pie chart showing area change of hotspot 3 from 2008 to 2015

The above figures and statistics of the three hotspots show maximum changes in the class of agriculture. The dominant class is the horticulture. The agricultural lands have been converted to horticulture and built up (Bhagawat *et al*., 2011[12], Amin *et al.*, 2012[13], Pooja *et al*., 2012[14]). The conversion into horticulture is attributed to the fact that horticulture provides more economic benefit to the farmers which compel them to shift towards horticulture (Iqbal *et al*., 2012)[15]. Water scarcity and faulty irrigation practices also contribute to the conversion. The increase in population and shifting towards industrialization from past few years lead to the construction and hence lands are getting converted (Rawat and Kumar, 2015)[16].

IV.CONCLUSIONS

Current study was taken to detect changes in land use land cover of upper Jhelum basin from 2008 to 2015. The Research objective was fulfilled by creating LULC maps and highlighting areas showing maximum changes.

The high resolution maps of hotspots were created. The LULC change detection showed that Agriculture is decreasing abruptly and changing to horticulture and built up. Agriculture practices do not provide sufficient gains to the farmers which make them to shift their lands to horticulture use. Water scarcity and improper irrigation practices further add to conversion. Agriculture lands are also getting converted to built-up. This might be due to increase in population that leads to increase in settlements. Forest cover, plantation, snow all show decreasing trend since 2008. It has been seen that forest cover is only changing into horticulture. The areas showing maximum changes in the upper Jhelum basin were highlighted and high resolution maps of these areas (hotspots) were created at a scale of 1:5000 for the year 2015.The total of three hotspots were highlighted and change detection was carried out from 2008 to 2015.The statistics of these hotspots were compared and it was analyzed that the agriculture is showing depleting trend and is getting converted to horticulture and built up.

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