Project Report

Geospatial Technology based approach for the tribal area development planning in Jammu and Kashmir

Submitted by

Dr. Ayaz Mohmood Dar (Fellow)

Under the Supervision of

Dr. Shahid Iqbal Choudhary, IAS (Director, TRI)
Dr. Abdul Khabir, JKAS (Deputy Director, TRI)

TRIBAL RESEARCH INSTITUTE,
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Dr. Ayaz Mohmood Dar

1. Introduction:

The Geospatial technology has comprehensively believed as a significant technological tool for tribal area development. The technology has been accepted worldwide for optimal management and better utilization towards improving the conditions of the tribal people. The National Aeronautics and Space Administration (NASA) has a long history of working with tribal nationals and tribal colleges and universities to build workforce capacities in science, technology, engineering, and mathematics (STEM). The two primary NASA programs involved are the applied science capacity building program (CBP) and the minority university research and education program (MUREP) [1,2]. The Bureau of Indian Affairs (BIA) has missioned itself to assist tribal governments and Indian Affairs to manage the cultural and natural resources by providing geographic information systems software, training, and technical support. The branch of Geospatial support (BOGS) is the technical support office to Indian Affairs (IA) and all federally recognized tribes for Geographic information systems (GIS) as part of the development of the interior- Bureau of Indian Affairs- ESRI enterprise license agreement. The dynamic significance of Geospatial technology for tribal area development has surfaced from many researchers across the world. Further, the technology has proven its vital significance for the efficient management of land resources, tribal climate planning and resilience, energy potential on tribal lands, addressing tribal issues, tribal area development planning, promotional interventions, decision making in tribal welfare, etc., [3-8]. In 2015, the department of Geosciences and Natural Resources, western Carolina University, USA, published the guest editorial preface highlighting the Geospatial technologies and indigenous communities engagement [9]. The research concluded that the intersection of Geospatial technologies and indigenous peoples are best considered in light of long-standing indigenous ontologies, innovative applications of Geospatial technologies, and advances in research ethics and participatory GIS approaches towards social justice. In general, the Geospatial technology can be believed as virtuous for the tribal area development vis a vis spatial monitoring of population, education, infrastructure development, climate change and mitigation policies, and all other related development factors and therefore immense enthusiasm for appropriate understanding of Geospatial technology and its application.

Geospatial Technology is an emerging field of study that includes Geographic Information System (GIS), Remote Sensing (RS), and Global Positioning System (GPS). Geospatial technology enables us to acquire data that is referenced to the earth and use it for analysis, modeling, simulations, and visualization. The ability to acquire information about any object or phenomenon has signified the Remote sensing applications across the globe with massive demand. The nature of Remote sensing applications has forced the leading space agencies to touch the skies with their increasing technologies. The space agencies like the National Aeronautics and Space Administration (NASA), European Space Agency (ESA), Indian Space Research Organization (ISRO), China National Space Administration (CNSA), and others have shaped the digital world mercurially. Further, the advancement in software technologies has reached efficient satellite image analysis and has made remote sensing studies most preferable with enormous applications. The basic mechanism of remote sensing is that it uses the part of the electromagnetic spectrum to record the reflections or emissions by the surface. However, the interpretation of satellite data depends upon the nature of the study and the type of imagery. The number of bands, band ratio, resolution and georeferenced system is directly linked to the image quality, image analysis, and observations of the study. The use of high resolution satellite imageries and digital elevation models has been proven significant for large-scale field investigation within less time and with high precision. Remotely sensed data enables large-scale investigation of the land features and mapping using satellite imageries are pivotal for different studies in design perspective in engineering, geology, climate and landscape evolution and monitoring. Further, Hyperspectral technology is at the forefront of remote sensing development in the 21st century and is one of the most important focuses of the remote sensing domain. The hyperspectral technology was used to identify composition and components in objects and inverse the physical and chemical parameters according to the spectral signatures. Good results have been achieved by hyperspectral technology, especially in geological prospecting, fine agriculture, environmental pollution monitoring, stratigraphic division, etc.

In the present study, the attempt was made to use Geospatial technology for the tribal area development of the Jammu and Kashmir. Though, the exhaustive approach and time is needed to achieve the goals, therefore the study was limited to estimate the general outlooks of the region and nearly-systematic attempts for the tribal regions of district Ganderbal of Jammu and Kashmir has endeavored.

2. Data and Methods:

The satellite data, census of India, geospatial software's, Ground truthing and Vocal conversations are the main datasets that are used for this study. The remote sensing analysis was used to study and estimate the land cover and to understand the features by digital and visual interpretations of satellite imageries. Based on our study, the Panchromatic and Multispectral satellite imageries were used for these interpretations. The aim of obtaining the remotely sensed data was based on considering algorithm transformations and networking analysis, and therefore convenient imageries have been used for the study. The study utilized appropriate datasets including LANDSAT 8, EO-1 Hyperion, SENITAL-II, LISS IV and Digital Elevation Models for convenient results. The geometric correction methods were used to correct the satellite imageries and therefore to represent their position for exact locations related to the earth's surface. These methods were used to fix the displacements produced by images and to match the pixel locations of the earth's surface. The techniques of Geo-rectification and Ortho-rectification methods were used to define the coordinate system and to correct the distortions produced by images. The images were digitally manipulated and precisely matched with the projection of the study area. The referencing system of WGS-1984-UTM-ZONE43N was set as an internal coordinate system and stored within the image file for all obtained data sets. The reference maps collected for study area from literature surveys were georeferenced by control point methods and polynomial techniques for further analysis. Image classifications were used to identify the surface features based on digital interpretation, visual interpretation, and quantitative techniques. Our study used a combined classification method for land use, land cover classification in the region. The combined classification method is a combination of unsupervised and supervised classification and recoding techniques. The spectral analysis work station, target, and anomaly detections were used for spectral recognition of surface features. The object-based classification, classification of mixed pixels, neural networking, and principal component analysis were also attempted for better recognition of surface features. Further, the census of India data was used and the database for the study area was created and imported to the GIS software. The software's including ArcGIS, Erdas Imagine, and Google Earth Engine was mostly adopted for this study. The decadal land changes were assessed via EarthData (NASA database) and Bhuvan (ISRO database) and were integrated with the LULC digital map calculated by convenient methodology from our study.

3. Results and Discussion:

The tribe of Jammu and Kashmir, a human social group, is spread across the union territory with strong imprints of cultural livelihood and social structure. They are dominantly known for the metaphysical conduct of their traditional utilities and standing behaviors. They are comprehensive in understanding the management of their living and are well versed with their languages. Further, the Jammu & Kashmir, a distinctive geographical landscape, adds effective anthropology to the tribes of union territory and therefore explicates supplementary potential in their favor. The Jammu and Kashmir is spread across approximately 42950 km^2 with picturesque landscape located in the Northwest Himalaya of the Alpine- Himalayan orogenic belt (Fig.1).

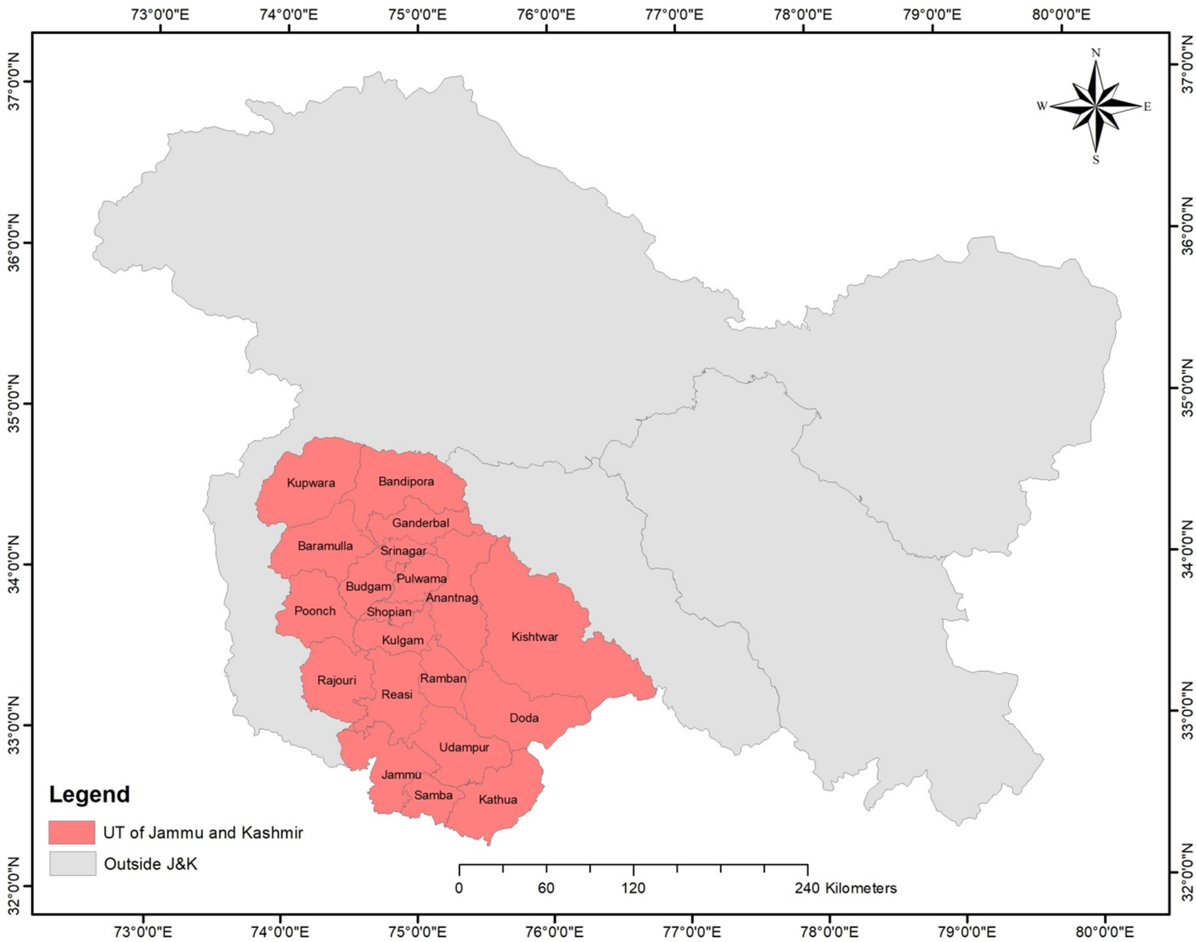

Fig.1. Geographical location of Jammu and Kashmir

The landscape of Jammu and Kashmir is gratifying by its mountain ranges, lake diversity, drainage structure, and bio-diversity, therefore, it customarily adds charisma to the guise of the tribal community. The Kashmir basin is geologically one of the unique intermontane basin in the world, and dominates the allure among all landscapes. The tribal population of Jammu and Kashmir makes up ~11 percent of the total population and is spread across the union territory.

The analysis shows that the districts of Rajouri and Poonch host the maximum tribe population. Among the total tribal population, these two districts yield 32 percent of the population in which Rajouri hosts 18% followed by Poonch with 14% of the total tribal population. The districts with a higher tribal population are Rajouri 18%, Poonch 14%, Anantnag 9%, Reasi 7%, and Ganderbal 5%. The detailed report of the tribal percentage is represented in Fig. 2. Further, the tribal population with respect to the total population of Jammu and Kashmir is represented in Fig. 3.

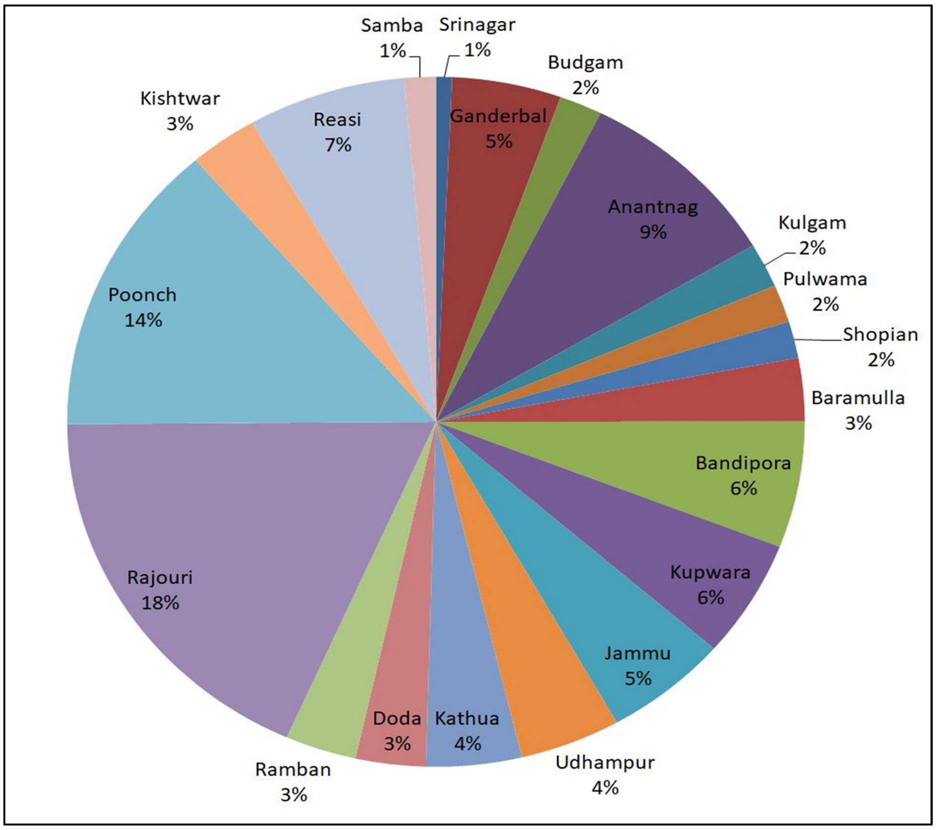

Fig.2. District-wise tribal population percentage of Jammu and Kashmir

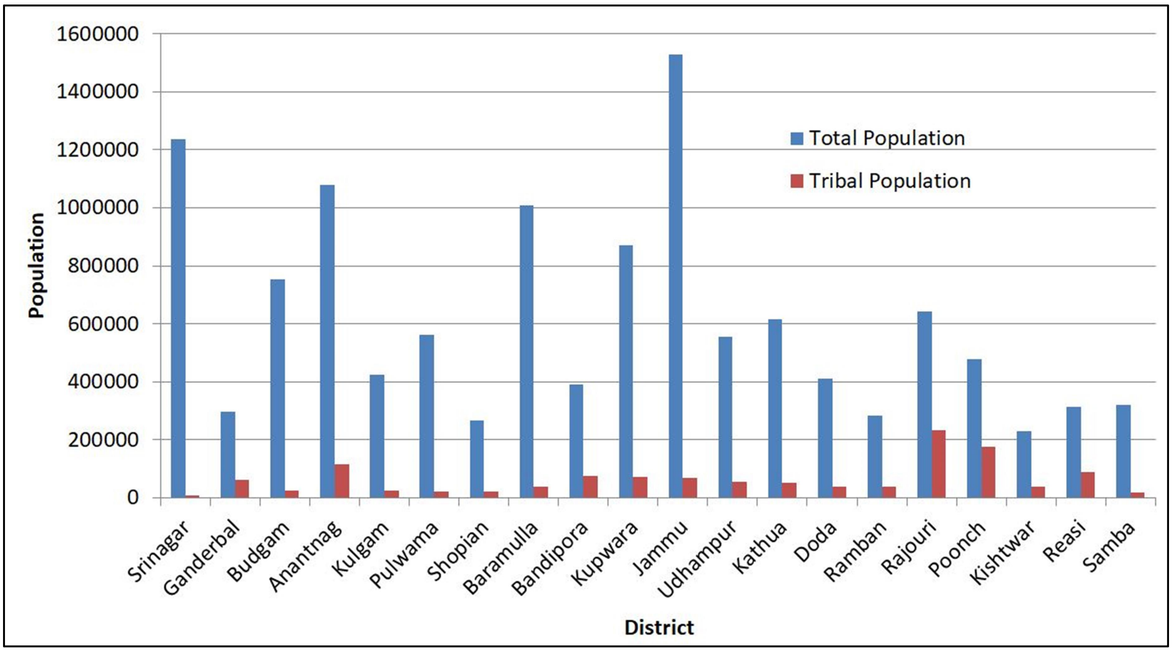

Fig.3. Tribal population with respect to the total population of Jammu and Kashmir

The highest tribal populated districts, Rajouri and Poonch, falls in the Southwest of Jammu and Kashmir are spread across 2232 km2 and 2040 km2 respectively. These districts lie immediately after the eastern Kashmir basin (Oval-bowl shaped basin), along the Pir-panjal mountain range. The more details about the district boundaries and the tribal population are represented in Fig. 4. While studying the topography of Jammu and Kashmir, the tribal population resembles an elevated socio-human group by its natural landscape. However, the landscape provides both positive and negative impacts ranging from inimitable bio-diversity to natural hazards. Further, the landscape including gorgeous mountain ranges, snow peaks, land diversity, hydrological structure, etc., make a very positive impact on the tribal population. Though the explanation of the topography will be giant, therefore Fig. 5 is prepared to understand the regional topography of Jammu and Kashmir.

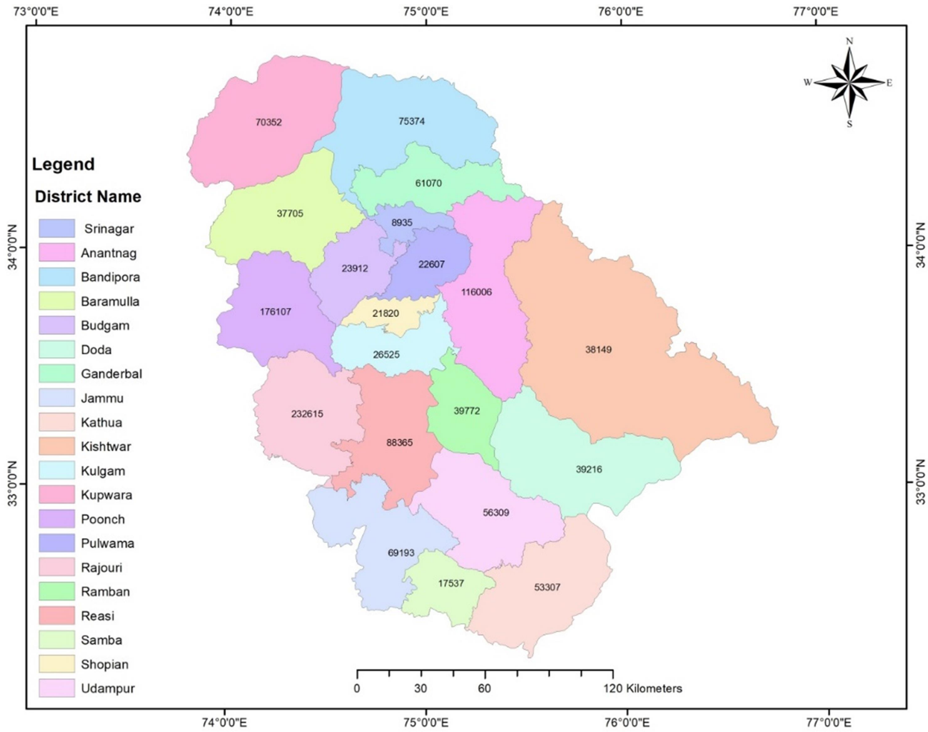

Fig.4. District boundaries with respect to the tribal population

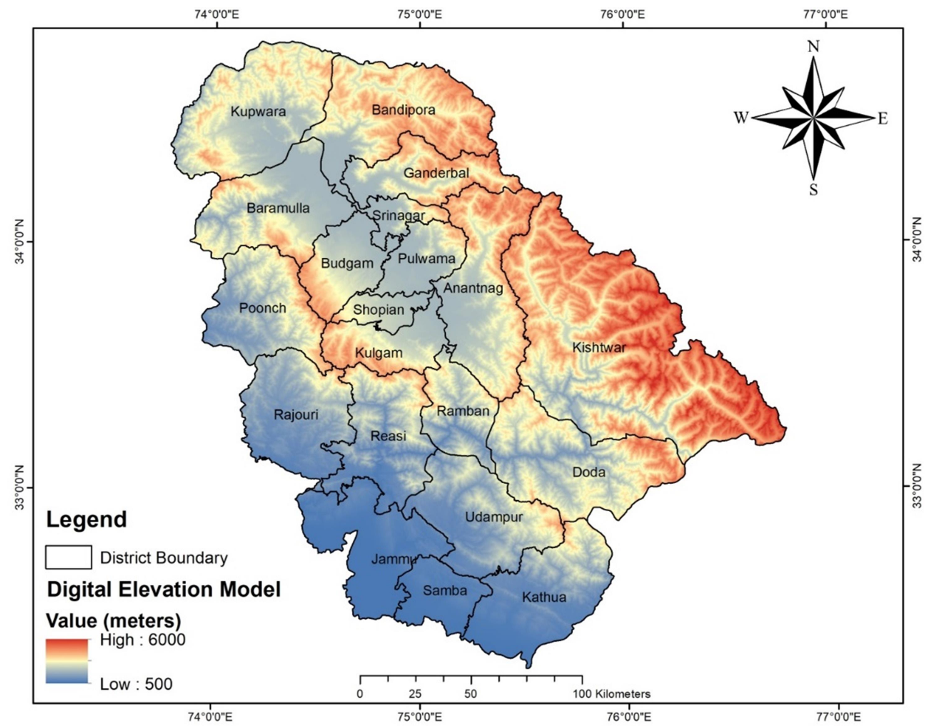

Fig.5. Digital elevation model overlain by the District boundaries

The Kashmir valley reflects as a green land with the majority of the regions covered with lush green forests (Fig. 6). About approximately 46 percent of its total land is occupied by forest cover. The basin is surrounded by dense forests from all sides and occupies almost all mountain terrains of the region. The presence of open forests can also be seen on the valley floor, though their density being very less than the surrounding ones. The valley floor is dominated by agriculture and horticulture besides grasslands and scrubs. The dense settlement can be seen at the center of the valley floor as well as the lesser settlement distributions all over the basin except in the higher altitudes of the greater Himalaya and Pir-Panjal range. The Jhelum basin is the longest river which carries the waters out from the basin through Baramulla gorge and the total length of the river was estimated at approximately 220km. The river rises from the deep spring at Verinag, south of Kashmir valley, and has developed meanders all along its course. The river is joined by numerous tributaries originating from surrounding mountain ranges before it reaches Wulur Lake, which controls its flow. The glaciers of the valley have reduced to a larger extent and can be seen with lesser distributions along with the greater Himalayan range. However, the seasonal snow covers approximately 3 percent of the total land and therefore remains as non-perennial snow regions after the melting of snow. The Kashmir valley has also abundant exposed rock mass surface and most of these regions are above the tree line. The exposed rock mass and barren land together comprise approximately 750km^2 (5.5%) of total land. A detailed description of land use and land cover classes is given in the figure (Fig. 7).

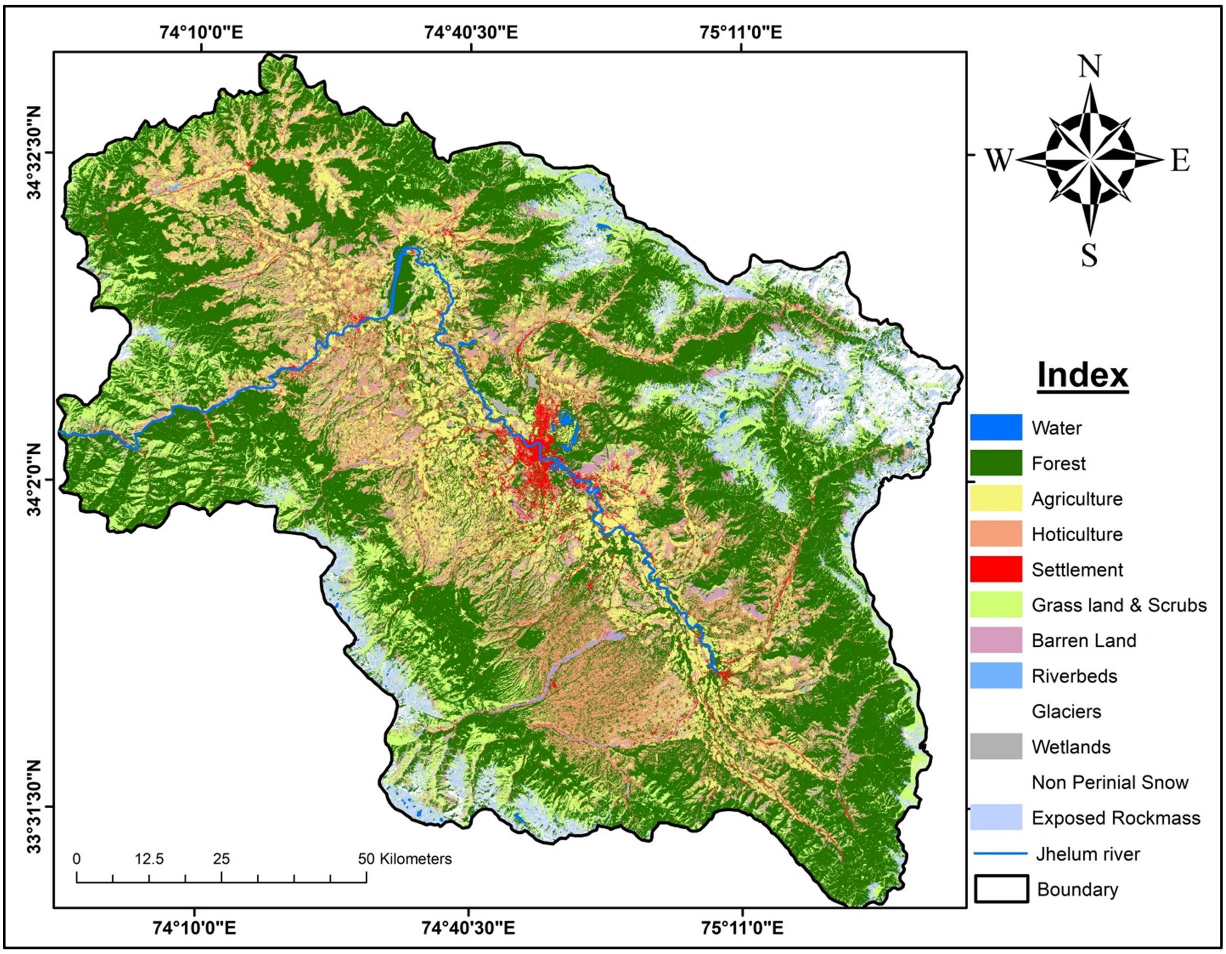

Fig. 6 Land use Land cover map of Kashmir valley.

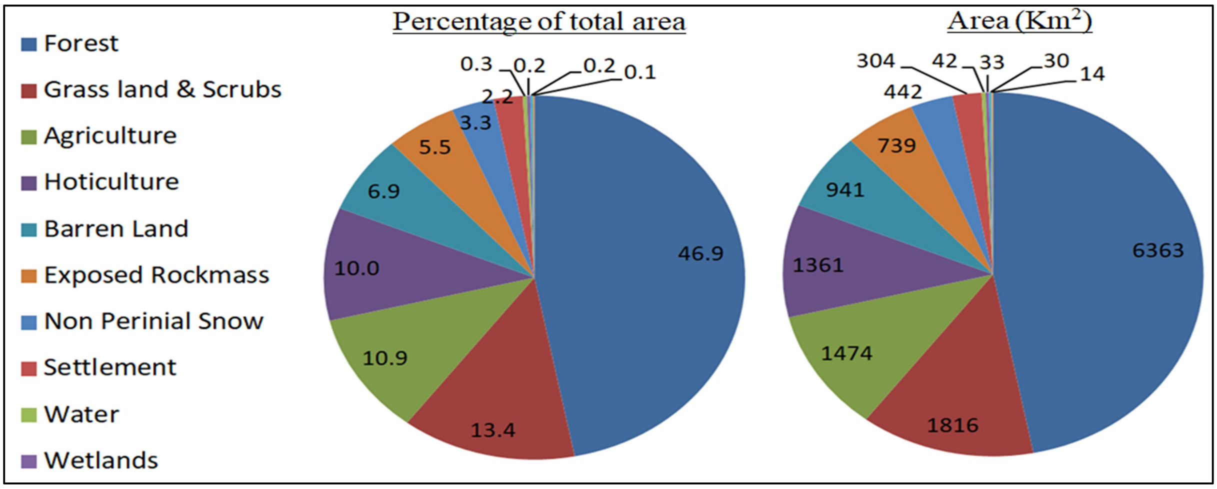

Fig. 7 Description of Land use, Land cover classes of Kashmir Valley.

3.1. Land use changes in Kashmir Valley:

There is a considerable land use change in the Kashmir valley over the period of 35 years. The land use classifications and the change detection were estimated from the year 1985 to the year 2020 as represented in Figure 8. The major land classes were considered for the change detection which include Cropland, Built-up, Scrubland/Rock mass, Water, Grassland, Forest, and Perennial Snow. The cropland has shown an increase of 4.95 percent and was seen as 4514.16 sq.km in the year 1985 and 4737.811 sq.km in the year 2020. The Built-up has shown an increase of 6.67 percent and was recorded as 284.95 sq.km in the year 1985 and 303.966 sq.km in the year 2020. The Scrubland/ Rock mass has shown an increase of 54.28 percent and was recorded as 544.08 sq.km in the year 1985 and 839.383 sq.km in the year 2020. The Grassland has shown an increase of 21.54 percent and was recorded as 1494.11 sq.km in the year 1985 and 1815.92 sq.km in the year 2020. However, the study shows a considerable decrease of the imperative resources including Water, Forest, and Perennial Snow. The water bodies show a decrease of 44 percent while as the Perennial Snow shows a decrease of 23.93 percent during the period of 35 years. Further, the forest area is showing a decrease of 13.40 percent and was recorded as 5810.31 sq.km in the year 1985 and 5031.54 sq.km in the year 2020. A detailed description of the land use changes in the Kashmir valley is given in Table1.

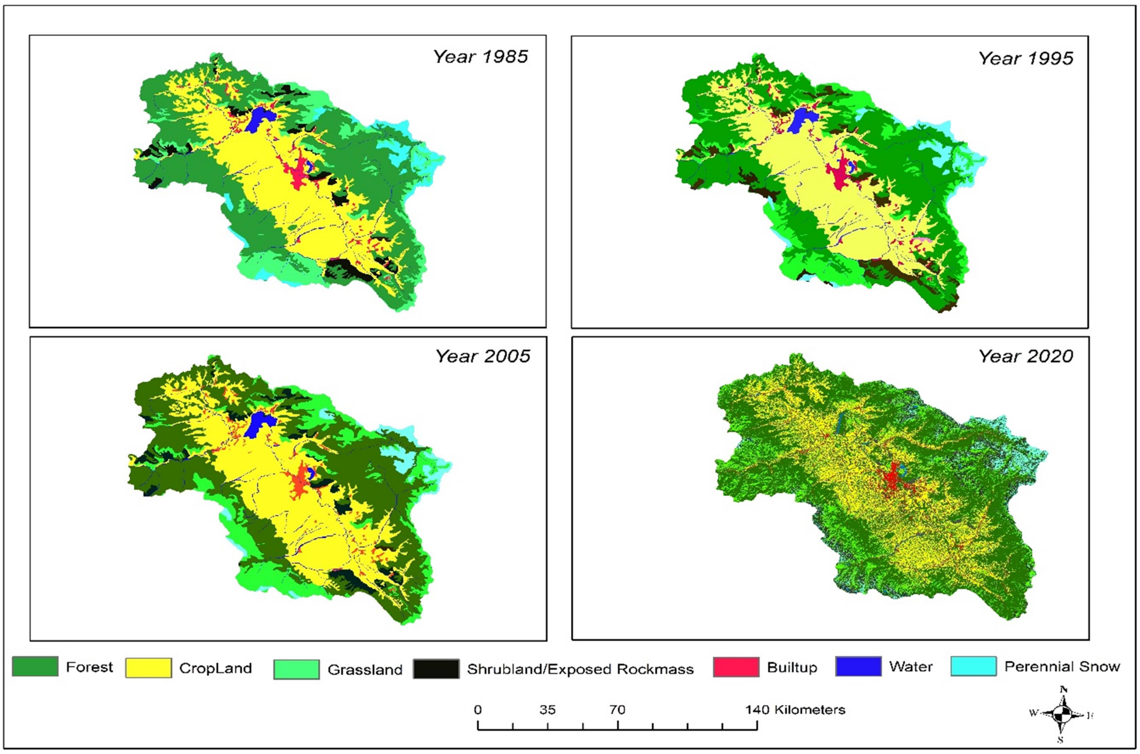

Fig.8 Land use changes in the Kashmir valley from 1985 to 2020

Table 1. Statistical description of the land use changes in the Kashmir valley

Land Feature	Area (Y-1985) sq.km	Area (Y-1995) sq.km	Area (Y-2005) sq.km	Area (Y-2020) sq.km	**Change in 35yrs (%age)**
Cropland	4514.16	4455.25	4560.97	4737.811	⇧ 4.95
Built-up	284.95	281.65	292.65	303.966	⇧ 6.67
Scrubland/ Rock mass	544.08	688.09	530.38	839.383	⇧ 54.28
Water	322.89	300.89	295.64	180.81	⇩ -44.00
Grassland	1494.11	1581.32	1957.36	1815.92	⇧ 21.54
Forest	5810.31	5722.81	5436.99	5031.54	⇩ -13.40
Perennial Snow	580.5	520.99	477.01	441.57	⇩ -23.93
Total	13551	13551	13551	13351	----------------

3.2. Slope analysis:

Kashmir Himalaya in the north-western part of the complex Himalayan belt is marked by vast relief variation and complex geological setting. Characterized by remarkable complexity, demonstrating many phases of tectonic and deformational events with collision- triggered highly deformed lithologies. Tectono-stratigraphically rocks of Higher Himalayan Crystalline (HHC), Tethys Himalaya, lesser Himalaya and sub-Himalaya (Siwalik) are enfolded and thrusted upon each other mounting treacherous and rugged terrains around the Kashmir Valley. Such rugged topography, complex geological setup with high seismicity, high intensity rainfall enhancing landslides and floods trigger substantial complications offer challenges to all infrastructural development. Planning, design and execution of infrastructure development programs are substantially impacted by such complex setup, even pose large risks to every infrastructure as well as to its environment in the region.

The region is dominated by variable amount of slopes changes. The slope ranges have been calculated ranging between 0-77 degrees from the valley floor towards mountain ridges. The majority of the valley floor is ranging between 0-5 degrees whereas the rest of the floor has developed slope ranging from 6-11 degrees. The 3860km^2 area has developed slopes ranging between 24-30 degrees and is estimated as 24 percent of the total land (Fig. 9).

The vast settlement has been built on the surface with slopes ranging between 5-11 degrees and is therefore directly attributed to the slope consequences in case of natural hazards. The analysis revealed that out of the total area of Kashmir valley (13555km2), 3860km2 (28%) have surface slopes ranging between 0-5 degrees, ~3200km2 (~22%) ranging between 11-24 degrees, ~1576km2 (~11%) ranging between 24 to 30 degrees, 1346km2 (~9%) ranging between 30-35 degrees, and ~ 1700km2 (~12%) have surface slope above 35 degrees. A detailed description of slope classes and the area covered is given in (Fig. 10). Such varied slope conditions add up to the risk level during earthquakes. Areas dominated by high slope angles pose a severe threat of earthquake-induced land sliding. Most of the settlements in Kashmir valley are located along the foothills of higher slopes that are vulnerable to these earthquakes induced landslides. During 2005 Kashmir earthquake, 25000 landslides were triggered, burying entire villages and killing thousands of people and destroying property worth billions. If such event occurs inside the Kashmir Valley, colossal damage can be observed by the earthquake induced landslides.

Kashmir Valley has a long history of earthquake triggered landslides, causing severe damage to the built environment.

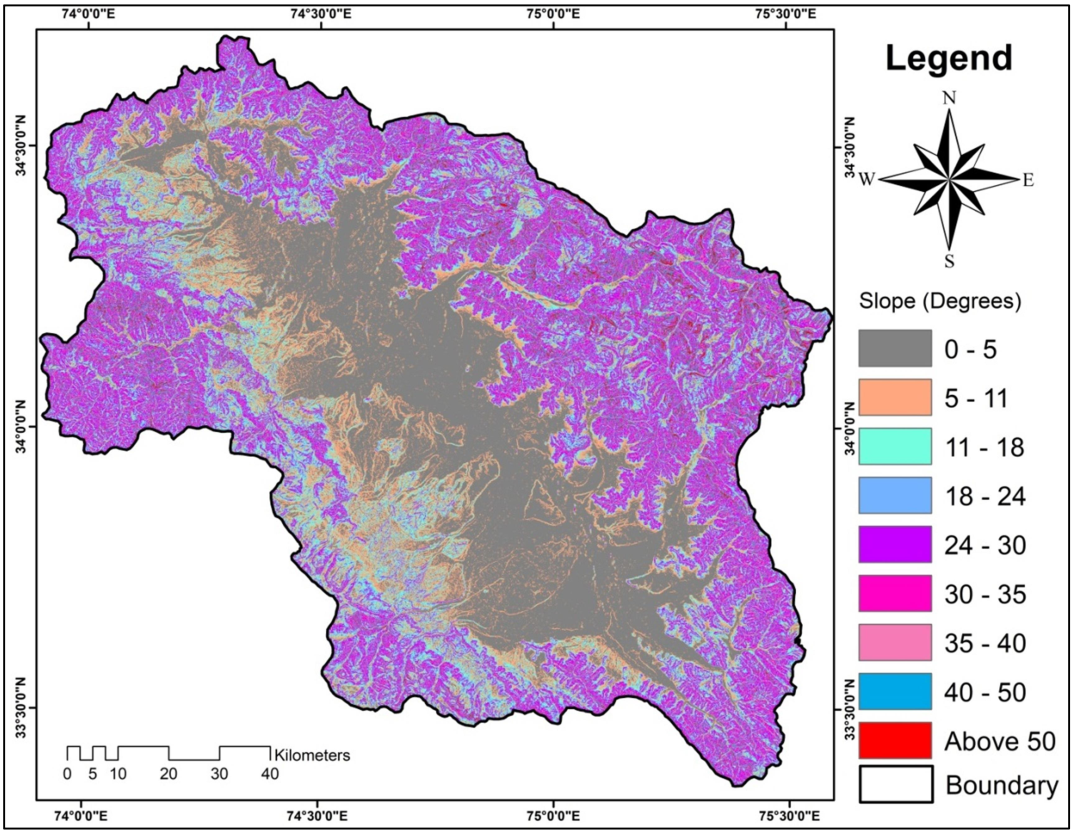

Fig. 9 Surface slope map of the Kashmir valley

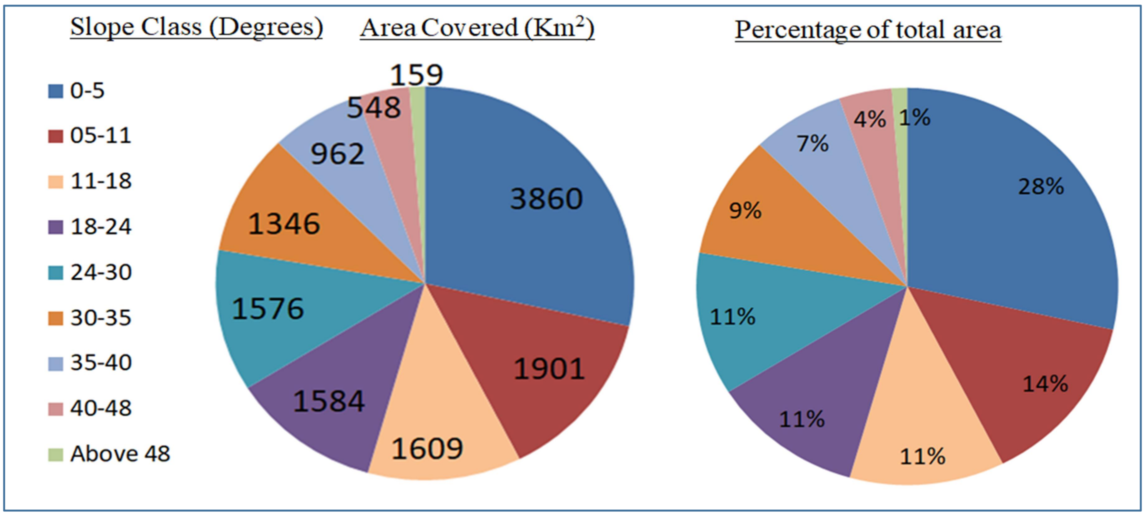

Fig. 10 Description of slope classes and area covered in Kashmir valley

3.3. Drainage Characteristics

The drainage pattern of Kashmir Basin is highly elusive. The Valley is geologically young with high of tectonic influence and activity due to continuous Himalayan uplift. This rapid uplift has modified the drainage pattern in the past and is currently controlling their shape, structure and pattern. Hard rocks mainly dominate the headwater/source region while as after entering the basin they pass over homogenous and soft rock lithologies, i.e., Karewas and recent flood plains. The Kashmir valley is drained by a single major river, the Jhelum River. It traverses through the center of the basin and is fed on both sides by several tributaries along its course and drains the basin through narrow gorge at Baramulla. The river is fed on north by Bringi, Kuthar, Aripat, Lider, Aripal, Dachigam, Sind, Erin and Madhumati, while as on south it's fed by Sandran, Veshaw, Rambiara, Romushi, Doodhganga, Shaliganga, Sukhnag, Ferozpor, Ningal, Garzan and Vijay-Dhakil, the Pohru and Mawar joins the it from east. The Jhelum River is more shifted towards north, closer to Greater Himalayan side due to continuous uplift of Pir Panjal range side. The river flows mostly on soft rocks and is characterized by considerable meandering along its course. This is due to very gentle slope of river course in the valley and presence of unconsolidated sediments along the river course. On northern side (Greater Himalayan side), the streams flow towards south and pass mainly through hard rocks for most of their river course before merging with Jhelum River. These rivers are mainly lithologicaly controlled. Among these Lider and Sind rivers show upto 6th order streams. These rivers are perennial in nature with high gradient. Smaller rivers (Madhumati, Erin, Dachigam, Aripal, Aripat, Kuthar, Bringi and Sandran) show upto 5th order streams. Most of these rivers show much entrenched narrower river course with highly incised steep valleys and gorges.

Much of the difference and evulsion is found on the north flowing river systems. The river basins on this side are elongated and with distinctive drainage divides in higher reaches and anomalous in lower portions due to inter-basin crossover of rivers. These rivers mostly pass over soft rock terrains (Karewa and river Alluvium) for most of their river course. These originate in the higher elevations of Pir Panjal range and flow towards north. Their river course is very different than the south flowing rivers. They have steep to gentle slopes and presence of various Knick points along their river course. Except Veshaw (7th order streams) most of these rivers show upto 5th order streams. However, these rivers show deflection and abrupt meandering at different locations which can be attributed to structural control (presence of faults).

3.3.1. Drainage patterns

In Kashmir Valley, various styles of drainage patterns are present like dendritic, trellis, radial, parallel, rectangular, and barbed patterns (Fig. 11). Dendritic drainage pattern is widely present with most low order tributaries meeting the higher at less than 90^{o}. This type of drainage is observed where lithology is homogenous and where lithology controls the drainage pattern with less structural control. Both antecedent as well as superimposed dendritic patterns are found in less resistant rocks as well as flat lying horizontal sedimentary, massive igneous and metamorphic rocks at different locations of the basin. This type of drainage is also found in folded and tilted rocks that can be attributed for superimposition of the drainage post folding and tilting of beds. The Pohru, Erin, Lider basins as well as higher elevated regions shows this type of drainage pattern indicating less structurally controlled drainage patterns. Sub-trellis to trellis pattern is observed in Madhumati and Sind basins. In these basins a system of parallel-sub-parallel streams flow along the elevated linear ridges. In these areas the major streams are found abruptly bending at 90^{o} while crossing the structural obstructions and low order streams (1st order) flow perpendicular with respect to main stream, however middle order (2nd and 3rd order) streams are mostly parallel to sub parallel with respect to each other. These drainage patterns suggest noticeable structural control of most stream courses. The trellis pattern is mostly fault controlled where by segmented and layered fault splays produce alternating bands of resistant and weak rocks. In Kashmir Valley, the trellis drainage patterns are found closely associated along Himalayan thrust sheets. The thrust sheets are folded and refolded producing alternate layers or bands of rocks suitable for the formation of trellis drainage. In the upper reaches of Sindh and Madhumati sub-basins presence of offset and linear drainage lines also suggest structural control.

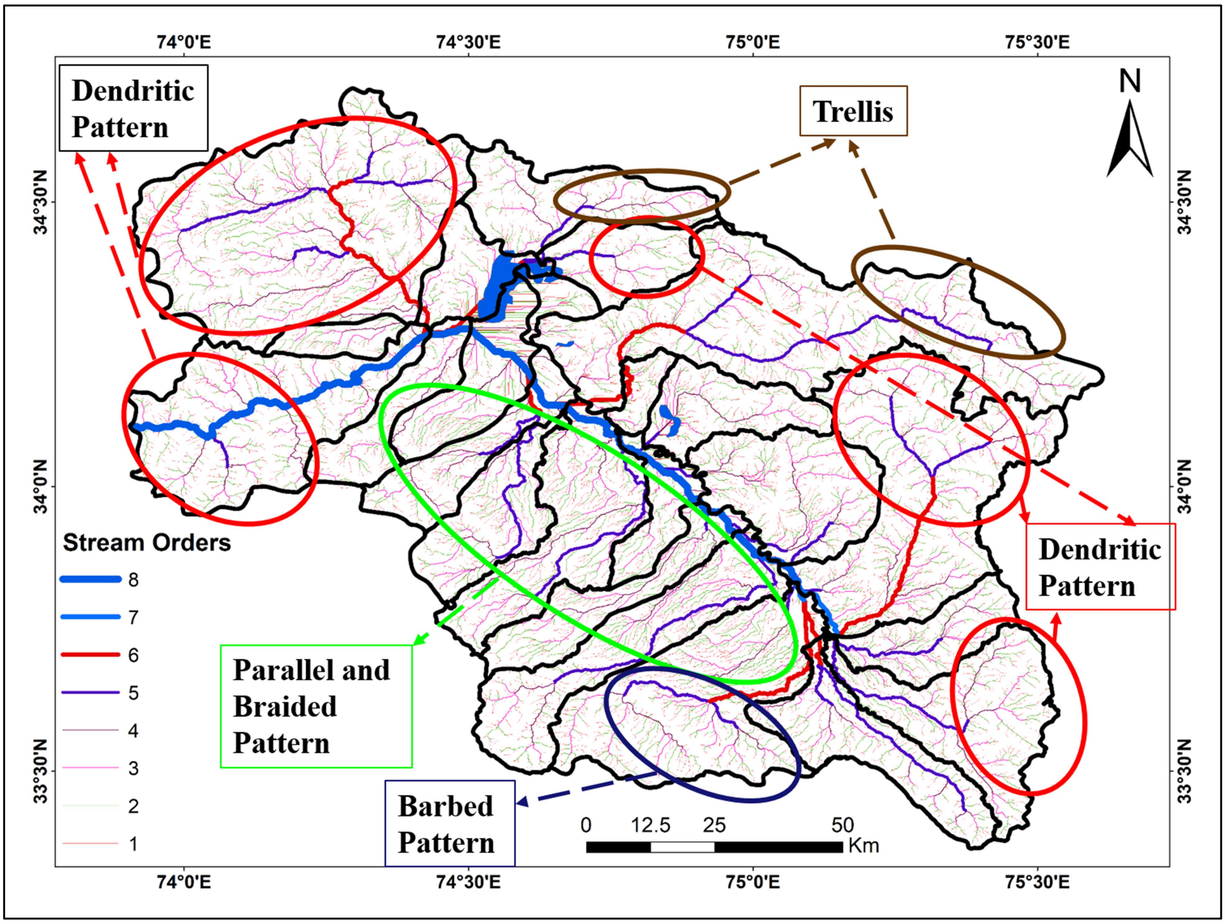

Fig. 11 Observed different types of drainage patterns in the Kashmir basin.

Most of the southern basins on Pir Panjal side show parallel drainage pattern. The basins are highly elongated with deeply incised valleys both in hard rocks as well as in Karewa sediments. The rivers flow irregularly with broad and braided pattern with tributaries mostly showing cross over trend in lower portions of the basin. In the Veshaw basin, the Kandai Kol tributary show barbed pattern flowing in opposite direction and take a hair pin bend before joining the main Veshaw river. The presence of paleo-channel, strath terraces and unpaired river terraces in Veshaw river near the Tangmarg village suggest that the basin has been uplifted and structurally controlled. The same features are observed in Rambiara, Doodhganga, Romushi sub basins indicating regional/local uplift and structural controls.

The Rambiara basin shows considerable amount of rejuvenated streams with braided bar deposits. Three fault splays representing surficial expressions of Balapur fault has produced beheaded streams. The Rambiara river near Balapur village has laid down ~500m wide braided bar in the middle of the channel due to dissection of this river by Balapur fault uplifting the northern segment causing damping and deposition of river sediments. The Balapur fault extends through most of the southern sub basins showing significant geomorphic expressions. In Doodhganga and Shaliganga sub basins the Balapur fault branches into two sections one moving towards the east while (Balapur fault) as the other one (Raithan fault) traverses towards northeast. The presence of uplifted strata terraces, dissected scarps and emergence of new streams suggest that these splays are tectonically young and active.

3.4. Ganderbal District:

The district Ganderbal of Jammu and Kashmir lies at the northern extent of India, at the foothills of the great Himalayan Mountains. The region consisting an area of approximately 1370 km^2 has a diverse landscape and varying topography. The district has a total population of approximately 297446 population including 61070 tribal population which makes up the total of approximately 25 percent of total tribal population. The geographic location of the study are is represented in Fig. 12.

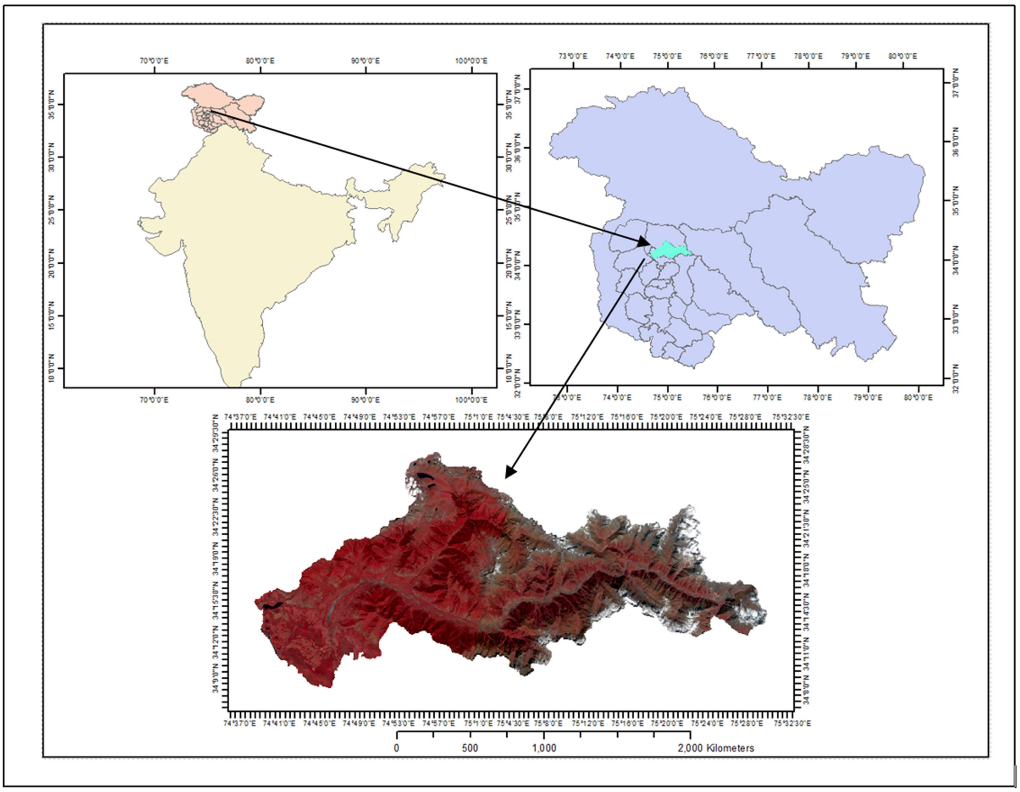

Fig. 12 Geographic location of district Ganderbal, Kashmir Valley

The topography of the area is wide-ranging and contains high mountain peaks and low-lying areas. The elevation map was projected using a digital elevation model (ASTER DEM) which was assessed via the United States Geological Survey portal. The model represents that the area is consisting of high peaks of approximately 5000m above mean sea level as well as low-lying areas at approximately 1500m above main sea level as represented in the Fig. 13. The highest mountain peaks including the Harmukh mountain ranges and Panjtarani mountains lie towards the northeast of the region. The area contains the rigged topography and features some of the most important glaciers of the region including Harmukh glaciers and Thajwas glaciers. The district also consists the low lying areas including the wetlands at the elevation of 1500m above main sea level, therefore featuring the diverse regional slopes in the area. The complete description of the elevations and slope interpretation is given in the Fig. 14.

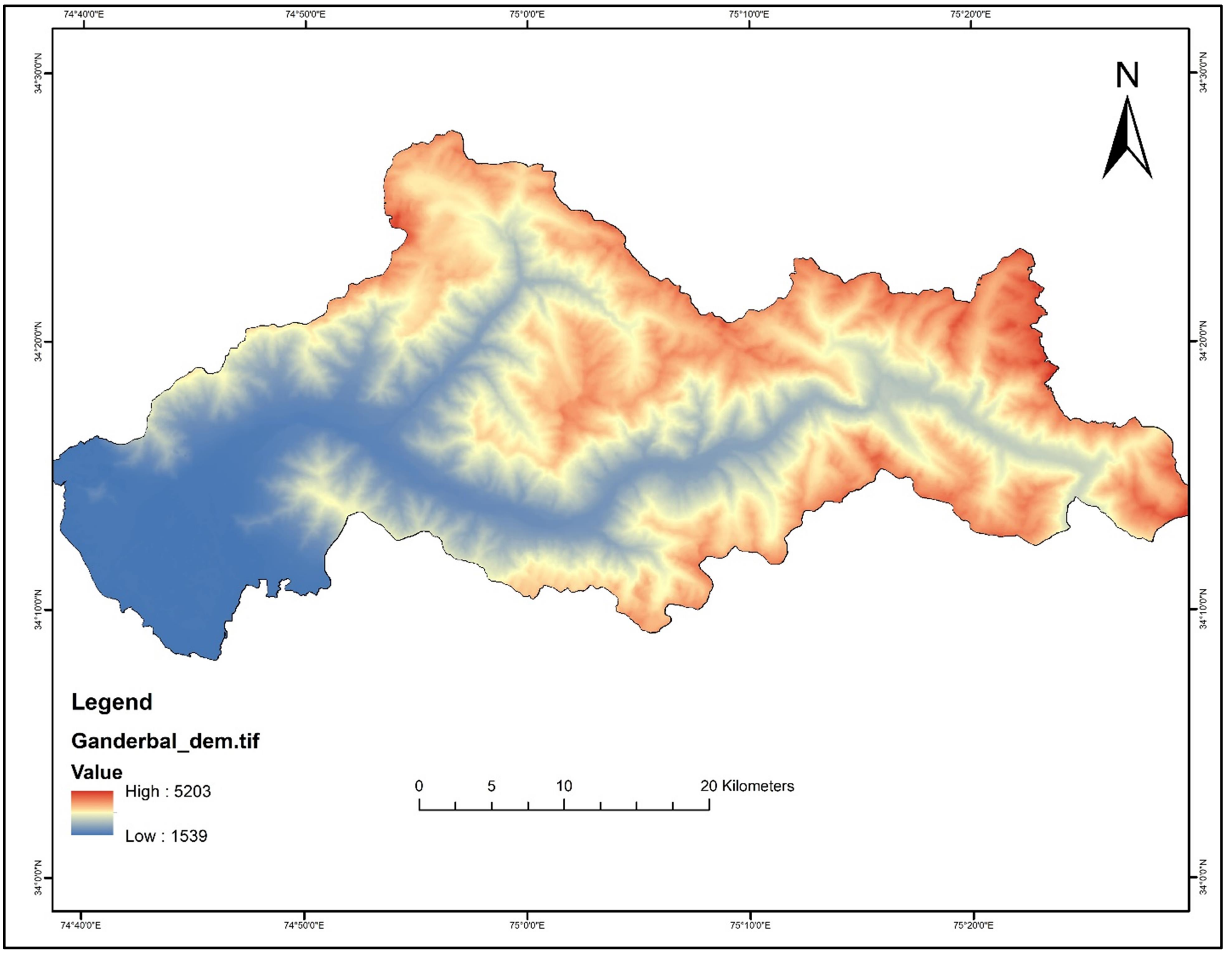

Fig. 13 Elevation map of district Ganderbal

The Ganderbal district reflects majorly as a green land with the majority of the regions covered with lush green forests (Fig. 14). About approximately 46 percent of its total land is occupied by forest cover. The region is dominated by agriculture and horticulture at the low lying areas. The dense settlement can be seen at the western side of the regions as well as the lesser settlement distributions along the upward. The general perception about the land use and land covers can be visualized in the map represented in the Fig. 15.

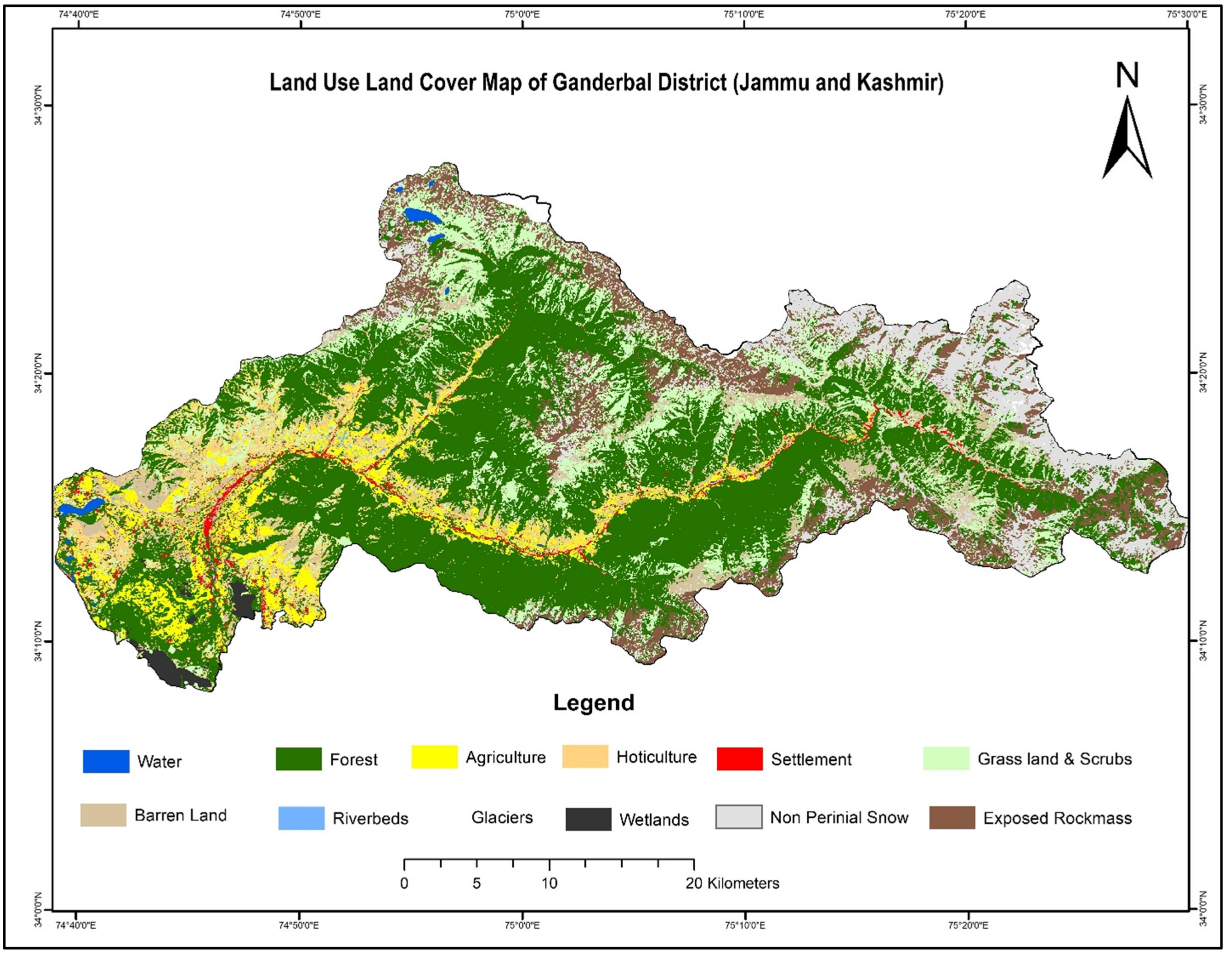

Fig. 14 Land use Land cover map of district Ganderbal.

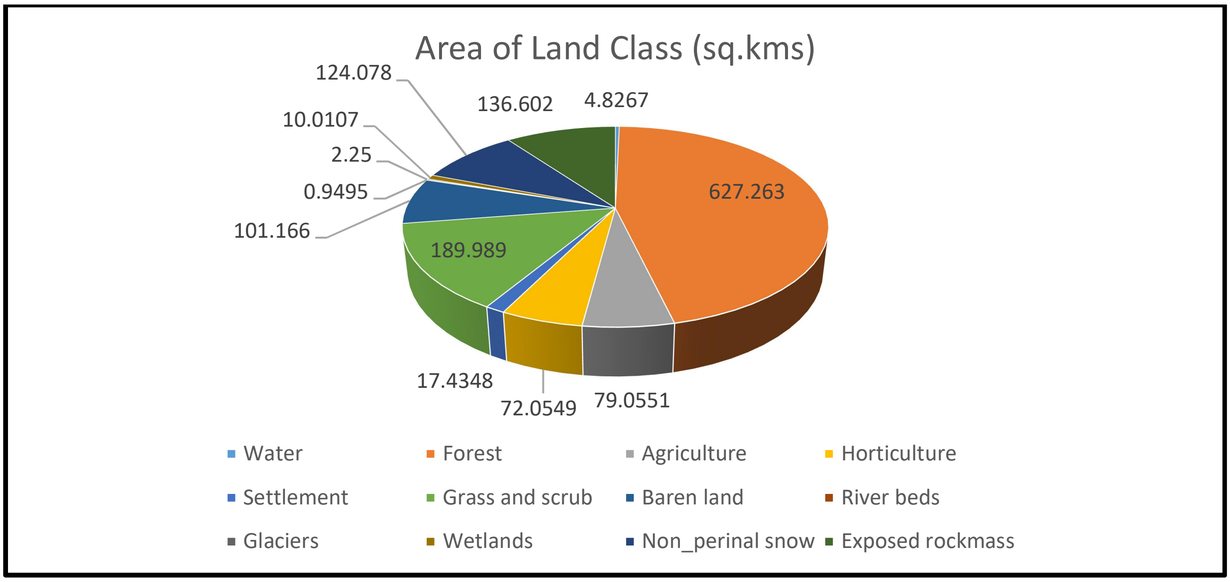

Fig. 15 Statistical description of Land use Land cover in district Ganderbal

The district Ganderbal is dominated by the forest cover which consists the total land of approximately 627 km^2 followed by the area of approximately 189.9 km^2 as grass and scrub land. The region has the agricultural land spread over 79 km^2 and horticulture land of 72 km^2. The water bodies of the region consist of 4.8 km^2 which include the greater Himalayan lakes on the upper region and the Manasbal Lake at the low lying region. The region has the glaciers spread over 2.2 km^2 and plays larger role in river dynamics during the melting of these glaciers. Apart from glaciers, the region covers the wide spread areas of the Non-Perineal snow which makes the total of 124 km^2 and provides considerable water flow during the summer season to the agricultural activities. The Ganderbal district also gives a space to the wetlands at its low lying areas including Shallabugh wetland and the total wetland areas are spread over the area of approximately 10 km^2. The region also covers the large exposed rock mass at its upper reaches which makes total area of approximately 136.6 km^2.

Considering the agricultural section of the district Ganderbal, it is mostly restricted to the lower regions whereas the lesser distributions can be seen ranging towards the minimal path of upper regions and has followed the linear pattern. At upper regions, the agricultural land is mostly lying along the banks of river Sindh and Naranag nalla, a tributary of Sindh River. Further, the horticulture of the region is also following the agricultural section and is spread within the periphery of agricultural land. The pattern of agricultural and horticultural land shows that these sections are only spread to the smaller extent and are mostly affiliated to the drainage network of the region. In contrary to these sections, the forest cover in the region is wide ranging and are dense except in the areas of exposed rock mass and less frequent in the settlement region. Further, the settlement of the district Ganderbal is also following the path of lower slopes and is dense in the low lying areas and linearly distributed towards the upper reaches. The pattern of the settlement, agricultural and horticulture can been seen in the Fig. 16.

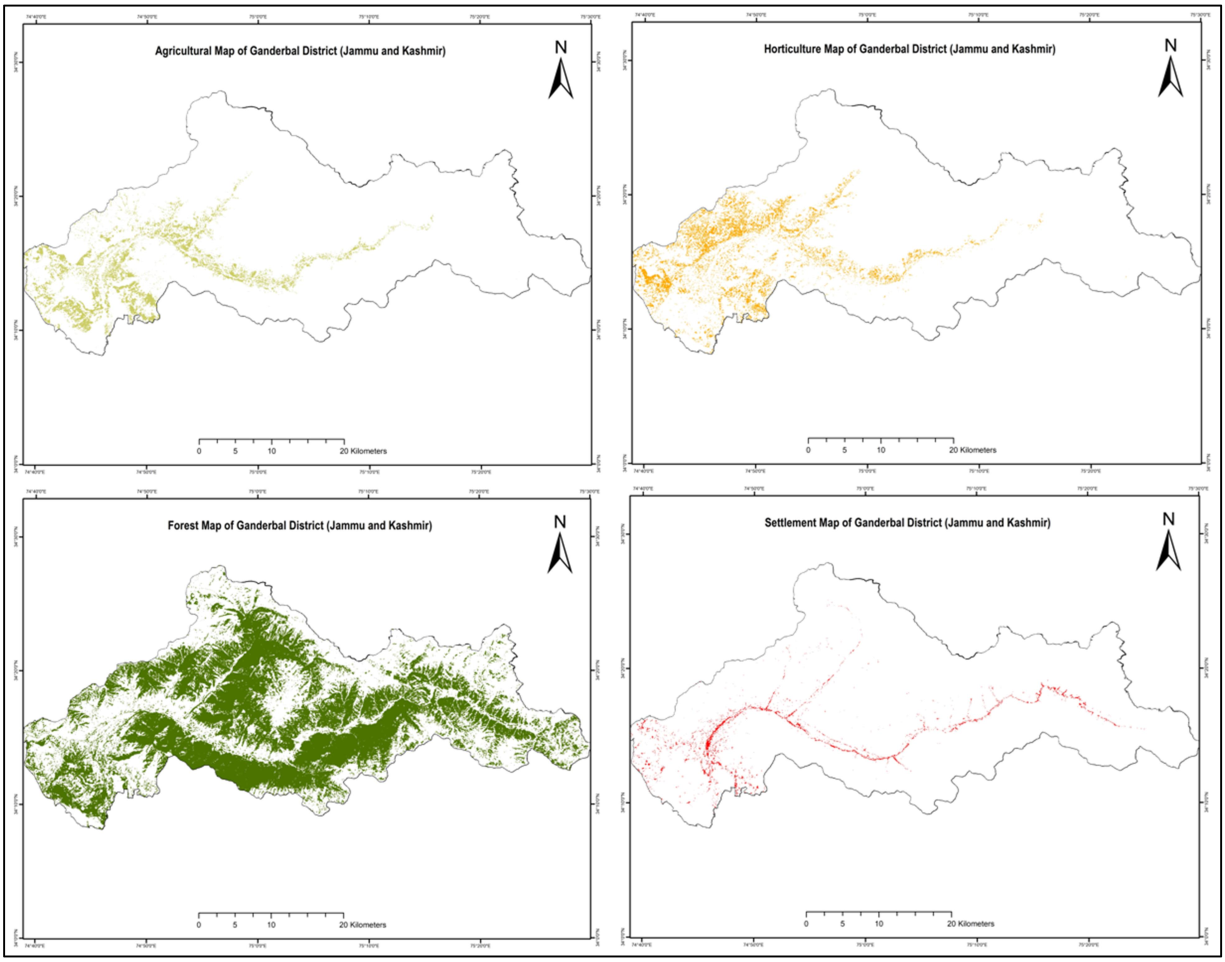

Fig. 16 Distribution and pattern by land classes of Agriculture, Horticulture, Forest and Settlement respectively.

As a generalization, the Ganderbal district can be seen as fascinating land surface which is featuring almost every land feature and can be therefore perceived as an ample opportunity for ecological empowerment as well as the wealth incitement for its people. Further, the biological diversity and its exploration in the upper reaches of district Ganderbal can be a big boost to the tribal people who are mostly residing at these areas. Further, the detailed investigations about the plant dynamics using advanced scientific tools will bring greater insights about unexplored land surfaces of mountainous regions of the district Ganderbal. Based on the ancillary data, the most of the tribal people in the Ganderbal district are residing in the upper regions, nearing the mountainous areas. These people are highly affiliated with the greater land slopes and unexplored plant genomics. Further, these areas have the least agricultural and horticultural diversity and are highly occupied by barren lands and non-perineal snows. Keeping this in view, detailed land scientific studies can be thought of utmost importance where integrated geospatial techniques in association with biological studies can play a greater role.

3.5. Tribal region of Ganderbal District:

This study was carried out to evaluate the populous tribal villages of Kangan Tehsil, district Ganderbal and to fetch prevailing developments using geospatial approaches and field surveys. In this study, 26 villages of Tehsil Kangan, consisting of the vast percentage of schedule tribes, were studied via ancillary data Vis a Vis geospatial technology. The study area is located in the northeast of Kashmir valley and is part of the topography pertinent to great Himalayan mountain ranges (Fig. 17).

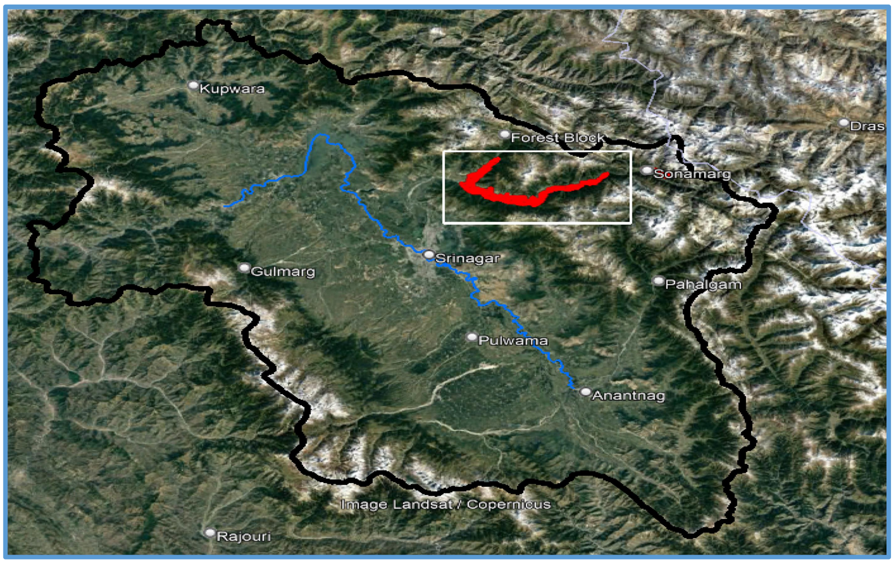

Fig. 17. Geographic location of the tribal region of Ganderbal. The red polygon area enclosed in a white rectangle represents the study area. The black line represents the boundary of the Kashmir basin.

3.5.1. Geographic identity and population distribution:

The study area consisting of 26 villages represents the settlement locality of approximately 70 sq. km in a curvilinear stretch geographically located at 34° 16' 54"N, 74° 53' 21" to 34° 17' 08"N, 75° 22' 18" with topographic variations at approximately 6000ft to 9000ft above main sea level. The villages fall in a mountain topography and are attributed to the greater Himalayas and Sindh Nallah in particular. The region has a total population of approximately 70 thousand which includes 33 thousand population of schedule tribe i.e. 46% of the total population (Fig. 18). The Gujjars and Bakarwals dominate the tribal population and are inherent in their culture and social communication.

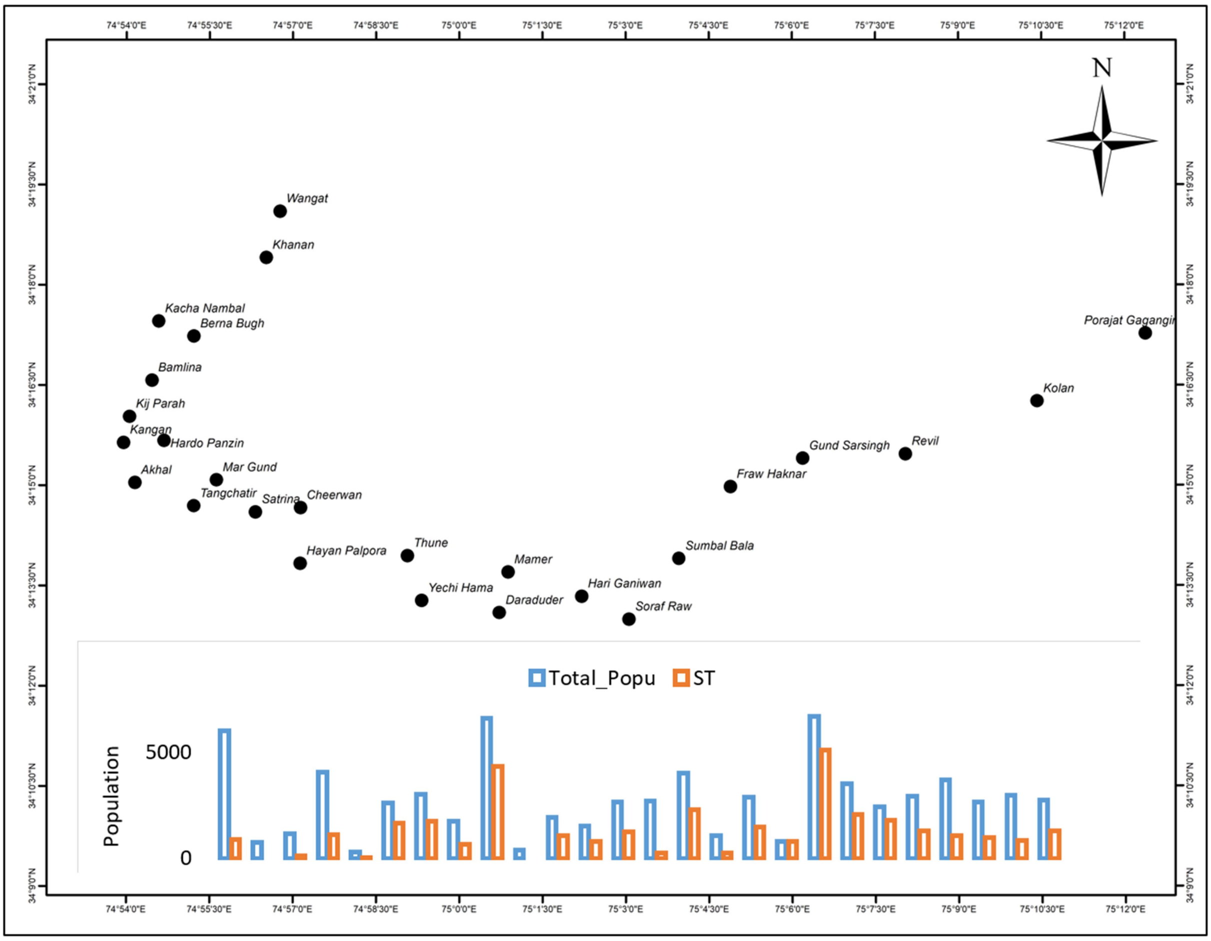

Fig. 18. Geographic location and tribal Population in Ganderbal.

3.5.2. Literacy:

The literacy rate of the region is approximately 55% which stands at 21% lower than the average literacy of Jammu and Kashmir. The Kangan town, which is the west extension of the cross-section (Fig. 19) and the nearest to the urban class has a literacy rate of 79.7%, and 14% of the tribal population. The Gagangir, a village at the east extension of the cross-section has a literacy rate of 42%, and 47% of the tribal population. This also shows that the literacy rate is decreasing nearly half with the increase of the tribal population and vice versa. The Gagangir village is approximately 30km distant from Kangan town and the graph (Fig. 19) shows a gradually decreasing trend in the literacy rate and therefore signifies the remoteness also as fall off factor.

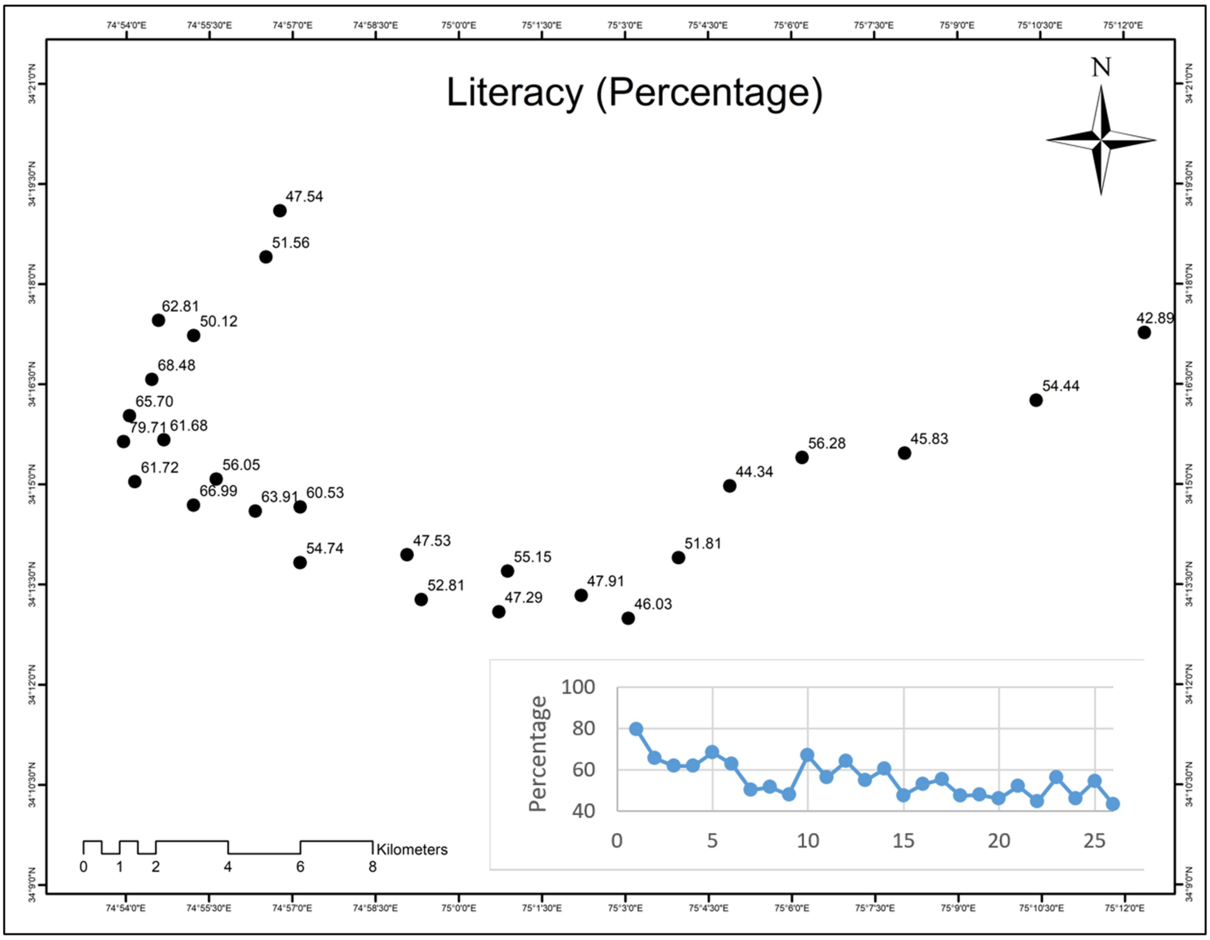

Fig. 19. Literacy rate of the tribal region of Ganderbal.

Further, considering the public communications and ground truthing, the study suggests that the lack of educational awareness, guidance and counseling, and motivation plays a significant role in the literacy dip.

The female literacy of the region stands at 43% which is 24% lower than male literacy and 33% lower than the average literacy of Jammu and Kashmir. The study suggests that the lower proportion of female literacy is a significant apprehension among all the highly populated tribal villages in the region. Some of the villages portray a literacy rate of around 35% and lower as represented in Fig. 20. The remoteness and awareness discrepancy is considered as the major implications for literacy attenuation in females.

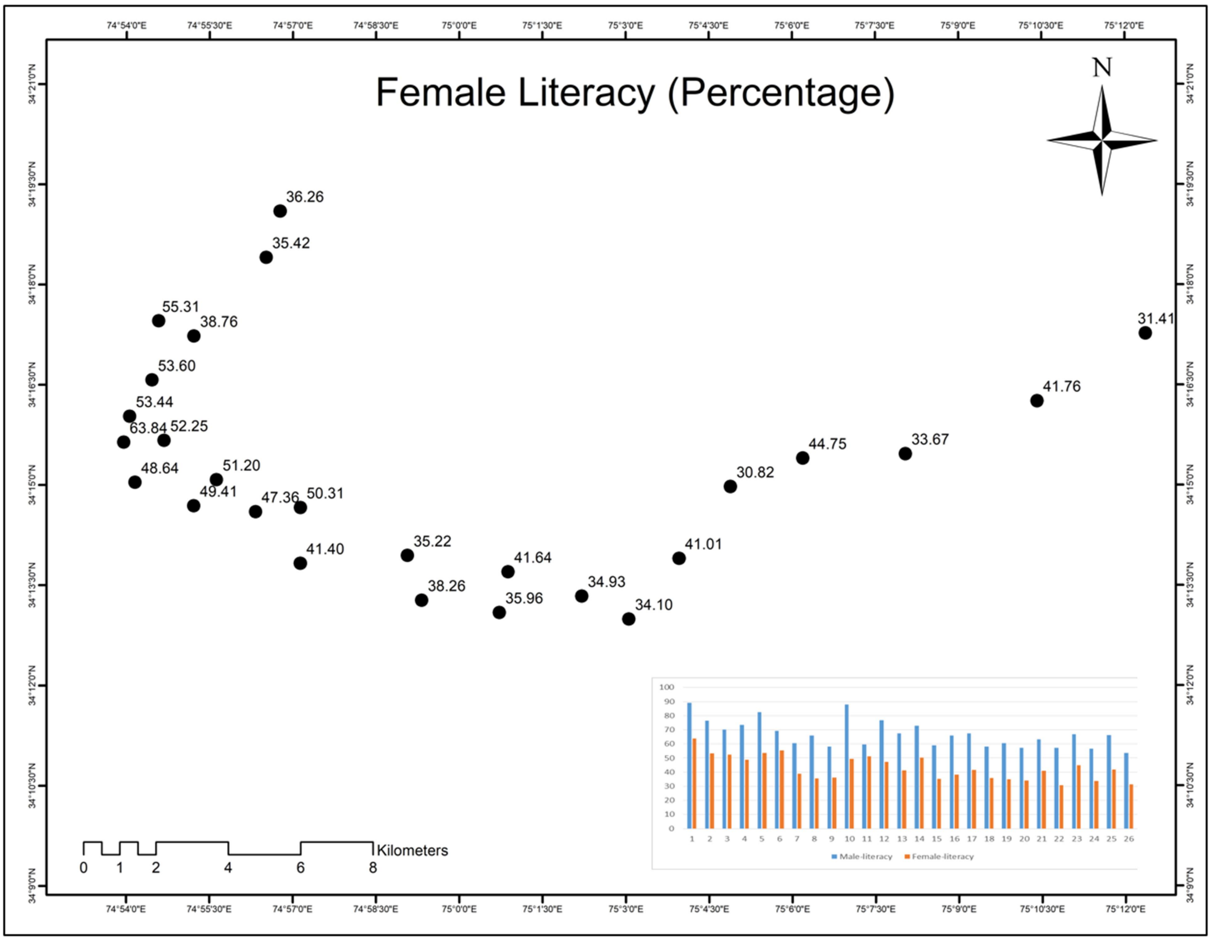

Fig. 20. Status of Female Literacy in the tribal region of Ganderbal district.

3.5.3. Employment Status:

The study area has a total population of approximately 70 thousand among which 19 thousand are workers according to the survey of India, Census 2011 (Fig.21a). However, the proportion of female workers stands at 17% and is even lower than 10% in 9 out of 26 villages. The proportion of female workers is very less compared to the male workers in the region (Fig.21b). Further, the volume of workers also lessens with the increase in the remoteness of the villages from the Kangan town. Considering the public communications and ground truthing, the study suggests that the region perceives the financial uncertainties and therefore necessitates employment generation.

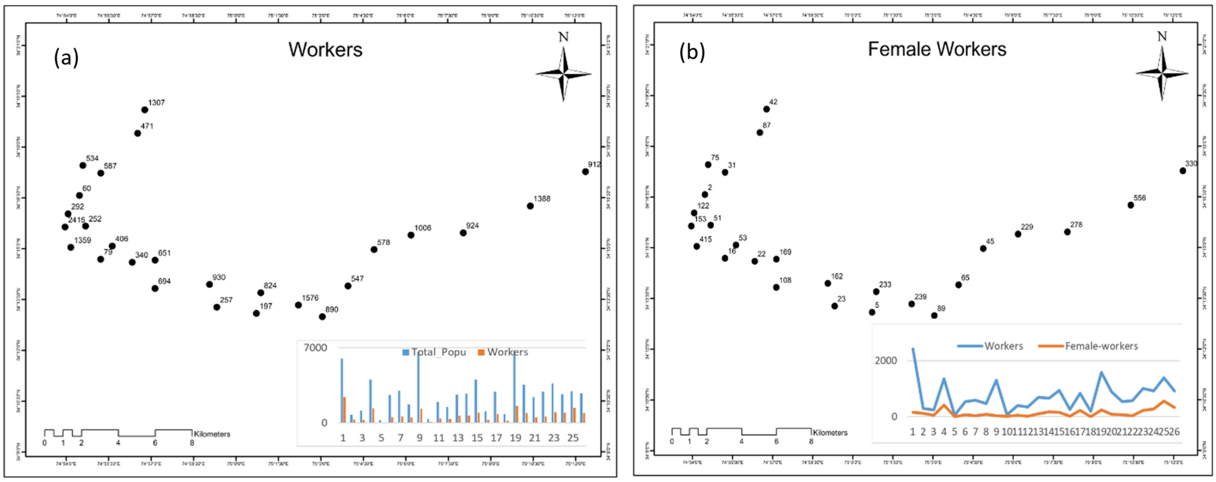

Fig. 21. Employment status in the tribal region of Ganderbal district.

3.5.4. Land Classifications:

The study area is dominantly surrounded by lush green forests and is spread to a larger extent. The major land classes in and around the study region include Forest, Agriculture, Horticulture, Water, Settlement, Grass and Scrub, Exposed rock mass, and Non-perennial snow. The black dots in Fig. 22 represent the location of villages on the land use land cover map. The study shows the sizable land features of agriculture as well as the ample traces of horticulture. However, these classes decrease in the area with respect to the distance from Kangan town along with the decrease in the settlement. Being a mountainous topography, the study region features a diverse landscape ranging from mountain peaks to ridges. The study region is also featured by glaciers at near traverses and therefore gives shape to the well-structured type of drainage system. Further, the adjacent landscape also features grasslands which act as the most suitable periphery for the animal ecosystem.

Since public communications and ground truthing are considered, the study suggests the recent land use change detection in the region. The anomaly is seen due to the fluctuations in irrigation which are undoubtedly linked to climate change and the recession of glaciers. The land use change has certainly played the role in the recession of agriculture.

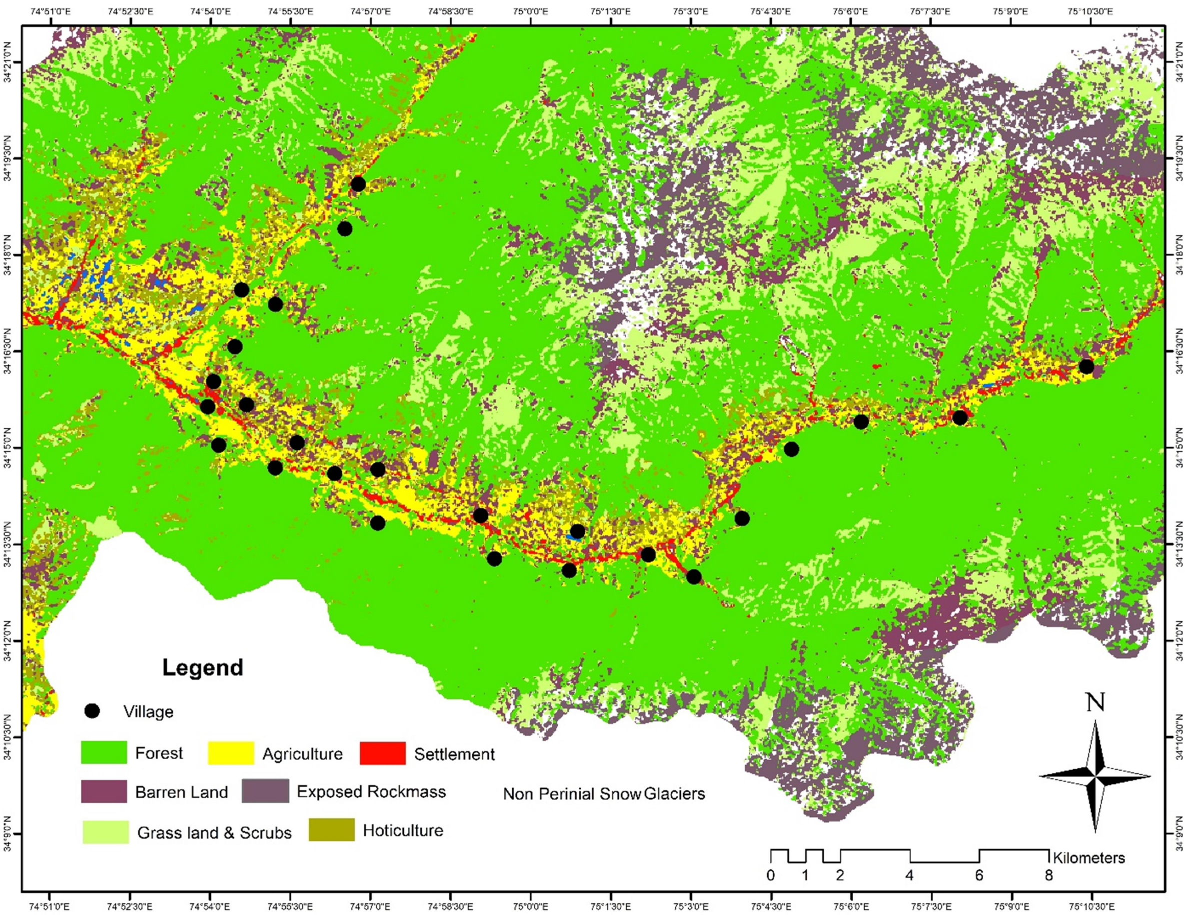

Fig. 22. Land use in the tribal region of Ganderbal district.

3.5.5. Land use changes in the Tribal region of Ganderbal district:

The land use classifications and the change detection for the period of 35 starting from the year 1985 to the year 2020 years were estimated as represented in the Figure 23. The major land classes were considered for the change detection which include Cropland, Built-up, Scrubland/Rock mass, Water, Grassland, Forest and Perennial Snow. The cropland has shown the increase of 56.30 percent and was seen as 30.53 sq.km in the year 1985 and 47.72 sq.km in the year 2020. The Built-up has shown the increase of 44.97 percent and was recorded as 6.04 sq.km in the year 1985 and 8.75 sq.km in the year 2020. The Scrubland/ Rock mass has shown the increase of 38.95 percent and was recorded as 2.67 sq.km in the year 1985 and 3.71 sq.km in the year 2020. The Grassland has shown the increase of 33.74 percent and was recorded as 137.02 sq.km in the year 1985 and 183.2573 sq.km in the year 2020. However, there is a considerable decrease of the imperative resources including Water, Forest and Perennial Snow. The water bodies show the decrease of 28.28 percent while as the Perennial Snow shows the decrease of 31.71 percent during the period of 35 years. Further, the forest area is showing the decrease of 30.55 percent and was recorded as 726.32 sq.km in the year 1985 and 504.39 sq.km in the year 2020. The detailed description about the land use changes in the region is given in the Table 2.

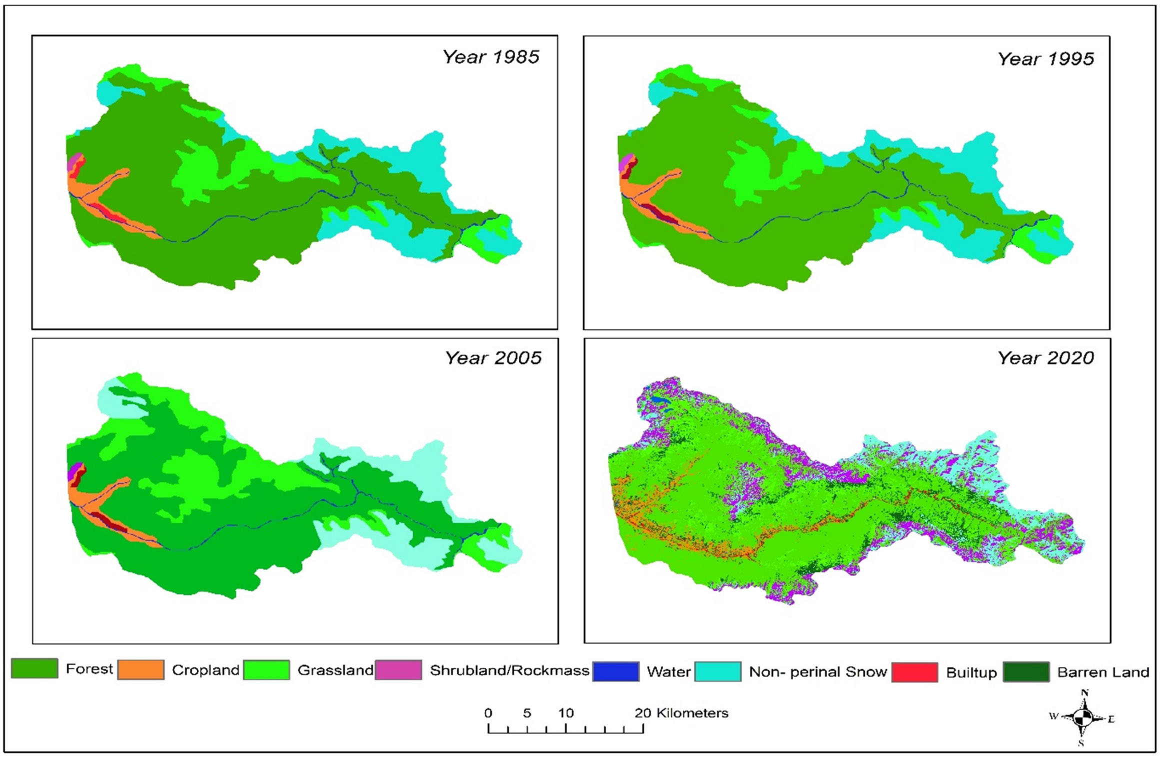

Fig.23 Land use changes in the populated tribal region of Ganderbal from 1985 to 2020

Table 2. Statistical description of the land use changes in the tribal region of Ganderbal

Land Feature	Year-1985 (sq.km)	Year-1995 (sq.km)	Year-2005 (sq.km)	Year-2020 (sq.km)	Change in 35yrs in %
Cropland	30.53	30.53	35.71	47.72	⇧ 56.30
Built-up	6.04	6.04	6.88	8.7562	⇧ 44.97
Scrubland	2.67	2.67	2.62	3.71	⇧ 38.95
Water	10.28	10.28	10.31	7.3724	⇩ -28.28
Grassland	137.02	118.82	150.54	183.2573	⇧ 33.74
Forest	726.32	743.73	648.21	504.3915	⇩ -30.55
Perennial Snow	179.17	179.96	160.76	122.3406	⇩ -31.71

4. Conclusion:

The tribal population of Kashmir valley is habitually living in remote and diverse topographies. Their infrastructure is mostly located away from the cities and densely spaced settlements with their own culture and living standards. They are closely linked to hillsides, green environments, and fast-flowing waters and are living their life in distant landscapes. The databases carried the important information and ecosystem description of the Kashmir valley and were stored digitally. However, before starting the building of the geospatial database, the study calculated the land use and land cover map of the Kashmir valley for proper estimations and reference maps. The Land use, Land cover map with an accuracy of >95% will be used for storing any digital information about the tribal areas of Kashmir valley in the future. The Land use and Land cover map will also be used as the reference map for the execution of future works. The study found a considerable change in the land ecosystem where some of the land features have increased in size while some have decreased. The considerable decrease of forest land, water bodies, and Perennial snow/Glaciers remain worrisome and can have certainly a negative impact on the tribal regions and Kashmir valley as a whole. These negative impacts will certainly play a greater role in the climate crisis and therefore the direct effect on the agriculture and horticulture sectors of the region. The afforestation and hydrological management appear to be convenient methods that can be used to procure ecological balance in the region.

The study was however restrained to performing field surveys and analyzing the status of tribal areas and the associated ecosystem characteristics of the most populated region of district Ganderbal. The land resources, biological diversity, natural hazards, etc. were evaluated for every visiting tribal region and were stored as the geospatial database. The Study consists of 26 villages, all included in tehsil Kangan of district Ganderbal and geographically situated in the mountainous landscape of greater Himalaya. Geologically, the region is a tectonic landscape and therefore consists of diverse geography including river flows, mountain peaks, meadows, rich vegetation, glaciers, lakes, etc. The Gujjar and Bakerwal is the dominant tribe in the region and comprises about 46% of the total population. The literacy rate of the region is low compared to the neighboring non-tribal region which stands at approximately 21% lower. The fall in the literacy rate is due to many reasons among which include remoteness, unavailability of education awareness, and insignificant motivation. The proper management of education infrastructure, visualizing and making connections at the ground level, creating education awareness teams, motivational speeches at the school level, discussing opportunities with students, etc., can play a significant role in enhancing literacy in the region. Also, female literacy, which is comparatively low, needs a convenient methodology to nurture the literacy of women which will, in turn, play a substantial role in the social development of the region. The study has found moderate to low economic settings in the region and the number of workers stands at 26% of the total population. The inferior revenue, according to the residents, plays a significant role in limited education apart from lack of awareness and motivation. However, the study suggests ample opportunities for economic growth considering the topography, climate, and land classification of the region. The area is neighboring the Great Himalaya Lakes, an adventurous trek, spectacular mountain valleys and meadows, glaciers, and radiant streams, and is therefore well suitable for economic tourism. The region already procures tourism at a small scale throughout the year because of its scenic land features. The study suggests that a convenient tourism policy, training of local guides, providing relevant skill education, creating a homestay environment, and sustainable land management will play a very significant role in economic tourism and Vis a Vis the development of the region. However, the study has found considerable land degradation which may prove taxing in the region, and the immediate mitigation policies like afforestation and surface water management may undeniably bring positive impacts. The decadal land cover changes are substantially evident and therefore the appropriate mitigation policies and convenient methodologies are of utmost use. Investment in Reforestation, invasive Species Management, estimating and restoring groundwater levels, and surface hydrological modeling is highly needed for the long-term development of the region.

Considering the fact that is lying in the project report, tribal research cannot be limited to a closed system, however, convenient methodologies are needed in order to understand the metaphysical characteristics as well as the anthropologic studies. I would always suggest the micro-zonation of the tribal regions and pursuing integrated scientific and engineering studies. The integration of various studies including sciences, engineering, social sciences, art sciences and humanities will dominantly play a vital role in understanding the tribal regions and therefore absolute mitigations and policymaking. Also, working for the higher-accuracy, micro-level land use land cover classifications and settings of bio-diversity will prove significant for the tribal population of Jammu and Kashmir. Further, incorporating all the knowledge provided via projects, academicians, researchers, etc., and building the geospatial database will certainly prove more efficient in understanding and developing the tribal regions of Jammu and Kashmir. The Geospatial technological labs can be thought of as a paramount approach for the long-term assessment vis a vis the conduit for the categorical development of the tribal population.

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