Land Degradation Risk Assessment in District Dir, Pakistan

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Soil erosion is a global concern, influenced by terrain, vegetation, soil, and climate factors. Traditionally, field-based techniques have been utilized for the measurement of soil erosion. In the present study, Remote Sensing and Geographic Information System (RS/GIS) techniques are used for soil erosion estimation. The Revised Universal Soil Loss Equation (RUSLE) is frequently utilized, incorporating various elements such as soil erodibility, rainfall erosivity, slope steepness, Land Use and Land Cover (LULC), and conservation practices. This study focuses on the Dir district in Pakistan, integrating the RUSLE model with RS and GIS to identify soil erosion-prone areas. The goal is to implement targeted interventions and sustainable land management practices to mitigate soil erosion in these areas. The output of the RUSLE model identifies key zones that need to be addressed to prevent further land degradation. This study also indicates higher C-factor values in Upper and Lower Dir, ranging from 0.001 to 0.2. Soil loss was calculated using all factors (R, K, LS, CP), showing that soil loss is approximately 31.6 tons/ha/yr in Upper Dir and 22.88 tons/ha/yr in Lower Dir, which is higher in Upper Dir due to high elevation (>30m) and more rainfall in Upper Dir (1275mm). Furthermore, annual rainfall values ranging from 508 mm to 1275 mm were noted, resulting in maximum rainfall erosivity values of 572.87 MJ mm ha/h/year in Upper Dir and 568.16 MJ mm ha/h/year in Lower Dir. Thus, this study provides critical data for society and policymakers to implement targeted soil conservation measures and sustainable land management systems, thereby mitigating soil erosion and preventing further land degradation in the district of Dir.

Keywords: Remote Sensing, GIS, Soil Erosion, Revised Universal Soil Loss Equation, Land-Use & Land-Cover.

Introduction:

Soil is loose natural matter that is created when minerals and rocks on the earth's crust mechanically and chemically disintegrate and decompose due to the action of natural, mechanical, or chemical activities of wind, water, gravity, or ice/glaciers [1]. Erosion is primarily caused by Several natural processes, including heavy rainfall, flowing water or run-off, deforestation and removal of vegetal cover, soil separation, and soil transportation by several forces [2]. One of the most significant issues with land degradation and a major global environmental concern in the modern era is the loss of soil due to water [3]. Soil erosion is one of the worst environmental issues, depleting soil enriched with organic matter and raising the organic sedimentation level in rivers and artificial lakes, shortening their capability and lifespan [4]. Unlawful farming methods, such as deforestation, have increased soil degradation by causing erosion brought on by population growth, economic expansion, and extreme weather [5]. Traditionally, an expensive and time-consuming field-based approach has been used to evaluate soil erosion. To achieve cost-effective monitoring, researchers choose to employ remote sensing (RS) and Geographic Information Systems (GIS) techniques. Previous studies utilized the Revised Universal Soil Loss Equation (RUSLE) model because of its high precision, low data requirements, and ease of use (e.g., [6]. Geospatial technologies, such as GIS and RS, have proven useful in monitoring natural resources and evaluating land risks like erosion [7]. As a finite natural resource, soil regulates the availability of food by absorbing carbon, water, and nutrients, filtering out pollutants, fostering the growth of ecosystems, preserving historical sites, and controlling the environment [8]. Furthermore, it might be useful in identifying the overall effect of climate and rainfall conditions over the study region [9]. GIS and RS technologies are particularly helpful and successful in defining changes in LULC [10]. This study is important because it may help Dir make decisions on policies and land management. Local government agencies and other interested parties can implement more effected conservation policies by identifying regions that are more vulnerable to deterioration and comprehending the underlying causes.

Research Objective:

The following are the major aims of the study:

To calculate soil erosion using GIS techniques and the RUSLE Model.

To modify the 6-factor layers for the RUSLE Model in ArcMap.

To develop LULC maps of the study area.

To study the impacts of different parameters on soil erosion.

Materials and Methods:

Study Area:

Dir is a district in the Malakand Division of Khyber Pakhtunkhwa (KP) province of Pakistan, located between 35° 50' to 34° 22' latitude and 71° 2' to 72° 3' longitude. The district has 1.294 million residents and a total area of 5284 km². The town of Dir serves as the district headquarters for the Upper Dir District, which is in the KP province of Pakistan's Malakand Division. The total area of Upper Dir is 3,699 km² with a population of 946,421. Upper Dir comprises three Tehsils, i.e., Sharingal, Wari, and Dir**,** and Lower Dir is a district located in the KP province of Pakistan's Malakand Division. Four Tehsils make up Lower Dir: Lal Qilla, Adenzai, Samar Bagh, and Timergara. Some of Pakistan's wettest areas are found in the Dir district, which receives an average of 58 inches of rainfall each year, with 400 mm (or 1.31 feet) received during the monsoon season from July to September and double that amount from December to April during the winter rainy season.

Data:

This study utilized multiple datasets, including satellite imagery from Sentinel-2 and topographic data from the SRTM DEM, to assess soil erosion in Upper and Lower Dir. Sentinel-2 imagery (10m resolution) was classified using supervised classification, with land cover classes, i.e., water, built-up, barren land, vegetation, glacier/snow cover, rangeland, and forest, identified through training samples. A maximum likelihood algorithm was applied in ArcMap for classification. DEM-derived slope maps and soil data from the Soil Survey of Pakistan (2023) supported the RUSLE model. Rainfall data from PMD were interpolated using the Inverse Distance Weighted (IDW) technique.

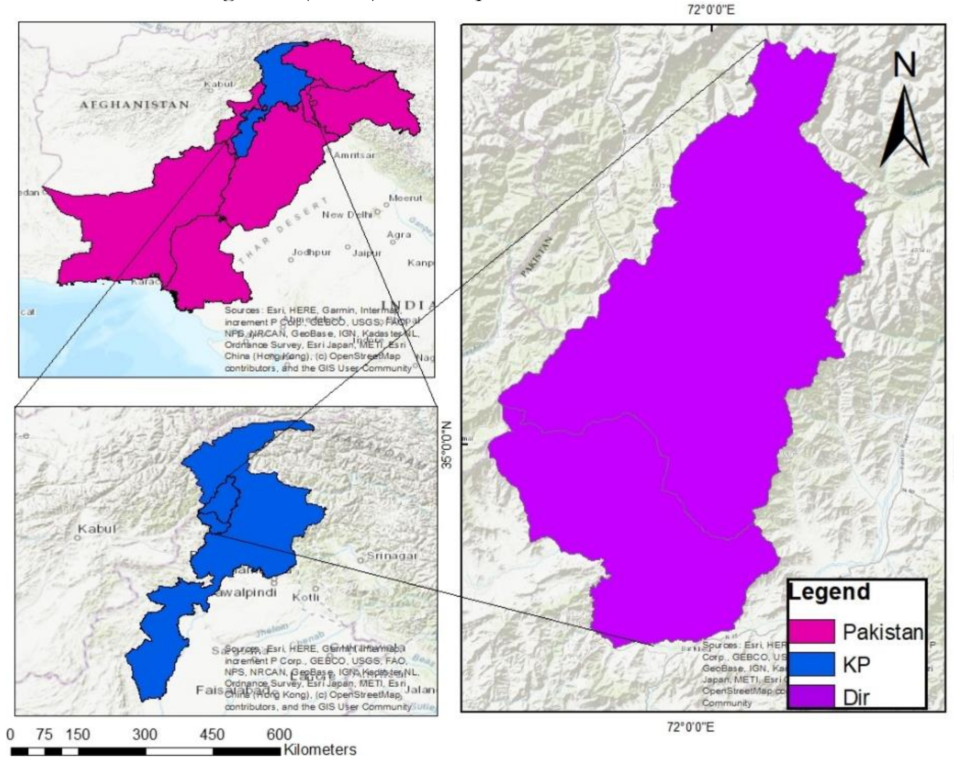

Figure 1. Study Area map of Dir District

Table 1. Datasets used in this study

Input Parameters	Data Sources
Image Data	Sentinel-2 (10 m resolution)
Soil Data	Soil Survey of Pakistan (year 2023)
DEM Data	SRTM (USGS) (30 m)
Rainfall Data	PMD

Soil Erosion Estimation:

The RUSLE model was selected due to its efficiency with limited data. It integrates five factors: Rainfall erosivity (R), Soil erodibility (K), Slope length and steepness (LS), Cover management (C), and Support practice (P). These were calculated using satellite and meteorological datasets and modeled in GIS [11]. The soil erosion equation used was:

$$A = R \times K \times LS \times C \times P \quad (1)$$

Where A represents soil loss per unit area in tons per hectare per year, R stands for the rainfall-runoff erosivity factor, measured in MJ mm ha^{-1} h^{-1} yr^{-1}. K denotes the soil erodibility factor, measured in tons ha^{-1} yr^{-1}, LS signifies the slope factor (unitless), C represents the cover management factor (unitless), and P stands for the conservation practice factor (unitless). The RUSLE was computed by integrating the factor maps of K, R, LS, P, and C generated in GIS to produce a comprehensive soil loss map in ArcMap.

Rainfall Erosivity Factor (R):

Rainfall is crucial for water erosion, with intensity and quantity being key elements. Strong rainfall events increase erosion likelihood, affecting the R factor [12]. Rainfall erosivity (R) was calculated from 20-year data from PMD weather stations (Chitral, Dir, Drosh, and

Saidusharif). Data was spatially interpolated using IDW to estimate rainfall erosivity distribution. The PMD provided the mean annual rainfall data for the four meteorological stations. The spatial distribution of average yearly rainfall (P) in the selected region was determined. The study used IDW techniques to interpolate points, producing a raster surface with interpolated rainfall values. Four weather stations measured the R Factor, and the method was used to determine precipitation changes based on elevation.

$$\text{Log R} = 1.93\text{Log}\sum\frac{\text{pi}^2}{\text{p}^2} - 1.52 \quad (2)$$

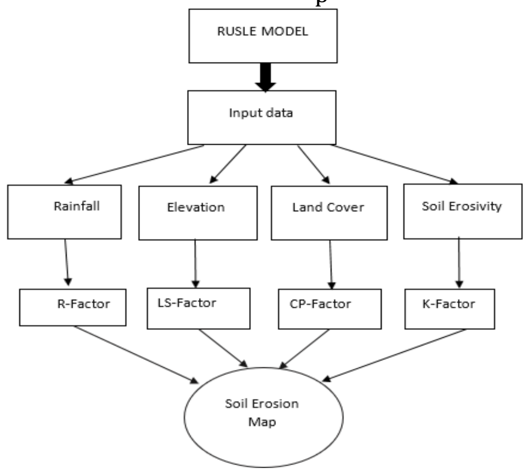

Figure 2. Flowchart of the methodology of the study.

Where;

R represents the rainfall-runoff erosivity factor (MJ mm ha^{-1} h^{-1} yr^{-1})

Pi = Monthly Rainfall

P = Annual Rainfall

Table 2. PMD Stations, R-value, and Annual Rainfall data

Sr.	Station	X (longitude)	Y (latitude)	Rainfall erosivity (R)	Annual Rainfall (mm)
1	Saidusharif	72.35	34.73	409.7167	977
2	Chitral	71.74348	35.84317	184.4306	437
3	Drosh	71.78286	35.56428	164.8684	515
4	Dir	71.87704	35.21399	572.8699	1275

Soil Erodibility Factor (K):

The soil erodibility factor (K) was derived using measured parameters (sand, silt, clay, and organic matter). Representative samples were used to produce a regional K-factor map. The soil erodibility factor (K) measures the soil's response to erosion caused by rainfall and runoff. The RUSLE model calculates K by integrating soil parameters like sand, silt, organic matter, permeability, and soil structure [13]. Samples were pooled to create representative samples for each zone, and K-factor values were computed based on the soil's composition. The final map of erodibility was then allocated to the corresponding zones.

Slope length and steepness Factor (LS):

Slope length and steepness (LS) factors were computed from a 30m resolution DEM using flow direction, accumulation, and slope angle. Soil erosion is influenced by slope steepness and slope length, which are significant topographic markers. Steeper slopes are more affected by erosion, while longer slopes increase their likelihood [14]. The LS factor in this study was determined using a 30 m resolution SRTM DEM from USGS, which was pre-processed with tools like fill, flow-accumulation, flow-direction, and slope. The LS factor for RUSLE was generated using slope and flow accumulation, and the LS factor was determined using equation (3).

$$LS = \text{Pow}([\text{flowacc}] \times \text{resolution} / 22.1, 0.4) \times \text{Pow}(\text{Sin}([\text{slope}] \times 0.01745) / 0.09, 1.4) \times 1.4 \quad (3)$$

Resolution = Pixel size of image used, i.e., 30m
Flowacc = Flow accumulation
Pow = Power

Factor of Cover Management (C) and Support Practice (P):

The cover and management aspect (C) is a crucial factor in influencing soil erosion, second only to topography. It assesses the impact of agricultural practices on runoff and soil erosion rate. Proper vegetation management, plant residue, and tillage can reduce soil erosion [15][13] Sentinel-2 imagery was used to estimate the C-factor, combining plant cover, production level, and cropping strategies. A land use/cover map was created using Sentinel-2, and a field survey validated the classification results. The C-factor reflects the impact of management on soil loss, influenced by vegetation type, growth stage, and extent. Higher conservation practices result in higher C-values in specific regions.

NDVI & NDSI:

The Normalized Difference Vegetation Index (NDVI) is a widely used vegetation index that categorizes areas into forest and non-forest areas based on reflectance values in red and near-infrared. It ranges from -1 to +1, with negative values indicating water bodies and positive values indicating thick green foliage [16] The NDVI was created using Sentinel-2 image data from September 2023, which measures the different wavelengths of visible and near-infrared sunlight reflected by plants. A higher NDVI rating indicates thick, healthy vegetation, while lower values indicate sparse vegetation. Sentinel-2 data, with its high spatial resolution of 10 meters, is used to collect detailed images of the vegetated regions of Dir. The Normalized Difference Snow Index (NDSI) is used to determine snow in mountainous areas, comparing the visible and shortwave infrared portions of the electromagnetic spectrum. Snow-free conditions are defined by larger NDSI values [17]

$$\text{NDVI} = \frac{B8 - B4}{B8 + B4} \quad (4)$$

$$\text{NDSI} = \frac{\text{Green} - \text{SWIR}}{\text{Green} + \text{SWIR}} \quad (5)$$

Table 3. NDVI classes

Classes	NDVI Range
Snow	-0.010
Water	-0.010-0.015
Built-up	0.015-0.14
Barren land	0.14-0.18
Range land	0.18-0.27
Sparse Vegetation	0.27-0.36
Dense vegetation	0.36-1

Table 4. Cover management (C-Factor) values

Sr #	Landcover Classes	Area %	C-values	Sources
1	Cropland	31.21	0.130	[18]
2	Built-up	3.47	0.050	
3	Forest	22.68	0.008	
4	Water bodies	1.63	0.001	
5	Snow/Glacier	2.31	0.001	
6	Barren Land	20.72	0.200	
7	Rangeland	17.98	0.020	

Results:

Factor of Rainfall Erosivity (R):

Upper Dir has varying rainfall erosivity factors, with the southern region having higher values and the northern region having moderate values. Lower Dir has varying rainfall erosivity factors, with annual values ranging from 410 MJ mm ha/h/year to 568.16 MJ mm ha/h/year. The mean annual erosivity is 485 MJ mm ha/h/year, with variations throughout the region. The northern region has the highest rainfall erosivity, while the south-eastern regions have moderate values. Variations in erosivity values throughout the region are evident.

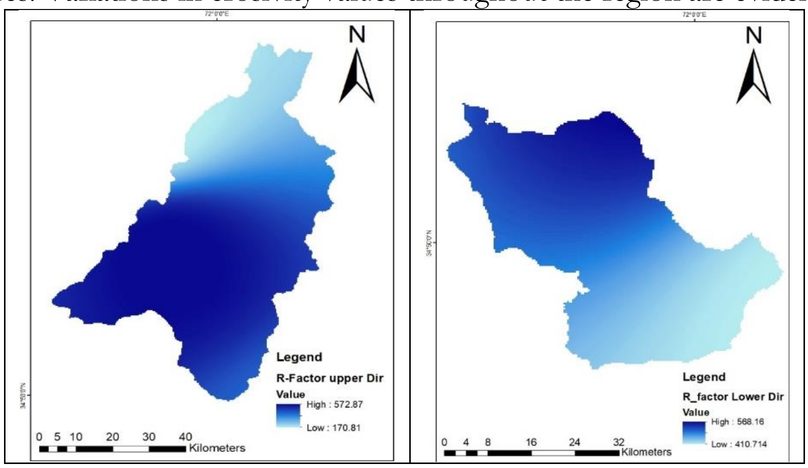

Figure 3. R-factor Map of Upper & Lower Dir

Factor of Soil Erodibility (K):

Soil erodibility, or K factor, measures a soil's vulnerability to erosion caused by runoff and rainfall. It is influenced by physical and chemical properties, such as particle size distribution, organic matter content, soil structure, and soil permeability. The RUSLE model identifies key physical properties affecting soil erodibility. The K factor values in District Dir range from 0.15 to 0.18 tons/ha/year. Upper Dir has a minimum value of 0.16 tons/ha/year and a maximum value of 0.18 tons/ha/year. Lower Dir has a minimum and maximum value of 0.15 and 0.18 tons/ha/year, respectively. Upper Dir has low soil erodibility values, while Lower Dir experiences moderate to high erosion. The middle region of Lower Dir has higher K values.

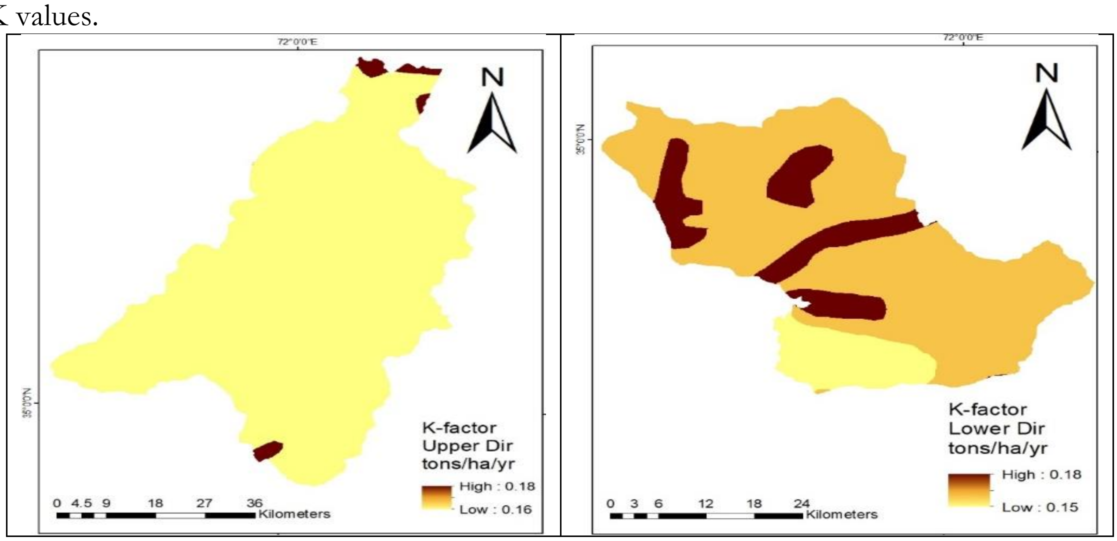

Figure 4. K-Factor Map of Upper & Lower Dir

Factor of Slope Length and Steepness:

Soil erosion is closely linked to the LS factor, which is more prevalent in areas with steeper and longer slopes. The LS factor, derived from the SRTM DEM, is commonly used in soil erosion studies due to its wide availability and free access. For this study area, the LS factor was computed using the 30 m SRTM DEM, with values ranging from 0 to 148.

Upper Dir's LS map shows that the northern parts of Upper Dir have more elevation, leading to more pronounced erosion in higher-elevation areas and higher LS values in the upper portion. The southern portion of the region has the lowest LS values due to the extremely low slope. The northern part of the district has the highest LS values, primarily causing severe soil erosion.

Lower Dir LS map shows that the northern parts have more elevation, leading to higher LS values in the upper portion of Lower Dir, while the southern part has the lowest LS values. This suggests that the LS factor significantly impacts erosion in the study area.

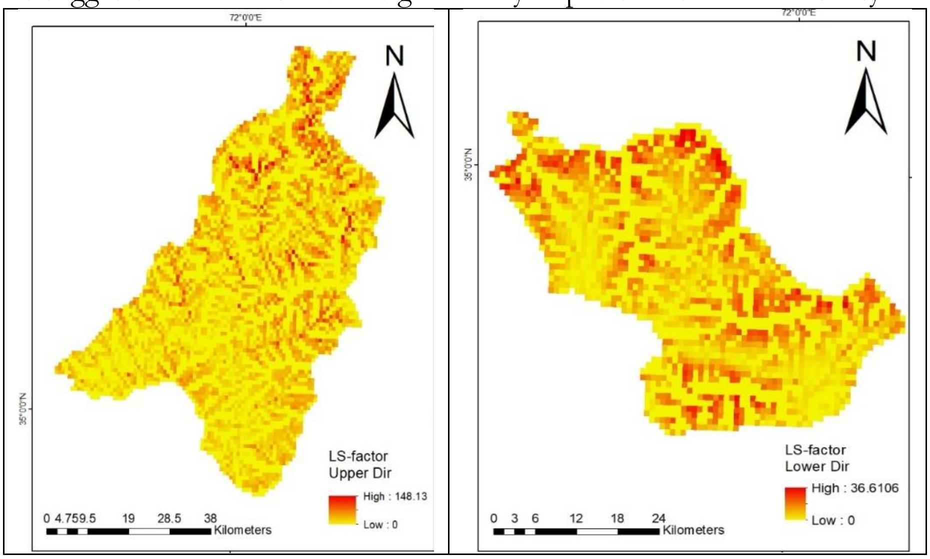

Figure 5. LS-Factor Map of Upper & Lower Dir

Cover Management Factor:

The Land Use and Land Cover (LULC) map for this research reveals a diverse range of land cover classes, including built-up, rangeland, water bodies, cropland, forest, snow, and barren land. The accuracy of the map is 91.19%. The C factor values ranged from 0.001 to 0.2 in both Upper and Lower Dir, with higher values in the northern part of Upper Dir due to high cultivation and forested areas. The lower C values in the central part of the area are due to plantation efforts. The C factor for Lower Dir ranges from 0 to 1, indicating the utility of ground cover in reducing soil erosion. Lower values indicate locations with substantial vegetation or well-managed agricultural lands providing better protection against erosion, while higher values indicate bare soil or poorly managed lands. The C-factor map is created by combining data on various vegetation types, land cover types, and land management practices observed in the region.

Soil Loss Risk in District Dir:

In the Upper Dir, soil loss was estimated to occur at a mean rate of roughly 31.6 tons/ha/yr. In around 47.17% of the region, the soil risk was found to be extremely low (less than 5 tons/ha/yr, low (between 5 and 25 tons/ha/yr) in 25.7% of the area, and moderate (between 25 and 50 tons/ha/yr in 13.98% of the area. High risk (50-100 t/(ha/yr)) and very high risk (>100 t/(ha/yr)) were found in 5.45 % and 7.7% of the region, respectively (Figure 7).

In Lower Dir, soil loss was estimated to occur at a mean rate of roughly 22.88 tons/ha/yr. In around 44.6% of the region, the risk of soil was found to be extremely low (less than 5 t/(ha/yr), low (between 5 and 25 tons/ha/yr in 27.9% of the area, and moderate (between 25 and 50 tons/ha/yr in 15.7% of the area. High risk (50-100 t/(ha/yr)) and very high risk (>100 t/(ha/yr)) were found in 7.08 % and 4.6% of the region, respectively (Figure

7). Comparing both regions of District Dir, it appears to have the highest erosion rates in Upper Dir. mainly because of higher elevation areas, slopes, and other factors.

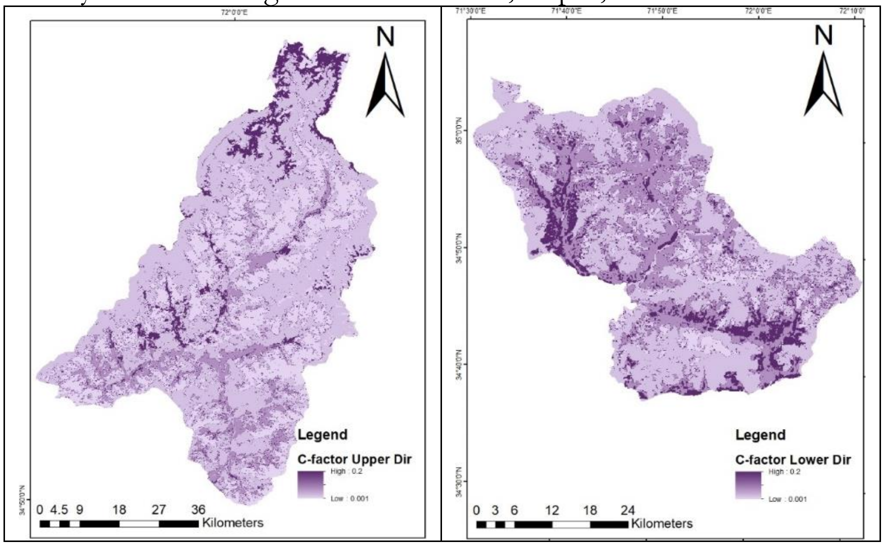

Figure 6. C-Factor map of Upper & Lower Dir

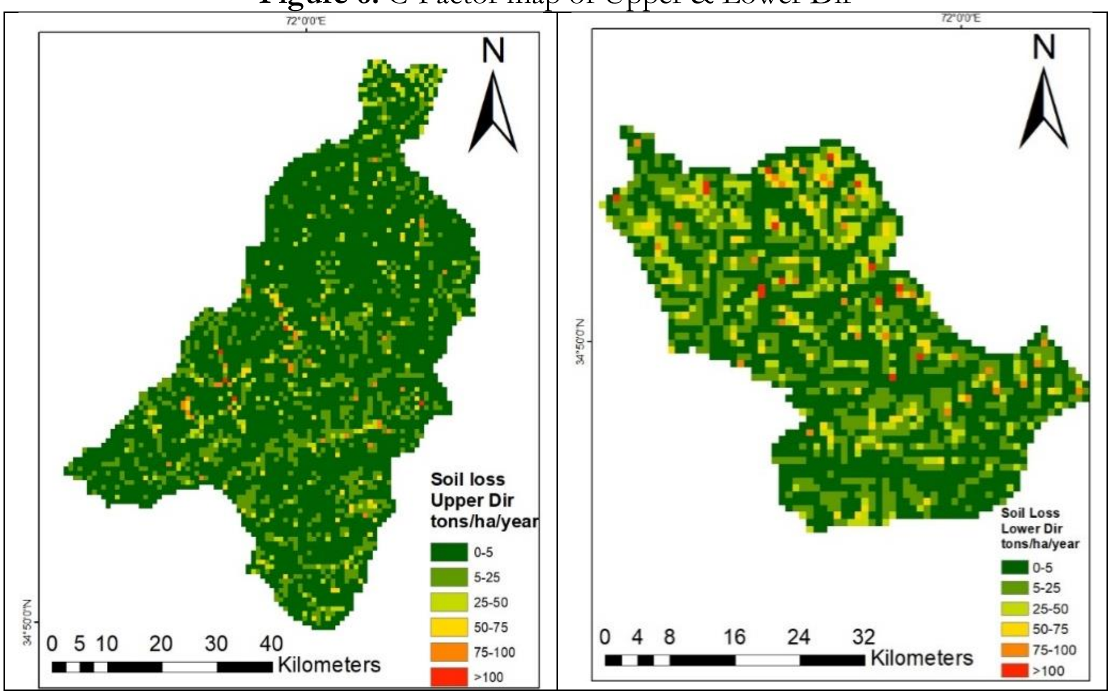

Figure 7. Annual Soil Loss Map Upper & Lower Dir (tons/ha/year)

Land Use and Land Cover:

The District Dir has a significant proportion of built-up and urban regions, with 3.47% of the total land cover being built-up areas. The majority of the area is used for agriculture, with lush plains and valleys being the primary agricultural areas. Forests, which provide essential ecosystem services like carbon sequestration and wildlife habitat, make up 22.68% of the total area. The remaining 20.72% is barren land, characterized by rocky outcrops and little to no vegetation. Rangeland, which comprises 17.98% of the district, is primarily grasses and shrubs, sustaining various species and used for animal grazing. Water bodies, such as lakes and rivers, make up 1.63% of the area, essential for aquatic habitats, drinking water, and irrigation. Snow/glaciers cover over 2.31% of the area. The C factor values assigned to various LULC classes indicate a higher risk of soil erosion.

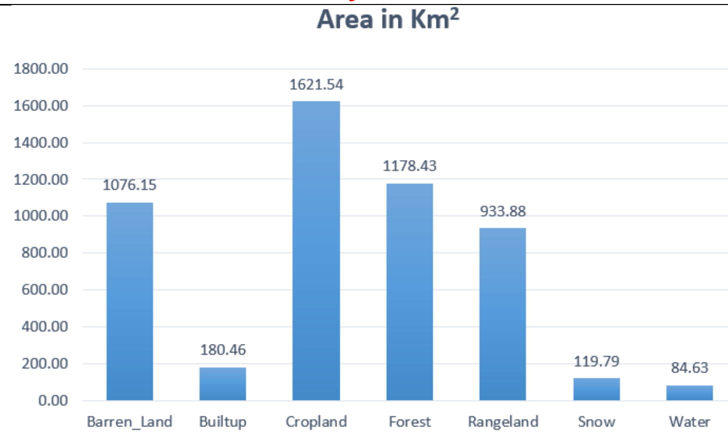

Figure 8. Bar chart showing the area (km^2) of LULC classes of the Dir district

Table 5. Land cover classes of the Dir district and C values

Sr #	Landcover Classes	Area %	Area in Km^2	C-values	Sources
1	Cropland	31.21	1076.15	0.130	[18]
2	Built-up	3.47	180.46	0.050	
3	Forest	22.68	1621.54	0.008	
4	Water bodies	1.63	1178.43	0.001	
5	Snow/Glacier	2.31	933.88	0.001	
6	Barren Land	20.72	119.79	0.200	
7	Rangeland	17.98	84.63	0.020	
Total		**100.00**	**5194.88**		

Table 6. LULC classes are in percentage and km^2 of Upper Dir

Land Cover	Area in km^2	Percentage
Barren Land	871.2999	23.97
Built-up	104.4733	2.87
Cropland	887.923	24.43
Forest	1006.4835	27.69
Rangeland	571.2295	15.72
Snow	118.3091	3.26
Water	74.4953	2.05
Total	3634.2136	100.00

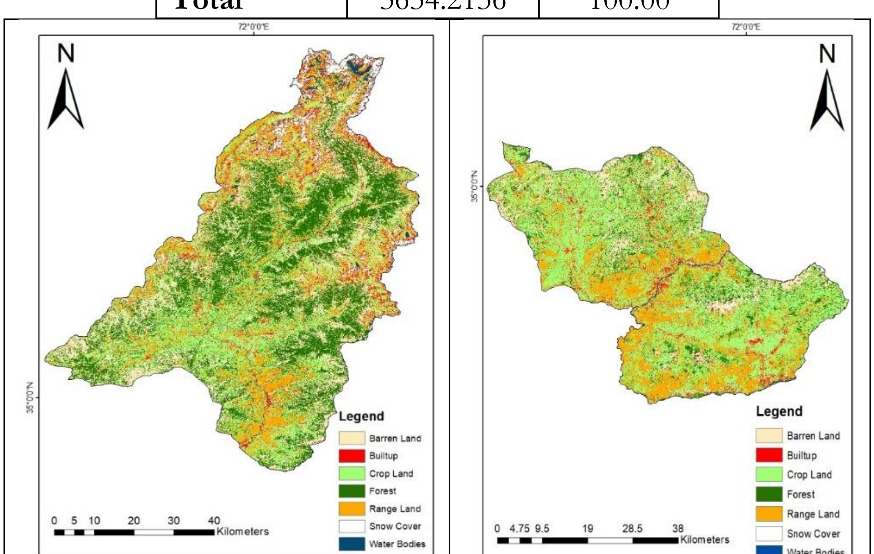

Figure 9. LULC Map of Upper & Lower Dir

Table 7. LULC classes Area in % and km^2 of Lower Dir

Land Cover	Area in km^2	Percentage
Barren Land	204.85	13.13
Built-up	75.98	4.87
Cropland	733.62	47.01
Forest	171.95	11.02
Rangeland	362.65	23.24
Snow	1.48	0.09
Water	10.14	0.65
Total	1560.67	100.00

NDVI:

The Normalized Difference Vegetation Index (NDVI) is a widely used vegetation index that categorizes areas into forest and non-forest areas based on reflectance values in red and near-infrared. It ranges from -1 to +1, with negative values indicating water bodies and positive values indicating thick green foliage. The NDVI was created using Sentinel-2 image data from September 2023, which measures the different wavelengths of visible and near-infrared sunlight reflected by plants. A higher NDVI rating indicates thick, healthy vegetation, while lower values indicate sparse vegetation. Sentinel-2 data, with its high spatial resolution of 10 meters, is used to collect detailed images of the vegetated regions of Dir. The NDVI is calculated using Sentinel-2 Band 4 and Band 8 bands, providing information on the health and activity of photosynthetic processes in plants.

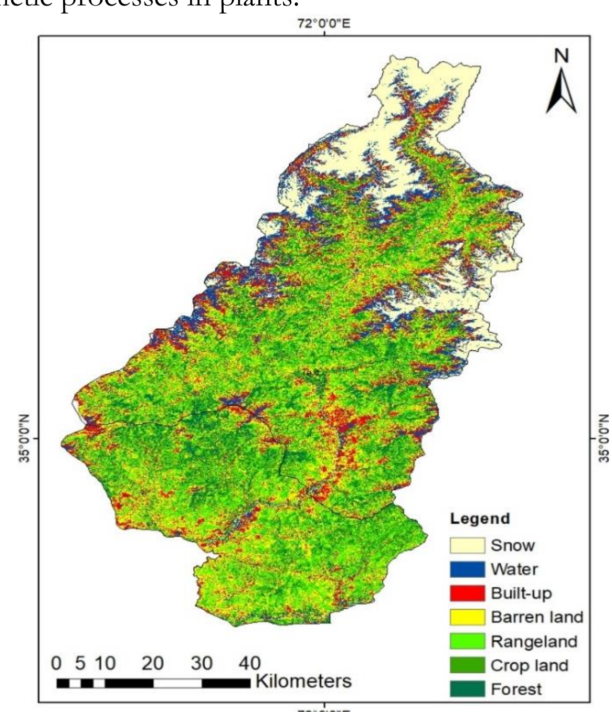

Figure 10. NDVI Map of Dir

NDSI:

Snow can be easily identified on satellite images due to its strong reflection in the visible spectrum. However, identifying snow in mountainous areas can be challenging due to cloud cover and mountainous shadows. The Normalized Difference Snow Index (NDSI) is used to determine snow in such environments. The NDSI is determined by comparing the visible and shortwave infrared (SWIR) portions of the electromagnetic spectrum. If the NDSI value of a pixel is greater than 0.4, it is classified as snow. Snow-free conditions are defined by larger NDSI values. The NDSI was produced using data from Sentinel-2 image data from

January 2023. The density of snow on mountainous land is calculated using the different wavelengths of visible and shortwave-infrared reflected by the snow.

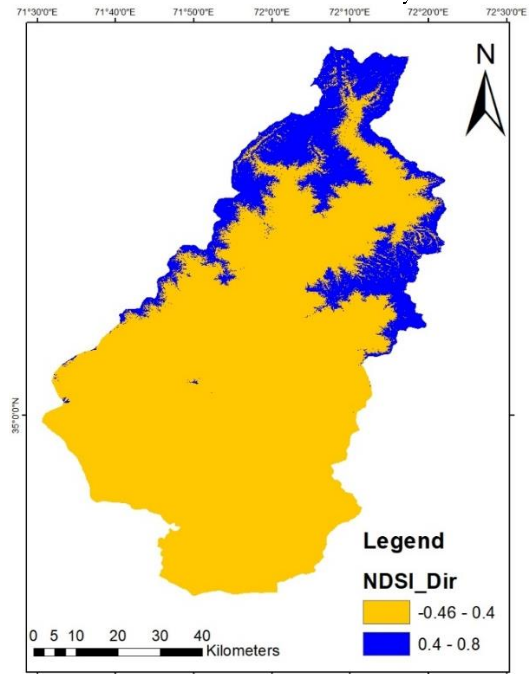

Figure 11. NDSI of Dir

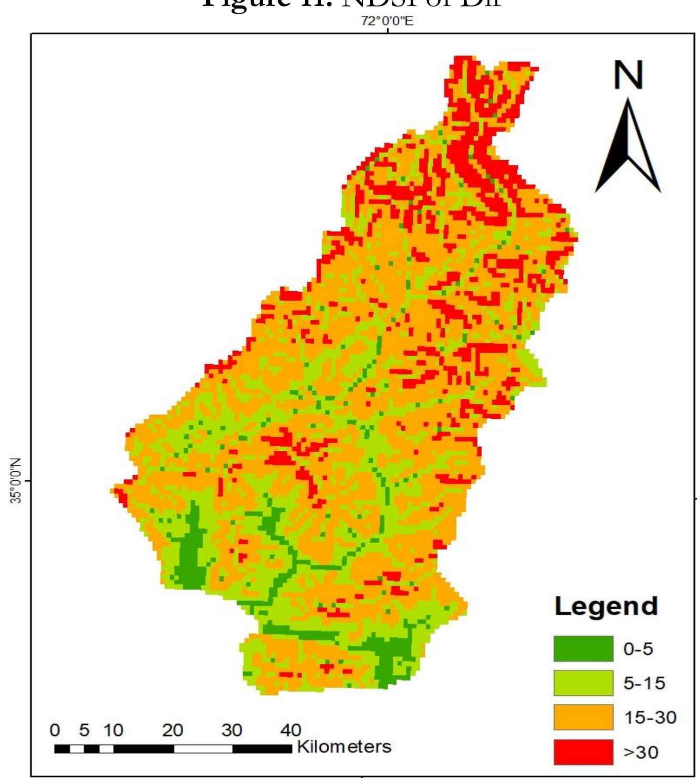

Figure 12. Slope (m) Map of Dir

A slope map is an essential tool for topographic analysis because it shows the slope or gradient of the ground, which is important for planning land uses, managing the environment, and understanding patterns of soil erosion. The slope map, which is divided into elevation ranges of 1 to 100, shows different levels of inclination throughout the terrain in the context of the Dir district. These ranges of elevation make it easier to locate regions with gentle slopes, moderate inclinations, and high gradients. Because they pose less of a risk for erosion, gentle slopes, which are generally found in lower elevation ranges, are more suited for urban development and agriculture. The Slope range lies between 0 to more than 30m. Higher elevation areas are more prominent in Upper Dir as compared to Lower Dir, which has the lowest elevation.

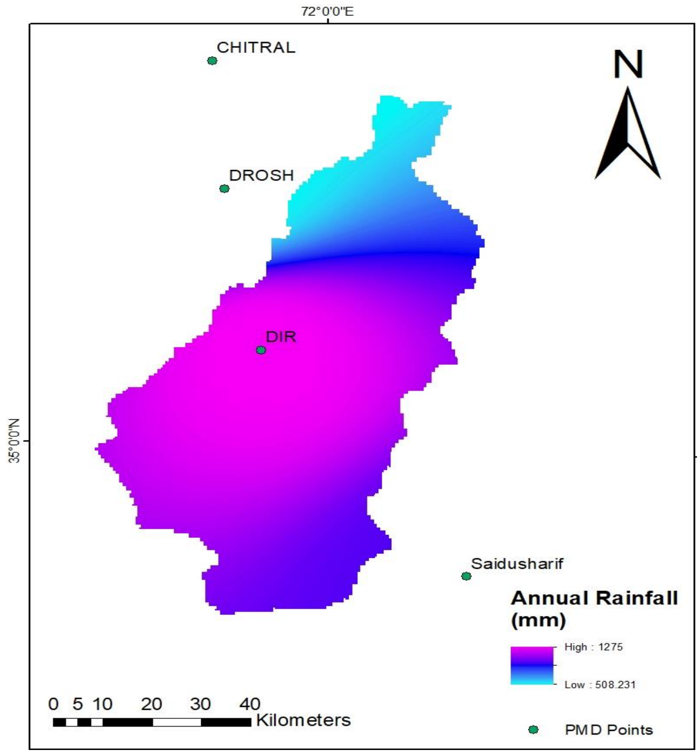

Figure 13. Annual Rainfall Dir

This map highlights notable changes in mean annual precipitation levels and shows the annual rainfall spatial distribution throughout the study region. The annual rainfall values range from 508 mm to 1275mm. The data shows the mean value and standard deviation of 1068 and 216, respectively. The middle regions of the selected area indicate an increased trend of rainfall, while the lowest rainfall can be seen north of District Dir.

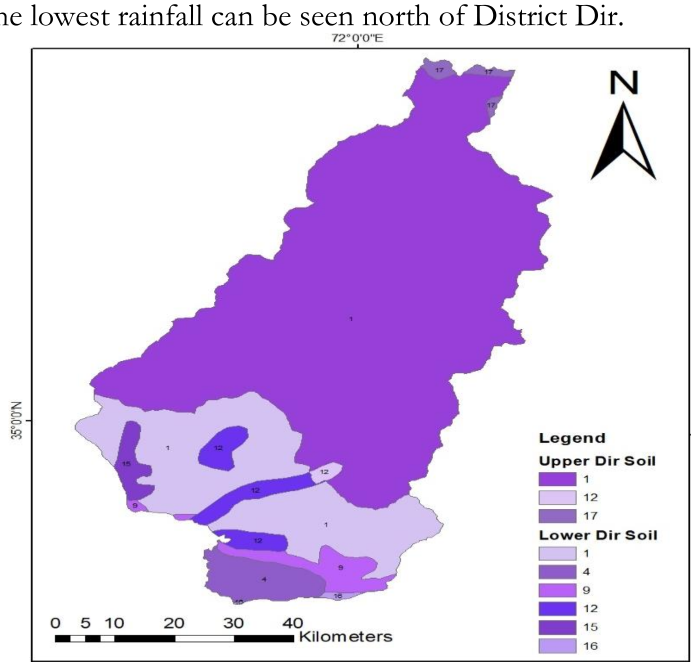

Figure 14. Soil map of Dir

There were seven soil mapping units recognized in the study area. Ranging between 1 and 20. The soil units from 1-4 lie in a mountainous valley, which covers 24.9 and 21.6 of % area and are more dominant in the upper region of District Dir. Soil unit 9 is mostly dominant in gentle sloping areas that mainly lie in lower Dir and consist of fine-textured soil covering 1.1 of % area. Soil Id 12-15 are present in nearly flat land and cover 1.5 and 1.3 of % area respectively. Soil unit 16 is present in gently sloping areas of District Dir, mainly in Lower Dir, consisting of coarse-textured soil and covering 0.2 % of the land. Soil Id 17 lies in areas with pronounced snow or glaciers, mainly in Upper Dir, covering 25.7% of the area of Upper Dir. Table 8 shows the characteristics of different soil IDs present in the study area covering different area in percentage.

Table 8. Major land types and soil mapping units

Soil ID	Area (%)	Soil Characteristics
1	24.9	Shallow and medium textured in valleys
4	21.6	Scattered and medium-textured soil is found in mountainous valleys
9	1.1	Moderately fine-textured soil in gently sloping areas
12	1.5	Coarse-textured soil in Alluvial basins and valleys
15	1.3	Medium-textured soil found on gentle slopes
16	0.2	Shallow and coarse-textured soil in an alluvial basin
17	25.7	The area comprises snow or a large mass of ice.

Conclusion:

In conclusion, the soil erosion risk assessment conducted in Pakistan's Upper and Lower Dir regions using the RUSLE model integrated with RS and GIS offers a comprehensive understanding of the spatial distribution and severity of soil erosion. RUSLE and GIS approaches work well together to quantify and map erosion from a region. Soil erosion in District Dir is influenced by terrain, rainfall, and urban areas. This study identifies that the annual rainfall values lie between the range of 508 mm to 1275 mm, due to which the maximum values of rainfall erosivity in Upper and Lower Dir are 572.87 MJ mm ha/h/year and 568.16 MJ mm ha/h/year, respectively. The study area shows seven different soil types. The maximum values of soil erosivity in Upper and Lower Dir are 0.18 tons/ha/year, respectively. The areas with steeper slopes are at more risk of soil erosion. Slope of the district Dir lies between 0 to more than 30m, the highest values of Lower and Upper Dir are 36 and 148, respectively. Upper and Lower Dir cover 3634 and 1560 km2 of total area, in which Upper Dir has more area covered by barren land, built-up, cropland, snow, and water bodies, whereas Lower Dir comprises more forest land, which is 1006 km2. NDVI values range between -1 to 1, showing the major classes of land use and land cover. NDSI values within the study area range between -0.4 to 0.8, showing 947.8 Km2 of area has snow and 4394.33Km2 of area has no snow. This study indicates the higher C-factor values in Upper and Lower Dir, i.e., 0.001-0.2. Soil loss was calculated with the help of all factors (R, K, LS, CP) which shows that the soil loss is roughly about 31.6 tons/ha/yr in Upper Dir and 22.88 tons/ha/yr soil loss in Lower Dir, that is higher in Upper Dir due to high elevation (>30) and more rainfall in Upper Dir (1275mm). Soil erosion can have significant impacts on different soil types, depending on their characteristics and locations. Understanding the susceptibility of each soil ID to erosion is crucial for developing effective strategies to prevent or mitigate soil erosion. By analyzing the soil characteristics and locations, we can identify areas that require special attention and implement measures to reduce the risk of soil erosion. To reduce soil erosion, focus on regions with steeper slopes, especially those larger than 30m. Regreen bare slopes by reseeding or replanting, especially in Upper Dir, which shows higher soil loss due to barren land and built-up areas. Promote sustainable agricultural practices, with active supervision from organizations like the Forest Department. Implement better water management strategies to control rainfall runoff and regularly monitor rainfall patterns to adjust soil conservation strategies.

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