Analysis of landuse and landcover changes in Kashmir valley, India—A review

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Abstract   Among all the natural and human forces acting on the land surface and shaping Landuse and Landcover (LULC), anthropogenic actions have been a dominant force, which has caused dramatic changes to the LULC throughout the globe. The situation of Kashmir Himalayas is no different. LULC changes are rampant and a cause for several environmental problems in the region. Under the changing climate regime and ever-growing anthropogenic pressures, the long-term analysis of LULC has become a necessity. The present study attempts to track the LULC change through a systematic review of literature, to analyse and discuss the trends and patterns of LULC dynamics in Kashmir Valley. The findings from several studies concerning the region that have applied geospatial technology to detect changes in LULC reveal that the changes have occurred at a faster pace in the last 20 years. Major landuse classes such as agriculture, forest, water, snow, and glaciers have shown a declining trend, in comparison to horticulture and built-up that has shown an increasing trend. These changes in LULC have far-reaching impact on the economy of the region. Climate change, population growth, economic compulsion, and unplanned development among others are the major causes /drivers of intensified LULC changes in the region.

Keywords   Climate change · LULC · Remote sensing and GIS · Land transformation · Kashmir valley · India

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Introduction

The widespread Landuse and Landcover (LULC) changes at regional scale have extensive implications on the environment (Shafiq et al., 2017). Landuse change is considered one of the major drivers of environmental change; it is one of the most important issues of environmental change witnessed at the global level and a key component to understand the various changes associated with the catchment characteristics and the man environment interactions (Nisar & Lone,

2013). Changes in LULC that are largely being altered by the human interference have considerable impacts on the Earth's Landscape, thus disturbing energy balance, chemical fluxes, and mixture which impact climate of the earth (Bae et al., 2015). Besides the emission of heat trapping greenhouse gases from various sources like industries, agriculture and other anthropogenic activities, climate of the earth is also affected by the humans through the changes in land use and land cover. This is due to a number of activities taking place on the surface of land, like cutting of trees, food growing and building of cities etc. (Loveland et al., 2012). LULC dynamics in the mountainous regions have wider ramifications, because the ecosystem is delicate and therefore it is more vulnerable to the negative impacts of such change. Cutting of trees, unplanned growth of settlements, bad agricultural practices, developmental activities and lack of proper planning and management have wide range of implication in mountainous regions (Shafiq et al., 2017). From the past few decades, human beings have changed these landscapes in order to fulfil their ever-increasing demands particularly for the basic needs like (food, fodder, timber and fuel) more rapidly than in any comparable period of time (Nisar & Lone, 2013; Millennium Ecosystem Assessment, 2005). Besides that, changes in natural environmental and human decision-making processes have also become one of the causes of land use changes. The change pattern of land use and land cover has reached up to such an extent that it has considerably affected the functioning of the biosphere, consequently becomes one of the main causes of the biodiversity loss and the climate change (Singh & Andrabi, 2014). The information of the land use/land cover is prerequisite for the selection, planning, policymaking, and implementation of management strategies in order to meet the growing demands for basic needs and welfare of the increasing human population (Pelorosso et al., 2009; Arveti et al., 2016).

Over the past few years, analysis of LULC change has become a serious concern before the scientific community because changes in LULC have been identified as a one of the important factors which is accountable for modifications in the environment worldwide (Xiao et al., 2006). Anthropogenic activities have widely altered the surface of the earth to analyse such changes that has happened over time is known as change detection. Therefore, we can define change detection as the process, which is used to identify the state of phenomena by observing/analysing it at different time points (Saini et al., 2019; Singh, 1989). India is one among the developing nations, which inhabits around 1.3 billion people as per the estimates of Census 2011. The increasing population and rapid urban growth are becoming common in various parts of India, which has led to the large-scale changes in the landuse from the past few decades. Hence, it is imperative to analyse urban growth, timely and accurate change detection of LULC features (Tiwari et al., 2018). It is also an important indicator to monitor and assess the anthropogenic impacts on environment. Furthermore, LULC changes also reflect the intensity at which human beings have modified and altered the earth's environment.

Remote sensing coupled with Geographic Information System plays an important role in collecting sufficient amount of data on LULC changes (Tiwari et al., 2018; Bauer et al., 2005). However, LULC changes in the past have been analysed using traditional surveys and inventories, but satellite based remote sensing and GIS is considered more useful and advantageous as far as cost and time saving is concerned. Furthermore, it provides a large-scale data on LULC changes and information about their geographical distribution (Serra et al., 2008; Hathout, 2002; Yuan et al., 2005). Nisar & Lone, (2013) has carried out a study on LULC changes in the Sind watershed for 10 years i.e., 1995–2005. Saini et al., (2019) has carried out change detection of LULC in Srinagar district. Singh & Andrabi, (2014) analysed the LULC dynamics in Baramulla district of Jammu and Kashmir. Fayaz et al., (2020) carried out an assessment of spatiotemporal changes in land use/land cover of North Kashmir Himalayas from 1992 to 2018. Besides that, a number of studies pertaining to LULC changes in the various parts of the Kashmir valley have been carried out by (Amin and Fazal 2012; Shafiq et al., 2017; Iqbal & Sajad, 2014; Singh & Andrabi, 2014; Romshoo et al., 2011; Fayaz et al., 2020; Malik et al., 2017).

Drastic changes in LULC have been witnessed in the Kashmir Himalayas and are accelerating at a considerable rate as well, causing a number of environment related issues in the region (Shafiq et al., 2017; Singh & Andrabi, 2014). These changes may be attributed to the increase in economic growth,

population, changes in agricultural practices, and particularly due to the execution of various developmental projects since the past 20 years. In light of the above discussion on LULC, the present study attempts to analyze the LULC change dynamics of Kashmir region through a systemic review of literature. The next sections of this paper include: (1) description of study area (2) summary of literature (3) application of geospatial technology (4) LULC annual rate of changes (5) drivers, and finally (6) concluding remarks.

Study area

Kashmir valley, engulfed between the Pir-Panjal range (South-West) and Greater Himalayas (Northeast) is the largest valley of Union territory of Jammu and Kashmir. Jhelum River originating from a perennial spring known as Verinag drains the valley of Kashmir up to 725 km (450 miles). Jhelum basin is comprised of 24 catchments/sub-watersheds that drain the whole valley headed by River Jhelum (Bhat et al., 2017).

The total area of Kashmir Valley is 15,948 Km^2 with an average elevation of about 1600 m above the seal level (Parveze et al., 2017). The valley of Kashmir is positioned between latitude 32° and 34° and longitude 74° and 75° (Fig. 1). Vegetation of the valley is mainly deciduous. The tress like, deodar, fir,

chinar, mulberry, kail, poplar and walnut are distributed across the valley (Kumar & Jain, 2010). The study region has been classified into 4 main physiographic divisions such as, mountains, foot-hills, Karewas and valley floor.

Kashmir Valley has temperate climate due to its unique geographical setting, characterized by cold wet winters and warm dry summers. Climate of the valley is mainly governed by elevation and amount of rainfall with temperatures varying from −9 °C in the months of winter to 38 °C in summer. According to Hussain, (1987) average mean maximum (T_{max}) and minimum (T_{min}) temperatures of Kashmir valley are 19.27 °C and 7.29 °C respectively, whereas average rainfall is estimated to be 84 cm. The main occupation of Kashmiris includes but is not limited to agriculture, horticulture and handicraft.

Summary of existing literature on LULC in the study region

Landuse and landcover change is a major driver of global environmental change. It is considered as a key component to analyse and understand the sequence of changes in catchment characteristics and man-environment interactions. Such changes have majorly influenced the basic resources of land and disturbed the variety of natural processes on the earth's surface
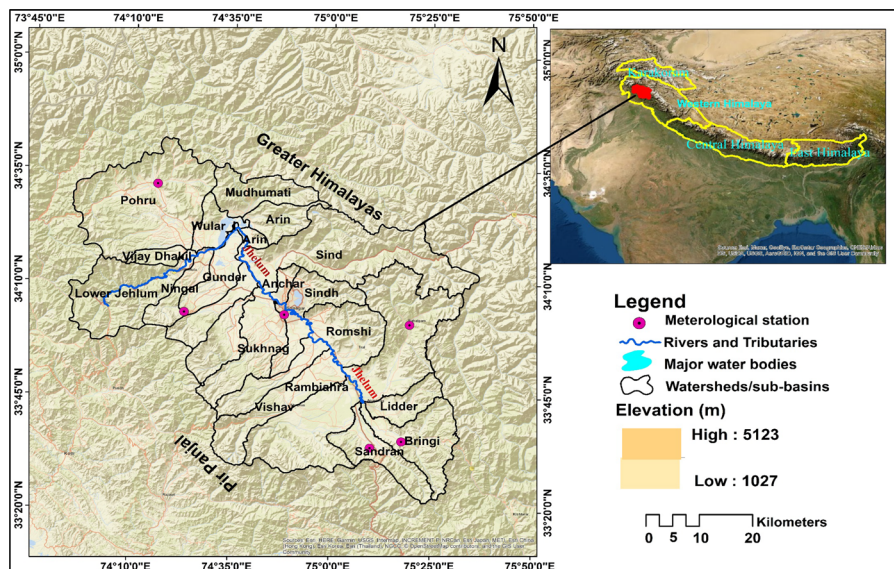

Fig. 1 Location map of the study region

(Nisar & Lone, 2013). Understanding concept of LULC change have undergone paradigm shifts, it has moved from simplistic approach towards the realistic approach and complexity since the last few decades. Initially, the focus of the studies relating to LULC changes was physical aspect of the change. However, with the passage of time scientific community realized that the processes on the surface of land (because of change in landuse pattern) influence the climate. Later in mid-1970s scientists added that the LULC changes modify the albedo of earth's surface. Hence, energy exchanges take place in the surface atmosphere with visible impacts on the regional climate of these areas. (Charney and Stone, 1975; Otterman, 1974). The greater impact of LULC change on agriculture, ecosystems, horticulture, goods and services, soil degradation, biodiversity etc. came into picture at a later stage (Sala et al., 2000; Trimble and Crosson, 2000; Vitousek, 1997; Praveen & Gupta, 1989). The key outcomes of major studies that focused on LULC changes in the study region are as under:

Amin et al., (2012) reports that Srinagar city has experienced significant changes in LULC from 1976 to 2007. Urban area of the city in particular has shown a remarkable increase from 8.06 Km^2 in 1976 to 29.33 Km^2 in 2007. Moreover, analysis reveal that due to significant landuse changes in the region has resulted in to loss of forest cover area and open spaces etc.

Alam et al., (2020) observed landuse and land cover change in Kashmir valley using Landsat satellite data. The data shows that, from 1992 to 2015 valley of Kashmir has undergone a substantial change in landuse and landcover. Based on their observation of three LULC change patterns, area under built-up, barren, marshy, shrubs and plantation have shown a consistent increase on the other hand water and agriculture have revealed a continuous decrease over the period of time. Furthermore, area under pastureland and forests decreased during 1992–2001, whereas it has shown increasing trend between 2001 and 2015.

Fayaz et al., (2020) has analysed Spatio-temporal dynamics of LULC in North Kashmir and the study reveal that major landuse categories such as agriculture, forest, snow and glaciers are decreasing in area where as horticulture, built-up (urban area) have shown an increase from 1992 to 2018. The major drivers identified as accountable for the LULC change

are mainly population increase, climatic variability and more importantly economic compulsions.

Ganaie et al., (2020) utilized Landsat imagery of 1991, 2001, 2011 and 2018 to assess the land transformations in Wular catchment of Jhelum basin. The study represents changes in various LULC classes like waterbody (−51.60%), swamps/marshy (−30.92%), plantation (−6.34%), dense forest (−10.56%) and snow cover (−3.66%). LULC classes such as barren (rocky), settlements and agriculture has revealed a positive correlation, whereas snow cover Swampy/waterlogged, dense forest, water bodies and plantation showed a negative correlation with respect to growing population.

Iqbal & Sajjad (2014) have carried out morphometry and LULC change study in Dodhganga watershed of Jhelum basin using geospatial techniques. The analysis demonstrates substantial changes in landuse from 1991 to 2010 particularly in agricultural lands, built-up, forest, plantation, wastelands and scrublands. The data shows 2.8%/year decrease in cultivated land, 9.06%/year increase in built-up land, 1.05%/year and 1.20%/year decrease in forest area and scrubland respectively and 1.17%/year decrease in wasteland has been observed in Dodhganga catchment over 20 years of study period.

Lone & Mayer (2019) has analysed the impact of changing LULC on food security in Anantnag district of Jammu and Kashmir. Change detection of two-time period was done using supervised classification (Maximum likelihood). The major findings of the study reveal that among various landuse classes agriculture and forest area has decreased by 3.7% and 2.26% respectively, whereas horticultural land and built-up land has shown an increase of 2.17 and 1.13% respectively.

Malik, (2012) has studied population growth and changes in LULC of Anantnag town located in south Kashmir. The data shows that Anantnag town has recorded an increase by 4.4 and 7.5-fold in population and area respectively over 30 years. The conversion of arable land into built-up area have been witnessed in the town, which is devoted to different urban land uses.

Malik et al., (2017) assessed the LULC change in district Baramulla and revealed that the area under horticulture, built-up and pastures have shown positive change and signifies higher conversion of other LULC classes into built-up. Area under rest of classes

such as agriculture, water, cryosphere has shown decrease from 1980 to 2014, especially forest has decreased by 137.3 Km^2, out of which 87.33 Km^2 has converted into pastureland.

Meer & Mishra (2020) utilized potential of remote sensing applications to explore LULC changes in Baramulla district of northern India. Large scale changes in built-up, agriculture and dense forest has affected the study region. The study reports decrease of 54.99% in agricultural land from 1979 to 2018. Moreover, increase in horticulture (52.13%) and decrease in dense forest cover (27.64%) has been observed during the period of 39 years. Conversion of agriculture land to horticulture in the study region has been attributed to decrease in precipitation. Study also reveals that increase in temperature and black carbon has resulted into melting of snow and glaciers in the region.

Nisar & Lone (2013) examined the LULC changes in Sindh watershed of Kashmir Himalayas and its impact on soils over a span of 10 years. Change detection analysis using combined approaches of Remote Sensing and GIS revealed that most important conversions that have occurred in Sindh catchment from 1995 to 2005 are due to deforestation, destruction of pastureland, urbanisation and intensification of agriculture. These changes have substantial impacts on the soils of the catchment.

Rafiq et al., (2018) have examined changes in land surface of Lidder catchment located in the south Kashmir. The study found that large scale changes in LULC classes such as horticulture, agriculture and built-up have been witnessed in the study region from 1979 to 2011. Furthermore, study reported decrease in agriculture area from 189.73 Km^2 to 77.18 Km^2 over 30 years, on the other-hand horticulture has increased at a rate of 3 Km^2 per year. The major reason behind this change is the scarcity of water, which has forced people to opt for horticulture.

Rasool et al., (2018) has utilized climate and field data to analyse the climatic and human induced determinants of agricultural land use changes in Shupiyan area of Kashmir valley. Mann- Kendall test shows an increase in mean minimum and maximum temperatures by 1.7 °C and 0.8 °C from 1985 to 1995 and is therefore a triggering factor for the conversion of landuse in the region. The precipitation on the other hand has shown a decreasing trend over the period. Economic benefits from horticulture and changing behaviour of people lead to its further growth with the passage of time.

Rasool et al., (2021) reports LULC changes in the Kashmir Himalayas based on remote sensing, Driver-Pressure-State-Impact-Response (DPSIR) approach and field survey. The finding of the study reveals that major LULC changes have occurred in selected classes, of which cropland agriculture losing the most (−5%) contrary to this economically beneficial, horticulture has gained the most (+ 4.29%) over 27 years i.e., 1990–2017. Various forces including natural, economic, and demographic have been considered as major driving forces that are accountable for the LULC change in the region.

Saini et al., (2019) analysed the dynamics of LULC change in Srinagar district of Jammu and Kashmir from 2008 to 2016 using remote sensing and GIS techniques. The study used Maximum likelihood classification technique to generate five different LULC classes such as urban, water, barren land, vegetation and forest. The results indicate a continuous increase in built-up area (urban, suburban and rural built-up) from 84.68 Km^2 in 2008 to 124.17 Km^2 in 2016 at the rate of 3.94 Km^2 per year. Vegetation has also increased from 121.33 Km^2 to 138.33 Km2. Contrarily, barren land and water area has decreased from 85.55 Km^2 and 24.07 Km^2 to 50.61 Km^2 and 21.86 Km^2 respectively.

Singh & Andrabi (2014) carried a study on the analysis of LULC changes in district Pulwama with concerning agroforestry in the region. Major changes in some LULC classes like agriculture, horticulture, built-up and forest cover have been observed. The change has been witnessed mainly by shifting of land from agriculture to horticulture because of economic benefits and increasing pressure of population. Area under agriculture has decreased by 7934 hectares with a negative growth rate of 18.6% from 1990 to 2010, whereas area under plantation has increased by 5485 hectares. The built-up area has also increased from 1793 hectares in 1990 to 3844 hectares with a growth rate of 102 hectares per year. Forest category has shown decrease of 1079 hectares, land under horticulture has increased whereas, snow and ice has shown decreasing trend over the period.

Shafiq et al., (2017) in his study 'geographical analysis of LULC changes in Lolab catchment of Kashmir valley' reports that a total of seven landuse classes have been categorised in the study region using

Maximum Likelihood classification. Out of which forest cover has shown a decrease from 45.31% in 2002 to 44.61% in 2014, whereas an increase from 8.05% in 2002 to 9.91% in 2014 has been observed in horticultural landuse. Agricultural landuse has also shown 1.04% of decrease over 14 years of study period.

Application of geospatial technology in LULC change detection

LULC change detection is a process to identify the changes in objects/phenomenon for several time-periods in the continuous or phased manners (Singh, 1989). Therefore, the process of change detection is crucial for monitoring and assessment of natural resources viz-a-viz planning for urban development.

According to Macleod & Cogation, 1998 there are four important aspects of change detection such as:

- Change detection that has occurred over time
- Identification of the nature of change
- Measuring the extent of change, and
- Assessment of spatial pattern of change

Mapping of LULC is one among the important and earliest applications of geospatial technology. However, the routine mapping over a large area as in case of longitudinal studies is comparatively a new marvel. Studying the spatio-temporal dynamics of LULC has been a challenging issue before the research community for quite some time now due to increasing pressures from drivers of LULC such as population explosion and climate change. New technology has replaced the conventional methods of early times to maintain revenue land records in digital repositories with fewer inaccuracies at the grassroots level.

Traditional methods (ground observation/field surveys) of LULC delineation and mapping are laborious, time consuming, and are therefore rarely used. Furthermore, they become outdated over the period due to rapid environmental changes. Advancement in geospatial techniques (Remote sensing (RS), Geographic Information System (GIS), and Global Positioning System (GPS)) has paved a way to prepare LULC maps accurately and do regular monitoring of changes over the period, the several emerging challenges, geospatial techniques, and tools appears to be a potent source of suitable information in the current

scenario. Thus, it has made easy to analyse the trends and patterns in LULC at global, continental, and regional level as well as to explore and predict the future changes. The widely used new technology has been highly benefiting and time saving.

The regular monitoring of LULC changes and subsequent risk-sensitive landuse planning is necessary for the sustainability of natural resources. Although studying LULC changes in complex terrains is rather a challenging task, satellite based remote sensing and GIS technology offers a wide range of opportunities to obtain valuable information about the changing environment.

Table 1 gives an overview of several key studies that have been grouped in a way to highlight the application of geospatial technology used one or the other way to produce results that are highly important for future landuse planning in the study region. There are no doubt limitations with these studies like choice of dataset especially the resolution of satellite images and errors during digitization and classification process. Nevertheless, most of them were addressed through the accuracy assessments. Table 1 depicts certain research studies with the following characteristics: (1) study area; (2) satellite data (including resolution (m)); (3) geospatial technique; (5) landuse classes; (5) accuracy assessment; and (6) Source of empirical study.

Annual rate of changes in major landuses

Several studies focused on different parts of the Kashmir valley have highlighted the status of LULC changes from the last 50 years i.e., 1970–2018 using remote sensing and GIS techniques. Some of the important studies include: North Kashmir (Fayaz et al., 2020), Kashmir Valley-AOI (Alam et al., 2020), Srinagar (Saini et al., 2019), Sindh Catchment (Nisar & Lone, 2013); Baramulla (Singh & Andrabi, 2014; Meer & Mishra, 2020), South Kashmir (Rasool et al., 2021), Anantnag (Malik et al., 2017; Lone & Mayer, 2019), Lidder Catchment (Rafiq et al., 2018), Dodhganga Watershed (Iqbal & Sajjad, 2014), Lolab Watershed (Shafiq et al., 2017), and Shupiyan (Rasool et al., 2016). The findings from these studies reveal that the major landuse classes (refer Table 2) have gone under tremendous change and the changes vary from region to region. Agricultural land, forest and

Table 1 An overview of peer-reviewed empirical studies in LULC research using geospatial technology

Study area	Satellite data, resolution (m)	Geospatial technique	Landuse classes	Accuracy assessment	Source
Regional (Local) level studies					
Lolab watershed	IRS-1C LISS III (23.5 m)	MLSC	Agriculture, Horticulture, Dense forests, Moderate forests, Sparse forests, Water body, Snow covered	No	Shafiq et al., 2017
Baramulla district	Landsat MSS, OLI, (30) and Google earth images	Unsupervised classification	Agriculture, barren, forest, horticulture, pasture, plantation, built up and water body	Yes	Malik et al., 2017
North Kashmir	Landsat and IRS-LISS-III (30, 23.5)	MLSC	Snow and glaciers, sparse forest, dense forest, pasture lands, built-up area, agriculture, horticulture, plantation, aquatic vegetation, water and the barren area	Yes	Fayaz et al., 2020
Kashmir valley (AOI)	Landsat TM, ETM + , OLI (30)	MLSC	Agriculture, Marshes, Built-up, Barren, Forrest, Plantation, Pasture, Water, Shrubs	Yes	Alam et al., 2020
Anantnag district	IRS-LISS-III (23.5)	MLSC	Dense forest, Sparse forest, Scrub, Horticulture/ Plantation, Agriculture, Built up, Water body, Wasteland, Glacier	No	Lone et al., 2019
Sind catchment	Landsat TM and IRS-LISS-III (30, 23.5)	MLSC	Forests, pastures, cultivated land, and urbanized areas	No	Nisar & Lone, 2013
Lidder catchment	Landsat MSS, TM, OLI (60, 30)	Visual interpretation	Ever green forests, mixed Forest, follow land, bare surface, open water, shrub land, ice and snow, horticulture, Agriculture and built-up	Yes	Rafiq et al., 2018
South Kashmir	Landsat TM, ETM + , OLI (30)	MLSC	Snow cover, Barren, Agriculture, Dense forest, Moderately, dense forest, Sparse/Scrub, Plantation, Horticulture, Built-up, Water bodies	Yes	Rasool et al., 2021
National (India) level studies					
Pune city	Landsat TM, OLI, &TIRS (30)	MLSC	Water body, forest land, built up, agricultural land, fallow land and shrub land	Yes	Gohain et al., 2021
Harike wetland	Resourcesat 2 LISS-IV (5.8)	on-screen visual interpretation	Agriculture, forest, built up, waste land, water bodies and wetland	Yes	Singh et al., 2020
Dehradun city	Resourcesat 2 LISS-IV (5.8) and SOI Toposheets	Manual interpretation	Urban and built up, Agriculture, Forest, Fallow, River bed, Vacant land, Restricted area, Mixed vegetation	No	Bhat et al., 2017
Ton river basin (Madhya Pradesh)	Landsat TM, ETM+ (30) and	Unsupervised classification	Deciduous forest, mixed forest, cropland, water bodies, built up area, fallow and barren land	Yes	Singh et al., 2018
Kamrup district of Assam	Landsat MSS, TM and ETM+ (30)	Supervised classification	Dense forest, open forest, agriculture land, urban settlement, water body and sand	Yes	Kumar, 2017

TM Thematic Mapper, *ETM+* Enhanced Thematic Mapper, *MSS* Multispectral Scanner, *OLI* Operational Land Imager, *TIRS* Thermal Infrared Sensor, *MLSC*, Maximum Likelihood Supervised Classification, *SOI* Survey of India, *IRS* Indian Remote Sensing

plantation have shown decrease of 278 Km^2, 43 Km^2 and 137 Km^2 respectively at an annual rate of 10.29, 1.59 and 5.07 Km^2 while built-up and horticultural land has shown an increase at the rate of 6.66 and 8.62 Km^2 per year in South Kashmir.

North Kashmir has also reported a decrease in agricultural land, forest and plantation at an annual rate of 6.5, 0.57 and 5.88 Km^2 respectively, contrarily built-up and horticulture has recorded an increase at a rate of 6.4 and 7.04 Km^2/year. From the above discussion, it is quite evident that significant landuse changes have been witnessed in the study region, which are expected to increase primarily due to climatic, demographic and economic factors.

Determining primary drivers of LULC change in the study region

Change in LULC is a continuous process mainly because of various drivers that govern it. Climate change and increasing population are among the major driving forces that are responsible for LULC change. In addition to this, combinations of several anthropogenic and natural factors/ processes cause land transformation with both advantages and disadvantages. The uncontrolled anthropogenic activities such as unplanned development are a recipe for cascading risks turning into new disasters. Nevertheless, the already existing information on LULC is a prerequisite for understanding trends and patterns in LULC to develop future land-use plans for the sustainable utilization of land.

LULC changes in the Kashmir Valley have produced mixed results, i.e., both positive and negative. Several underlying causes motivate planners and common people to transform land. Among them climatic, demographic, and economic pressures are very dominant. The next sections discuss each of them in detail.

Climatic

Climate change is a global concern and strongly affecting the Himalayan region (Ahmed et al., 2021; Almazroui et al., 2020; Mir et al., 2018). Kashmir valley is not an exception to these climatic changes. The change has been a triggering factor for farmers to shift from agriculture to horticulture and cultivate

drought resistant crops for sustainable livelihood. By far climate has been one among the dominant forces that has caused changes in landuse. This is in line with the climatic research that analyzes trends and patterns of climate and their observations such as differences in extent as well as distribution of temperature and precipitation over the region.

Climate is a dynamic natural factor with changes in decadal, annual, and seasonal scales. Temperatures in Kashmir Valley show a warming trend with annual rate of increase as 0.05 °C and 0.01 °C in mean maximum (T_{max}) and mean minimum temperature (T_{min}) respectively (Fig. 2a, b). However, decrease in precipitation at the rate of 4.22 mm/year from 1980 to 2016 has been observed with data from six metrological stations (Shafiq et al., 2019). Increase in average maximum temperature (T_{max}) and minimum temperature (T_{min}) in the Kashmir Valley from 1980 to 2018 by 1.61 °C and 0.95 °C respectively has been also confirmed by Romshoo et al., (2020) (Fig. 3). Several studies were conducted in the region that focus on changes in climate (temperature and precipitation) with observations similar to the previous studies. (Rafiq et al., 2018; Mishra and Rafiq 2017; Rafiq & Mishra, 2018). Reduction in snowfall, glacier recession, drying up of springs and decreasing water levels of streams and rivers (Talib, 2007; Jeelani, 2008; Mir, 2018), also gives an indication of climate as a driver for LULC change in the region.

Demographic

The mountain ecosystems and its biological diversity (flora and fauna) are facing a big threat from the anthropogenic activities stirred because of exponential growth in population. The pressures from such a change are visible in the ecologically fragile and geopolitically sensitive mountain ranges of Himalayas. The population of Kashmir Valley has increased by manifold over the last four decades (1971–2011). In 1971, the total population of Kashmir region was approximately 24 lakhs that increased to 69 lakhs in 2011, which means around 183% increase at the rate of 4.5% per year as per Census of India 1971 and 2011. Table 3 gives details about population growth (including percentage change and annual rate of change) of selected districts of Kashmir Valley such as Anantnag, Pulwama, Srinagar, Budgam, Barmulla and Kupwara from 1971 to 2011. The rapid growth of

Table 2 Net change in area and annual rate of increase/decrease of major land uses in Kashmir valley from 1970 to 2018

Catchment/District/ Region	Landuse class	Total area (Km^2)		Net change (Km^2)	Rate of change/year (Km^2)	Data source
Kashmir valley (AOI)		(1990)	(2015)	(1990–2015)		Alam et al., (2020)
	Agriculture	133,8.25	952.11	−386.14	−16.78	
	Built-up	55.70	166.27	+ 110.56	+ 4.80	
	Forest	104.98	97.85	−7.13	−0.31	
	Plantation	344.91	648.37	+ 303.45	+ 13.19	
	Water	117.55	60.14	−57.40	−2.49	
		(1990)	(2017)	(1990–2017)		
South Kashmir	Agriculture	1359	1081	−278	−10.29	Rasool et al., (2021)
	Built-up	133	313	+ 180	+ 6.66	
	Forest	1487	1444	−43	−1.59	
	Plantation	438	301	−137	−5.07	
	Horticulture	176	409	+ 233	+ 8.62	
	Water	68	61	−7	−0.25	
		(1979)	(2018)	(1979–2018)		
Baramulla	Agriculture	401.81	180.87	−220.94	−5.56	Meer & Mishra, (2020)
	Built-up	32.39	127.18	94.79	2.43	
	Dense Forest	777.54	563.99	−213.54	−5.47	
	Horticulture	334.38	518.65	184.27	4.72	
	Water	28.68	18.1	−10.59	−0.27	
		(1992)	(2018)	(1992–2018)		
North Kashmir	Agriculture	1515	1343	−169	−6.5	Fayaz et al., (2020)
	Built-up	124	292	+ 168	6.4	
	Forest	2952	2937	−15	−0.57	
	Plantation	412	259	−153	−5.88	
	Horticulture	160	344	184	7.07	
	Water	74	50	−24	−0.92	
		(2002)	(2014)	(2002–2014)		
Lolab watershed	Agriculture	98.65	95.73	−2.92	−0.24	Shafiq et al., (2017)
	Dense Forest	28.86	26.93	−1.93	−0.16	
	Horticulture	22.67	27.91	5.24	0.43	
	Water	22.24	21.08	−1.16	0.09	
		(1976)	(2007)	(1976–2007)		
Srinagar city	Agriculture	72.98	50.96	−22.02	−0.71	Amin et al., (2012)
	Built-up	20.88	75.67	54.79	1.76	
	Forest	27.01	72.59	45.58	1.47	
	Plantation	28.38	8.90	−19.48	−0.62	
	Water	21.69	10.69	−11	0.35	

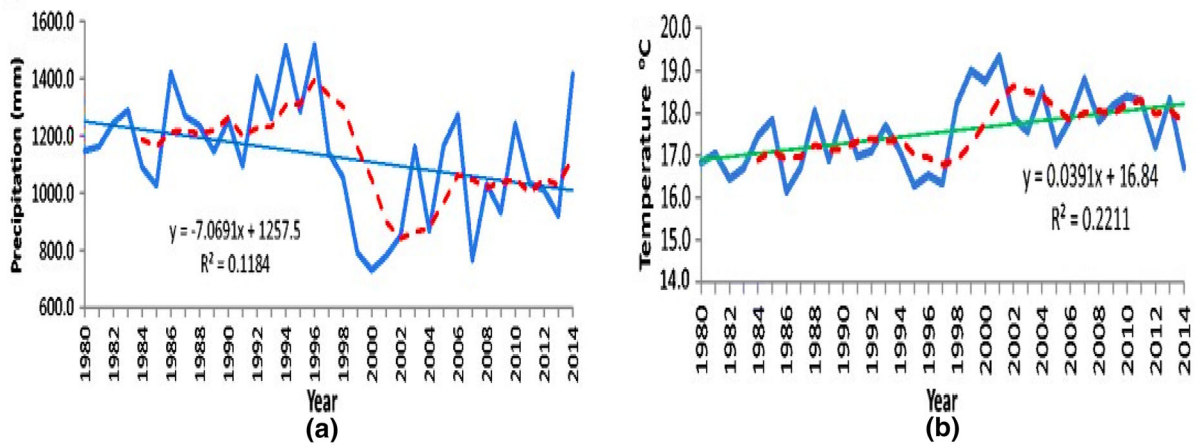**Fig. 2 a, b** Trends in mean maximum and minimum temperatures and precipitation of Kashmir valley from 1980 to 2016. *Source:* Shafiq et al., 2019
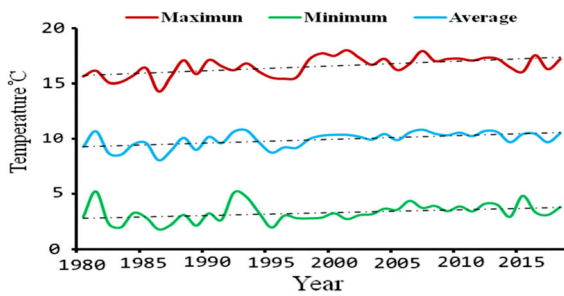

Fig. 3 Trends in mean maximum and minimum temperatures of Kashmir valley from 1980 to 2018. *Source:* Romshoo et al., (2020)

population puts tremendous pressure on existing natural resources in the region.

Economic

Changes in LULC result from several factors (driving forces) acting on the land surface with complex interactions and origins in both human activities and natural forces. Among the drivers of LULC change, population growth and climate play a major role. The impacts of increasing population are expedited by flawed landuse policies, plans, and interrelated institutional factors, which affect the LULC in the end. For example, LULC change in West Africa (Lambin et al., 2001).

Accommodating more people on the same patch of land means more pressure on natural resources and landuse, which results in loss of resources at alarming rates. Further, it has encouraged agricultural specialization towards limited (high yield) crops and abandoning/replacing of traditional (homegrown) crops in the study region. Growing populations, particularly the urban population affects consumption patterns, because of increased demands for processed food, dairy products, and meat with huge consequences on natural resources (Godfray et al., 2010).

The increased demand for food has put tremendous pressure on land resources, directly or indirectly affecting people's abilities to cultivate traditional crops but forcing them to find suitable alternatives, in reality altering LULC. For example, the combined

Table 3 Population growth of selected districts in Kashmir Valley (1971–2011)

Source: Census of India, 1971, 2011

District name	1971	2011	1971–2011	Change (%)	Annual rate of change (%)
Anantnag	518,122	1,078,692	560,570	108	2.7
Pulwama	314,158	560,440	246,282	78	1.95
Srinagar	558,664	1,236,829	678,165	121	3.02
Budgam	269,033	753,745	484,712	180	4.5
Baramulla	517,900	1,008,039	490,139	95	2.37
Kupwara	257,824	870,354	612,530	238	5.95

threat of minimal returns and scarcity of water has encouraged farmers in the Kashmir Valley to invest on shifting from agriculture to horticulture to obtain maximum returns and secure their livelihoods. The land transformation from traditional agriculture to horticulture in the study region is going at a faster pace due to higher-income returns (Siddique, 2007; Rasool et al., 2021).

Government institutions through their policies and plans have urbanized more land to accommodate the growing population, which has resulted in shrinking of open spaces and put pressure on water bodies as informal settlements continue to grow around them. The increased efforts in the name of tourism, urban development, and emergence of small-scale industries to boost local economy and generate employment has affected LULC of the region.

Concluding remarks

In the present study, an intensive literature review was carried out to understand the status of LULC dynamics in the valley of Kashmir. The primary drivers (climatic, demographic and economic) of LULC change were analyzed in detail, which act as push-factors for change in land uses in the study region. The major conclusions based on this study are briefly deliberated as below:

- Agricultural activity is the main economic activity in the valley of Kashmir. Area under this landuse class has tremendously transformed in last two to three decades. Agricultural land has shown significant decrease mainly because of conversion to horticultural land, and for residential, tourist and commercial purposes.
- Area under forest, water, snow and glaciers show a decreasing trend.
- Increasing population and growing demand for timber, fuelwood and other developmental activities has accelerated the conversion of forestland into pastures, built-up and in some cases into horticultural land.
- Decrease of area under water, snow and glaciers is considered a repercussion of changing climate in the study region as is reflected in a few climate change perception related studies.

- Horticultural land in the study region has shown significant positive change over time. Since people of Kashmir have shifted from agricultural to horticulture mainly because of economic benefits.
- Shifting from paddy and other traditional irrigation-based crops to drought resistant crops and rain-fed fruits in the study region is mainly in response to climatic variability.
- Climate is a dynamic natural driver of LULC change while as pressures from human activities such as growing population and economic concerns alter land cover of the study region.

Land transformation of this extent coupled with a lack of comprehensive land-use policy and unstable political environment, the economy of the region may suffer in future. The present study is a step towards effective monitoring and assessment of LULC in the study region. The synthesis of existing literature is to guide future LULC studies over the region using geospatial technology. Further, it provides insights into planning and decision making for natural resource management and sustainable landuse in the region.

Declarations

Conflicts of interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethical approval All the ethical standards of research publishing were taken care of during this review-based study.

References

Ahmed, R., Wani, G. F., Ahmad, S. T., Sahana, M., Singh, H., & Ahmed, P. (2021). *A review of Glacial lake expansion and associated glacial lake outburst floods in the Himalayan region*. Springer, Germany: Earth Systems and Environment.

Alam, A., Bhat, M. S., & Maheen, M. (2020). Using landsat satellite data for assessing the land use and land cover change in Kashmir valley. *GeoJournal, 85*(6), 1529–1543.

Almazroui, M., Saeed, S., Saeed, F., Islam, M. N., & Ismail, M. (2020). Projections of precipitation and temperature over

the South Asian countries in CMIP6. *Earth Systems and Environment, 4*(2), 297–320.

Amin, A., Amin, A., & Singh, S. K. (2012). Study of urban land use dynamics in Srinagar city using geo-spatial approach. *Bulletin of Environmental and Scientific Research, 1*(2), 18–24.

Arveti, N., Etikala, B., & Dash, P. (2016). Land use/land cover analysis based on various comprehensive geospatial data sets: A case study from Tirupati area, south India. *Advances in Remote Sensing, 5*(02), 73.

Assessment, & M. E . (2005). *Ecosystems and human well-being: wetlands and water*. US: World Resources Institute.

Bae, J., & Ryu, Y. (2015). Land use and land cover changes explain spatial and temporal variations of the soil organic carbon stocks in a constructed urban park. *Landscape and Urban Planning, 136*, 57–67.

Bauer, M., Loeffelholz, B., & Wilson, B. (2005). Estimation, mapping and change analysis of impervious surface area by Landsat remote sensing. In *Proceedings, Pecora 16 Conference* (pp. 23–27).

Bhat, P. A., ulShafiq, M., Mir, A. A., & Ahmed, P. (2017). Urban sprawl and its impact on landuse/land cover dynamics of Dehradun city, India. *International Journal of Sustainable Built Environment, 6*(2), 513–521.

Bhatt, C. M., Rao, G. S., Farooq, M., Manjusree, P., Shukla, A., Sharma, S. V. S. P., & Dadhwal, V. K. (2017). Satellite-based assessment of the catastrophic Jhelum floods of september 2014, Jammu & Kashmir, India. *Geomatics, Natural Hazards and Risk, 8*(2), 309–327.

Charney, J., Stone, P. H., & Quirk, W. J. (1975). Drought in the Sahara: A biogeophysical feedback mechanism. *Science, 187*(4175), 434–435.

Fayaz, A., & ul Shafiq, M., Singh, H., & Ahmed, P. . (2020). Assessment of spatiotemporal changes in land use/land cover of North Kashmir Himalayas from 1992 to 2018. *Modeling Earth Systems and Environment*. https://doi.org/10.1007/s40808-020-00750-9

Ganaie, T. A., Jamal, S., & Ahmad, W. S. (2020). *Changing land use/land cover patterns and growing human population in Wular catchment of Kashmir valley India.* GeoJournal. https://doi.org/10.1007/s10708-020-10146-y

Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., & Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. *Science., 327*(5967), 812–818.

Gohain, K. J., Mohammad, P., & Goswami, A. (2021). Assessing the impact of land use land cover changes on land surface temperature over Pune city, India. *Quaternary International, 575*, 259–269.

Hathout, S. (2002). The use of GIS for monitoring and predicting urban growth in East and West St Paul, Winnipeg, Manitoba, Canada. *Journal of Environmental Management, 66*, 229–238.

Hussain, M. (1987). *Geography of Jammu and Kashmir state* (pp. 11–18). Rajesh Publication.

Iqbal, M., & Sajjad, H. (2014). Watershed prioritization using morphometric and land use/land cover parameters of Dudhganga catchment Kashmir Valley India using spatial technology. *Journal of Geophysics and Remote Sensor, 3*, 115.

Jeelani, G. (2008). Aquifer response to regional climate variability in a part of Kashmir Himalaya in India. *Hydrogeology Journal, 16*(8), 1625–1633.

Kumar, D. (2017). Monitoring and assessment of land use and land cover changes (1977–2010) in kamrup district of Assam, India using remote sensing and gis techniques. *Applied Ecology and Environmental Research, 15*(3), 221–239.

Kumar, V., & Jain, S. K. (2010). Trends in seasonal and annual rainfall and rainy days in Kashmir Valley in the last century. *Quaternary International, 212*(1), 64–69.

Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., & Xu, J. (2001). The causes of land-use and land-cover change: Moving beyond the myths. *Global Environmental Change, 11*(4), 261–269.

Lone, S. A., & Mayer, I. A. (2019). Geo-spatial analysis of land use/land cover change and its impact on the food security in District Anantnag of Kashmir Valley. *GeoJournal, 84*(3), 785–794.

Loveland, T., Mahmood, R., Patel-Weynand, T., Karstensen, K., Beckendorf, K., Bliss, N., & Carleton, A. (2012). *National climate assessment technical report on the impacts of climate and land use and land cover change*. U.S: Department of the Interior, U.S. Geological Survey, Reston, VA.

Macleod, R. D., & Congalton, R. G. (1998). A quantitative comparison of change-detection algorithms for monitoring eelgrass from remotely sensed data. *Photogrammetric Engineering and Remote Sensing, 64*(3), 207–216.

Malik, M. I. (2012). Analysis of population growth and land use change in Anantnag town of South Kashmir using remote sensing and geographical information system. *Journal of Experimental Sciences, 3*(5).

Malik, M. M., Tali, J. A., & Nusrath, A. (2017). Assessment of land use and land cover change in district Baramulla, Jammu and Kashmir. *Res Rev Journal of Space Science and Technology, 6*(3), 1–14p.

Meer, M. S., & Mishra, A. K. (2020). Remote sensing application for exploring changes in land-use and land-cover over a district in Northern India. *Journal of the Indian Society of Remote Sensing.* https://doi.org/10.1007/s12524-019-01095-2

Mir, R. A. (2018). Recent changes of two parts of Kolahoi Glacier and its controlling factors in Kashmir basin, western Himalaya. *Remote Sensing Applications: Society and Environment, 11*, 265–281.

Mir, R. A., Jain, S. K., Lohani, A. K., & Saraf, A. K. (2018). Glacier recession and glacial lake outburst flood studies in Zanskar basin, western Himalaya. *Journal of Hydrology, 564*, 376–396.

Mishra, A. K., & Rafiq, M. (2017). Analyzing snowfall variability over two locations in Kashmir, India in the context of warming climate. *Dynamics of Atmospheres and Oceans, 79*, 1–9.

Nisar, M., & Lone, F. A. (2013). Effect of LULCchange on soils of a kashmir himalayan catchment-sindh. *International Journal of Research in Earth & Environmental Sciences, 1*(1), 13–27.

Otterman, J. (1974). Baring high-albedo soils by overgrazing: A hypothesized desertification mechanism. *Science, 186*(4163), 531–533.

Parvaze, S., Ahmad, L., Parvaze, S., & Kanth, R. H. (2017). Climate change projection in Kashmir Valley (J and K). *Current World Environment, 12*(1), 107.

Pelorosso, R., Leone, A., & Boccia, L. (2009). Land cover and land use change in the Italian central Apennines: A comparison of assessment methods. *Applied Geography, 29*, 35–48.

Praveen, B., & Gupta, D. (1989). Multispectral-TIR data analysis by split window algorithm for coal fire detection and monitoring. Singh A. 989–1003.

Rafiq, M., & Mishra, A. K. (2018). A study of heavy snowfall in Kashmir, India in January 2017. *Weather, 73*(1), 15–17.

Rafiq, M., Mishra, A. K., & Meer, M. S. (2018). On land-use and land-cover changes over Lidder Valley in changing environment. *Annals of GIS, 24*(4), 275–285.

RasoolulShafiqAhmedAhmad, R. M. P. P. (2018). An analysis of climatic and human induced determinants of agricultural land use changes in Shupiyan area of Jammu and Kashmir state India. *Geojournal, 83*(1), 49–60.

Rasool, R., Fayaz, A., ul Shafiq, M., Singh, H., & Ahmed, P. (2021). Land use land cover change in Kashmir Himalaya: Linking remote sensing with an indicator based DPSIR approach. *Ecological Indicators, 125*, 107447.

Romshoo, S. A., Ali, N., & Rashid, I. (2011). Geoinformatics for characterizing and understanding the spatio-temporal dynamics (1969 to 2008) of Hokersar wetland in Kashmir Himalayas. *International Journal of Physical Sciences, 6*(5), 1026–1038.

Romshoo, S. A., Fayaz, M., Meraj, G., & Bahuguna, I. M. (2020). Satellite-observed glacier recession in the Kashmir Himalaya, India, from 1980 to 2018. *Environmental Monitoring and Assessment, 192*(9), 1–17.

Saini, R., Aswal, P., Tanzeem, M., & Saini, S. S. (2019). Land use land cover change detection using remote sensing and GIS in Srinagar. *India Int Journal of Computer Applications, 178*, 42–50.

Sala, O. E., Chapin, F. S., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R., & Wall, D. H. (2000). Global biodiversity scenarios for the year 2100. *Science, 287*(5459), 1770–1774.

Serra, P., Pons, X., & Saurí, D. (2008). Land-cover and land-use change in a Mediterranean landscape: A spatial analysis of driving forces integrating biophysical and human factors. *Applied Geography, 28*, 189–209.

Shafiq, M., Mir, A. A., Rasool, R., Singh, H., & Ahmed, P. (2017). A geographical analysis of land use/land cover dynamics in Lolab watershed of Kashmir Valley, Western Himalayas using remote sensing and GIS. *Journal of Remote Sensing GIS, 6*, 189.

Shafiq, M. U., Rasool, R., Ahmed, P., & Dimri, A. P. (2019). Temperature and precipitation trends in Kashmir Valley, north western Himalayas. *Theoretical and Applied Climatology, 135*(1), 293–304.

Siddique, M. O. H. A. M. M. A. D. (2007). Growth and development of horticulture in Jammu and Kashmir (1947–1997). *Fifty Years of Indian Agriculture, 1*, 300–309.

Singh, A. (1989). Review article digital change detection techniques using remotely-sensed data. *International Journal of Remote Sensing, 10*(6), 989–1003.

Singh, H., & Andrabi, R. H. (2014). Changing land use/land cover analysis in Pulwama district of Jammu & Kashmir. *International Journal of Scientific and Research Publication, 4*(8), 1–8.

Singh, S. K., Laari, P. B., Mustak, S. K., Srivastava, P. K., & Szabó, S. (2018). Modelling of land use land cover change using earth observation data-sets of Tons river basin, Madhya Pradesh, India. *Geocarto International, 33*(11), 1202–1222.

Singh, S., Bhardwaj, A., & Verma, V. K. (2020). Remote sensing and GIS based analysis of temporal land use/land cover and water quality changes in Harike wetland ecosystem, Punjab India. *Journal of environmental management, 262*, 110355.

Talib, A. H. (2007). *On the brink? A Report on climate change and its impact on Kashmir*. Kashmir: Actionaid.

Tiwari, A., Suresh, M., Jain, K., Shoab, M., Dixit, A., & Pandey, A. (2018). Urban landscape dynamics for quantifying the changing pattern of urbanisation in Delhi. *Journal of Rural Development, 37*(2), 399–412.

Trimble, S. W., & Crosson, P. (2000). US soil erosion rates–myth and reality. *Science, 289*(5477), 248–250.

Vitousek, P. M., Mooney, H. A., Lubchenco, J., & Melillo, J. M. (1997). Human domination of Earth's ecosystems. *Science, 277*(5325), 494–499.

Xiao, J., Shen, Y., Tateishi, R., Tang, C., Huang, Z., et al. (2006). Evaluating urban expansion and land use change in Shijiazhuang, China, by using GIS and remote sensing. *Landscape and Urban Planning, 75*, 69–80.

Yuan, F., Sawaya, K. E., Loeffelholz, B. C., & Bauer, M. E. (2005). Land cover classification and change analysis of the twin cities (Minnesota) metropolitan area by multitemporal landsat remote sensing. *Remote Sensing of Environment, 98*, 317–328.