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Drainage basin morphometric analysis and its relationship with altitude of Uttarkashi District

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Abstract: The area of investigation lies between Maneri and Gangnani along the Bhagirathi river in the lesser and central Himalayan block of Garhwal Himalayas. The rocks of Garhwal group are represented by quartzites, sericite quartzite's and talc chlorite schist intruded by metabasics, whereas the Central crystallines are constituted by gneisses, schists, migmatites and amphibolites. For the purpose of drainage basin morphometric analysis 100 third order drainage basins were marked. Drainage basin morphometric parameters of 100 basins were calculated. On the basis of lithology and tectonic setup,the area was divided into three morphogenetic units viz Central crystallines, Thrust zone and Garhwal group. The basins which were situated below 2500 mts are categorized under low altitudes and above 2500 as basins of higher altitudes.The relationship between deainage basinmorphometric parameters and altitude suggest that basins situated at higher altitude have higher value of stream frequency, number of first and second order streams,fine texture and low drainage density.

Keywords: Altitudes, Central crystallines, Drainage basin, Garhwal group, Morphometric parameter

INTRODUCTION

The study area is located between the latitude $30^{0}40^{1}$-$30^{0}55^{1}$ N and longitude$78^{0}30^{1}$–$78^{0}45^{1}$ E. The national highway joins Rishikesh with Gangotri connecting number of pilgrim centers. River Bhagirathi originate from Gangotri glacier at Gaumukh. Initially it follows the NE-SW course and N-S trend near Malla and Bhatwari and again follows the NE-SW direction. Number of perennial streams like Helgu gad, Montru gad, Paper gad, Din gad, Dogadda gad Kamar gad and Maneri gad meet the river Bhagirathi at right angle. The study area is characterized by rugged topography,steep slopes and river Bhagirathi carves out deep gorges at Bhukki and other places. The Maneri Bhali project, Khariatal Lakes and hotspring of Gangnani are located in the area.. Area was also triggered by the earthquake of 20th November 1991 and various number of new springs and landslides were reactivated. The geology of the area has been worked out by various geologists. Griesbach(1891) took the traverses in the Upper Bhagirathi valley. Heim and Gansser (1939) introduced the term Main Central Thrust (MCT) and Central crystallines. Auden (1937, 1949) named the rocks of Uttarkashi as Barhat series and later renamed as Garhwal series. Valdiya and Bhatia (1980) studied the rocks of the lesser Himalaya area. Stratigraphy and tectonics of lesser Himalayan region of Uttarkashi were studied by Jain (1971). The geology of upper Bhagirathi valley and Yamuna valley was studied by Aggarwal and Kumar (1973). The petrology and metamorphism of the rocks of upper Bhagirathi valley has been studied by Gupta and Dave (1982). Pant (1975) recognized fossil valley in Maneri and Bhukki area. Regional geology and structure of the area was worked out by Saklani and Nainwal (1986). Geomorphological observations were made by Prasad and Rawat (1982) and Naithani (1992), Naithani and Bhatt (2011).

The purpose of present study was to calculate the drainage basin morphometric parameters and the litho-tectonic control on these parameters, Rainfall and other climatic conditions are influenced by alttitude so the attempt has been made to find out the relationship between different drainage basin parameters and altitude.

MATERIALS AND METHODS

The toposheet (Survey of India) on 1:50,000 scale was used as a base map. The various lithological units and structures were identified and plotted on the base map. Total IIIrd order drainage basins were marked on topographic map. Linear measurements were measured with the help of rotameter and area by planimeter. The investigated area was divided into three morphogenetic units on the basis of lithology and structure viz Garhwal group, Thrust zone and Central crystalline zone. 16 drainage basin morphometric parameters , their range and average values were calculated for three morphogenetic units. Drainage basin parameters were calculated as (i) direct measurement(length, width, area,number of Ist and IInd order stream and cumulative length of stream and (ii) calculated parameters(basin shape, length ratio,

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bifurcation ratio, drainage texture, drainage density and ruggedness number). All the parameter were calculated as suggested by Horton(1932, 1945 and Doornkamp and King (1971). As drainage basin characters were also influenced by the climatatic conditions, in winter high peaks remain snow cover and the area receives maximum rainfall in the month of July and August. For this purpose, the relationship between altitude and drainage basin morphometric parameters were analysed.

RESULTS

Geology of the area: Geologically the area comprises two different types of rocks viz. Garhwal group and Central crystallines separated by MCT which passes near Sainj and exposed along Kumalti gad and Dogadda gad. The trend of main Central thrust in this area is NW-SE with dip varying from 25^0 to 65^0 due NE.

The rocks of Garhwal group are represented by white cream colored quartzites, epidiorites, sericite quartzite's and talc chlorite schist. These rocks have been intruded by dolerite along main central thrust which is definitely post tectonic(Gupta and Dave, 1982). The rocks of Central crystallines include migmatites, schists, gneisses and amphibolites, biotite-schist and garnetiferous-mica-shist. Lithotectonic succession of the area is shown in Table 1 and geological map in Fig.1.

Drainage basin morphometric analysis: Drainage basin morphometry is the quantitative study of the characters of drainage basin. A drainage basin is the area which contributes water to the particular channels or set of channels. Ridges are the initial type of landforms which also act as water divide. The morphometric parameters, their range and average values were calculated as shown in Table 2 and III order drainage basins were marked as shown in Fig.2.

It was observed that the number of first order stream is

Table 1. Lithotectonic succession between Maneri and Gangnani.

	Augen gneisses
	Banded gneisses with bands of garnetiferous mica schist
	Migmatites
Central crystallines	Augen gneisses
	Quartz muscovite schist's
	Mylonitic migmatites
	Augen Gneisses
------- Main ---------	Central ----------Thrust ------
	Talc –chlorite schist
	Sericite quartzites
Garhwal group	Epidiorites
	White cream colored quartzites

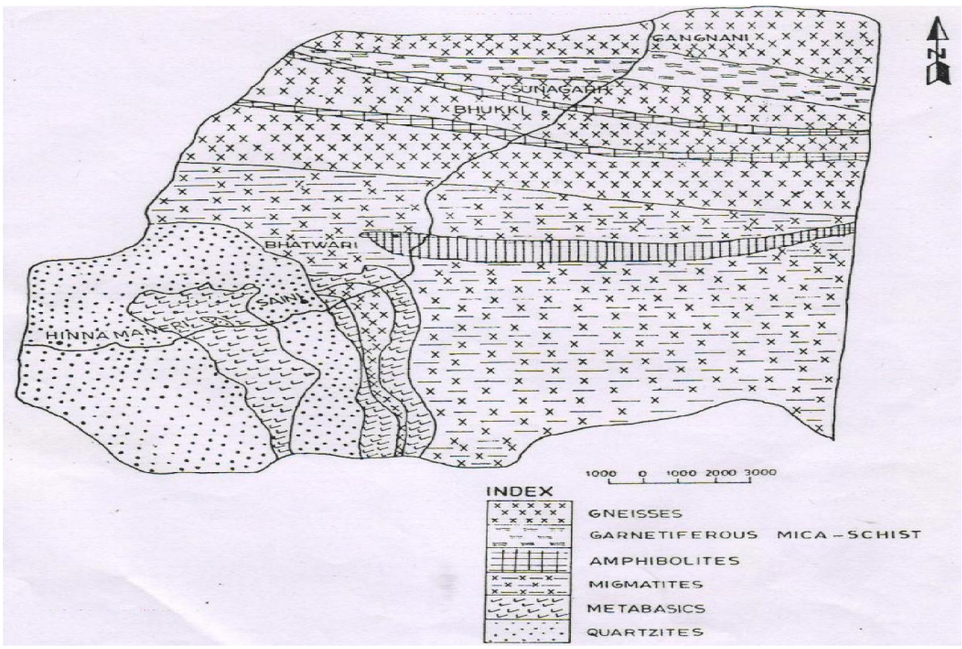

Fig. 1. *Geological map between Maneri and Gangnani.*

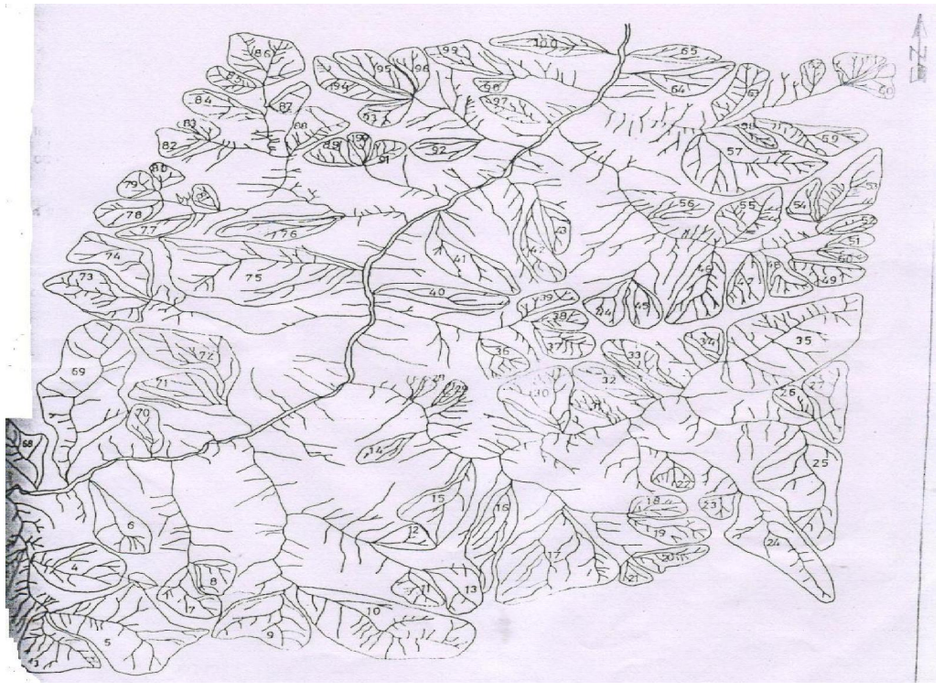

Fig.2. *Third order drainage basins.*

maximum in the basin of Central crystallines and minimum in the basin of Garhwal group, but the average value is maximum in Garhwal group followed by Thrust zone and central Crystallines.The maximum second order streams are present in the basin Central Crystallines, but the average value is high in Garhwal group followed by Thrust zone and central Crystalline zone.The larger basin is present in the Thrust zone, but the average value is high in Garhwal group followed by Thrust zone and Central crystalline zone. Longest first order stream is located in the Central Crystalline zone but the average value of length of first order stream is maximum in Garhwal group followed by Thrust zone and central Crystalline zone.Longest second order stream is also located in Central crystalline zone but the average value of length of second order stream is maximum in Thrust zone followed by Garhwal group and Central crystallines.The longest basin is present in Thrust zone, but the average value of basin length is more in Garhwal group followed by Thrust zone and Central crystallines.The highest basin is located in the Central crystallines. The average value of basin altitude is high in Central crystallines and followed by Thrust zone and Garhwal group.

Calculated parameters: The average value of basin shape is higher in Central crystallines. The value of basin shape indicates wider basins in crystallines while the basins of Thrust zones are more elongated.he value of bifurcation ratio is high in Thrust zone and Garhwal group and less in Central crystalline zones. The differences in bifurcation ratio suggest structural variation. As MCT is the main structural feature in the area, other structures are Bhatwari fault and Gangori-Jamak fault in the area. Horton (1945) proposed stream frequency as number of stream segments per unit area. The stream frequency is maximum in Central crystallines which suggest heavy rainfall and snowfall in the area.

The average value of stream density is high in Central crystallines and followed by Thrust zone and Garhwal group. Arthur (1964) explained that basins of low drainage density have coarse texture and higher drainage density has fine texture. The average value is maximum in Crystallines indicate basins of fine texture and low value in Garhwal group show coarse texture.The average value of length ratio is high in Thrust zone followed by Garhwal group and Central crystallines. The average value is maximum in Central crystallines and minimum in Garhwal group.The average value of relief ratio is high in Central crystallines followed by Thrust zone and Garhwal group.

Morphomoteric parameters and altitutde: In the investigated area it was analyzed that Morphometric parameters are controlled by lithology, structures and climate of the area. As the study area comes under lesser and Central Himalaya the climate shows variation with altitudes. The winter season remain longer than summer and heavy precipitation and cloud burst occurs in middle altitudes in the rainy season.

The relationship between Stream frequency and altitude shows that in Central crystallines and in Thrust zone the basins at higher altitude has higher stream frequency but in the case of Garhwal group the basins located at

Table 2. Range and average value of morphometric parameters in morphogenetic zones.

S.No.	Morphometric parameter	Central crystalline		Thrust zone		Garhwal group	
		Range	Average	Range	Average	Range	Average
1.	No. of I order stream	4-44	11.2	5-29	13.64	4—33	16 .4
2.	No. of II order stream	2-9	2.98	2-8	3.64	2-6	3.8
3.	Basin area (Sq Km.)	0.560-15.04	2.68	1.12-17.33	5.12	2.57-10.24	5.7
4.	Length of I order stream1	1.07-17.0	4.23	2.22-14.95	6.04	3.12-16.65	8.52
5.	Length of II order stream	17-6.67	1.66	0.17-3.67	1.76	0.90-3.57	2.55
6.	Basin length	1.55-5.45	2.22	1.32-6.42	2.98	2.30-5.12	3.26
7.	Basin altitude	2200-3800	31.08	1900-2700	2215	2100-3200	2600
8.	Basin shape	0.12-0.96	0.53	0.14-0.76	0.38	0.19-0.40	0.32
9.	Bifurcation ratio	2-6.6	3.68	2.5-8	4.09	2.2-6.6	4.09
10.	Stream frequency	0.9-40.7	-	2.13-8.93	4.75	2.72-5.99	3.63
11.	Stream density	1.51-9.90	3.05	1.32-4.59	2.49	5.86-2.74	2.20
12.	Drainage texture	2.91-160.40	28.96	2.81-40.98	13.60	4.75-16.4	8.51
13.	Ruggedness number	0.10- 6.79	1.65	0.13-3.54	1.03	0.27-.68	0.42
14.	Length ratio	0.66-5.8	2.70	1.70-5.80	3.65	2.62-4.44	3.28
15.	Texture ratio	0.17-7.61	3.49	1.22-5.35	2.76	1.46-2.53	2.04
16.	Relief ratio	0.12-1.2	0.43	0.28-0.53	0.39	0.27-0.43	0.31

lower altitude has higher stream frequency.The relationship between stream density and altitude shows that in the case of Central crystallines, the basins located at higher altitude has lower value of stream density, but at lower altitude the value of drainage density is higher. In the case of Garhwal Group the basins at lower altitude has higher drainage density than higher altitude. In Thrust zone the relationship is not clear.

The relationship between Ruggedness number and Altitude shows that basins at higher altitude have higher value of ruggedness number in the case of Garhwal group and Central crystallines. In the case of Central crystallines and Thrust zone the higher altitude basins shows the fine texture and lower altitude shows coarse texture, while in Garhwal Group the relationship is inverse.

Therefore, it appears that altitude effect the various parameters because the extent of precipitation is controlled by altitude in Himalaya. Maximum rainfall is seen between 1400 to 1800 meters and the rainfall is very less above 3000 meters. (Prasad and Rawat,1982).

Pariwaise relationship : The value of length ratio increases with the increasing value of bifurcation in the case of Central crystallines and Thrust zone. In the case of Garhwal Group, the value of higher bifurcation ratio has lower value of length ratio.All three morphogenetic zones show that basins having higher drainage density has higher value of drainage texture while the basins with low drainage density has the low value of drainage texture.

In the case of Garhwal Group and Central crystallines, wider basins posses a fine texture, while the elongated basins show the coarse texture. In the case of thrust zone the relationship is reverse.

In the investigated area, the rainfall and other climatic conditions are influenced by the altitudes. The winter seasons remain longer than the summer. Most of the ridges remain snow covered during winter and feed the large number of perennial streams. As the parameters have relationship with altitude it can be state that dtainage development influenced by the climatic conditions.

DISCUSSION

The presence of first order stream indicate newly emergent surface (Prasad, 1977). In the presence investigated area the central crystallines show maximum numbers of first order stream at higher altitudes.High stream frequency in central crystalline formation indicates glacial activity in the area (Selvan *et al.*, 2011) The shape of the basins indicates condition of newly emergent surfaces. Wider basins are located at higher altitudes in Central crystallines while narrow and elongated basins are near Thrust zone suggesting the presence of subsequent surfaces along Thrust zone. Narrow and elongated basin in the thrust area is due to the main central thrust, highly fractured and mylonitic nature of rocksThe study area shows that Central crystallines show greater stream frequency at higher altitudes and Garhwal Group shows higher altitude show low stream frequency. It suggests that surface of Garhwal Group is newly emergent and thrust zone is still subjected to some activity Main central thrust extended all over the Himalaya and major earthquake of 1991 in Uttarkashi and 1999 of Chamoli other landslides are reactivated to the activity along main central thrust. Stream density also

higher at low altitude suggest highly dissected with rapid hydrological response to rainfall activity. High drainage density at low altitude accelerate more and more erosion as shown by the landslide of Bhatwari in the year 2010. Drainage basin morphometric analysis shows that at higher altitude the basins are oval, highdrainage texture and highly rugged topography with high relief and straight and steep slope in the upper reaches providing movement of water. Maximum value of bifurcation ratio in the thrust zone suggests its structural variation.

Conclusion

The study concluded that Central crystalline zone is characterized by maximum number of Ist and IInd order streams,wider basins, high stream frequency,high ruggedness number high drainage textured) Thrust zone indicate elongated basins,high bifurcation ratio,and length ratio. Garhwal group drainage basin showed maximum length of Ist and IInd order stream,low stream frequency,low drainage texture and less rugged topography. The relation between drainage basin morphometric analysis and altitude showed that basins at higher altitude are characterized by maximum number of Ist and IInd order stream, wider basins.In central crystalline and thrust zone, the stream frequency and stream density is high at higher altitude but in Garhwal group the stream frequency and stream density is maximum at low altitude.

REFERENCES

Aggarwal, N.C and Kumar G (1973). Geology of upper Bhagirathi and Yamuna valley, Uttarkashi District, Kumaon Himalaya. *Him. Geo.*, 3: 1-23

Arthur, N. Strahler (1964). Quantitative geomorphology of drainage basins and channel network in VI Chaw (Ed). Handbook of Applied hydrology pp. 4-39.

Auden, J.B (1937). The structure of Himalaya in Garhwal Rec G.S.T-71, 409-410.

Auden, J.B (1949). *In Director General, general report for 1939.Rec.Geol.Surv. India* ,78 : 74-78.

Doorn Kamp, J. C. and King C.A.M.(1971). *Numerical analysis in geomorphology an introduction.* Edward Arnold ondon London, 372.

Heim, A. and Gansser, A (1939). Central Himalayan geological observations of the Swiss expedition. *Mem. Sos. Halv. Nat.,* 77(1): 245.

Horton, R. E. (1932). Drainage basin characteristic. *Trans. Amer. Geophys. Union,*13 : 350-361.

Horton, R.E. (1945). Erosional development stream and their drainage basins: Hydrological approach to quantitative morphology. *Bull Soc.Amer.*, 51: 275-375.

Grieshbach, C. L (1891). Traverces in Central Himalaya, Mem Geo Surv:India. 1-23.

Gupta, S.K and Dave, V.K.S (1982). Petrology and metamorphism of Bhagirathi valley, Central crystallines district Uttarkashi. *Himalayan Geol.,* 9 : 512-528.

Jain, A.K.(1971). Stratigraphy and tectonics of lesser Himalayan region of Uttarkashi, Garhwal Himalaya. *Himalayan Geol,* 25-38

Naithani, N.P. (1992). *Study of Quaternary sediments between Maneri and Gangnani area, District Uttarkashi Garhwal Himalaya (U.P)* D. Phil thesis, Garhwal University Srinagar Garhwal.

Naithani, N.P. and Bhatt, Mala (2011). Geo-environmental hazards around Bhatwari area, District Uttarkashi Garhwal Himalaya Uttarakhand. *International Journal of Current Research,* 3 (4) : 200-205.

Pant, G. (1975). Observations of the fossil valley and epigenetic gorges of the BhagirathI and Alaknanda valley. *Himalayan Geol.,*193-206.

Prasad, C, (1977). *Geomorphological and sedimentological studies in Doon valley,* D.Phil. Thesis, Meerut University, Meerut.

Prasad, C. and Rawat G.S. (1982). *Bhagirathi flash flood, a geomorphological appraisal, Him, Geol.,* 9:734-743.

Saklani, P. S. and Nainwal, D. C (1986): *Metamorphism and migmatites of Sainj Area Uttarkashi district Garhwal Himalaya,* U.P. Current Trend in Geology volume IX Himalayan thrusts and associated rocks Saklani (Ed) 1986, pp 99-122.

Selvan, M.Tamil, Ahmad,Sarfaraz and Rashid, S.M. (2011). Analysis of geomorphic parameters in high altitudes glacier terrain using SRTM DEM data in central Himalaya. *ARPN Journals of Science and Technology,* 1 (1): 22-27

Valdiya, K.S. and Bhatia S. B. (1980). *Stratigraphy and correlations of Lesser Himalayan formations*' Hindusttan publishing corporation (India), Delhi.