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ANALYSIS OF LAND USE LAND COVER AND ITS IMPACT ON EXTENT OF SOIL EROSION IN CHITRAL RIVER BASIN, HINDU KUSH

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ABSTRACT

The current study focuses on the impact of changes in Land Use Land Cover on Extent of Soil Erosion in Chitral River Basin, Hindu Kush. Soil erosion is one of the major natural process happening in the Hindu Kush region of Pakistan. Owing to steep slope, meager vegetation covers and augmented by erratic rain fall the soil erosion has become one of the important natural hazard in the region. The study made use of the remote sensing data where Landsat, Digital Elevation Models, precipitation and soil data was used as input variables. The study observed that there are considerable changes occurred in the Land use land cover of Chitral River Basin. It was found from the analysis that radical changes mostly recorded in snow cover area and barren land. It is very unfortunate that the area under snow cover is gradually decreasing in the study area as a result of which the surface is exposed to soil erosion. Similarly, with the population growth, there is increasing demand for shelter and infra-structure to fulfill the demands of the growing population and this has subsequently multiplied the area under the built-up environment. The micro-level analysis revealed that cover of vegetation cover into built-up area has been identified a major land use land cover class. While analyzing the rate of soil erosion and soil loss, a standard methodology and RUSLE approach has been used. The analysis indicates that with increase in barren surfaces from 1990 to 2020, there is also increase in annual rate of soil loss. The analysis of 1990 to 2020 revealed that the annual loss of soil erosion almost doubled during the past three decades.

KEYWORDS: River Basin, RUSLE, Remote Sensing, GIS, Soil erosion

1. INTRODUCTION

Land Use Land Cover (LULC) is a constant and evolving process that happening everywhere (Mas et al., 2016). It is clear from the LULC study that such changes occur at an exponential rate in less developed nations (Fujaco et al., 2016). Land use refers to the various human activities that take place on the surface of the earth, such as settlement, agriculture, commerce and industrialization. While land cover refers to the natural or man-made covering of the earth's surface, it most frequently refers to features like forest cover, barren land, grassland and water bodies (Lambin et al., 2011).

The observable changes over the earth surface is a process, in which a phenomenon and or an object is visualized at various intervals and times, to explore the variations in the type of changes. The most significant natural events that result in to the land change are flood, climate change, earth quake, forest fire and desertification. While population growth, economic development, urbanization, government policies and industrialization are the man-made factors responsible for LULC changes (Ganasria & Dwarakish, 2015). With the increase of population, more food, settlements, harvesting and raw material are required, so it result into an enormous pressure on the earth limited resources and causing more cultivation expansion and deforestation in cities (Madurapperuma, et al., 2013).

The changes in LULC has serious environmental implications such as soil erosion. Besides erosion of soil, there are some negative effects of LULC changes including sharp decline in per capita arable land, expansion in barren land, poor quality of water, variability in climate, destruction of natural habitats, occurrences of flash and riverine floods, changes in frequency and intensity of rainfall (Lambin et al., 2011). Scientific literatures also attribute adverse consequences of land transformation to global climate changes and subsequent modifications (Hacıoglu, 2020). The increasing share of greenhouse gases in the atmosphere has led to inclination in the global land temperature, which as a result caused rise in sea level, increase in the snow and glacier melting and rising trend of hydro-meteorological disasters. In Pakistan, the progress of LULC changes is same as around the world. Urbanization, industrialization, deforestation and the extension of farmed land are the primary changes in land use and land cover. Due to rural urban migration and high birth rate the urban area are expanded (Raza et al., 2012).

In order to find out the changes in LULC the use of GIS and remote sensing technology is very effective and useful (Shalaby & Tateishi, 2007). Satellite images can be used to find out quickly the LULC changes with perfect accuracy and economically (Samiullah et al., 2019). The use of temporal and multi-spectral Satellite images for the analysis of LULC combine with GIS is very useful for creating real time mapping because the other techniques used for the analysis of LULC are time consuming and costly. In recent time, GIS and remote sensing data are precisely used in many field and decision making like forestry, planning and Management, conservation of forest and for the forecasting of various naturally events like cyclone, heat wave etc. (Shalaby & Tateishi, 2007). The main advantage of Satellite data as that it can be used for those area where others methods of data collection and survey are difficult to conducted (Fonji & Taff, 2014). In

Pakistan, rapid changes in LULC are occur shown by the images collected from satellite (Samiullah et al., 2019).

One of the major factors limiting sustainable use of land resources is erosion of soil. It is considered as one of main environmental problem at the global scale resulting in negative impacts (Marques et al., 2008). This process is based on several factors like use of land, climate, vegetation and topography. It also depends on soil physical factors like structure, texture, porosity and organic matter. Amongst these, two of the most important factors are LULC that affects the intensity of surface runoff and erosion of soil. The leading impacts of soil erosion is the loss of fertile farmland as well as the distribution of how the land is used that increases the competition between human and land resource. To understand correlation between LULC and their implications on the rates of soil erosion and vulnerability, several researches have been conducted in various parts of the world keeping in view regional as well as site specific LULC activities (Santos et al., 2017).

Erosion of soil is a natural process which resulted to land and degradation of soil, which raises to the movement of particles soil by wind and running water and some other factor like tillage and extensive farming that ultimately consequences in lessening the productivity of soil causes by loss of physical topsoil, subtraction of plants nutrients, decrease depth in rooting and loss of water. The topsoil, which is profuse in organic substance, fertility and soil life is either moved "off-site" where it fills in drainage channels and has “off-site” effects like contributing to the pollution of nearby water course, wetlands and lakes or it is moved "on-site" where it accumulates over time and has onsite effects like reducing cropland productivity. With the sharp increase of population, there is more pressure on cultivated land for more production which cause the loss of structure of soil and fertility and make it more exposed to different geomorphic agents for erosion (Balasubramanian, 2017).

Chitral is the northern mountainous region of Pakistan, where vegetation is scanty and rainfall is erratic. Among the list of problems, the Chitral river basin is also exposed to exponential changes in land use land cover mainly triggered by rapid population growth, degradation of vegetation cover, overgrazing, ruthless cutting of forest cover, over exploitation of natural resources and increase in intensity of rainfall are some of the major problems in Chitral river basin. In Chitral river basin, due to limited availability of forest cover and over exploitation of natural resources, there is a gradual loss of soil. This has also posed a serious threat to food security in the study region. It is therefore, this study attempt to explore the spatio-temporal changing pattern of land use land cover and its impact on soil loss in the Chitral river basin, Pakistan.

2. MATERIAL AND METHODS

2.1 Study area

The study area is located in the northern part of Khyber Pakhtunkhwa province, Pakistan. The total area of district Chitral is 14,850 sq. km making it the largest district of Khyber Pakhtunkhwa province. The study area (Chiral River Basin) roughly follows the District Chitral boundary and covering 20% of the provincial landscape. The topography of Chitral district is extremely harsh and rugged, in between this the river Chitral and its so many tributaries are flowing. The elevation of the valley decreases from high snow covered mountain as one goes downhill towards the valley, where the high snow covered mountain are replaced by barren mountain of debris and rocky cliffs. After passing from Chitral Valley River Chitral enters to Afghanistan near Arandu.

Geographically, Chitral river basin stretches between latitude 35° 14´ 58” to 36° 56´ 01” North Latitude and from 71° 10´ 58” to 73° 50´ 57” East Longitude. The population of study area is increasing at a rapid pace and poses threats to various ecological systems. During the 2017 population census, the population of district Chitral increased and marked the figure of 447,362 (GoP 2017). Relatively, Chitral river basin is bordered on the East by Gilgit-Baltistan, on the south by District Dir Upper and District Swat, whereas Afghanistan lies across the border toward the North and West (Figure 1).

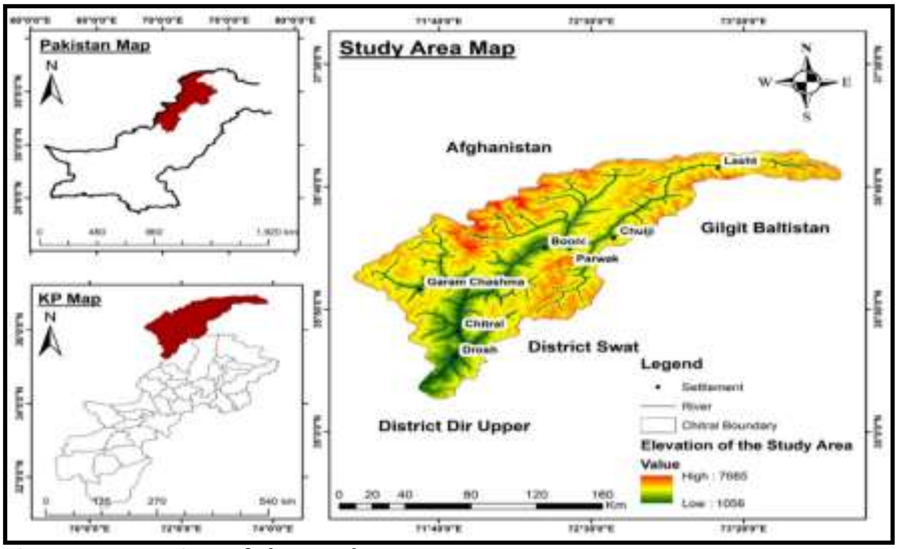

Figure 1. Location of the study area

The study area is surrounded by the world highest mountains called Hindu Kush-Himalayas. Most of the Chitral river basin falls in the western Hindu

Kush. Similarly, the extreme western and northern part of the basin falls in the extreme western Himalayas. Likewise, in the south-eastern section lies the Hindu Raj Mountains. The elevation of the study area varies from 1017m in the south to 7633m towards northwest from mean sea level. In the study region, Tirich Mir is the highest peak with elevation of 7,690m. Other, notable highest peaks are Shogharan Dak (7300m) Koyo (7290m), Kotal Kash (7280-m), Boni Zom (7160m) and Soriawi (7100m). The presence of the uneven landscape and high altitudinal variation, large number of small valleys have been formed. In these valleys, due to rapid soil erosion and active glacier deposition, the alluvial fan has been reported (Ahmad et al., 2006).

2.2 Data Collection and Analysis

The present study RUSLE model has been used to find out the impacts of LULC (land use land cover) changes on the extent of soil erosion. The different parameter used in RUSLE model were obtained from different sources. The rainfall data of the study area were collected from regional meteorological department, Peshawar. For this purpose, the rainfall data were collected for Chitral, Drosh, Upper Dir, Kalam and Saidu Sharif meteorological stations. Soil data of the Chitral river basin was collected from Soil Survey and agriculture department of Khyber Pakhtunkhwa and United Nations Food and Agriculture Organization. For slope map and topographical analysis, the SRTM data of 30m were downloaded from Earth explorer website.

To find out the LULC of the Chitral river basin, the Landsat satellite images of 1990, 2000, 2010 and 2020 were used. These images were downloaded from free source USGS website (http:// earthexplorer.usgs.gov/). Multivariate supervised classification was carried out using ArcGIS10.8 for the creation of LULC maps of the study area. From the classification of these images total five LULC classes namely, barren land, vegetation cover, water bodies, snow cover and built-up area were created. Further to verify accuracy of the classification, detailed accuracy assessment was carried out. To find out the accuracy of the image classification, accuracy assessment was carried using high resolution image i-e Google earth as well as ground validation points.

RUSLE model is one of the most widely used techniques to quantify the amount of soil erosion. To find out the annual soil erosion in the Chitral river basin, the RUSLE model was used. RUSLE model is used for site assessment and planning purposes and it provides help in the decision process in order to mitigate the effects of soil loss. RUSLE model provides an estimation of the soil erosion severity. RUSLE contains both factors including the capacity and susceptibility of soil erosion. The following are the factors used in RUSLE model.

A= R*K*LS*C*P ……Eq. 1

i. A is the average soil loss year wise (t/ ha-1 /y-1)
ii. R.is the capacity factor of rain and overflow (MJ mm/ha-1/ h-1/ y-1)
iii. K is the factor of soil erodibility (t/ ha /h /ha-1 / MJ-1 mm-1)
iv. LS is the factor related to slope length steepness
v. C is the soil loss factor under a specific land cover
vi. P factor is the protection methods apply

Finally, the results were displayed in the form of tables, statistical diagrams, and maps.

3. RESULTS AND DISCUSSION

3.1 Analysis of Land Use Land Cover

To find out the LULC of the study area the Landsat images of the study area of 1990, 2000, 2010 and 2020 were obtained from USGS and different LULC classes namely, water bodies, vegetation cover, snow cover, barren land and built-up area were extracted from these images. From the analysis of LULC of Chitral river basin it was fund that large changes in LULC were occurred from 1990 to 2020. The area under built-up were increased from 1065.83 sq km in 1990 to 1819.3 sq km in 2020. Similarly, the area under barren land were also increased from 5052.33 sq km in 1990 to 7889.4 sq km in 2020. The area under water were decreased from 1885.21 sq km in 1990 to 1667.4 sq km in 2020. Snow cover area decreased to 2646. Sq km in 2020. While it was 5718.21 sq km in 1990. The area of vegetation also decreased from 1990 to 2020. The changes in different LULC classes are mention in the Table 1 and Fig. 2.

Table 1, Comparative Analysis of LULC (1990 to 2020)

Year	Barren Land Built-up area (sq.km)	Built-up area (sq.km)	Water bodies Built-up area (sq.km)	Snow cover Built-up area (sq.km)	vegetation cover Built-up area (sq.km)
1990	5052.33	1065.83	1885.71	5718.21	1127.92
2000	7226.2	1266.1	1696.5	4111.8	549.4
2010	7226	1790.7	1761.5	2991.1	808.5
2020	7889.4	1819.3	1667.4	2646.6	827.2

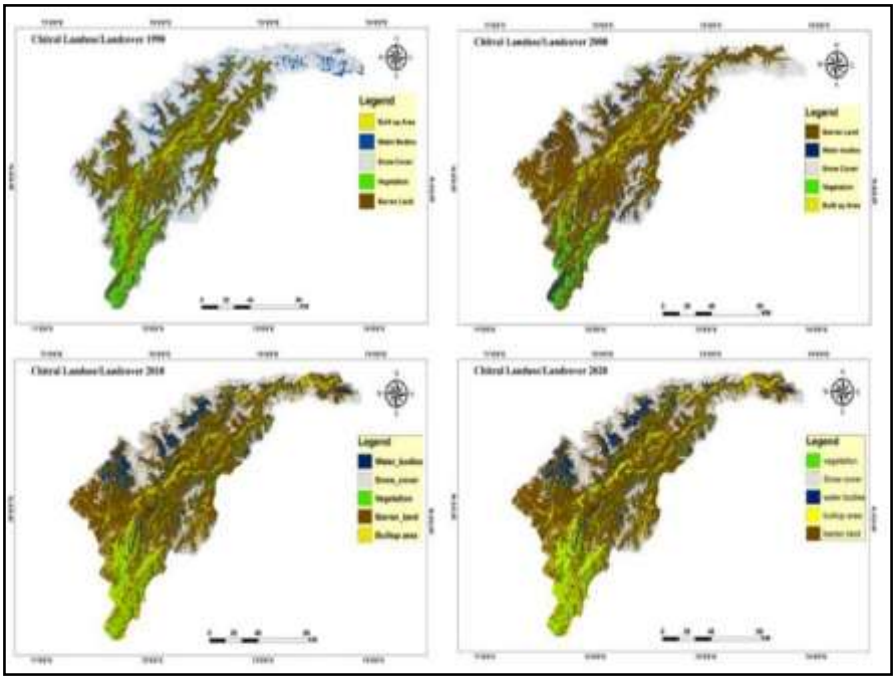

Figure 2. Chitral River basin LULC 1990, 2000, 2010 and 2020

Accuracy assessment of the classified images were carried out for each data (1990, 2000, 2010, and 2020). The classified image was compared with the ground point collected with the support of GPS, visual interpretation and Google earth data. Google earth data is used as referenced data for 1990, 2000 and 2010 (Table 2) Landsat classified image, while GPS and visual interpretation used for 2020 classified image. The producer accuracy, user accuracy, overall accuracy and Kappa Co-efficient were also carried out of the five LULC classes. The result of the classified images of the study area show a sizable higher overall accuracy 80.56 to 94.8 and Kappa Co-efficient 0.75 to 0.94. The images of the study area were classified in to five LULC classes (Built up area, snow cover, vegetation cover, water bodies and Barren land). The producer and User accuracy of each LULC classes of different classified images are shown in Table 2.

Table 2. Accuracy Assessment of classified satellite images, 1990, 2000, 2010 and 2020

Land Use/Land Cover Classes	Year							
	1990		2000		2010		2020	
	PA	UA	PA	UA	PA	UA	PA	UA
Built Up Area	56.56	86.15	78.78	81.25	95.91	87.03	88,67	97.91
Water bodies	54	94.73	93	88.54	90	95.74	100	89.28
Snow Cover	100	97.08	98	100	98	100	100	98.03
Vegetation cover	95	81.19	90	94.73	90	91.83	100	94.33
Barren land	97	61.78	79.79	79.79	93.87	87.03	88.67	95.23
Overall Accuracy	80.56		87.95		93.54		94.8	
Koppa coefficient	0.75		0.84		0.91		0.94	

3.2. Extent and Appraisal of Soil Erosion

3.2.1. Rainfall Erosivity Factor (R)

The Rainfall Erosivity factor (R) has the potential to cause sheets and rill erosion without any protection. In compared to normal rainfall more and prompt erosion of soil is occurred caused by heavy rain with large raindrop size. In comparison to normal rainfall, rapid soil erosion is caused by heavy rain with large raindrops and similarly the rate or amounts of erosion of soil is more by erratic and heavy rainfall. The immediate and fast flow of this erratic and heavy rainwater causes the rapid and more erosion of soil by rill, sheet and splash and gully (Biswas, & Pani, 2015). The strength, duration, and rainfall of the storm can all affect how much soil erosion will occur, since significant storm and runoff increases the quantity of soil erosion. Different scholars used different equations but for this study the following equation…2 were used. The year-wise rainfall data from1990 to 2020 were collected from the two weather stations located in the study area the Chitral weather station and the Drosh weather station (Figure 3).

$$R = 79 + 0.363 \times AAP \quad \text{…………………. Eq 2.}$$

Where Rainfall Erosivity is represented by *R* and annual average rainfall *by AAP*.

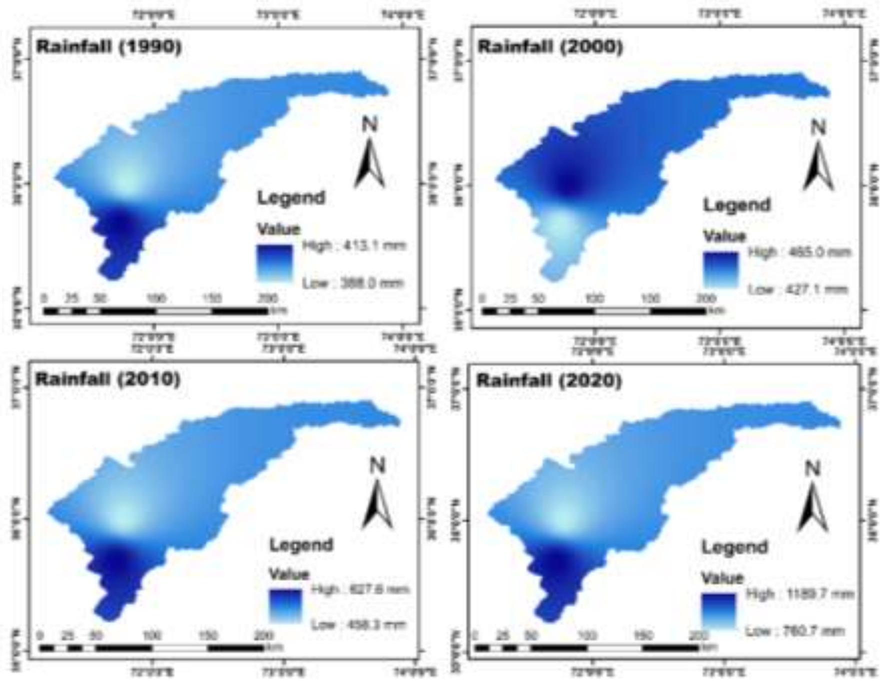

Figure 3. Chitral river Basin Rainfall Erosivity Factor (R) 1990, 2000, 2010 and 2020

3.2.2. Soil Erodibility Factor (K)

The physical, mineralogical, morphological and chemical characteristics of the soil are all covered by the (K) Erodibility factor (Pérez-Rodríguez, et al., 2007). The soil Erodibility factor and soil properties which have close relationship with the soil type will be calculated. The value of K is specified to a definite class of soil loss assuming a typical research plot (22.18 m length, 1.83 m wide, and 9% slope) with the soil continuously covered by farming (Kim et al., 2012). The value of K factor values ranges from 0.01 to 1. The equation created by Williams and Sharply (1990) (Eq. 2) to determine the K factor was used in this study equation…3. To calculate the K factor from 1990 to 2020 the soil data of the Chitral river basin were obtained from soil survey and soil and water conservation department Khyber Pakhtunkhwa (Fig. 4).

$$K = fcsand \times fcl - si \times f\,orgc \times fhisand \quad \text{……………………Eq.3}$$

Where: *Fcs and is the fraction of course sand in soil, fcl is fraction of clay, f orgc is the fraction of organic matter and fhisand is fraction of sand.* In the current study the information related to soil is obtained from United Nations Food and Agricultural Department's Digital Soil Map of the World.

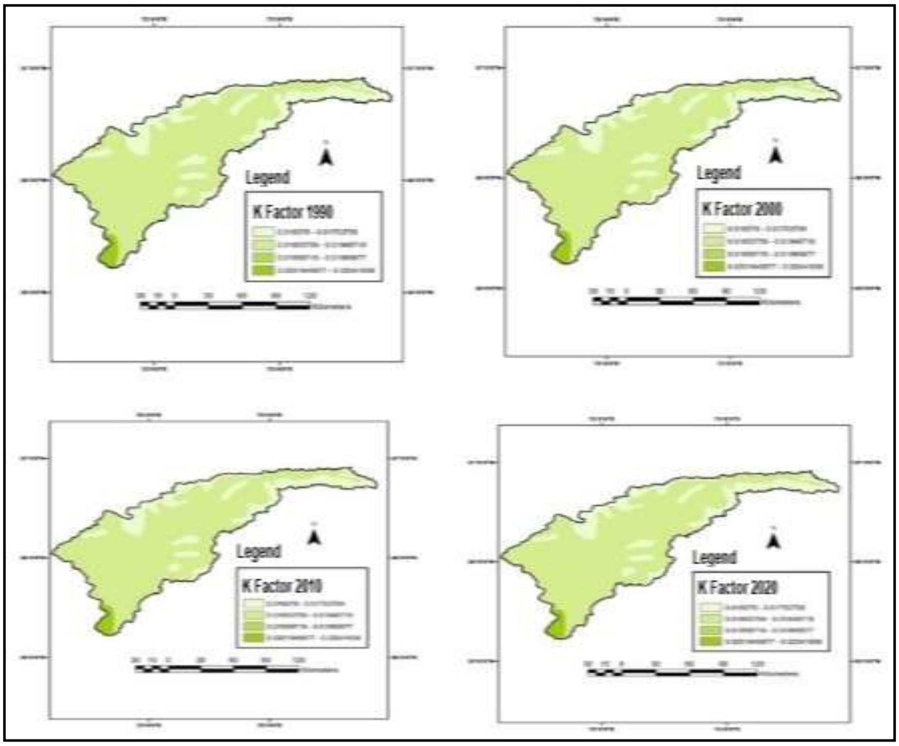

Figure 4. Chitral River Basin Soil Erodibility Factor (K) 1990, 2000, 2010 and 2020

3.2.3. Slope Length and Steepness (LS) Factor

Landscape play a significant role in erosion and landslide. It describes the effects of erosion on landscape, slope steepness and length of the slope. The intensity and rate of soil erosion also increase with slope length and steepness, whereas a decrease in position and slope angle leads to the deposition of the eroded material. The slope length is represented by L while steepness of slope is representing by S. More soil loss is occurred due to steepness of slope as equated to length of slope. SRTM data having spatial resolution of 30m were used for the creation of DEM of the study area (Fig. 5). In the present research, the Equations 4 were used, which is preferred by numerous scholars and is globally used for calculation of LS factor by numerous scholars.

$$LS = \frac{(slope\ length)^{0.4}}{22.13} \times \frac{(0.01745\ sin\theta^{1.4}}{0.0896} \times 1.4 \text{ .... Eq 4}$$

Where: Slope length is the flow accumulation × Cell size of DEM used and θ= slope in Degree

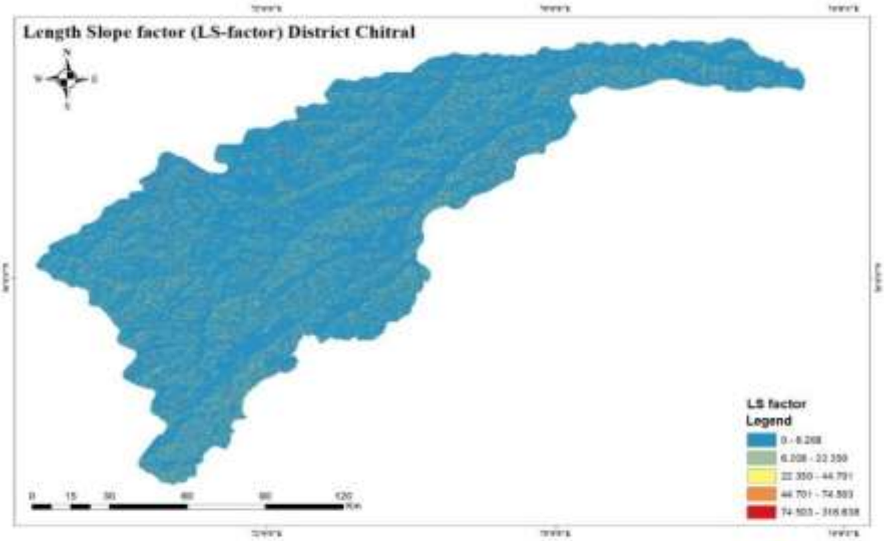

Figure 5. Chitral river Basin Slope length and steepness factor (LS)

3.2.4. Cover and Management (C) Factor

The C factor describes how crop, plant, and erosion control strategies affect consequences on the environment (Figure 9). The value of the cover management factor is 1.0 in barren land formerly the plants grow and 0.0 in water body area. The degree of soil erosion will gradually grow if the vegetation cover is diminished since it is essential for controlling the erosive strength of raindrops on soil surface.

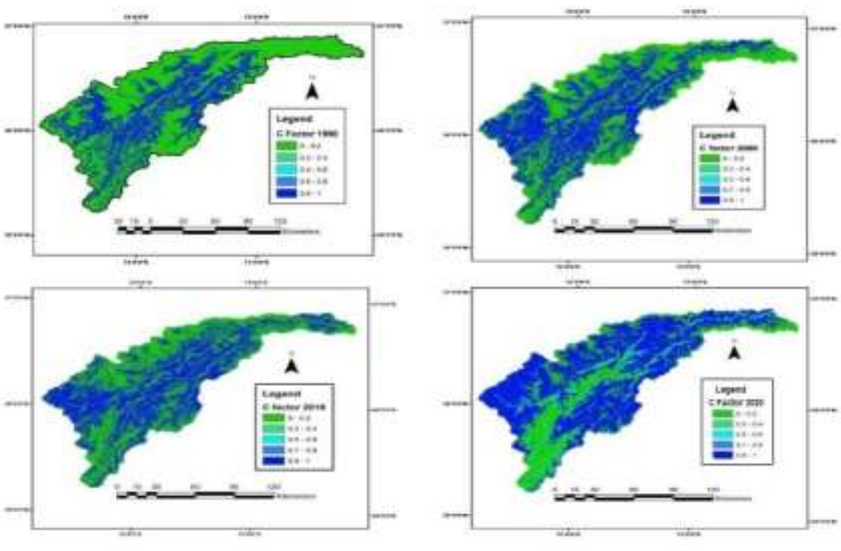

Figure 6. Chitral River Basin Cover and Management (C) Factor, 1990-2000, 2010 and 2020

As a result, it is crucial in reducing runoff rates and controlling erosion of soil. In this study, the C factor was calculated from Landsat satellite images of 1990, 2000, 2010 and 2020 with 30m resolution. These images which is used in the current study are obtained from Earth explorer website of USGS and different LULC are obtained after the classification of these images.

3.2.5 SUPPORT PRACTICE (P) FACTOR

Contouring, strip-cropping, terrace farming, and sub-surface drainage are the support factors for cultivated areas that are mostly assumed to be present. Based on the technique devised by Koirala et al., (2019) for the calculation of P factor, the DEM of the study area were classified in to 5 slopes classes. The P factor of the study area of 1990, 2000, 2010 and 2020 are shown in the Fig. 10.

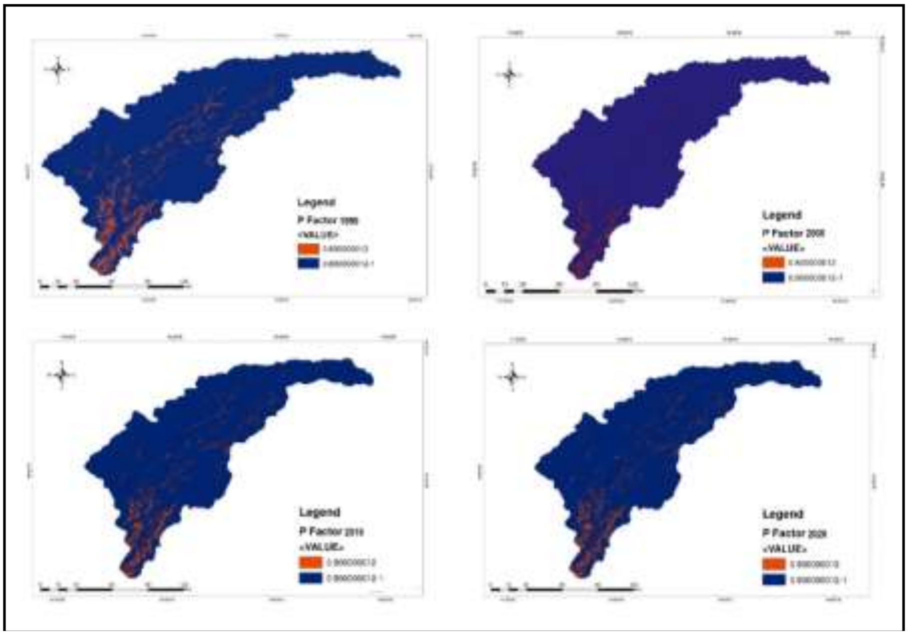

Figure 7. Chitral River Basin Support Practice (P) Factor

3.3 Nexus of Land use Land cover and Soil loss

From comparison of soil loss and changes in LULC in Chiral river basin. It further highlights the factors responsible for the soil loss due to erosion. The data was analyzed using the hotspot technique and presented on maps created in ArcGIS software. The analysis indicates that soil erosion was comparatively slow in the past. In 1990, the maximum soil loss in the study area was 28.29 tons per hectare per year which increased to 36.24 tons per hectare per year in 2000. During this period the notable changes occurred in Barren land and Snow cover area, the area under barren land were increased from 34.02% in 1990 to 48.66 % in 2000. In 1990 snow cover was the major land cover type encompassing over 38% area of the land area. However, it was reduced to 27.69% in 2000. If we compare the soil erosion during this period it was also augmented from 84.14 sq.km to 196.46 sq.km. Drastic changes have occurred during the study period in three main land cover classes i.e. built up, snow cover and barren land. The built up environment has gradually increased from 1065 to 1819 sq.km. The snow cover area decreased by 7.55 % and the area occupied by Barren land increased by 1.83 %. During the same period from 2000 to 2010 the rate of soil loss is increased from 36.24 tons per hectare per year to 48.10 tons per hectare per year, which shows an increase of 11.84 tons per hectare per year. At the same time area of very high soil erosion increased from 2000 to 2010 period i-e 196.46 sq.km to 320.29 sq.km. From the analysis of LULC from 2010 to 2020 the main changes in LULC classes were snow cover and Barren land. The area of snow cover was decreased while the area of Barren land was increased. The snow cover decreased 2.32 % while the barren land increased by 2.64 % from 2010 to 2020. During this period the rate of soil erosion increased from 48.10 tons per hectare per year in 2010, while in 2020 it increased to 80.43 tons per hectare per year. The area of very high soil is also increased from 2010 to 2020.

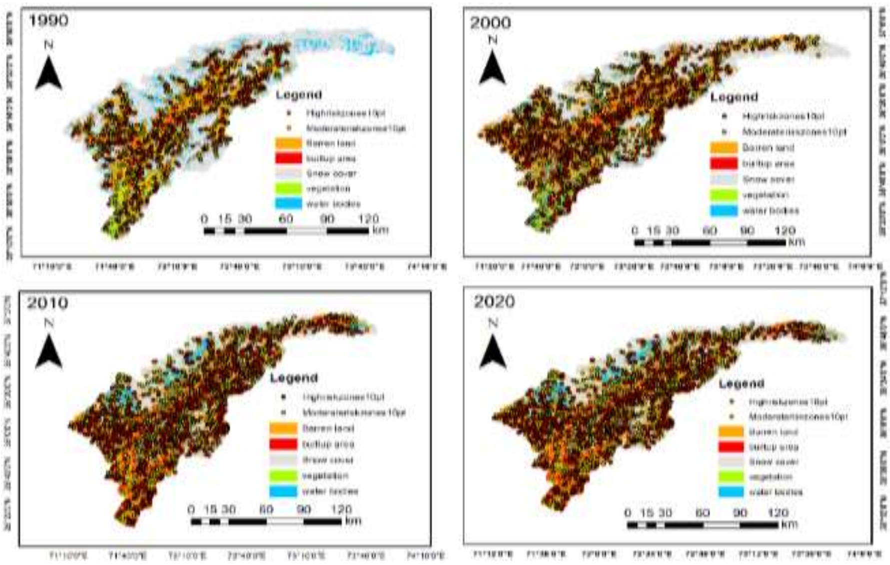

Figure 8. Chitral River Basin, LULC/ Moderate and High risk Zone of Soil Erosion

From analysis of LULC it is evident that there has been a consistent decline occur in the snow cover in the study area. The data suggest that an overall 3071.61 sq. km area of snow was lost during 30 years. From the analysis of

LULC of the study area it was observed that most of the snow covered area was converted to barren land which make it more liable to weathering and soil erosion. Similarly, the barren land increased from 1990 to 2010, it was 5052.33 sq.km in 1990 which is increases to 7889.4 sq km in 2020. During 30 years the barren land increased by 2837.07 sq.km. An increase in barren land mean more exposure of the soil to erosion as the combined effect of splash orison accumulates water to speed up the flash erosion. Existence of vegetation cover is an important agent that inhibits the erosion of soil.

On slopes where vegetation is dense, erosion if low and on slopes where there is no vegetation cover the erosion is high. There has been a gradual decrease in vegetation cover. In 1990 the area covered by vegetation was 1127.92 sq.km which reduced 827.2 sq km, around 300.72 sq. km of area under vegetation was lost during the last 30 years. The area covered by water bodies was also decreased from 1990 to 2020. In the year 1990 water bodies were spread over an area of 1885.71 which has been reduced to 1667.4 sq.km in 2020. Overall a decline of 218.31 sq km was observed in water bodies from 1990 to 2020.

At the same time there has been a rapid growth of population occur, which resulting to the growth of built-up area which increased from 1990 to 2020. Built up area augmented from1065.83 in 1990 to 1819.3 sq.km in 2020. In 30 years, it is increased by 753.47 sq.km.

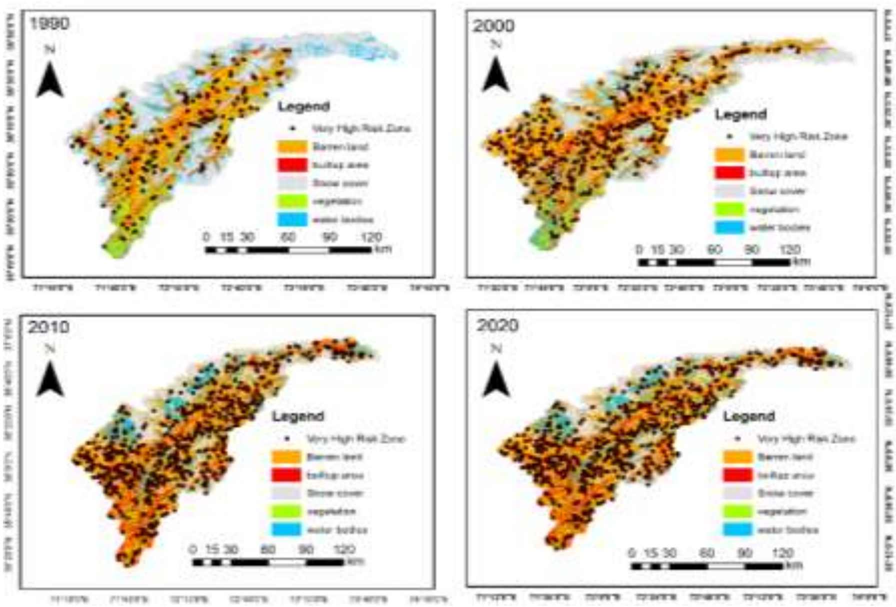

Figure 9. Chitral River Basin, LULC and very High risk zone of soil erosion

With the help of soil erosion inventory, the hotspot areas were identified and presented in the form of maps. The hotspot areas of soil erosion were identified from 1990 to 2020. Year-wise hotspots were identified and it was found that with the changes in LULC the rate and area of soil erosion has also increased. The maximum change in LULC class occurred from 1990 to 2020 in the snow cover area and barren land. The area of snow cover has been drastically reduced very rapidly in the study area while the area under barren land increased. With the removal of snow cover the soil was exposed and the chances of soil erosion were increased that accelerated the rate of soil erosion. In Chitral River Basin, after quantification of soil loss for the year 1990, 2000, 2010 and 2020, the resultant maps were classified into erosion free, low soil erosion, moderate, high and very high zones (Fig. 14 and 15).

The zones, where annual soil loss was more than 20 tons per hectare was declared as very high erosion hotpots. It was found from the analysis that the area under very high erosion hotpots were 84.14 sq.km in 1990 (Table 3) and the maximum soil loss were 28.29 tons per hectare per year, which multiplied and increased to 36.24 tons per hectare per year in 2000 and the area of very high soil erosion were 196.46 sq.km (Table 3). Nevertheless, the situation was further aggravated when annual soil loss in very high erosion hotpots marked figure of 48.1 tons per hectare per year in 2010. Similarly, the area under very high soil erosion was also increased to 320.29 sq.km (Table 3).

The soil erosion was further increased in 2020 touching 80.43 tons per hectare per year. It is very alarming that there is consistent increase in the hot-spot area with very high soil erosion. It calls for decision makers and line agencies to devise effective strategies for halting this environmental challenge of soil loss.

Table 3. Chitral River Basin High and Moderate Soil Erosion 1990-2020

Year	Moderate risk zone (area in sq.km)	Percent of the total Basin area	High risk zone (area in sq.km)	Percent of the total Basin area	Very High risk zone (area in sq.km)	Percent Change of Total Area
1990	307.03	2.06	212.27	1.42	84.14	0.56
2000	464.52	3.12	343.07	2.31	196.46	1.32
2010	524.95	3.53	378.57	2.54	320.29	2.15
2020	810.3	5.45	427.8	2.88	385.45	2.59

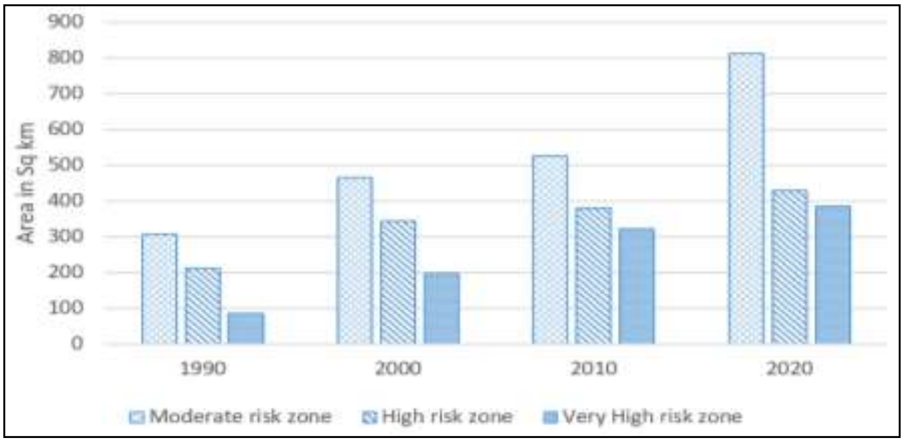

Figure 10. Chitral River Basin, Soil Erosion classes, 1990-2020

4. CONCLUSION

From the present study, it is concluded that there are large changes occurred in the LULC of Chitral River Basin. It was found from the analysis that radical changes mostly recorded in snow cover area and barren land. It is very unfortunate that area under snow cover is gradually decreasing in the study area as a result of which the surface is exposed to soil erosion. Similarly, with the population growth, there is increasing demand for shelter and infra-structure to fulfill the demands of the growing population and this has subsequently multiplied the area under the built-up environment. The micro-level analysis revealed that area of vegetation cover into built-up area has been identified a major LULC class. While analyzing the erosion of soil rate and loss of soil, a standard methodology and RUSLE approach has been used. The analysis indicates that with increase in barren surfaces from 1990 to 2020, there is also increase in annual rate of soil loss. The analysis of 1990 to 2020 revealed that the annual loss of soil erosion almost doubled during past three decades. It is predicted that if the same trend continues there will further loss of soil and the same will have severe environmental impacts on socio-economic and physio-ecological environment. As most of the population existing in these mountainous region depends on this precious natural resources. It is therefore, a high time to prepare mitigation plan and check the soil loss. Based on the field observations, there is gradual but consistent loss of soil are occurring in the study area, which is demarcated as hotspot areas. Such hotspot areas need to be given special attention for overcoming the menace of soil loss. A land use planning and regulation is another effective strategy to tackle the problem of soil erosion and the consistent encroachment of built-up areas over the farmland and forest cover is creating irreversible impact on the precious land resources and pose serious threat to ecological environment. This calls for the policy makers to check the unprecedented impact and implement mitigation strategies for effective addressing soil erosion.

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