IMPACT OF GEOMORPHIC VARIABLES ON DISSECTION INDEX IN WESTERN DOON OF DEHRA, UTTARAKHAND (INDIA)

ABSTRACT

Dissection Index is a scale of measure of degree of roughness of the earth surface. The degree of roughness of earth surface is consolidated outcome of morphometric elements like – average slope, relative relief, absolute relief, drainage density and lithology. The dissection index is very useful variable in the study of the terrain. The purpose of researcher is to explore the effect of morphometric elements on the dissection index. The formula put forth by Dove Nir (1957) has been adopted to find out the dissection Index. The Wentworth Method has been adopted to calculate the average slope. Study reveals that the coefficient of correlation between relative relief and dissection index is 0.882. It is 0.627 in case of average slope and dissection index. The coefficient of correlations is 0.527 in case of absolute relief and dissection index. Investigation reveals that relative relief has highly impacted the dissection index in the area. Average slope has moderately influenced the dissection index. The coefficient of correlation between drainage density and dissection index suggests the less impact of drainage density on dissection index.

Keywords: [Absolute Relative, Correlation, Dehra, Doon, Dissection Index, Lithology, Matrix }

1. INTRODUCTION:

Dissection index is the scale of measurement of roughness of earth surface created by ravines and valleys. The area is said to be highly dissected, when, the variation in diamension of relative relief is highly variable in the area. This is an important index in the examination of topography and watershed dynamics as well. It may also be used as a morphometric determinant of the stages of terrain development. The researcher has attempted to investigate the affect of slope, drainage density relative relief, absolute relief and lithology on the dissection index in Doon of Dehra.

The study area is situated between 30°14' 10" N to 30° 31' 32" N latitude and 77° 34' 15" E to 78° 05'39" E longitudes. The area covered by Doon is 834.28 sq. kilometers. Song water divides in the east, Mussoorie hills in north, Yamuna in west & north- west and Siwaliks in south constitute the boundaries of the area under study. Administratively, the study area falls in Dehradun district of Uttarakhand (India).

The study area is tectonically structural doon, extending in north - west to south - east direction. The crests of Lesser Himalayas and Siwaliks constitute the boundaries of study area respectively in north and south. Structural hills forms the northernmost part of study area. The crest line of these hills has a height range of 1800 meters to 2229 meters. The topography is rugged with steep to moderate slopes. Faults, scraps, mass wasting material and barren land are the major characteristics of the upper part of denudo - structural hills (Mussoorie hills). The middle and lower slopes of these hills are covered with younger doon gravels. There are some hillocks and erosional hills below the 'Main Boundary Fault' line in the area. Southern upland in the form of Siwaliks attains a height of about 900 m. The Siwaliks represent a ravine zone in upper reaches. The southern upland is gentler as compared to northern uplands (Mussoories). The tract between these two uplands is the alluvial plane of Doon. the wide strips of the piedmont zone. The alluvial plane includes the river terraces and flood plain of Asan river and its tributaries. There is a heavy deposit of alluvium in the form of sand, silt, pebbles and boulders.

Comment [e1]: The

Comment [e2]: River

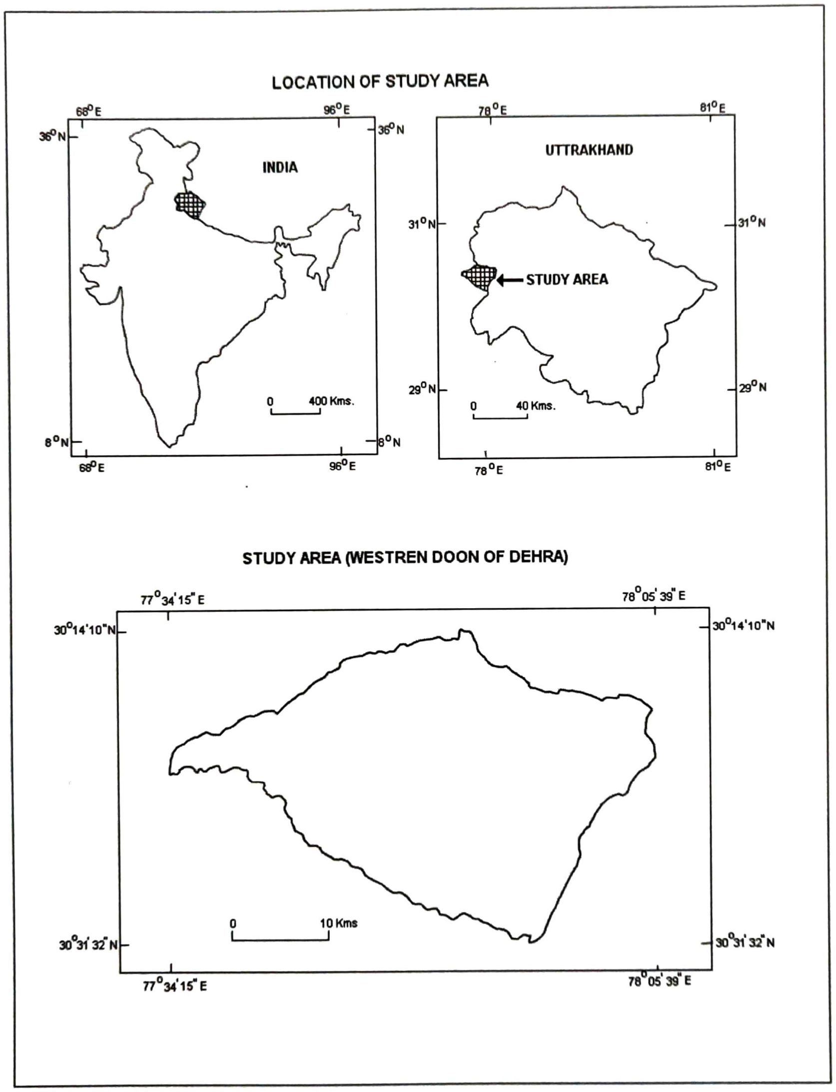

Fig.1. Location Map

2. DATABASE AND METHODOLOGY

Major database of study is the topographical sheets, published by the Survey Department of India. The topographical sheets, bearing number - 53F/10, 53F/11, 53F/14, 53F/15 and 53J/3 have been used for the study. The scale of these sheets is 1:50,000.

The area under investigation has been carpeted with a net of one square kilometer grid forthe calculation of grid wise values of geomorphic variables. To calculate the areas for various categories of different geomorphic variables planimeter and grid method has been used. Various maps have been superimposed to study the correlation between different geomorphic variables. Wentworth Method is applied to compute the grid – wise slope. The formula is changed into the metric system. The formula used is as under:

$$\tan\theta = (\text{no. of contour cutting per km} \times \text{contour interval} \times 3.3)/3361$$

Dissection index is calculated, using Dove Nir's (1957) method. The method put forward by the scholar is as under:

Comment [e3]: For the

Dissection Index (DI) = Rr/Ar; where Rr & Ar respectively stands for relative relief and absolute relief

Grid wise absolute relief has been calculated using contours or trigonometrical stations or spot heights. Grid wise elevation difference (H-h) has been taken to calculate relative relief. Here, H&h respectively stands for highest and lowest in the grid. Karl Pearson's product-moment method has been used to find out correlation between two variables. The formula is as under:

$$r = \frac{N\Sigma xy-(\Sigma x)(\Sigma y)}{\sqrt{[N\Sigma x^2-(\Sigma x)^2][N\Sigma y^2-(\Sigma y)^2]}}$$

Remote sensing data have also been used to confirm the facts.

3. EXPOSITION

3.1 Distribution of Dissection Index (D_I):

Dissection index (Rr/Ar) may be used as a morphometric determinant of the stages of terrain evolution. The ranges of dissection index - 0.0 to 0.1; 0.1 to 0. 3 and >0.3 are generally related to penultimate, equilibrium and in-equilibrium stages respectively (Pandey 1994). Five classes of DI are taken to categorize the area. These are: 1) extremely low (below 0.1), 2) low (0.11 to 0.20), 3) moderate (0.21 to 0.30), 4) high (0.31 to 0.40) and 5) very high (above 0.40)

More than 84% of the entire Doon of Dehra falls in the classes of low or very low dissection index (table-1& figure-2), out of which 65% of the area exhibits extremely low direction index and 18.93% area is covered by low category. The spatial coverage of the low category of dissection index spread over doon which extends between foothills of Siwaliks and Mussoorie hills. Another area of this category is found in the form of a narrow strip near the confluence of Yamuna and Asan River. Extremely low (0.1 or less) dissection index suggests the region to be in the penultimate stage. Most of the watershed under the study is covered by deposits of older doon gravels, younger doon gravels and alluvium. Therefore, this index should not be taken as a morphometric determinant of the terrain development at least for depositional areas.

Moderate dissection index, which occupy more than 23% of the study area extends on debris slopes of Lesser Himalayas and cover whole the Siwaliks, except the narrow strip towards the confluence of Asan and Yamuna. This suggests that 23.51% area of Doon of Dehra is in dynamic equilibrium stage. If low (0.1-0.2) and moderate (0.2-0.3) categories are added together, then it comes out to be more than 97% area. It means that the rate of erosion and deposition is almost equal in this tract.

About 2.85% of the catchment falls in the class of high and very high dissection index. This category indicates that the region having these categories is in in-equilibrium stage. It means that the rate of denudation is high as compared to deposition and upliftment in this geomorphic unit. Such type of area in the region is confined to scarp faces of the region.

Preceding text clearly indicates that the distribution of dissection index varies from one area to another which ranges between 0.0 1 to 0.36. This variation indicates the effect of Slope, drainage density, absolute relief, relative relief, lithology, vegetation and rainfall on dissection of the area. Due to differences in geomorphic variables, vegetative cover and rainfall, Asan and its tributaries have different intensity of erosion. As a result different sub – basins have different value of dissection index in spite of the fact that some sub-basins fall in same altitudinal zones. The affect of selected geomorphic parameters on the dissection index as has been investigated is described in the following

Comment [e4]: Doon

Comment [e5]: Doon

Comment [e6]: Doon

text.

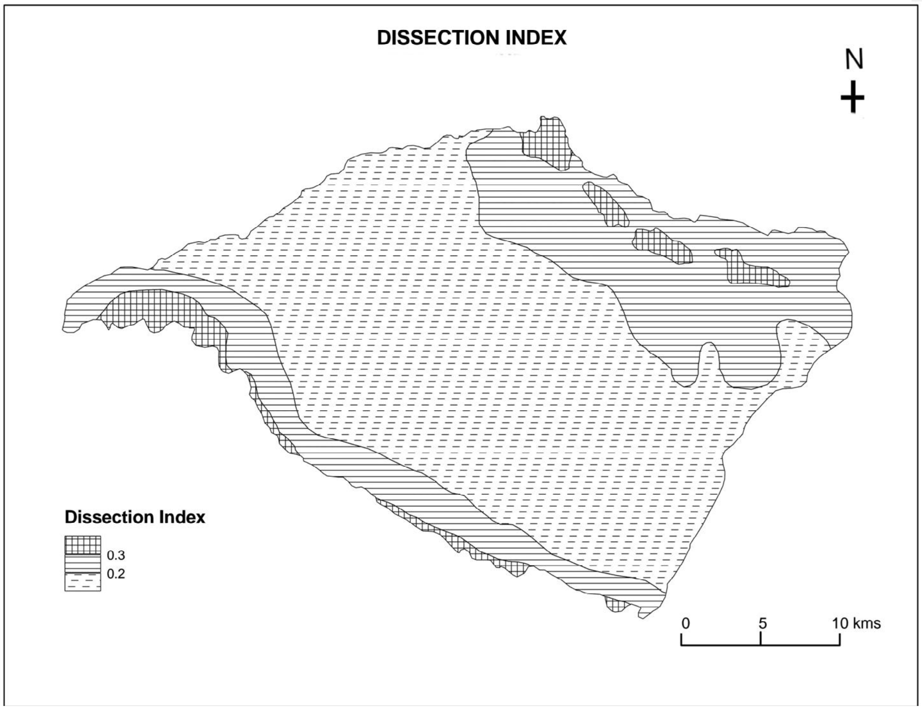

Fig.2. Dissection Index

3.2. Absolute Relief (A_R) and Dissection Index (D_I):

An appraisal of co-matrices of absolute relief and dissection index (Table-1& figure -2,3) point out that the very low DI class is distributed on the low and very low absolute relief. In the category of very low and low absolute relief 97% and 81.3% area of category is respectively under very low D_I.

Moderate (700 - 900 m) and high absolute relief (900 - 1200 m) classes are characterized low dissection index. About half of areas in each of these categories of absolute relief have low D_I. A moderate dissection index is primarily concentrated in the areas of high absolute relief. In the category of high absolute relief more than 57% area is under moderate dissection index. More than 20% area of moderate and high absolute relief classes are also under moderate D_I. Very high D_I is confined only to small areas of high and very high absolute relief.

Table (1): Area Co- Matrix of Dissection Index and Absolute Relief

(Data Classified in two ways)

Classes $D_I \rightarrow$ $A_R \downarrow$ (Area Km^2)	Area of Different Group in Square Kilometers					
	0.0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	> 0.4	Total Area (Km2)
< 500 m	166.88 (97%)	2.63 (1.5%)	2.24 (1.5%)	-	-	171.75 (100%)
500-700 m	320.15 (81.3%)	48.52 (12.2%)	22.04 (5.6%)	3.00 (0.8%)	0.43 (0.1%)	394.14 (100%)
700-900 m	47.18 (32.6%)	64.66 (44.8%)	30.25 (20.9%)	2.47 (1.7%)	-	144.56 (100%)
900-1200 m	8.91 (16.7%)	24.75 (46.3%)	13.86 (26.0%)	3.97 (7.4%)	1.90 (3.8%)	53.39 (100%)
> 1200 m	-	17.24 (24.5%)	41.2 (58.5%)	10.0 (17.0%)	-	70.44 (100%)
Total Area (Km2)	543.12	157.80	109.59	21.44	2.33	834.28
Correlation between absolute relief and dissection index = +0.527						

The overall analysis indicates that very low and low absolute relief categories play a dominant role in governing the dissection index. High and very high classes of absolute relief have low and moderate degrees of the dissertation index. This indicates absolute relief and dissection index are poorly correlated. The quantitative value of correlation (+ 0.527) confirms the result.

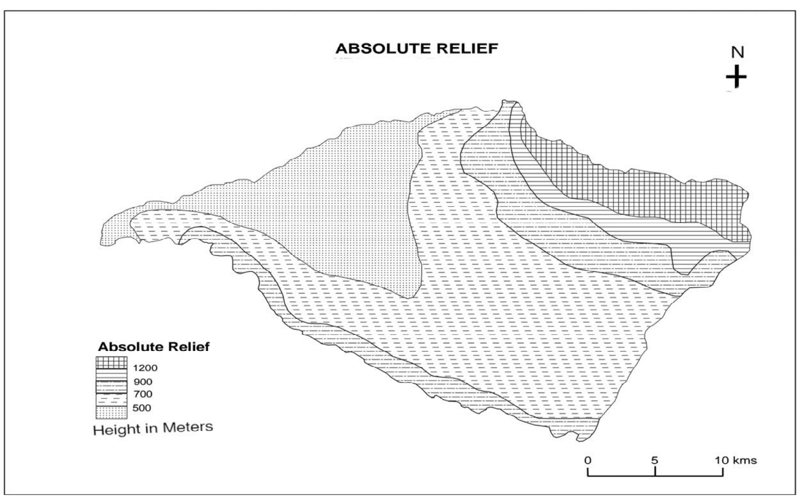

Fig.3. Absolute Relief

3.3. Relative Relief (R_R) and Dissection Index (D_I):

Analysis of table (2) points out that very low dissection index is mainly concentrated in the areas of very low, low and moderately low classes of relative relief. More than 97% area in each class of very low and low relative relief have dissection index ranging from 0.0 to 0.1. Low D_I class is primarily spread on moderately low and low R_R. Moderate dissection index is primarily spread over high and very high relative relief categories. More than 63% area in these categories have moderate dissection index.

The overall assessment indicates that all the three categories of low relative relief viz. very low, low and moderate play an important role in governing the dissection index. High and very high R_R is dominated by moderate D_I. Low D_I is absent in high and very high R_R classes. High D_I is absent in categories of low R_R. This shows a positive relationship between R_R and D_I. This relationship has a statistical measure of +0.882. This value indicates that relative relief has greatly influenced the dissection index in the area.

Table (2): Area Co- Matrix of Dissection Index and Relative Relief
(Data Classified in two ways)

Classes $D_I \rightarrow$ $R_R \downarrow$ (Area Km^2)	Area of Different Group in Square Kilometers					
	0.0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	> 0.4	Total Area (Km2)
0-20	350.99 (99.4%)	2.19 (0.6%)	-		-	353.18 (100%)
20-40	115.36 (97.8%)	2.64 (2.2%)	-		-	118.00 (100%)
40-100	76.77 (54.3%)	59.87 (42.3%)	4.76 (3.4%)		-	141.40 (100%)
100-200	-	75.55 (60.2%)	45.05 (35.9%)	5.0 (3.9%)	-	125.60 100%)
200-400	-	17.55 (32.1%)	34.65 (63.2%)	2.60 (4.8%)	-	54.8 (100%)
> 400	-	-	25.13 (60.8%)	13.84 (33.5%)	2.33 (5.7%)	41.3 (100%)
Total Area (Km2)	543.12	157.80	109.59	21.44	2.33	834.28
Correlation between relative relief and dissection index = +0.882						

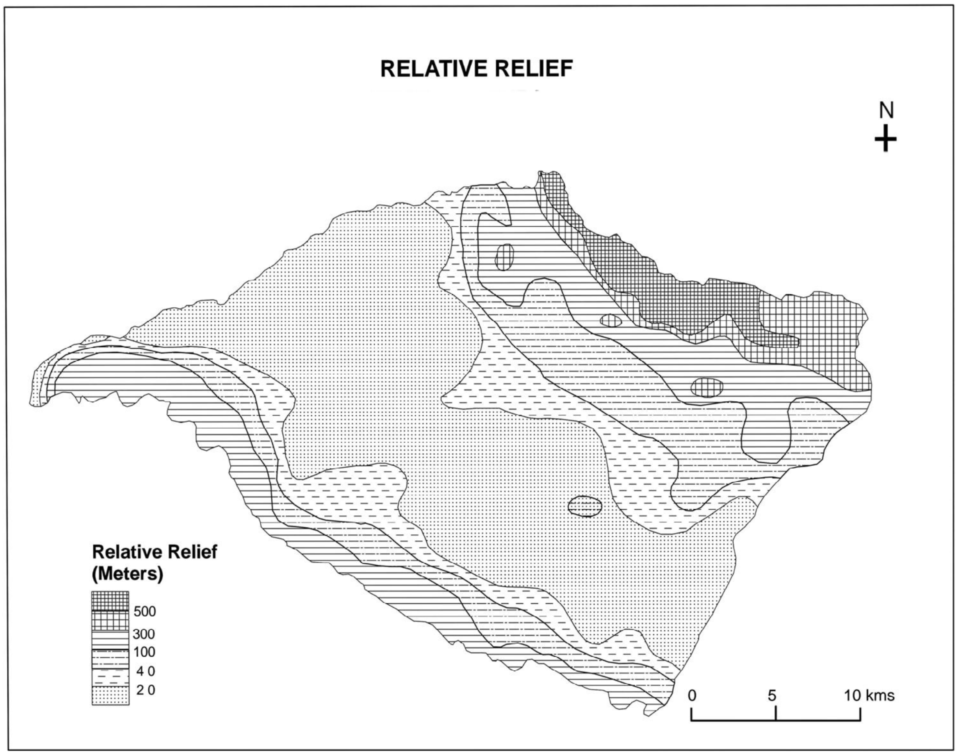

Fig.4. Relative Relief

Comment [e7]: It is best to use colors to clarify areas

3.4. Average Slope (A_S) and Dissection Index (D_I):

A examination of the table (3) exhibits that 100% area in the gentle slope (0°-2°) falls under low dissection index. This figure is 89.9% and 60.6% for gentle and moderately gentle slopes respectively. Low dissection is predominantly distributed in moderate and steep groups of slope. Moderate dissection index is primarily distributed on steep and very steep slopes. More than 42% area in the category of steep slopes is under moderate dissection index and 62.6% area of steep slope is under moderate DI. The very low DI is absent on very steep slopes. Moderate and high DI is absent on gentle slopes. All this shows the some relationship between these two morphometic parameters. The quantitative measurement of the correlation (+0.627) suggests the average slope has moderately influenced the dissection index.

Table (3): Area Co- Matrix of Dissection Index and Average Slope

(Data Classified in two ways)

Classes D_I → Slope (degree) ↓ (Area Km^2)	Area of Different Group in Square Kilometers					
	0.0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	> 0.4	Total Area (Km2)
0°-2°	227.7 (100%)	-	-	-	-	227.7 (100%)
2°-5°	197.04 (89.9%)	19.85 (9.1%)	2.22 (1.0%)	-	-	219.11 (100%)
5°-10°	72.76 (60.6%)	35.18 (29.3%)	12.19 (10.1%)	-	-	120.13 (100%)
10°-20°	36.03 (26.3%)	63.45 (46.3%)	32.29 (23.6%)	4.98 (3.6%)	0.33 (0.2%)	137.08 (100%)
20°-30°	9.59 (10.3%)	33.79 (36.3%)	39.52 (42.5%)	8.04 (8.7%)	2.0 (2.2%)	92.94 (100%)
> 30°		5.53 (14.8%)	23.37 (62.6%)	8.42 (22.6%)	-	37.32 (100%)
Total Area (Km2)						
Correlation between slope and dissection index = +0.627						

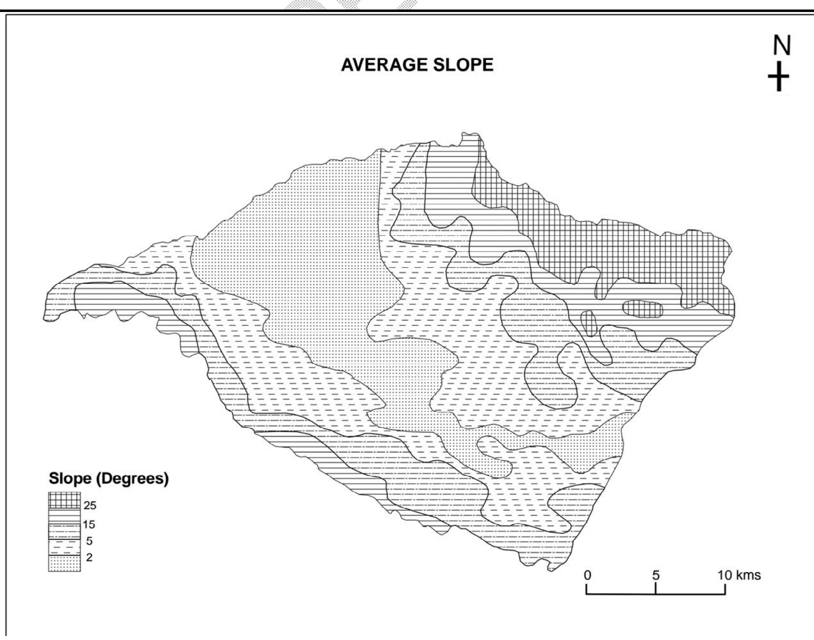

Fig.5. Average Slope

3.5. Drainage Density (D_D) and Dissection Index (D_I):

An analysis of the table (4) indicates that a very low dissection index is associated with very low to medium drainage density. More than 70% area in each category of drainage density has the dissertation index ranging from 0.0 to 0.1. Moderately high and high groups of drainage densities groups have low dissection index. More than 30% area in each category is associated with low drainage density. More than 84% area in the group of very high drainage density has the moderate dissection index. Statistical value shows the positive between these two variables. The correlation value +0.437 indicate that drainage density has little impact on dissection index.

Table (4): Area Co- Matrix of Dissection Index and Drainage Density

(Data Classified in two ways)

Classes D_I → D_D ↓ (Area Km2)	Area of Different Group in Square Kilometers					
	0-0.1	0.1-0.2	0.2-0.3	0.3-0.4	> 0.4	Total area Sq . Kms.
0-1	142.41 (94.6%)	4.27 (2.8%)	3.85 (2.6%)	-	-	150.53 (100%)
1-2	124.70 (89.3%)	10.65 (7.6%)	3.40 (2.4%)	1.0 (0.7%)	-	139.75 (100%)
2-3	130.77 (69.9%)	34.18 (18.2%)	19.25 (10.3%)	3.00 (1.6%)	-	187.20 (100%)
3-4	74.00 (55.1%)	37.88 (28.1%)	19.02 (14.2%)	2.13 (1.6%)	1.33 (1.0%)	134.36 (100%)
4-5	51.88 (37.5%)	46.83 (33.9%)	32.63 (23.6%)	6.00 (4.3%)	1.0 (0.7%)	138.34 (100%)
5-6	19.36 (24.9%)	23.99 (30.7%)	26.40 (33.7%)	8.40 (10.7%)	-	78.15 (100%)
> 6	-	-	5.04 (84.7%)	0.91 (15.3%)	-	5.95 (100%)
Total area Sq. Kms	543012	157.8	109.59	21.44	2.33	834.28
Correlation between drainage density and dissection index = +0.437						

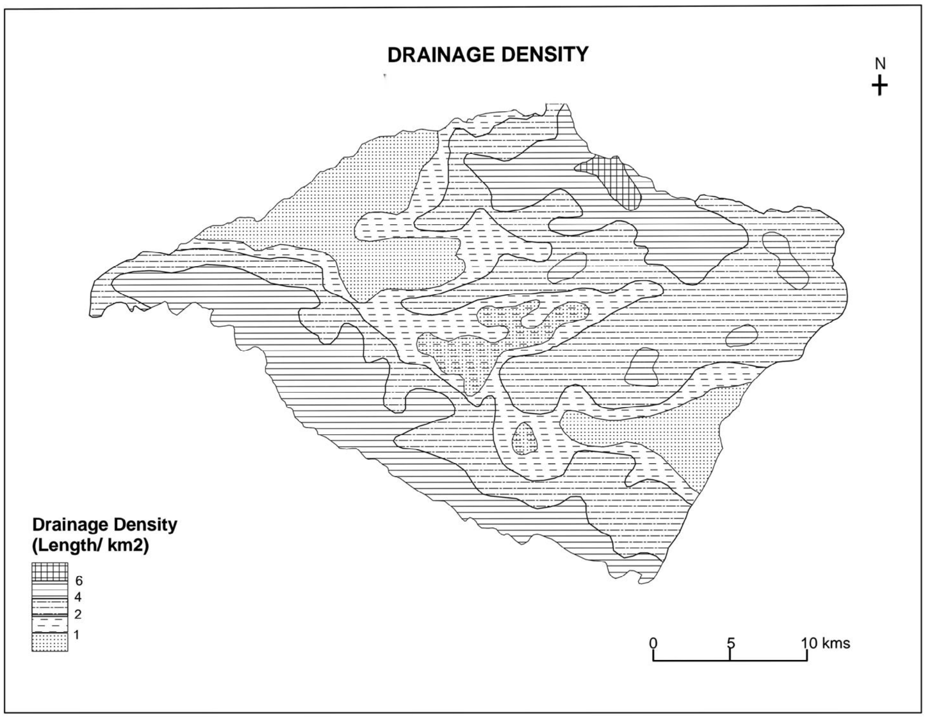

Fig.6. Drainage Density

3.6. Lithography and Dissection Index (D_I):

Three lithostratigraphic units have been identified in the area under investigation. These are Mussoorie hill, Doon gravels & alluvium and Siwaliks. Uppermost part of Mussoorie hills (pre - tertiary) has hard rocks. Middle and lower part of Mussoorie hills and the upper part of Siwaliks consist of granite and sandstones. Lower parts of Mussoories are characterized by faults, thrusts and lineaments. Middle Siwaliks are characterized by soft medium to coarse grained sandstones. This unit has the pebbles - conglomerate and boulder - conglomerate of quartzite and sandstones. Doon gravels consist of boulders and pebbles are firmly and deeply mixed with reddish clay matrix. The boulders in the area primarily consist of quartzite schist. Alluvium consists of sand; silt and clay are mixed with boulders, pebbles, gravel.

High dissection index which constitutes 3% area of Doon is associated with the lithology of lower tertiaries (lower to middle part of Mussoorie hill) and Upper Siwaliks (south of doon). Medium dissection index extends on both sides of the doon. It extends on pre - tertiaries (upper Mussoorie hills), middle and upper Siwaliks.
Whole the investigation shows that high D_I covers the area characterized by faults, thrusts and lineaments. Moderate D_I, covering the peaks of Mussoories has hard rocks of quartzites and phyllites. This category also covers middle Siwaliks. Because of calcareous cementing material in this unit rocks have become very hard and stand out prominently against weathering and erosion. Low dissection index covers about 75% of the area of the region. This group of dissection extends on alluvium and gravels of doon. Doon gravels are hard and less erodible. It seems that plains of alluvium have little

Comment [e8]: Doon

impact on the dissection index. Here, slope plays a dominant role in determining the dissertation index.

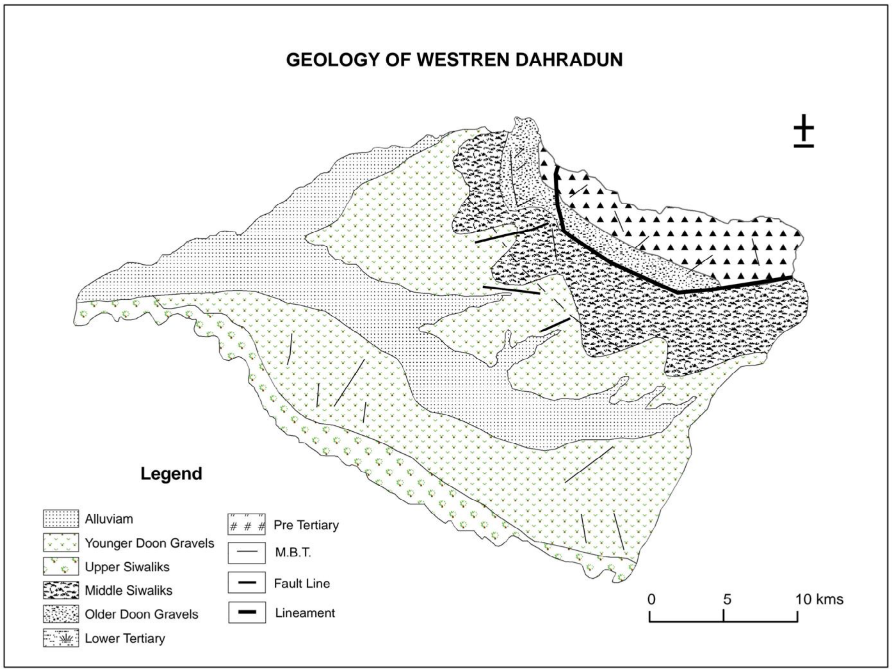

Fig.7. Geology of Dun of Dahra

4. CONCLUSION

The distribution of dissection index varies from one area to another which ranges between 0.0 1 to 0.36. More than 84% of the entire Doon of Dehra falls in the class of low dissection index. Different sub – basins have different value of dissection index in spite of the fact that some sub-basins fall in same altitudinal zones.. This variation indicates the affect of absolute relief, Slope, drainage density, lithology, vegetation and rainfall on dissection of the area.

The study of absolute relief versus dissection index indicates that very low and low absolute relief categories play a dominant role in governing the dissection index. High and very high classes of absolute relief have low and moderate degrees of the dissertation index. This indicates absolute relief and dissection index are poorly correlated. The quantitative value of correlation (+ 0.527) confirms the fact.

High positive correlation has been observed between dissection index and relative relief. This relationship has a statistical measure of +0.882. This value indicates that relative relief has greatly influenced the dissection index in the area.

The quantitative measurement of correlation between average slope and dissection index is +0.627. This value indicates that slope has moderately influenced the dissection index in the region.

Statistical value of correlation between drainage density and dissection index is +0.437. This value suggests the drainage density has comparatively less affected the dissection index as compared to other variables under study.

Investigation also indicates that high DI covers the area characterized by faults, thrusts and lineaments. Moderate dissection index, covering the peaks of Mussoories have hard rocks of quartzites and phyllites. It seems that plains of alluvium have little impact on the dissection index.

To sum up, it can be concluded that variation in dissection index in the Doon of Dehra is greatly contributed by the impact of geomorphic variables like, absolute relief, Slope, drainage density, and lithology. Due to differences in these geomorphic variables, vegetative cover and rainfall, Asan and its tributaries have different intensity of erosion. As a result there is a lot of difference in attainment of dissection index though some sub-basins fall in same altitudinal zones.

REFERENCES:

Comment [e9]: The references are few and old. It is preferable to use a recent references

Dove Nir (1957): The ratio of relative and absolute altitude of Mountain Camel, Geogl. Rev., Vol. 47, PP. 564- 569.

Horton, R.E., (1945): Erosional development of the streams and their drainage basins: hydrophysical approach to quantitative morphology, Bull Geol., Soc., Am., Vol. 54, PP. 275- 370.

Pandey, A and Joshi, R. C. (1994): Geomorphic impact on dissection index - A case study of saryu basin Kumaun Himalaya Geographical Review of India, Vol. 56(4), PP. 25-32.

Smith G.H. (1935): Relative relief of Ohio, Geographical Review volume 25, PP. 272- 84, Am. Geogl. Soc.

Wentworth, C.K. (1930): A simplified method of determining the average slope of land surfaces, Amer. Jour. Sci., Vol.20, PP. 184.

Alvi Z. (1995): Statistical Geography: Methods and applications,Rawat Publications, Jaipur 141-150.