



Spatial Distribution of Dissection Index (Erosion Intensity) versus Geomorphological Environment in Parkha Watershed, Central Himalaya

Rekha Deolia and Anita Pande

Department of Geography
Kumaun University Nainital-263001(UK)

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ABSTRACT

In the present paper, an attempt has been made to study the spatial distribution of dissection index (Erosion Intensity) versus Geomorphological Environment in Parkha Watershed. Author have evaluated the morphometric characteristic on the basis of Survey of India toposheet at 1:50,000 scale. For this detailed study, survey of India toposheet (1:50,000) were used for relief aspect of morphometric parameters. Dissection Index (the roughness of the earth surface) is a ratio between relative relief and absolute relief, consequently its range is a combined result of various geomorphic factors viz. lithology, absolute relief, relative relief, average slope and drainage density. A quantitative study is designed to investigate the impact of these factors upon dissection index. The correlation coefficient between dissection index and aforesaid factors show that absolute relief, relative relief, average slope and drainage density determine positive impact on the growth and development of varying degree of dissection in Parkha watershed

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1. Introduction

The morphometric characteristics at the watershed scale may hold important information about its formation and development because all hydrologic and geomorphic processes occur within the watershed (Singh, 1990). Dissection Index (DI) is expressing a ratio of the maximum relative relief to maximum absolute relief. It is an important morphometric indicator of the nature and magnitude of dissection of terrain. (Singh, S, 2002). Morphometric analysis of a watershed present a quantitative description of the drainage system, which is an important aspect of the characterization of watersheds (Strahler, 1964). The word dissection index itself defines the roughness of

the surface created by numerous valleys or ravines. It is an important parameter of drainage basin and useful in the study of the terrain and drainage basin dynamics, the stage attained by the stream in the course of the evolution of basin concerned. In this study an attempt has been to observe the impact of lithology, relief, average slope and drainage density (Pande and Joshi, 1994). Recently this type of work is highly considerable of interest by various geographers, Joshi and Patil (2009), Dutta and Sunvindu (2012), Pareta, Kuldeep and Pareta Upasana (2012), Prakasam, C and Biswas, B (2012), Bhunia et al (2012), Tejpal (2013), Gayen et al (2013).

The study is based on the quantitative analysis of the

*Corresponding Author

E-mail address : rekha.deolia@gmail.com (R. Deolia)

morphometric parameters and reveals some basic aspects of presented area. However in this study area nobody has done this kind of work on this theme. Author believes that the study will provide an opportunity to the researchers for better insight to this field.

2. The Study Area

The 'Parkha Watershed' extends between the latitude of 29° 26' 31"N and 29° 31' 41"N and the longitude of 79° 41' 48"E and 79° 45' 00"E. Encompassing an area of 80 km² in lesser Himalaya, the watershed lies in the SOI topographical sheet of 53 O/10 and 53 O/11(scale 1:50000).The watershed lies in Nainital District and Almora District of Uttarakhand State and constitutes a part of Kosi –West Ramganga drainage system of Central Himalaya. This watershed is under the influence of tectonic feature, viz. South Almora Thrust (S.A.T.) and structure

the area. As per the Meterological station located in the watershed the hottest month of June received 22.05°C temperature while the coldest month January gets 4.45°C temperature. The maximum rainfall received by the month of August (377.6mm) while the minimum rainfall received by the months May and November.

3. Methodology

Field based data and Methods

Present study is an attempt on the basis of Dove Nir's (1957) definition. The ratio between relative relief and absolute relief is known as dissection index. Further the formula as expounded by him is:

$$D.I = Rr/Ar$$

where D.I. is dissection Index, Rr is Relative relief, Ar is Absolute relief.

The morphometric analysis of the study was carried out using the survey of India toposheet (1:50,000).The

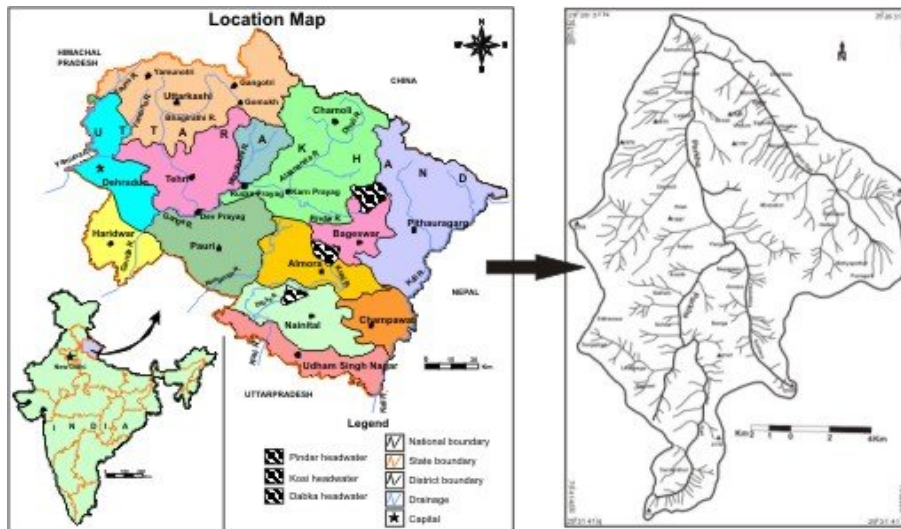


Fig. 1 : Parkha Watershed Location Map

has played a significant role in the determination of morphogenetic nature of hazard zones. The area possesses classical mixture of different lithologies including the rocks of Ramgarh Group and Almora Group. The altitude of the area ranges between 1200 m to 2346 m. The high variation of altitude produces classical mixture morphological features (broad valley to sharp spurs and extended ridges). Vegetation diversity produces variations in the degree and extent of hazardous slope processes. The Himalayan sub – tropical pine forest, oak forest, Rhododendron forest and Deodar forest are the characteristic feature of

entire watershed area is divided into grid of 1 km². A total of 103 grids were made for the morphometric characteristic of the study area. With the help of contour map the above formula of Dove Nir is applied and resultant value are grouped into five categories. These categories are <0.05(Very low)dissection index, 0.05-0.10(Low)dissection index, 0.10-0.15(Moderate)dissection index, 0.15-0.20(High) dissection index and >0.20(Very high)dissection index. These five categories of dissection index, the category 0.10-0.15(Moderate)dissection index acquires the maximum area(49.24%)while the category

<0.05 (Very low) dissection index acquire the minimum area (1.1%). Area of each category is obtained with the help of planimeter. Thus placing the computed values, the depiction of dissection index is made by drawing isopleths for the whole area. Absolute relief ranges between 1260m to 2280m where in the maximum area (37.72 %) falls under high relief zone (1900 to 2000m), while minimum area (6.1 %) is confined to low relief zone (below 100). Relative relief (Smith, 1935) extends between 20m to 440m elevation. Maximum area (52.09%) lies in between (200 to 300m), while minimum area (1.6%) is found in very high relief zone (above 400). Average slope (Wentworth, 1930) varies from 1° to 31° . Maximum area (36.78 %) falls under moderate slope (17° to 21°) while minimum area (4.79%) is under low slope zone (below 13°).

4. Results and Discussion

The geomorphic impact upon dissection index has been pointed with the help of bivariate frequency analysis among dissection index and various geomorphic indices. (geology, relative relief, absolute relief, and slope and drainage density) which statistical measures are shown in Table 1. It is known that the range of dissection index is measured by resistant lithology where as loose rock are the indication of its degree but sometime it is also noticed that in few cases, opposite phenomena have been observed in which the resistant rocks help in the development of dissection index range and these development checked by loose rock. The tectonic control is responsible for this observation. The gradient of earth surface, which is a fundamental feature, is only responsible to make variation in dissection index

Spatial Distribution of Dissection Index

The regional distribution of dissection index varies from north to south and east to west (Fig-2) which ranges between 0.01 to 0.30, thus indicating the impact of relief, slope, lithology, drainage density and vegetation cover. Table 2 illustrates the regional distribution of dissection index in Parkha watershed. Table-2 reveals highest area is covered by the group of moderate which is 39.39 km² or 49.24 percent of the total area. The lowest dissection index is under the group of below 0.05 which is 0.88 km² or 1.1 percent of the total area.

Due to the different aspects like slope, relative relief, absolute relief, geology, drainage density and vegetation cover the Parkha and its tributaries have the varying degree of erosion intensity. Consequently there is much variation in the attainment of dissection

index in different parts of the basin though the sub-basins lie in almost same altitudinal zones. The impact of various geomorphic properties is observed as evident from the following description:

Lithology and Dissection Index

The Parkha Watershed lies under stratigraphical unit of lesser Himalaya. Hard metamorphic rocks and limestone are mainly concentrated in this domain. This unit also possesses the old unfossiliferous sedimentary rocks of Palaeozoic and Precambrian periods, other available rocks are slate, limestone and quartzite. Lesser Himalaya is the area of maximum monsoon-rain, so the numerous streams and rivulets have created several landforms through erosion. The Lesser Himalayan domain under study area is characterized by the rocks of two groups:

- (i) Ramgarh Group associated with Nathuakhan formation.
- (ii) Almora Group associated with Augen-Gneiss and Saryu-Gumalikhhet -Munsiari Formation.

The occurrence of each lithology under different dissection index groups has been set out in Table 3 and the spatial distribution of geology in Parkha watershed shows in Fig.3.

Low dissection index constitutes 11.83 km² of the area. Saryu-Gumalikhhet-Munsiari has the highest (7.50 km²) and Augen Gneiss have lowest (0.5 km²) coverage of area in this category.

Moderate dissection index has maximum area of 38.49 km². Saryu-Gumalikhhet-Munsiari formation comprising an area of 27.05 km², has maximum coverage of area Augen Gneiss formation having the minimum area of 3.39 km² of this Index.

High dissection index included maximum lithology of Saryu-Gumalikhhet-Munsiari formation covering 19.15 km² while Nathuakhan formation constitutes the minimum area of 2.32 km².

Very high dissection covers 3.82 km² area. Its lithology is mainly confined to Saryu-Gumalikhhet-Munsiari (3.50 km²) and Augen Gneiss (0.32 km²) formation.

The overall analysis indicates that Moderate to High dissection index covers maximum area, the main lithology of which is Saryu-Gumalikhhet-Munsiari Formation.

Absolute Relief and Dissection Index

The maximum and minimum occurrence of each absolute relief zone under different dissection index groups have been set out in Table. 4 and the spatial distribution of absolute relief in Parkha watershed shows in Fig.5.

Table 1: Parkha Watershed: Geomorpha-Statistical Measures

Statistical Parameters	Absolute Relief (m)	Relative Relief(m)	Average Slope(m)	Dissection Index (m)
Mean	1958.40	256.63	18.32	0.14
Median	1984.47	256.88	19.36	0.13
Mode	2034.3	256.16	18	0.14
Range	1020	420	30	0.29
Quartile ₁	1800.42	209.12	15.59	0.11
Quartile ₃	222.70	310.35	21.30	0.168
Quartile Deviation	161.14	50.62	2.86	0.029
Coefficient of Quartile Deviation	0.82	0.19	0.15	0.21
Standard Deviation	276.86	78.11	5.14	0.049
Coefficient of Standard Deviation	0.304	0.141	0.28	0.347
Mean Deviation from Mean	181.37	55.192	3.67	0.035
Mean Deviation from Median	204.77	3.59	7.70	0.035
Mean Deviation from Mode	214.50	54.98	3.85	0.044
Coefficient of Mean Deviation from Mean	0.093	0.22	0.20	0.25
Coefficient of Mean Deviation from Median	0.103	0.014	0.39	0.25
Coefficient of Mean Deviation from Mode	0.11	0.21	0.21	0.31
Coefficient of Skewness	-0.27	0.006	0.062	0.020

Table 2: Parkha Watershed: Areal Distribution of Dissection Index

Dissection Index	Area	Cumulative Area km ²	Area (%)	Cumulative Area (%)	Remark
<0.05	0.88	0.88	1.1	1.1	Very low
0.05-0.10	10.72	11.6	13.4	14.5	Low
0.10-0.15	39.39	50.99	49.24	63.74	Moderate
0.15-0.20	25.56	76.55	31.95	95.69	High
>0.20	3.46	80	4.31	100	Very high
Total	80		100		

Table 3: Lithology and Dissection Index

Dissection Index	<0.05	0.05-0.10	0.10-0.15	0.15-0.20	>0.20	Total
Geological formation	Very low	Low	Moderate	High	Very High	
Augun-Gneiss	-	0.5	3.39	3.31	0.32	7.52
Saryu-Gumalikhhet-Munsiari	0.59	7.50	27.05	19.15	3.50	57.79
Nathuakhan	0.49	3.83	8.05	2.32	-	14.69
	1.08	11.83	38.49	24.78	3.82	80.00

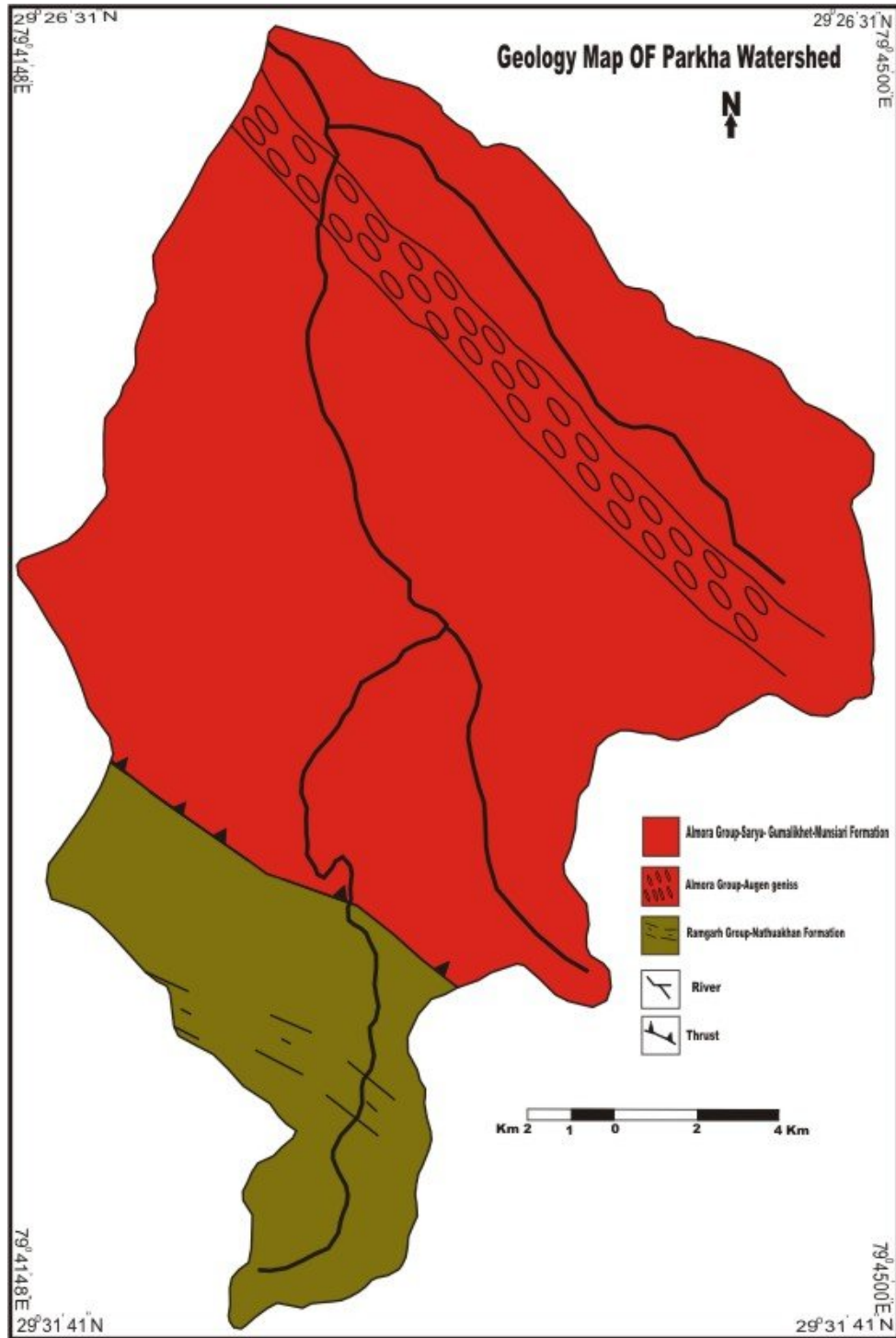


Fig.3 Parkha Watershed: Spatial Distribution of Geology

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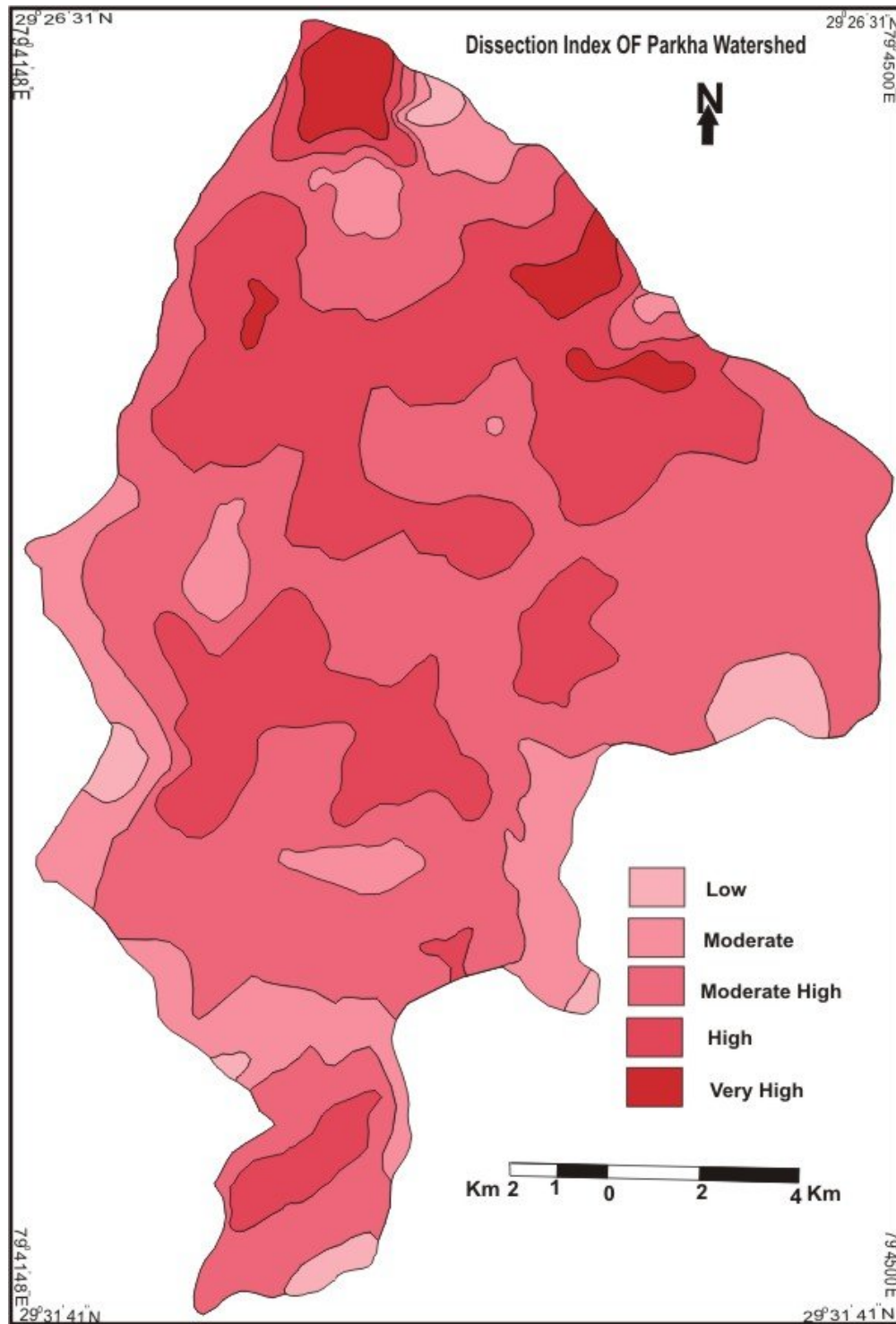


Fig.2 Parkha Watershed: Spatial Distribution of Dissection Index

Table 4: Absolute Relief and Dissection Index

Absolute Relief(m)		<1500	1500-1700	1700-1900	1900-2100	>2100	Total
Dissection Index	Remark	Low	Moderate	Moderate high	High	Very High	
<0.05	Very Low	0.21	-	-	-	1.46	1.67
0.05-0.10	Low	1.73	-	0.24	2.29	5.76	10.02
0.10-0.15	Moderate	1.99	3.19	7.93	16.9	11.38	41.39
0.15-0.20	High	0.85	3.99	7.91	8.32	3.67	24.74
>0.20	Very High	1.06	0.43	0.69	-	-	2.18
		5.84	7.61	16.77	27.51	22.27	80.00

Very low dissection index group is highly concentrated on the very high absolute relief area covering 1.46 km² while the lowest concentration is in Low absolute relief area with 0.21km².

Low dissection index group constitute its maximum concentration in very high absolute relief, covering 5.76km² while the lowest concentration (0.24km²) is visible in Moderate high absolute relief area. Other relief area also shares this index category through having small area.

Moderate dissection index group lies in High absolute relief area constituting 16.9km² while the lowest area i.e 1.99km² lies in the Low absolute relief area. Other relief areas also provide a good concentration of this index group in comparison to other index categories. High dissection area is found in High absolute relief area covering 8.32km² and the lowest area 0.85km² lies in Low Absolute area.

Very high dissection index group constitute its maximum concentration in low Low absolute relief area (1.06km²) and lowest area lies in Moderate absolute relief area (0.43km²).

The overall analysis indicates that the High to Very High absolute relief groups play a dominant role (27.51 and 22.27 km²) in governing the dissection index. The Low absolute relief group has the lowest degree of dissection index which shows a positive correlation between absolute relief and dissection index. The statistical measurement of correlation i.e +0.54 confirm this result.

Relative Relief and Dissection Index

The maximum and minimum occurrence of each relative relief zone under different dissection index groups have been set out in Table. 5 and the spatial distribution of Relative relief in Parkha watershed

shows in Fig.4.

Very low dissection index group is highly concentrated in low relative relief area having 0.26km² while the smallest part of the index is seen in Moderate High relief area of 0.07km². Very high relative area shows an absence of this index category.

Low dissection index group covers its maximum area in Moderate relative relief area comprising 7.57km² while Low relative area possesses the smallest part (0.25km²) of this index category.

Moderate dissection index group comprises its maximum area of 29.62km² in Moderate High relative area and only 0.65 km² area is seen very high relative area presenting the lowest concentration of this index group.

High dissection index group has maximum concentration in High relative relief area and minimum concentration is found in Low relative relief area 0.60 km².

Very high dissection index group has maximum concentration in High relative area (0.83km²) and minimum area (0.44km²) concentration in Low relative relief area.

The overall analysis reflects that the moderate high relative area dominates strongly (41.15km²) among all other relative relief areas in reference area to the impact of relative relief on dissection index. Very low dissection index category is absolutely absent in very high relative area and very high dissection index group shows its neutrality in very low and very high relative relief areas. This shows almost positive relationship between both indices which statistically stands at +0.95.

Average Slope and Dissection Index

The maximum and minimum occurrence of each

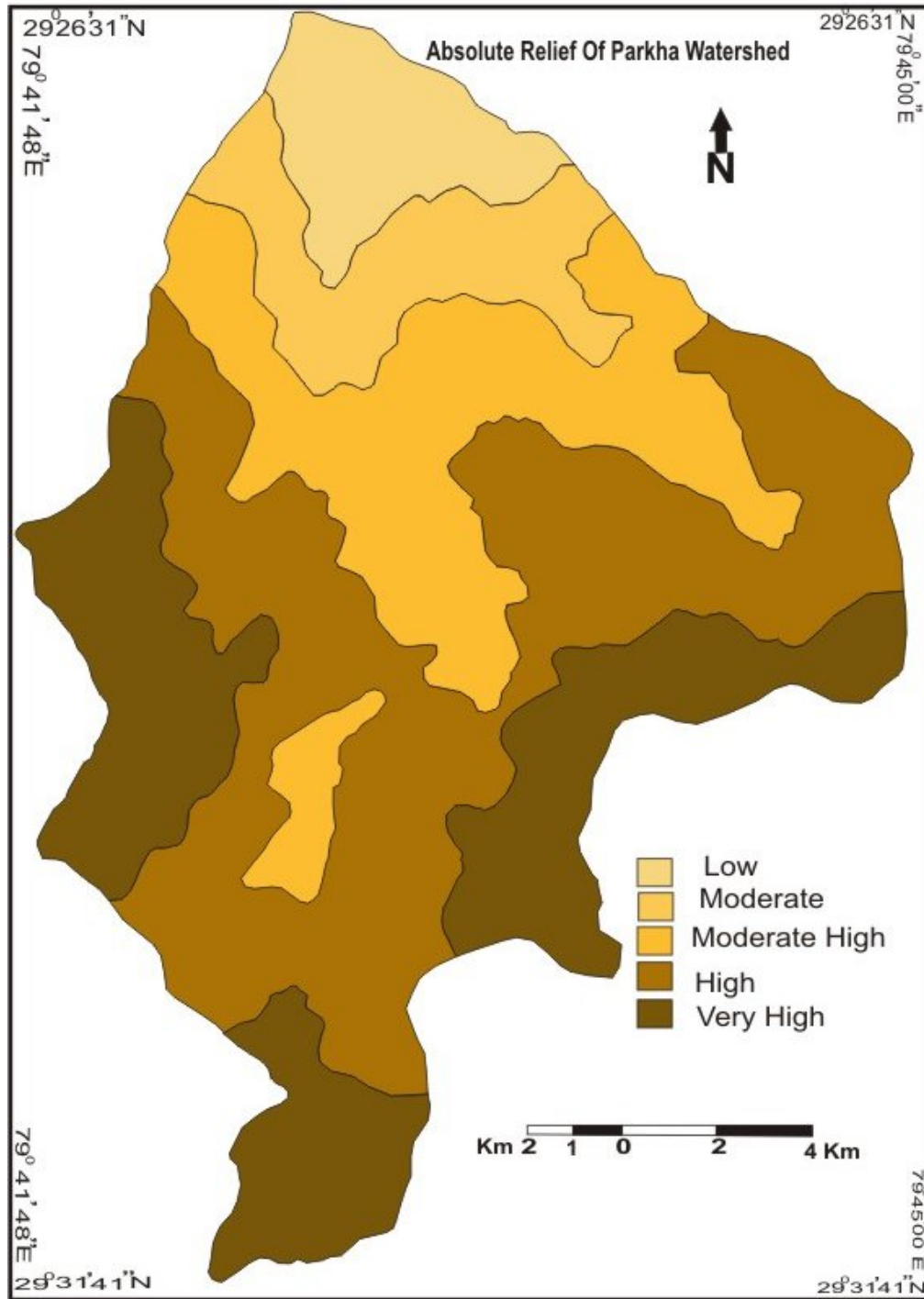


Fig.5 Parkha Watershed: Spatial Distribution of Absolute relief

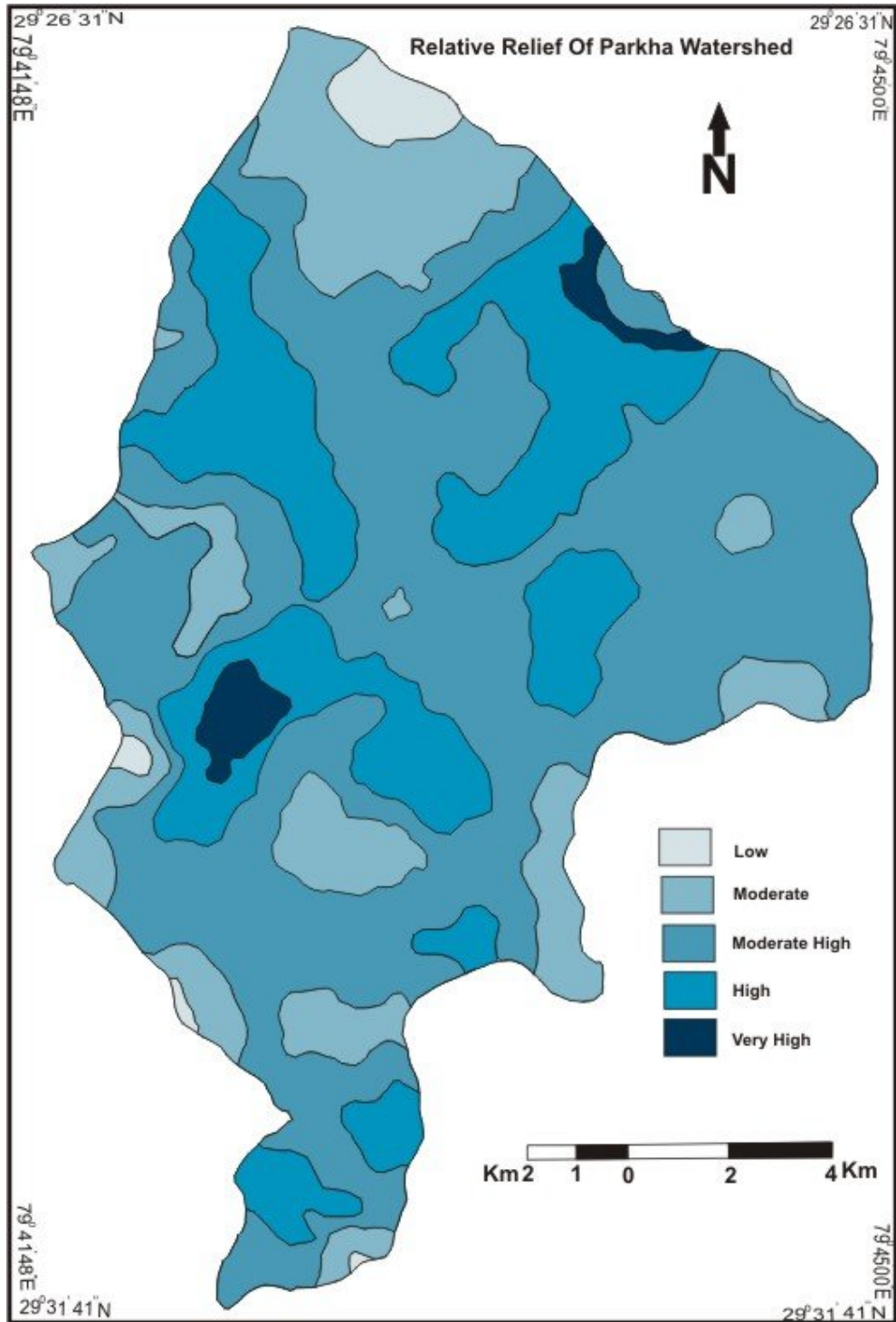


Fig.4 Parkha Watershed: Spatial Distribution of Relative relief

Table 5: Relative Relief and Dissection Index

Relative relief(m)		< 100	100-200	200-300	300-400	>400	Total
Dissection Index							
	Remark	Low	Moderate	Moderate high	High	Very high	
<0.05	Very low	0.26	0.24	0.07	-	-	0.57
0.05-0.10	Low	0.25	7.57	2.46	1.0	-	11.28
0.10-0.15	Moderate	0.99	5.57	29.62	3.61	0.65	40.44
0.15-0.20	High	0.60	1.82	9.0	13.66	0.72	25.8
>0.20	Very high	0.44	0.64	-	0.83	-	1.91
		2.54	15.84	41.15	19.1	1.37	80.00

average slope zone under different dissection index groups have been set out in Table 6 and the spatial distribution of Average slope in Parkha watershed shows in Fig.6.

Very low Dissection index group its maximum area under Gentle slope region 0.98 km² and minimum area falls under low slope region of 0.30 km². Moderate, Moderate steep and Steep zones have been absolutely ignored by this dissection index.

Low dissection index dominates in Moderate slope zone, having an area of 3.56 km². The steep slope zone

has the minimum concentration of this index which possesses only 0.59 km² area. The other slope zones also have almost regular distribution of area of this index.

Moderate dissection index has its maximum concentration in moderate slope zone where it covers 14.52 km² area. Steep slope zone has lowest concentration of 2.63 km².

High dissection index is typified by the highest concentration of Moderate slope zone i.e. 12.93 km². On the other hand the minimum area of 0.40 km²

Table 6: Average Slope and Dissection Index

Slope(°)		< 13	13-17	17-21	21-25	>25	Total
Dissection Index							
	Remark	Low	Gentle	Moderate	Moderate Steep	Steep	
<0.05	Very Low	0.30	0.94	-	-	-	1.24
0.05-0.10	Low	2.83	3.22	3.56	2.70	0.59	12.9
0.10-0.15	Moderate	2.79	12.72	14.52	6.83	2.63	39.49
0.15-0.20	High	0.40	4.39	12.93	5.64	0.6	23.96
>0.20	Very High	0.24	0.57	0.94	0.60	0.06	2.41
		6.56	21.84	31.95	15.77	3.88	80.00

Table 7: Parkha Watershed: Impact of Drainage Density on Dissection Index

Dissection Index	Remark	Drainage Density (km/km ²)
<0.05	Very low	0.85
0.05-0.10	Low	2.16
0.10-0.15	Moderate	2.35
0.15-0.20	High	2.02
>0.20	Very high	2.17

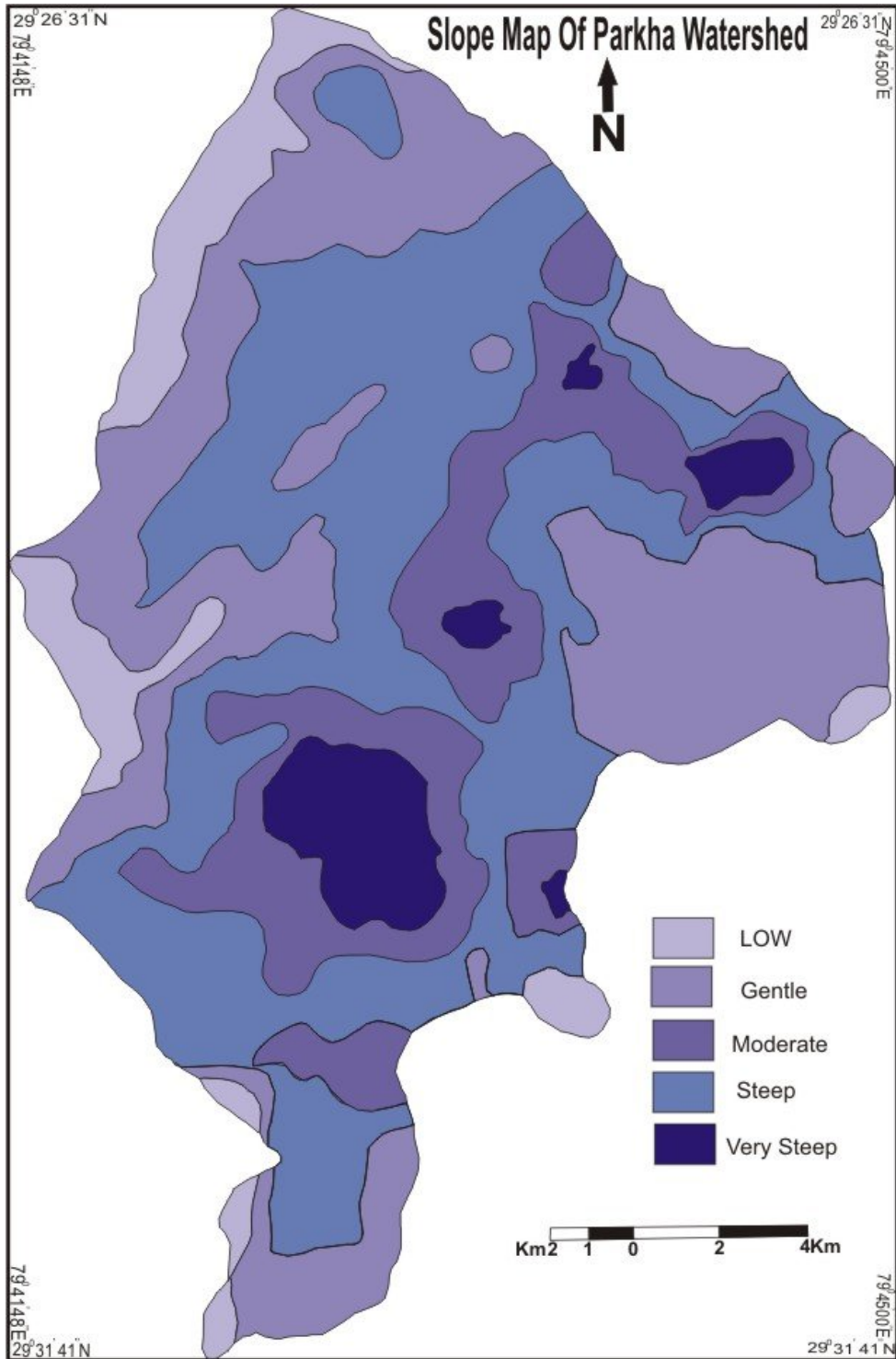


Fig.6 Parkha Watershed: Spatial Distribution of Average slope

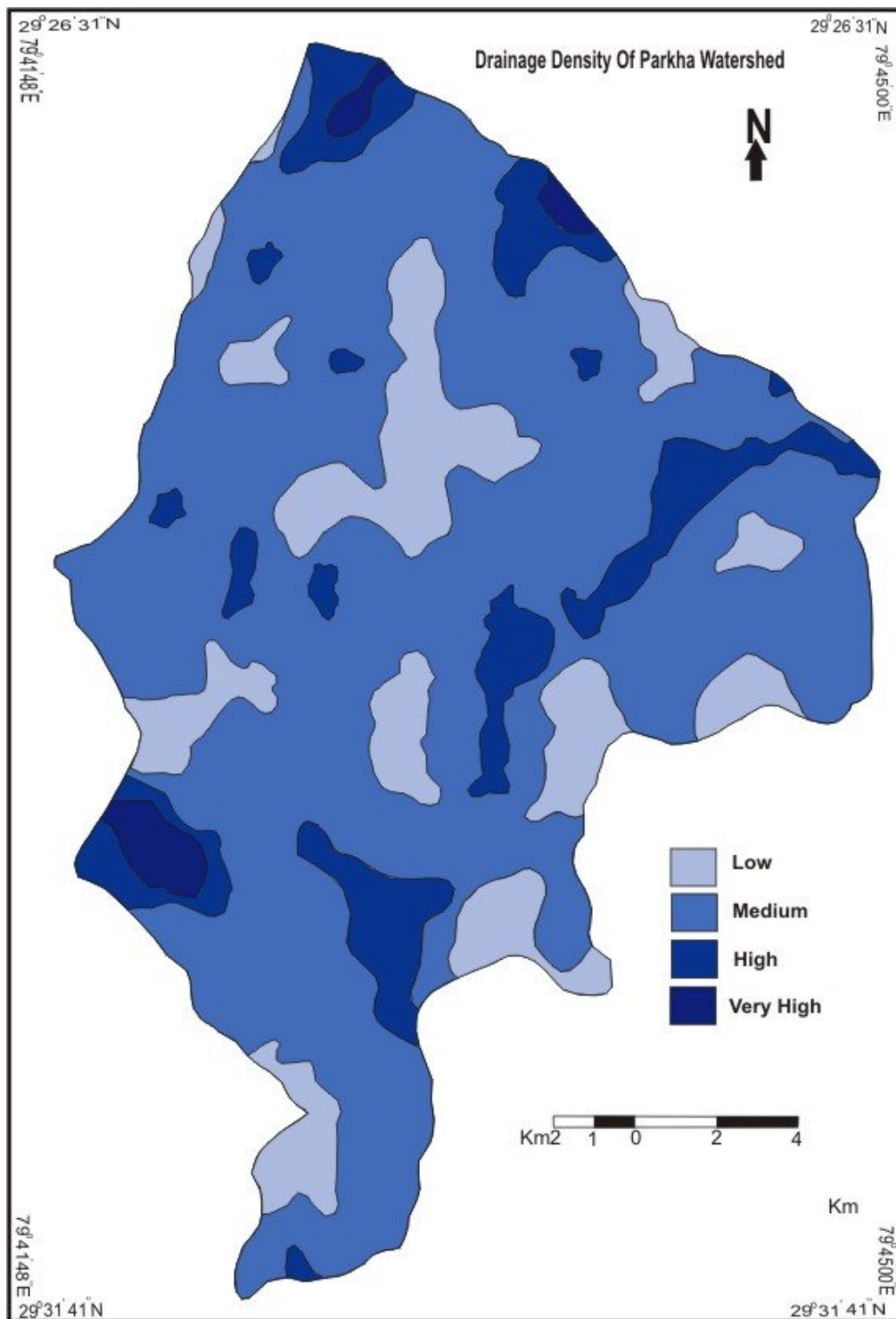


Fig.7 Parkha Watershed: Spatial Distribution of Drainage density

of this under is covered by low slope zone.

Very high dissection index has its maximum concentration in Moderate slope zone where it covers 0.94 km² area. Steep slope zone has lowest concentration of 0.06 km².

The overall picture clearly portrays that the highest extension of dissection index is visible in moderate slope zone, which constitute 31.95 km² area while the lowest range of dissection index comprises 3.88 km² is confined to steep slope zone. The very low dissection index group is zero in steep slope zone. There is a positive relationship these variables which is indicated by the correlation value of +0.94 showing a positive relationship.

Drainage Density And Dissection Index

Dissection index of any area is affected by its drainage density. Generally low dissection index possess low drainage index and High dissection index occurs in the places of high drainage density. But this positive relationship seems to disappear in those dissection index areas where others controls the area in place of drainage density. In this condition the role of drainage density becomes less than other factors to influence dissection index (Table.7). The spatial distribution of Drainage Density in Parkha watershed shows in Fig.7. The maximum value of drainage density i.e. 2.35 km/km² is attained by moderate dissection index areas while the very low dissection index covers minimum range of drainage density i.e. 0.85 km/km².

5. Conclusion

Lithology has effectively influenced the range of dissection index. Lithological analysis concluded that Moderate to High dissection index covers maximum area and the main lithology of which is Saryu-Gumalikheth-Munsiari Formation. The lowest area is covered by very low dissection index, the lithology of it is Nathuakhan Formation. Absolute relief has a positive impact upon dissection index not a perfect one. Higher groups of absolute displays high dissection index. Relative relief determines a positive impact upon dissection index although perfect one. Slope analyses have a positive impact upon dissection index although not a perfect one. The Moderate slope corresponds to high dissection index while Steep slope leads to low dissection index. Drainage density has a positive impact upon dissection index.

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