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RESEARCH ARTICLE

Remote Sensing Application for Exploring Changes in Land-Use and Land-Cover Over a District in Northern India

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Abstract
This study aims to detect land-use and land-cover changes in Baramulla district of Kashmir valley using geospatial technology. This district is affected by large-scale changes in agriculture, horticulture, built-up and dense forest. Satellite data of 1979, 2001 and 2018 are used to generate land-use and land-cover classification using on-screen digitization. This classification includes agriculture, horticulture, built-up, dense forest, barren land, water body, pasture, scrub and sparse forest. Furthermore, census data of 2001 and 2011 are correlated with the thematic maps generated from on-screen digitization. Environmental driving factors like precipitation, temperature and black carbon (BC) data were used to relate with land-use and land-cover changes over the study area. The present research reports a decrease of about 54.99% in agricultural area form 1979 (401.81 km^2) to 2018 (180.87 km^2). Furthermore, horticulture has increased by 35.52% from 1979 (334.38 km^2) to 2018 (518.65 km^2). Dense forest shows a decrease of about 27.46% from 1979 (777.54 km^2) to 2018 (563.99 km^2). We also report a decadal increase of about 7.71 nm during winter and 3.47 during summer in black carbon. Increase in BC concentration and temperature over study area results in snow melt. We also report an annual decreasing trend of about 1.74 cm in precipitation over study area. Decrease in precipitation results in conversion from agriculture to horticulture. Results presented in this research highlight the importance of policy making to minimize the rapid changes in land-use and land-cover over study area.

Keywords Climate change · Land-use and land-cover change · RS and GIS

Introduction

Research on land-use and land-cover (LULC) provides a base for exploration of natural resources. Increases and decreases in local populations may have large impact on land-use and land-cover. Demographic changes include not only changes in fertility and mortality but also shifts in household structure and dynamics that include labour availability, migration, urbanization and the breakdown of extended families into multiple nuclear families (Lambin et al. 2003; Bloom and Canning 2004). It may be noted that natural environmental changes in combination with the human decision-making processes may cause land-use and land-cover changes. Under climate change scenario, exceedingly moveable ecosystem conditions intensify the stresses arising from high stress on land resources (Foley et al. 2005). Natural changes in land-use and land-cover may also lead to socio-economic unsustainability (Munasinghe 1993).

Exploring LULC changes over complex terrains is a challenging task. Remote sensing and geographic information system (GIS) offer an opportunity to explore changes in LULC. Cihlar (2000) presented a review of techniques for exploring LULC changes over various parts of the globe. An approach based on integrating remote sensing and GIS was utilized by Rawat and Kumar (2015) to examine the changes and LULC over a complex terrain in Uttarakhand. Landsat satellite observations of two different time periods, i.e., landsat thematic mapper (TM) of 1990 and 2010 were acquired by global land cover facility site (GLCF) and earth explorer site to explore the changes from 1990 to 2010 over a period of 20 years over study area. Integration of remote sensing and model was used to

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assess the changes in LULC over a costal desert region in Europe (Halmy et al. 2015). Liping et al. (2018) explored LULC changes over a hilly region in China using remote sensing and GIS. This study also predicted the future changes in LULC by integrating cellular automata and Markov chain analysis. Sajjad and Iqbal (2012) examined changes in LULC over Kashmir and linked them with urbanization using remote sensing and GIS approach. Impact of LULC changes over water quality of Jhelum River in Kashmir was assessed by Rather et al. (2016). This study demonstrated the integrated approach utilizing the multivariate statistical techniques, data from remote sensing, lab and field-based observations for quantifying the impact of massive land system changes on water quality of the river Jhelum.

Past studies put focus on exploring land-use and land-cover changes and their implications on climatic variables (Bae et al. 2008). It is interesting to note that increase in horticulture and decrease in agriculture land depict the picture of adaptation due to climate change. Furthermore, changes in economic classes are very crucial for sustainability and competition. Increase in temperature is observed with an increase in precipitation extremes over the valley of Kashmir (Rafiq et al. 2016; Rafiq and Mishra 2016, 2018; Mishra and Rafiq 2017). The increase in horticulture in Lidder valley and decrease in agriculture are attributed to decline in precipitation and increase in temperature. This causes decline in demographic area of agriculture cultivator's population (Rafiq et al. 2018). Thus, these changes in land-use and land-cover causes socio-economic changes (Malik and Bhat 2015; Rafiq et al. 2018). Furthermore, the winter tourism may get severely affected due to decline in snowfall and extreme weather events which may often block roads and trigger natural disasters (Rafiq and Mishra 2018). This also affects the natural resources of the region (Rafiq and Mishra 2016).

The study of land-use and land-cover change is very important in the northern state of India which experienced rapid growth of population in recent decades from 1981 to 2011 (Rafiq and Mishra 2018). Remote sensing offers a unique opportunity to explore land-use and land-cover changes. This study focuses on exploring land-use and land-cover changes over Baramulla district in Kashmir valley of India using remote sensing and GIS. Environmental and socio-economic aspects have also been explored.

Study Area

The present study was carried for district Baramulla of Jammu and Kashmir in North India and is shown in Fig. 1. Study area is located at 34.198 N, 74.3636 E and covers an area of about 20204.06 km^2 approximately. This district belongs to northern India. The district is located on the bank of river Jhelum (the main tributary of Kashmir valley originating from Verinag from south Kashmir of district Anantnag). Jhelum River is the main

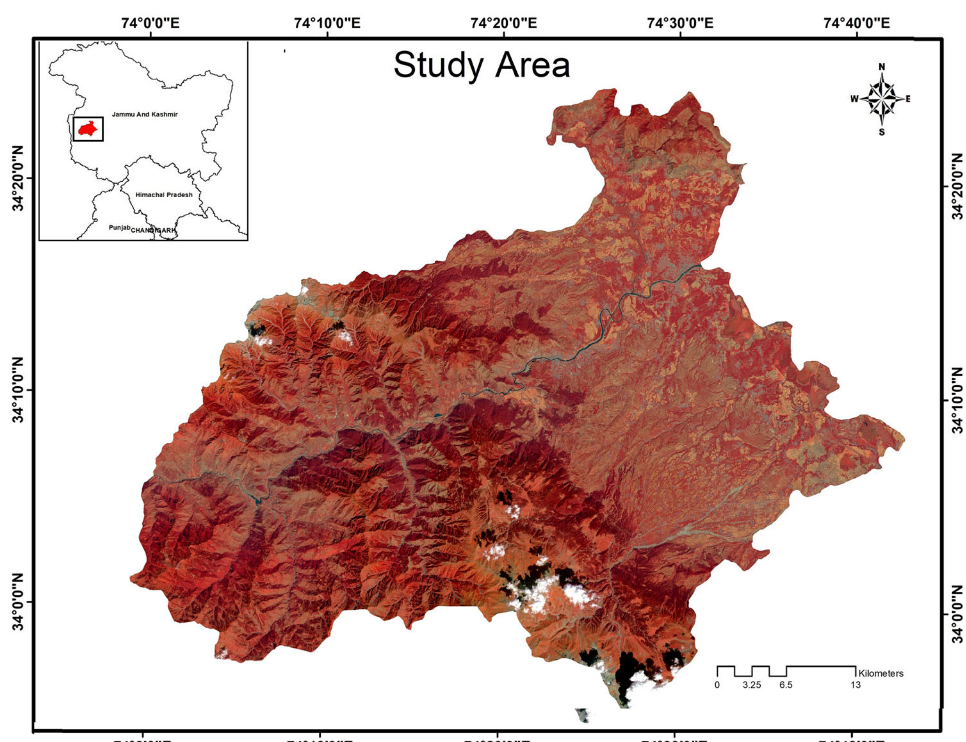
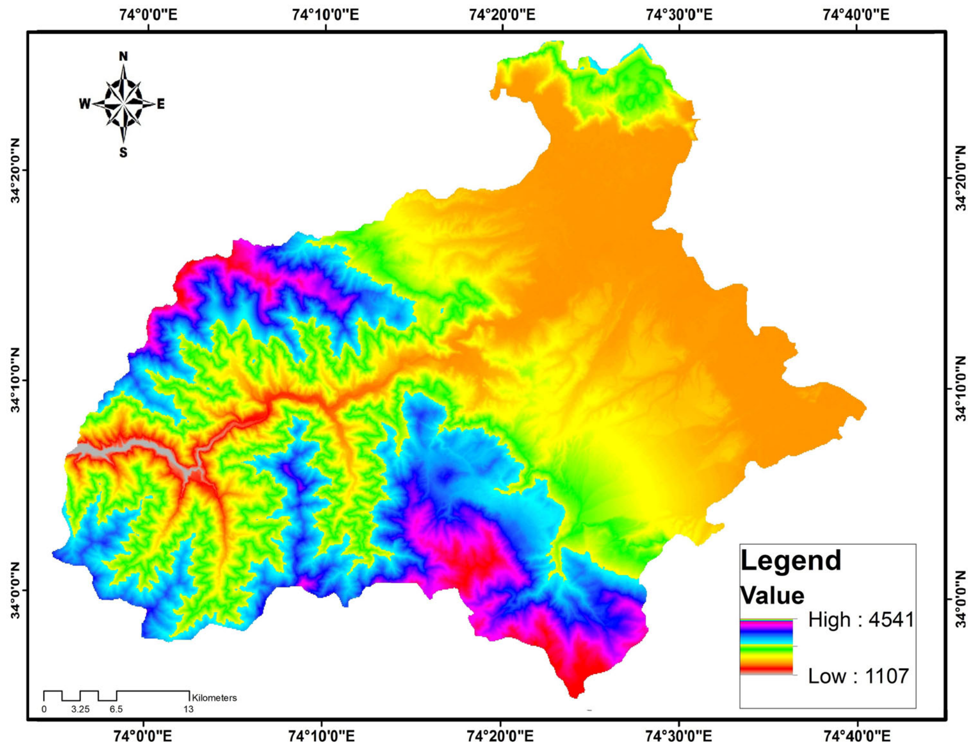


Fig. 1 Study area

Fig. 2 DEM of study area



source of water and income for the valley. The topography of study area is mainly hilly with lofty mountains of Himalayan range of Pir Panjal series terrain with the elevation ranges from 1107 to 4541 metres as shown in Fig. 2.

Materials and Methods

This study utilizes Landsat satellite data of 1979, 2001 and 2018 (Table 1) for analysing. These datasets include Landsat MSS, Landsat ETM + and Landsat 8 imagery data (https://www.usgs.gov). Image without cloud cover were utilized and were subjected to radiometric and geometric distortions (Lillesand et al. 2014). Land-use and land-cover changes were analysed by virtual image interpretation in order to generate data as horticulture, aquatic vegetation, barren land, built-up, dense forest, pasture, scrub, sparse forest and water body for the years 1979, 2001 and 2018 at scale of 1:30000. Black carbon (BC) data were acquired from MERRA-2. We have used gridded precipitation data from India Meteorological Department (IMD) in the present study. Temperature and black carbon from MERRA 2 have been used in the present study. All the datasets were statically analysed and related to land-use and land-cover and socio-economic changes. Census data were procured from the census department at Srinagar. These data were linked to land-use and land-cover cover maps generated from time-series satellite imagery in GIS environment. Various parameters which were directly or indirectly linked with land-use and land-cover changes were considered. The schematic diagram of methodology is shown in Fig. 3. We have used data from field survey to validate the thematic maps generated from landsat data. A total number of 79 GPS [Trimble Juno SB (hand-held)] points were taken in the accessible areas using the random sampling method as shown in Fig. 4.

Table 1 Details of satellite data used in the present study

S. no.	Satellite	Data and path/row	Spatial resolution (m)
1	Landsat MSS	06 November 1979	57
2	Landsat ETM+	30 October 2001	28.05
3	Landsat 8	10 October 2018.	15

Validation with Field Observation

Figure 5 shows the location of GPS points for validation purpose. Table 2 shows error matrix of three classified images, i.e., Landsat MSS 1979, Landsat ETM + 2001 and Landsat 8 that display statistics for assessing image classification accuracy by showing the degree of misclassification among classes. The various classes for which error matrix was generated are horticulture, built-up, agriculture, aquatic vegetation, dense forest, sparse forest, scrub, barren land, pasture, water body and are shown in Table 3. The error matrix results are useful for knowing the overall classification accuracy as well as class-wise accuracy and kappa statistics, which is essential for knowing the amount of error-free classification (Figs. 5 and 6). SOI map was used for the accuracy assessment for the Landsat MSS 1979. So, this conventional method of doing accuracy assessment was used. Kappa statistics is derived below:

KAPPA($K^{\wedge}$)STATISTICS

$k = (\mathrm{pr}\ (a) - \mathrm{pr}\ (e) / (1 - \mathrm{pr}\ (e) = 0.67$

Sum of diagonals $= 59$

Total sum $= 79$

Over all Accuracy $= 59/79 * 100 = 74.68\,\%$

where Pr (a) is the relative observed agreement among rates, and Pr (e) is the hypothetical probability of chance agreement, using the observed data to calculate the probabilities of each observer randomly saying each category. Cohen's kappa coefficient is a statistical measure of inter-rater agreement. It is generally thought to be a more robust measure than simple per cent 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 moderate category (with value of 0.67 as substantial area).

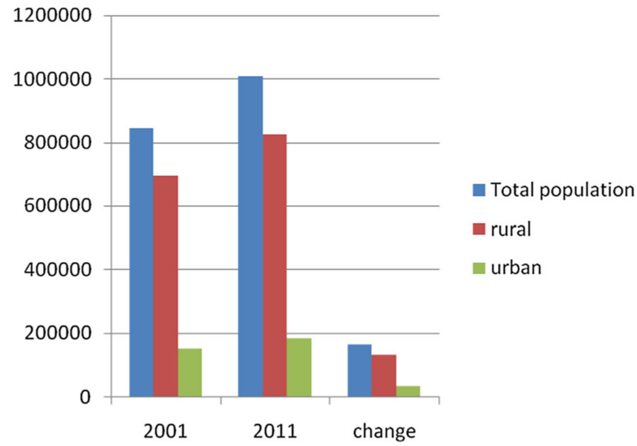


Fig. 4 Total population (census data) from 2001 TO 2011(urban rural)

Results and Discussions

GIS database was developed for land-use and land-cover detection. Detailed land-use and land-cover was generated by on-screen digitization on scale of 1:30000. Land-use and land-cover was classified into different classes including agriculture, water body, marshy land, dense forest, horticulture, built-up, sparse forest, scrub, pasture and barren. Figure 6 illustrates the Areas of LULC in 1979, 2001, 2018 and changes in areas from 1979 to 2018. Figure 7 shows that there are large negative change in the area

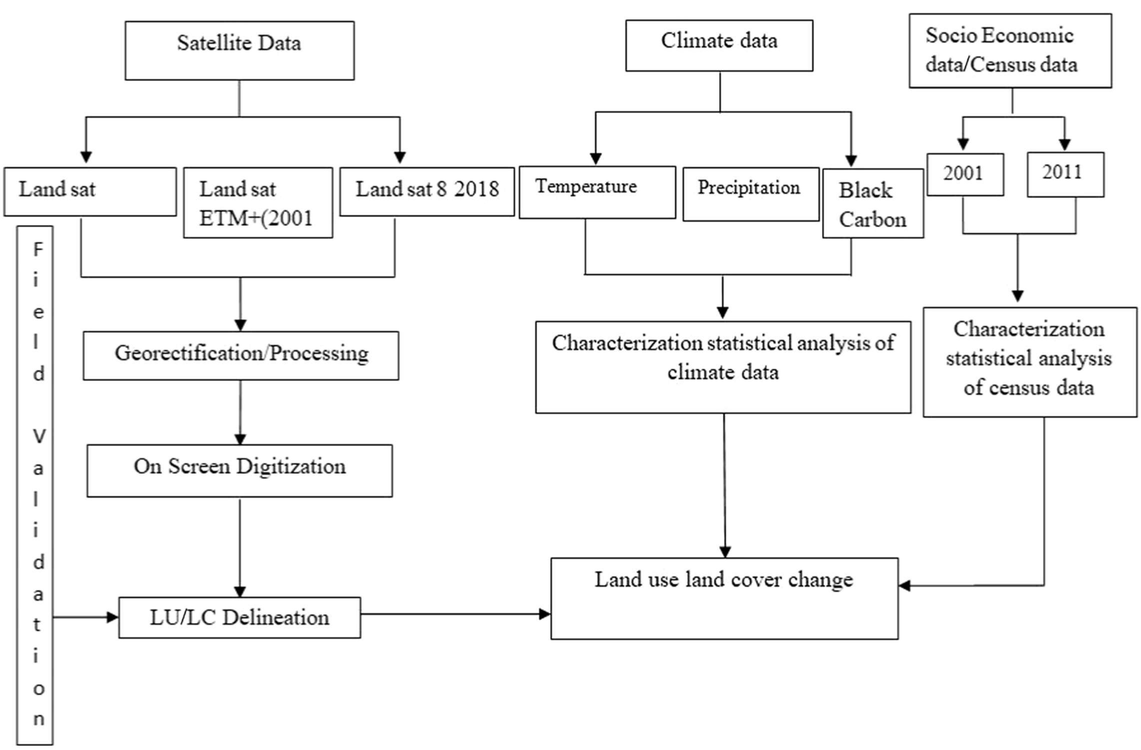


Fig. 3 Flow chart of methodology

Table 2 Changes in land-use and land-cover from 1979 to 2018

Category	Area (km^2) (1979)	Area (km^2) (2001)	Change from 1979–2001 (km^2)	% Change from 1979–2001	Area (km^2) (2018)	Change from 1979–2018 ((km^2))	% Change from 1979–2018
Agriculture	401.81	304.3	− 97.51	− 24.27	180.87	− 220.94	− 54.99
Barren land	235.6	266.65	31.05	13.18	294.6	59	25.04
Built-up	32.39	74.31	41.92	129.42	127.18	94.79	292.65
Dense forest	777.54	688.65	− 88.89	− 11.43	563.99	− 213.54	− 27.46
Horticulture	334.38	441.62	107.24	32.07	518.65	184.27	55.11
Pasture	59.34	75.32	15.98	26.93	86.59	27.24	45.90
Scrub	223.04	224.23	1.19	0.53	232.29	9.25	4.15
Sparse forest	96.14	111.77	15.63	16.26	181.79	85.65	89.09
Water body	28.68	17.21	− 11.47	− 39.99	18.1	− 10.59	− 36.92
Marshy land	15.14	0	− 15.14	− 100.00	0	− 15.14	− 100.00

Table 3 Error matrix of LULC classes

Class	Agriculture	Horticulture	Built-up	Scrub	Sparse forest	Dense forest	Barren	Water body	Total	Users accuracy %
Agriculture	**10**	3	0	0	0	0	0	5	18	55.56
Horticulture	4	**8**	0	0	0	0	0	0	12	66.67
Built-up	0	0	**10**	0	0	0	0	0	10	100.00
Scrub	0	0	0	**8**	0	0	0	0	8	100.00
Sparse forest	0	0	0	0	**6**	3	0	0	9	66.67
Dense forest	0	0	0	0	3	**5**	0	0	8	62.50
Barren	0	0	0	2	0	0	**6**	0	8	75.00
Water Body	0	0	0	0	0	0	0	**6**	6	100.00
Total	14	11	10	10	9	8	6	11	79	
Producers %	71.43%	72.73%	100.00	80.00%	66.67%	62.50%	100.00%	54.55%		

of agriculture, water body, marshy land and dense forest. We also report a positive change in the area of horticulture, built-up, sparse forest, scrub, pasture and barren land from 1979 to 2018.

We also report a decrease of about 54.99% in agricultural area from 1979 to 2018. This decrease is attributed to reduction in precipitation over study area as shown in Fig. 8. It is important to observe that agriculture requires more water as compared to horticulture. Decrease in agriculture is observed at the expense of increase in horticulture over study area. It is interesting to note that horticulture is increased by about 55.1% from 1979 to 2018. Horticulture gives six times more benefit than agriculture (Romshoo et al. 2018; Rafiq et el. 2018).

We report an increase of about 16% in total population from 2001 (843,892) to 2011 (1,008,039) over study area. Increase in built-up is consistent with the increase in total population of study area. It can be seen that the built-up has increased by about 292% from 1979 (32.39 km^2) to 2018 (127.18 km^2) as shown in Table 4. It is reported that increase in built-up area is observed at the expense of agricultural land (Fig. 9).

The study area includes a part of Asia's larges freshwater lake (Wular) which changed a lot causing a decrease in agricultural land. Decrease in agricultural land affects aquatic land and marshy land. It may be noted that the fresh water area of lake is decreased by about 65.60% from 1979 (84.57 km^2) to 2018 (29.09 km^2) and is shown in Figs. 10 and 11. Furthermore, water bodies in the study have decreased by about 36.92% from 28.68 km^2 (in 1979) to 18.10 km^2 (in 2018). Furthermore, marshy land shows complete extinction in 2018. Marshy land was converted to agriculture and horticulture.

Dense forest is decreased by about 27% from 777.54 km^2 (in 1979) to 563.99 km^2 (in 2018). Decrease in dense forest is observed at the expense of increase in sparse forest which shows an increase of about 89.09% from 96.14 km^2 (in 1979) to 181.79 km^2 (in 2018). Scrub is increased by about 4.15% from 223.04 km^2 (in 1979) to 232.29 km^2 (in 2019). Pasture has been increased by about

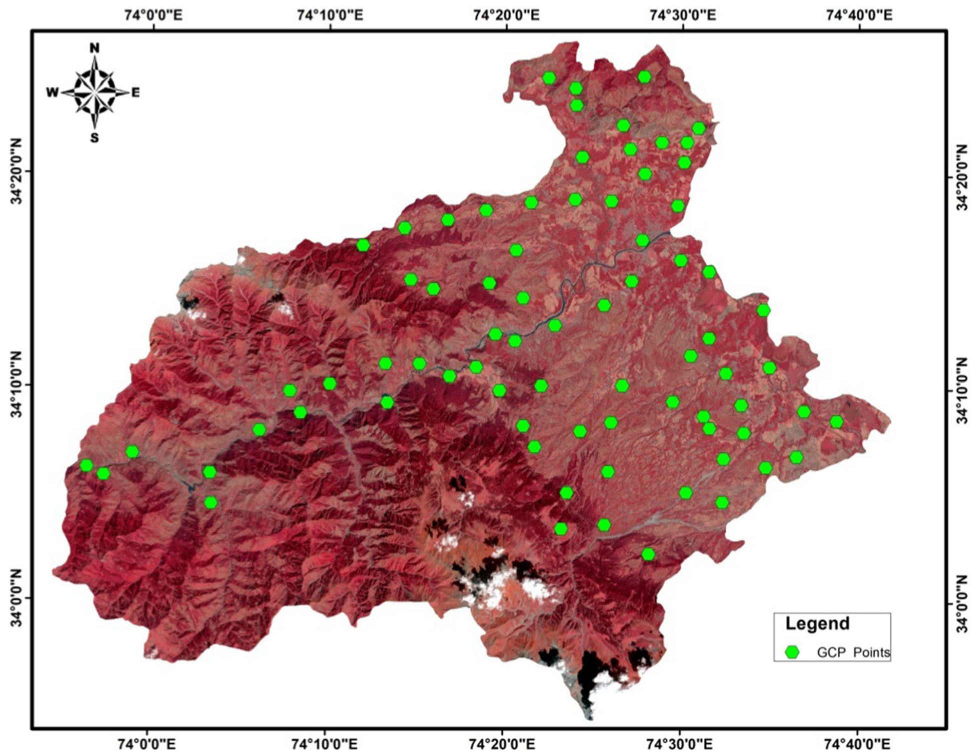


Fig. 5 GPS points collected during field survey

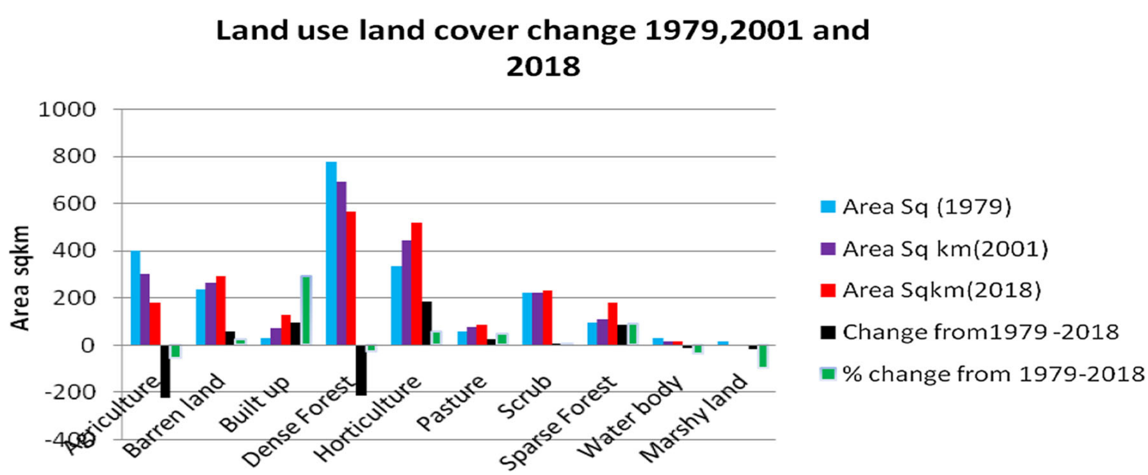


Fig. 6 Land-use and land-cover changes from 1979 to 2018 over study area

45.90% from 59.34 km^2 (in 1979) to 86.59 km^2 (in 2018). Increase in pasture may be attributed to increase in landslides and overgrazing. Table 3 shows that barren land is increased by about 25.04% from 235.60 km^2 (in 1979) to 294.60 km^2 (in 2018), respectively. Increase in barren land is attributed to various factors including snow avalanche and land slides as a result of increase in natural disasters. It may be noted that there has been significant increase in natural disasters over the study area (Mishra and Rafiq 2017). Increase in barren land presents a serious threat to ecosystem and sustainable development of study area.

It may be concluded that the conversion of land-use and land-cover from dense forest to barren land is accelerated by increase in population, built-up and uncontrolled grazing activities in forest area. Additionally, increased landslides over study area as a result of climate change-induced heavy rainfall events may also result in significant change in land-use and land-cover (Mishra 2015).

We also report a significant increase in the population of rural areas. It can be noted that there has been an increase of about 19% in rural population from 2001 to 2011. The population of urban area is increased by 22% from 2001 to 2011. Increase in total population has huge impact on land-

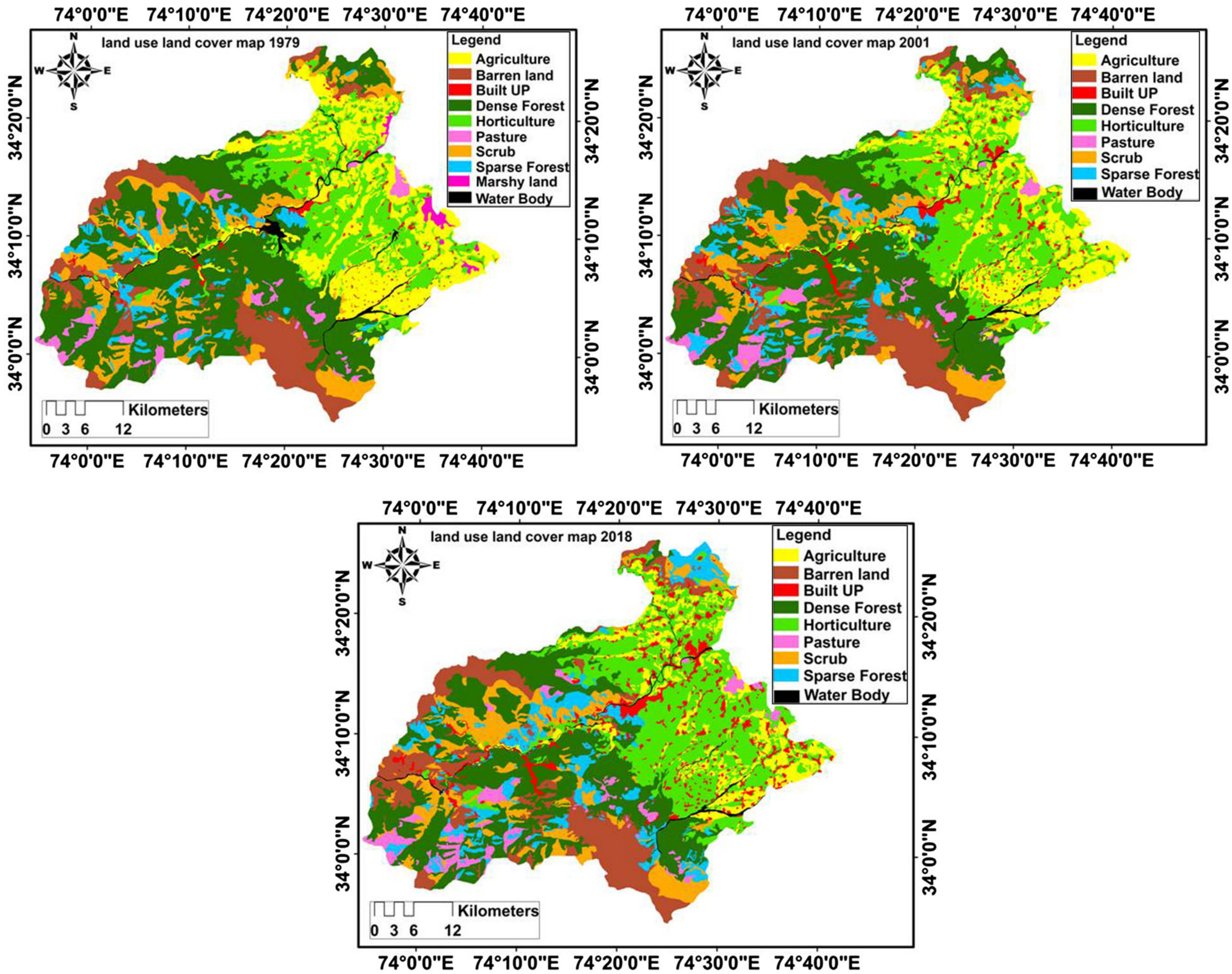


Fig. 7 LULC maps of 1979, 2001 and 2018

Fig. 8 Variability of annual precipitation (rainfall) and temperature

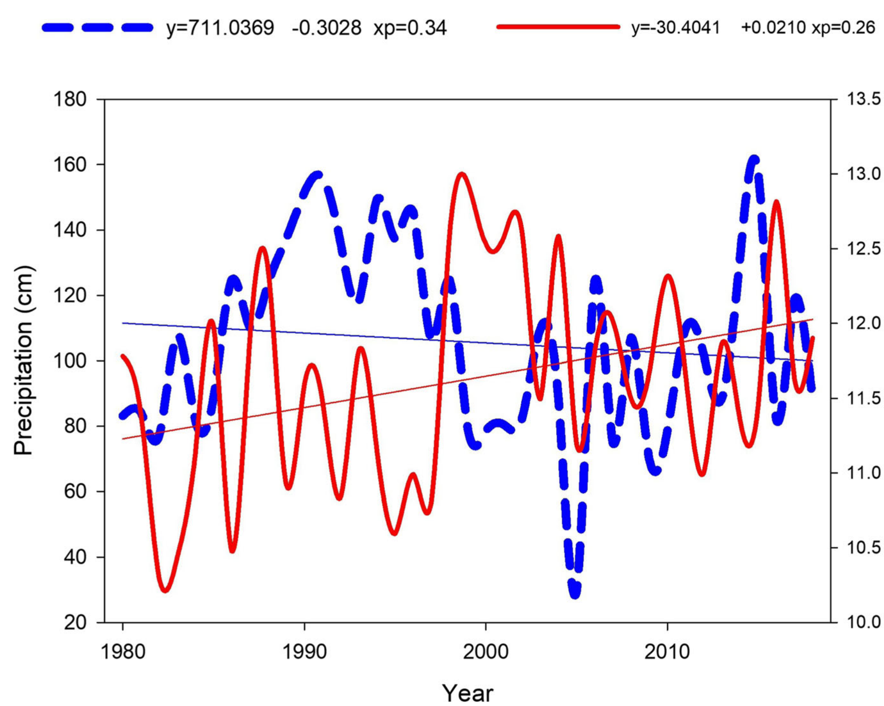


Table 4 Census data of 2001 and 2011 over study area

Data type	2001	2011	Change from 2001 to 2011
Total population	843,892	1,008,039	164,147
Rural	693,992	825,539	131,547
Urban	149,900	182,500	32,600

use and land-cover. Increase in LULC changes are more over rural areas as compared to urban region. This may be attributed to the fact that increase in rural population is more as compared to urban population.

The annual average IMD-gridded data show a significant decreasing trend in precipitation. Conversion from agriculture to horticulture may be attributed to decrease in precipitation over study area. We also report a significant increase of about 0.34 °C temperature, respectively, over the region from 1980 to 2018. Increased warming over study area causes a decrease in soil moisture which affects agricultural productivity (Fig. 8). Changing characteristics of snowfall in the context of anthropogenic warming also presents a major challenge to the tourism and socio-economic growth over the study area (Mishra and Rafiq 2017).

Recently, Mishra and Rafiq (2017) reported a decline of about 24% in snowfall per unit degree increase in temperature over the study area. They also attributed this decline to increase in black carbon concentration over study area which is produced from burning of wastage from increased horticulture over study area.

Figure 9 shows the variability of BC over study region during winter and summer. Increase in BC is more during winter season as compared to summer season. Winter brings misery to the population over study area. Roads are blocked due to heavy snowfall which cuts the supply of cooking gas. It is noted that population over study area burn horticulture by-products for cooking and keep themselves warm. Increase in BC during winter is more (double) as compared to the summer season. Thus, increased horticulture results in increased BC which causes increase in regional temperature over study area.

This increase is consistent with an increase in horticulture. Bhat et al. (2017) also reported a significant increase in black carbon as a result of burning of biomass over the study area. This increase in black carbon also affects the flight/traffic operations by reducing the visibility especially during winter season.

Conclusion

The present research reports a significant change in land-use and land-cover over study area. These changes affect different dimensions of environment and socio-economic sustainability. The increase in horticulture, built-up, sparse

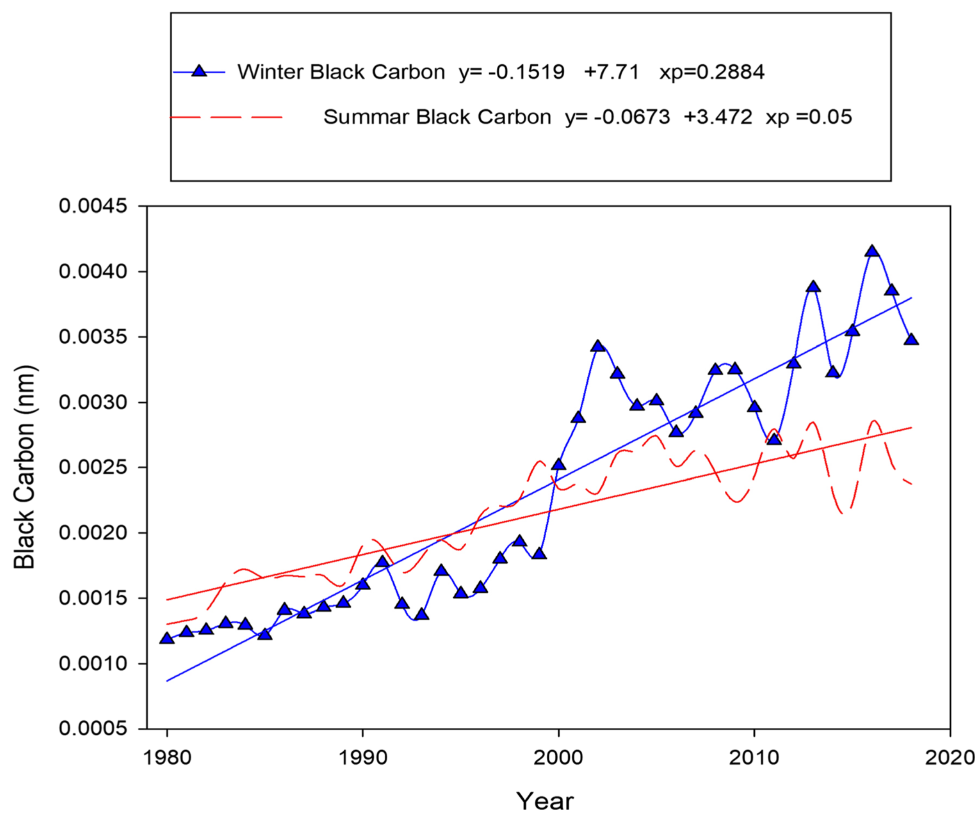


Fig. 9 Variability of black carbon during winter and summer from 1980 to 2018

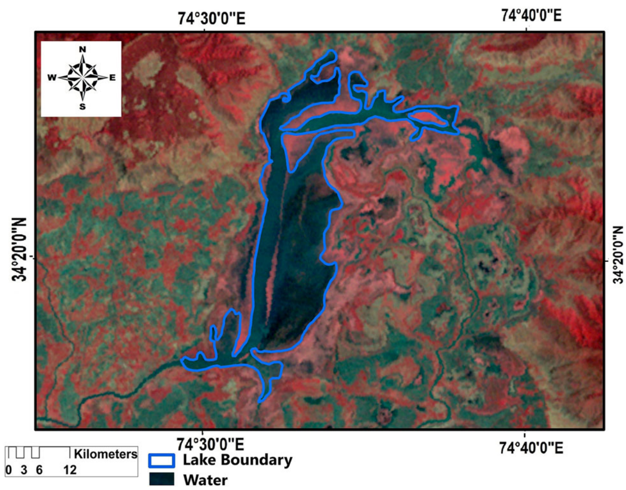


Fig. 10 Area of Wular lake in 1979

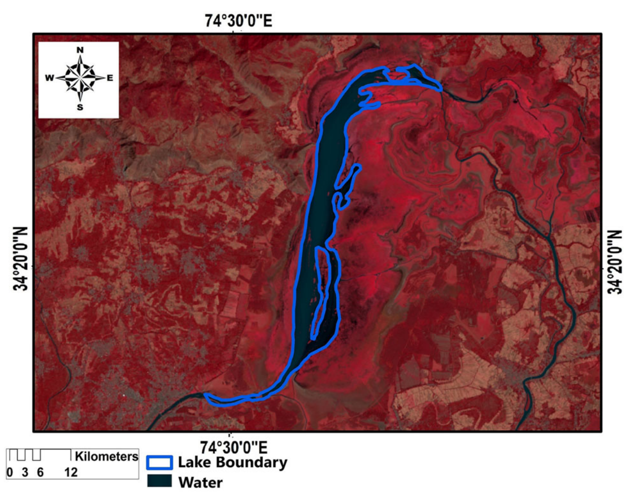


Fig. 11 Area of Wular lake in 2018

forest, scrub, pasture and barren and decrease in agriculture, water body, marshy land have been reported in this study. These changes in land-use and land-cover are linked to climate change. Increased floods and droughts as a result of climate change-induced increased precipitation extremes cause decrease in agricultural production. Increased horticulture has been resulted in the expense of agriculture. Burning of biomass from increased horticulture may result in increased black carbon which causes serious threat to ecosystem. Decrease in dense forests also results in black carbon increase over study area. Apart from anthropogenic activities, climate change-induced natural disasters like landslides and snow avalanche also play a key role in land-use and land-cover changes. Increase in the growth of aquatic vegetation causes a significant decline in carrying capacity of water body due to increased siltation load. Decreased carrying capacity of water body results in heavy flooding during heavy rain events (Mishra 2015). Furthermore, increased aquatic vegetation leads to biological oxygen demand causing serious threat to human health. It can be concluded that there are significant changes in land-use and land-cover as a result of anthropogenic activities. These changes in land-use and land-cover affect the ecosystem of study area. Given the inaction of mitigation of these anthropogenic activities, adaptation and mitigation strategies are imperative against these changes.

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