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Application of Remote sensing and GIS for analyzing geospatial changes in Kupwara northern district of India and their role for changing atmosphere

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Abstract

The present research zooms land use land cover (LULC) changes in northern district Kupwara of Jammu and Kashmir India. The research reports a significant decrease in the area of agriculture, Dense forest and water body. Positive changes are experienced in the area of Horticulture, Barren land, Built-up, Pasture, Plantation, Scrub and sparse forest from 1979 to 2018. Using on-screen digitization land use land cover classes were generated for the year 1979,2001 and 2018. Environmental parameters like precipitation (both rain and snow), temperature and black carbon were analyzed to relate to LULC changes in the study area. The research high lights that there is a decrease in the area of agriculture, dense forest and water body by 38.344%,28.78% and 25.84% respectively. On the Other hand positive changes were observed in the area of barren land, built-up, horticulture, pasture, plantation, scrub, sparse forest with 9.05%,206%,35.40%,29.69%,319.22%,61.272%,45.78% respectively. The decrease in agriculture was attributed to the decrease in precipitation over the study area. The analyses report that there is a decadal decrease of 1% precipitation over the study area. The drastic increase in horticulture and a decrease in the dense forest have resulted in a significant increase in black carbon. The reports attribute 2% decadal increase in black carbon from 1980 to 2018. This increase in black carbon experiences the study area towards warming. The area needs strict policies to mitigate the impact of LULC change on the study area.

Keywords:* *Satellite data;climate change; Land-use and land-cover change; RS & GIS

Introduction

Land use land cover is essential element heaving directly or indirectly relation with earth related and socioeconomic processes. The increasing rate of socioeconomic processes by increase in population resulting increasing in land use land cover changes. These changes are unparallel that resulted enormously transformation of large proportion of earth land surface (Lambin et al. 2001; Foley et al. 2005).The rapid conversion of land use land cover depends on social, economic and political characteristics by human (Ojima et al. 1994).The study of land use land cover change has become essential for indentifying the role of changing environment and human. (Foody 2002; Herold et al. 2002; Ji et al. 2005; Diallo et al. 2009; Hegazy and Kaloop 2015; Liu and Yang 2015).The analysis of land use land cover is important to check the various environment issues at certain regional level such as decline in agriculture, wetlands and wildlife habitat (Anderson et al. 1976). The increasing pressure on land resources by population growth will result disaster for future generation. Reducing the land use land cover changes has similar policy on disaster reduction (DDR) and climate change adaptation (Davidet al. 2016; Shaw and Banba 2017). The change in precipitation and surface temperature are experienced by changes in land use land cover (Gogoi et al 2019). All the aspects of land use land cover changes are experienced reliably using remote sensing and GIS. The use of satellite data with different resolution in different models help us to picture past, present and future land use land cover pattern (Lambin 1997; Liet al. 2014).The use of satellite data in remote sensing for change detection in LULC is cost and time effective way (Barnsley and Barr 1996; Yang 2002; Yang and Liu 2005; Guler et al. 2007; Erener et al. 2012; Shah 2012).The detection of land use land cover changes has become primary outcome of satellite data.(Nelson 1983; Singh 1989; Turner et al. 1993; Seto and Kaufmann 2005). The study area witnessed drastic changes from last few decades in land use land cover mainly by increase in population size, economic growth and other social and environmental reasons. However geospatial technology is used to monitor these changes systematic way. In this study we attempt to map and quantify the land use land cover changes during last three decades (1979,2005 and 2018) using multi-temporal satellite data.

Study area

The study area district Kupwara is located in the northern area of Jammu and Kashmir on 34.5262° N and 74.2546° E (Figure 1). Kupwara is considered as the backward frontier district of Kashmir valley. The district is covered with lofty mountains which adds the beauty of the district. These lofty mountains are mainly covered by dense forest area which makes it significant for tourism and wildlife. The District is situated at an average altitude of 5300 feet from sea level. The north-west part of the district faces line of actual control (L.O.C) while the southern portion of the study area is bound by district Baramulla. The district has a major tributary "Pohru" which is considered a main tributary for Jhelum in the northern Kashmir.

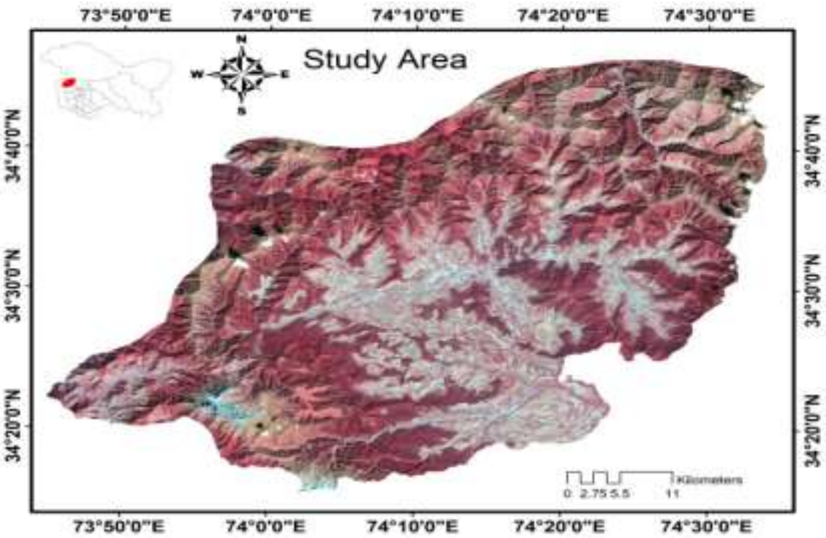

Figure 1. Study Area (District Kupwara)

Materials and Methods

Present studies utilize time series land-sat satellite data of 1979,2005 and 2018 for generating LULC classes. The Landsat data includes Landsat MSS(Multi scanner system), Landsat ETM (Enhanced thematic mapper) and Landsat-8 OLI (Operational Land Imager). (https://www.usgs.gov). Selected image without cloud cover was considered for radiometric and geometric distortions (Lillesand et al. 2014). Using on-screen digitisation at the scale of 1:30000 LULC classes were generated for change identification using virtual image interpretation. The generating classes are Agriculture, horticulture, aquatic vegetation, barren land, built-up, dense forest, pasture, scrub, sparse forest and water body for the year 1979,2005 and 2018. Atmospheric data like Black carbon (BC) precipitation, temperature were acquired from MERRA-2(Modern-Era Retrospective analysis). All the data sets were statistically analysed and were related to land use land cover and socioeconomic changes. Census data were used from the census department at Srinagar (https://www.census2011). These atmospheric and socio-economic data sets were linked with land use land cover classes generated from time-series satellite imagery in GIS format. The field data was collected during filed survey to validate the thematic maps generated from landsat data using cohen's kappa (k) statistics (Dellepiane and Schowengerdt, 1999; Dymond and Johnson; 2002). A total number of 89 GPS Trimble Juno SB (hand-held) points were taken in the accessible areas using the random sampling method as shown in

Figure 2. Trimble handheld GPS was used to collect ground control points from various classes in district Kupwara . The GPS accuracy was improved with "GAGAN" and inbuilt internet support to minimize the positional error (Horizontal) to <1.5 m. Furthermore, GPS points were draped on the map generated from satellite imagery in order to identify the generated LULC classes. For checking the digitization error kappa coefficient calculated . The equation for calculating the Kappa coefficient (given in equation 1).The kappa coefficient is the statistical measurement of the inter-related agreement for qualitative items (Lillesand et al., 2014).

$$K = \frac{N\sum_{i=1}^{t} Xii - \sum_{i=1}^{t}(X_{i+}.X_{+I})}{N^2 - \sum_{I=1}^{r}\left(X_{i+}.X_{+i}\right)} \qquad (1)$$

Where

N= total Number of observation, X_{ii}=number of observations in i column; X_{i+}=Number of Observations in row i; X_{+1}=Number of observations in row i; X_{+1}= Number of observation in column i; r = number of rows in error matrix.

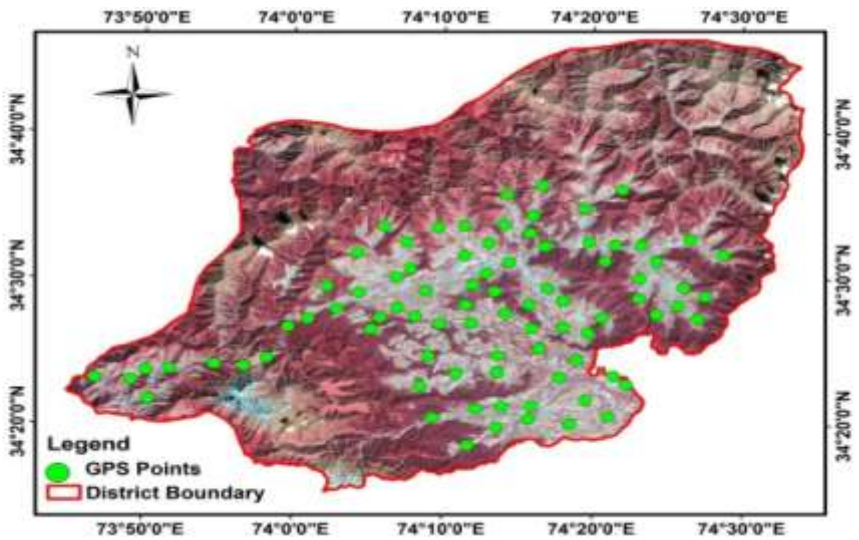

Figure 2. GPS points collected during field for validation

Validation with field Observation

The calculated error matrix is shown in table 1. The kappa coefficient showing the degree of misclassification among classes. The classes for which the error matrix was generated are Horticulture, Built-up, Agriculture, Dense forest, Sparse forest, Scrub ,Barren land, Pasture, Plantation, Water Body. The error matrix results are used to know the overall accuracy of classification as well as class-wise accuracy and kappa statistics, which is essential for knowing the amount of error-free classification. The conventional method of doing accuracy assessment was used.

Kappa statistics is derived below:

KAPPA (K^) STATISTICS

Sum of Diagonals =75
Total Sum=89
Over all accuracy=75/89*100=84.26%
kappa coefficient =0.79
Cohen's kappa coefficient is a statistical measure of interior agreement. It is generally more a robust measure than a simple percent agreement calculation. Kappa coefficient has five categories, namely 0–0.20 as slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial and 0.81–1 as almost perfect agreement. Kappa coefficient derived in this study falls in Substantial category (with value of 0.79 as a substantial area).

Table 1. Error matrix of LULC classes

Class	Agriculture	Horticulture	Built-up	Scrub	Sparse Forest	Dense Forest	Barren Land	Pasture	Plantation	Water Body	Total	Users Accuracy %
Agriculture	**15**	2	0	0	0	0	0	0	0	3	20	75
Horticulture	1	**13**	0	0	0	0	0	0	0	0	14	93
Built up	0	0	**10**	0	0	0	0	0	0	0	10	100
Scrub	0	0	0	**3**	0	0	0	0	0	0	3	100
Sparse Forest	0	0	0	2	**10**	2	0	0	0	0	14	71
Dense Forest	0	0	0	0	2	**12**	0	0	0	0	14	86
Barren land	0	0	0	1	0	0	**5**	**0**	0	0	6	83
Pasture	0	0	0	0	0		0	**1**	0	0	1	100
Plantation	0	1	0	0	0	0	0	0	**3**	0	4	75
Water Body	0	0	0	0	0	0	0	0	0	**3**	3	100
Total	16	16	10	6	12	14	5	1	3	6	**89**	
Producers %	**93.75%**	**81.25%**	**100%**	**50%**	**83.33%**	**86%**	**100%**	**100%**	**100%**	**50%**	**85.94%**	

Results and Discussion

LULC classes were generated of northern district "Kupwara" of Jammu & Kashmir India using on-screen digitisation technique on scale 1:30000 (Figure 3).The generated classes are Agriculture, Horticulture, Barren land, Built-up, Dense Forest, Pasture, Plantation, Scrub, Sparse forest, Water Body. A significant decrease in the area of agriculture, dense forest and water body has been observed. At the same time a significant increase in the area of Horticulture, Barren land, Built-up, Pasture, Plantation, Scrub and Sparse Forest. The area of agriculture, Dense forest and Waterbody underwent a significant decrease of 38.344% ,28.706 and 25.842 respectively from 1979 to 2018.Reported increase in Horticulture, Barren land, Built-up, Pasture, plantation, Scrub and sparse forest with 35.407%, 9.05%, 206.22%, 29.693%, 319.226%, 61.272% and 45.789% respectively. The area of agriculture was reduced by 38.34% from 1979 to 2018. Significant decrease of agriculture in study area is attributed by decadal decrease of 1% in precipitation from 1980 to 2018 figure 6 (Rafiq et el., 2018).The decreased land of agriculture was converted to horticulture. The study area experiences 35.407% increase in horticulture. As horticulture which is understood cash crop as compared to agriculture generates six times more income (Meer & Mishra 2019).An increase in built up of 206.22% has been reported in the study area. The drastic increase in the built-up area is attributed to increase in population over study area. The study intensifies that total population of the area was increased 25.28% from 6.50 lakhs year (2001) to 8.70 lakhs year (2011).The built up area is increased at the expense of agriculture land. Dense forest were decreased by 28.706% from 1979 to 2018.The decrease in dense forest were observed at the expense of increased sparse forest which shows increase of 45.789% from 1979 to 2018. Scrub show increase of 61.272% from 1979 to 2018.The area of scrub is increased on expense of dense forest to sparse forest and finally to scrub. During same period pasture has increased by 29.693%.

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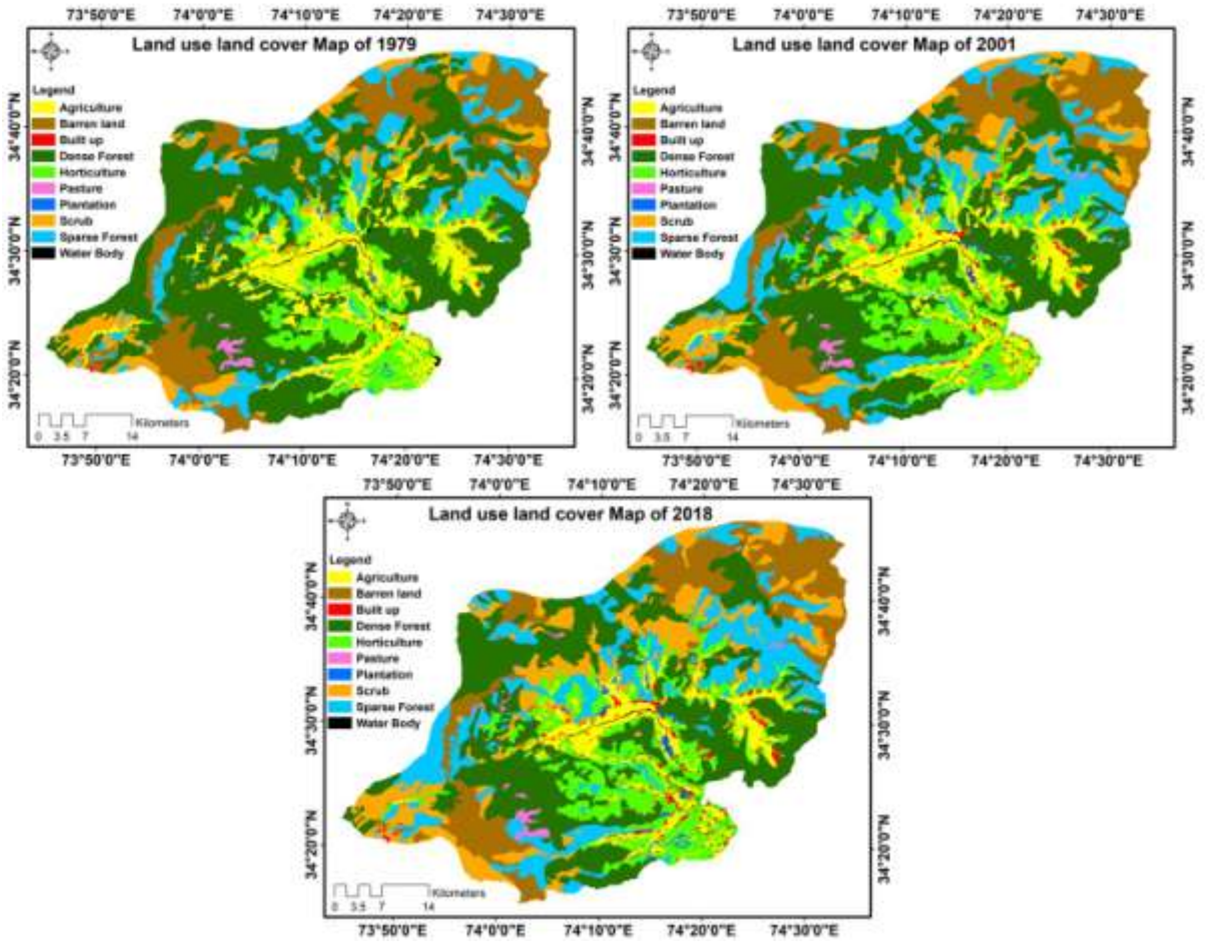

Figure 3. Showing the land use land cover changes in study area

An increase of about 35.40% of horticulture has been analysed over study area .The increase of horticulture may increase BC(black carbon) over the study area. The population of the study area use horticulture by-products for cooking and keeping themselves warm especially during winter. Thus the increased horticulture causes significant increase in Black carbon. As we have reported a 2.9% increase of black carbon over study area (figure 4).The increase of BC is a serious concern for life. An increase in black carbon causes warming over the study area (Yasunari et al., 2015).The increase of BC experiences an increase in 2% temperature over the study area (Figure 5). The increase of BC is attributed to increase in horticulture and forest fire over study area. Increased black carbon also affect air traffic (due to smog formation) ,health care, and contributes in glacier melting by increasing regional temperature.

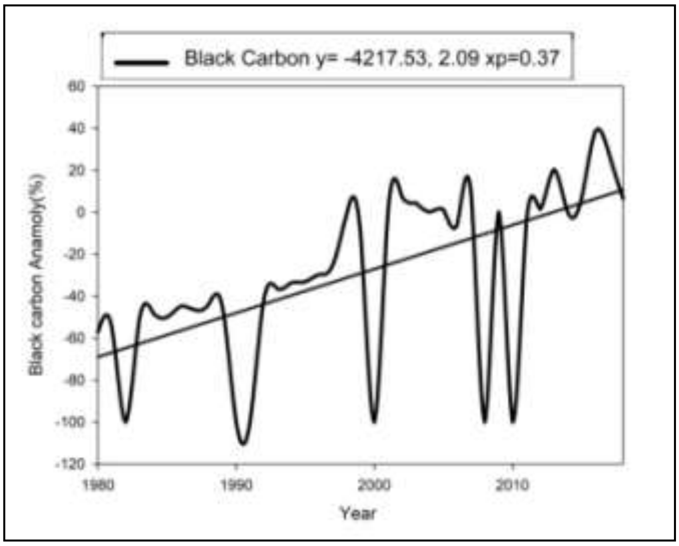

Figure 4.Showing Trend in Black Carbon

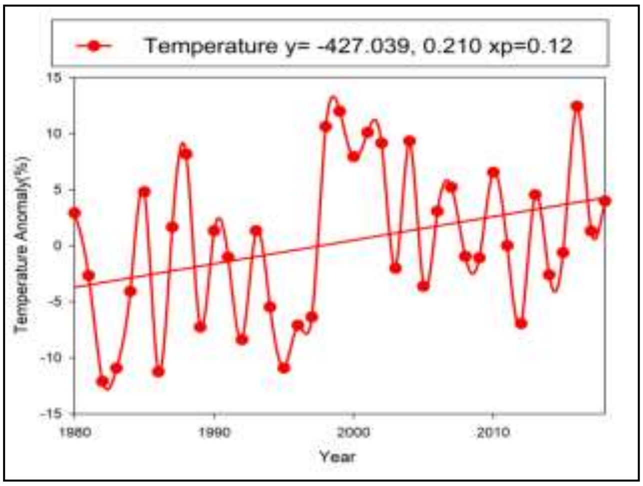

Figure 5.Showing trend temperature of the study area

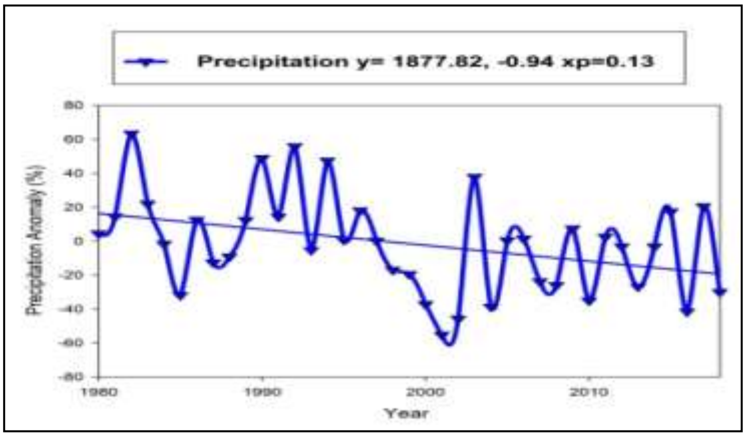

Figure 6.Showing trend in Precipitation in study area

Conclusion

The study highlights the changes in LULC and their linkage with the atmosphere over study area. The increase in horticulture ,Built-up, sparse forest, Pasture and barren land with a significant decrease in agriculture ,water body and dense forest over the study area. The decline in the area of dense forest and incline in the area of horticulture attributes an increase of black carbon and contribute to warming. The increase in the warming results disturbance in precipitation patterns over study area. (Rafiq and Mishra 2018; Mishra and Rafiq 2017). The disturbance in area of LULC has affected the natural ecosystem of the study area causing a serious threat to surrounding life. There is a need of framing effective government policies for minimizing the land use land cover changes over study area.

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