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DRAINAGE ANALYSIS OF UPPER PINDAR RIVER BASIN, CENTRAL HIMALAYA

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ABSTRACT

Drainage basin, an open system with combination of numerous subsystems is shaped by various geomorphic processes. The study area is located in central Himalaya under Bageshwar district in Uttarakhand state. The altitude of the study area is ranging between 1997 meter to 6855 meter. Geologically the study area is made up of Joshimath fm., Pandukeshwar fm., and Pindari fm., comprising gneiss, schist, quartzites, mica and biotite. In the study area there is one thrust (main central vaikrita thrust) and two faults. In the present study an attempt has been made to study the drainage characteristics of upper Pindar river basin including areal aspects, linear aspects and relief aspects. For the analysis of drainage characteristics second and third order sub-basin has been taken. The Pindar River, lying in the eastern part of Kumaon Himalaya, is a dominant name in the drainage networks of it. For this reason, several attempts of study were made by various scholars for analyzing the overall condition of the Pindar Basin from 19th century. Most of the works on the Pindar River are mainly on the basis of geology, morphology, chronological sequence of terraces and valley development, snout retreat, recent changes in the position of snout and impacts of flood.

Keywords: Catchment, Morphometry, Areal aspect, Linear aspect, Relief aspect

INTRODUCTION

The drainage basin has an important role in the field of landforms development. So the study of drainage basin has a great significance in geomorphic studies. Although there are so many factors responsible for erosion in the field of geomorphology continuing from the origin of the earth, but in the field of erosional landforms rivers is one of the most dynamic factors, so the drainage study covers a major part of the study. Therefore, the study of drainage basin has a great significance in the geomorphic studies.

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The information about the development of a landform may be collected on the processes which actually fashion the surface of the earth at the present time because these processes are responsible for the production of particular types of landforms. Gregory and Willing (1973), have argued that the drainage basin is the entire area providing run off to and sustaining part or all of the stream flow of the main stream and its significance is hinted in the synonyms which have gradually been adapted, including drainage area, catchment area, especially employed in river control engineering and watershed utilized especially in water supply engineering.

The river Pindar offers a fascinating study of Himalayan drainage basin evolutionary process under fluvial and glacial environment in particular. The drainage network and basin morphology has been used to express the stage of development and network parameters have been employed as the indicators of the influence of geological structure. Thus the significant contribution of drainage network analysis provides opportunity for the study of fluvially eroded landscapes.

As the main objectives of this chapter was to discover whole stream properties from the measurement of various stream attributes, detailed morphometric analysis is carried out for the upper Pindar river basin and discuss their feature and characteristic and also attempt to find out the stage of geomorphic development with the help of different morphometric parameters. Thus the morphological study of a river is very important to study the behavior of a river, its aggradations, degradation, sifting of river course and erosion of river banks etc.

Present chapter deals with geomorphic characteristics with the help of various parameters of drainage basin including stream order, bifurcation ratio, stream length, stream length ratio, mean stream length, drainage density, stream frequency, circularity ratio, ruggedness number and drainage pattern etc. in general the entire basin is selected for the morphometric analysis in following heads-

1. Linear aspect
2. Areal aspect
3. Relief aspect

STUDY AREA

The area of present study lies in the Kumaun Himalaya in Bageshwar district of Uttarakhand. The area is situated in between 30°05’02” to 30°19’ 34’ N latitude and 79°47’51” E to 80°05’36” E longitude. The total study area is about 348km². The altitude of the area ranges from about 1997meter to 6855meter. Pindar River is a tributary of Alaknanda which are joining at Karanprayag locality. The upper catchment of Pindar River is formed by the tributaties originating from the glaciers known as Pindari, Sunderdhungha and Kafni.

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DATABASE AND METHODOLOGY

The present investigation is based on both primary and secondary sources. To determine the drainage characteristics of upper Pindar river basin the survey of India topographical map on 1:50000 scale was used for the preparation of the base map for the catchment delineation. Drainage analysis i.e. linear (stream order, stream length, mean stream length, stream length ratio, bifurcation ratio), Areal (basin relief, relief ratio, ruggedness number), Relief (drainage density, stream frequency, texture ratio, form factor, circularity ratio, elongation ratio) was carried out using the morphometric approach as suggested by Strahler, Horton, Shumn and Miller.

Linear aspects

The linear aspects of a channel system deal with the quantitative analysis of landform in a watershed area, where the running water has been acted for a long period of time modifying the surface geometry. Linear aspects of a drainage basin enclose channel pattern of drainage network by which the topographical characteristic of stream segment has been studied.

1. Stream order: The analysis of the composition of branching system of channels is considered as the first linear property of a stream system. Stream order is a measure of the position of a stream in the hierarchy of tributaries, (Leopold 1969). Following the method of Strahler there are 572 first order streams, 114 second order streams, 22 third order streams, 3 fourth order streams and 1 fifth order stream in upper Pindar river catchment.
2. Stream length: The study of stream length expresses the length of the flow of water over ground before it merges in a definite channel. Stream length is measured from the farthest drainage divide to the mouth of a river based on the law proposed by Horton (1945). The total stream length of first order is 340 km. and second order, third order, fourth order and fifth order stream length is 83km, 38km, 18km and 9.5km respectively.
3. Mean stream length: – Mean stream length is a characteristic property related to the drainage network components and its associated basin surface (Strahler, 1964). This has been calculated by dividing the total stream length of any order by the number of stream segment in that order. Mean stream length for first order basin is 0.59Km. and 0.72Km, 1.72Km, 6Km and 9.5Km for second, third, fourth and fifth order basin respectively.
4. Stream length ratio: The stream length ratio is the ratio between the average length of stream of an order and average length of stream of its previous order. Stream length ratio between first and second order is 1.22, between second and third order is 2.39, between third and fourth order is 3.49 and between fourth and fifth order is 1.58.

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5. Bifurcation ratio: Bifurcation ratio is the ratio between the number of streams in the lower order and that of the next higher order. Bifurcation ratio is 5.01 between first and second order, 5.18 between second and third order, 7.33 between third and fourth order and 3 between fourth and fifth order.

Areal aspects

Areal aspect of a drainage basin is also an important morphometric factor. It is possible to describe the area of the basin which contributes water to each stream segment. The watershed can be traced from where the stream has its confluence with the higher order stream along hillcrest to pass upslope of the source and return to the confluence. This lines separates slope which feed water towards the streams from those which drain into other stream. Horton stated that the main basin area of successive orders tends to form a geometric series and the basin area increases with the increase in stream order.

1. Basin relief: Basin relief is the difference of highest and lowest altitude of the basin. In the present study area basin relief ranges between 355meter and 3463meter for second order basin while it is ranges between 1103meter to 3575meter for third order basin.
2. Relief ratio: Relief ratio is defined as the ratio between the total relief of a basin i.e. elevation difference of highest and lowest point of basin and the longest dimension of the basin parallel to the principal drainage line (Schumm, 1956). The value of relief ratio of second order basin varies from 177.7 to 1309.09 and for third order basin it varies from 265.75 to 866.25. The high value of relief ratio indicates steep and high relief, while low value of relief ratio indicates gentle slope and low relief.
3. Ruggedness number: Ruggedness number is the product of relative relief and drainage density of an area, which is formed to combine the qualities of slope steepness and length. The value of ruggedness number for second order basin ranges between 0.11 and 7.72 and for third order basin value ranges between 1.99 and 7.47.

Relief aspects

Relief aspects of a drainage basin related to the three dimensional features of the basin involving area, volume and altitude of vertical dimension of land form where in different morphometric methods are used to analyze terrain characteristics.

1. Drainage density: The term drainage density first introduced by Horton in 1932. He defined it as total stream length per unit area. In the Upper Pindar river basin snow cover is a determining factor of drainage density. In the northern part of the basin drainage density is very low because the whole area is snow covered which is an obstacle in the

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development of streams. Drainage density value for second order basin ranges between 0.04 and 6.4 and for third order basin value ranges between 0.60 and 4.16.

2. Stream frequency: Horton (1932, 1945) was the first who used the term stream frequency as a morphometric parameter and defined it as the number of stream segments per unit area. In the study area stream frequency is very low in northern, north - eastern and north – western part because these areas are covered with glacier.
3. Texture ratio: The relative spacing between the streams of a river network is aptly described as drainage texture. Texture ratio of a drainage basin can be divided into three groups. First group is fine textured drainage which indicates a closer network of stream channels. Second one is the medium texture which indicates that the distance between streams is medium type. Where the distance between streams is greater, this structure is known as coarse textured drainage.
4. Form factor: Form factor is the numerical index (Horton, 1932) commonly used to represent different basin shape. The ratio of basin area to square of the basin length is defined as the form factor. Form factor is the dimensionless number. The value of form factor varies from 0.1 to 0.8 but it would always be less than 0.754, (For a perfectly circular watershed). In the study area value of form factor ranges between 0.09 and 0.565 for second order basin and from 0.177 to 0.483 for second order basin.
5. Circularity ratio: The term circularity ratio is regarded as a significant method related to outline of the basin. The shape of a drainage basin as it is projected upon the horizontal datum plane of map is known as circularity ratio of the particular basin. Its study is based on the resemblance of circle. Value of circularity ratio ranges between 0.139 and 0.958 for second order basin while for third order basin value ranges between 0.243 and 0.841. Among the 114 second order basin six basins shape are nearer to being a circle while 44 basins are far from being a circle shape. For third order basin among 22 basin only two basins are close to a circular shape and five basins are far from being a circle shape. Regional distribution of circularity ratio has been shown in table
6. Elongation ratio: Shumm, 1956 used the term elongation ratio and defined it as the ratio of diameter of a circle of the same area as the basin to the maximum basin length. Values of elongation ratio vary between 0 and 1. Where 1 denotes a full circular shape while 0 denotes a long shape. In the present study of upper Pindar river basin values of elongation ratio varies between 0.38 and 0.84. Only one basin shows an oval shape. Maximum basins fall under elongated shape. Among the 114 second order basins 67 basins have elongation ratio value 0.5 to 0.7, represent high relief and steep ground slope and 9 second order basin show less elongated shape. Among 22 third order sub basins 16 basins show elongated shape and 6 sub basins are less elongated or oval shape. Regional distribution of elongation ratio has been presented in table.

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CONCLUSION

Pindar river, which is the 5th order tributary of the Alaknanda river represent a morphometric characteristics of the Himalayan river system. Drainage analysis of the upper Pindar river basin reveals a variation in different morphometric parameters from region to region. The entire basin represents a dendritic drainage pattern. The northern part of the watershed covered with snow which affects different morphometric aspects such as drainage density, stream frequency, ruggedness number, texture ratio etc. In this part the values of drainage density, stream frequency and ruggedness number are very low because there are less stream in this region.

Table No. 1: stream ordering of upper Pindar river basin

Stream order	Number of the stream
First order	572
Second order	114
Third order	22
Fourth order	3
Fifth order	1

Table No. 2: Upper Pindar river basin: Stream length

Stream order	Stream length in Km.
First order	340.00
Second order	83.00
Third order	38.00
Fourth order	18.00
Fifth order	9.5

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Table No. 3: Upper Pindar river basin: Mean stream length

Stream order	Number of stream	Stream length in Km.	Mean stream length in Km.
First order	572	340.00	0.59
Second order	114	83.00	0.72
Third order	22	38.00	1.72
Fourth order	3	18.00	6.0
Fifth order	1	9.5	9.5

Statistical measurement second order basin: upper Pindar river basin

Aspect	**SL**	**LU**	**Lr**	**br**	**H**	**Rh**	**Rg**	**Dd**	**Sf**	**Tr**	**F**	**Cr**	**Re**
M	5.79	0.69	1.75	4.49	2206	427.12	1.98	1.39	2.27	4.12	0.342	0.62	0.62
Md	3.56	0.79	1.81	3.61	2472	431.52	1.35	0.76	0.93	3.82	0.358	0.64	0.66
Mo	1.62	0.84	0.11	1.59	2621	351.34	1.17	0.50	0.63	3.72	0.379	0.67	0.68
MD M	4.12	0.32	1.13	2.64	703	128.97	1.36	1.17	2.10	0.92	0.102	0.10	0.13
MD md	3.85	0.32	1.13	2.58	670	128.52	1.24	1.02	1.79	0.86	0.101	0.09	0.10
MD mo	4.28	0.32	1.64	2.95	667	136.62	1.25	1.03	1.84	0.87	0.101	0.09	0.10
Co.MD M	0.71	0.47	0.65	0.59	0.32	0.30	0.68	0.84	0.92	0.22	0.299	0.16	0.21
Co.MD md	1.08	0.40	0.62	0.72	0.27	0.29	0.92	1.34	1.92	0.22	0.282	0.14	0.15
Co.MD mo	2.64	0.38	14.96	1.85	0.25	0.39	0.63	2.06	2.92	0.23	0.267	0.14	0.15
SD	4.75	0.38	1.35	2.95	814	158.85	1.71	1.40	2.81	1.22	0.127	0.12	0.14
Co.SD	0.82	0.55	0.77	0.66	0.37	0.37	0.86	1.00	0.73	0.29	0.371	0.20	0.23
Q1	1.78	0.43	0.47	1.72	1451	330.38	0.78	0.32	0.54	3.27	0.236	0.54	0.53
Q2	9.05	1.1	2.61	7.11	2772	563.53	2.97	2.32	3.46	4.71	0.407	0.71	0.71
QD	3.63	0.33	1.07	2.69	660	116.57	1.09	1.0	1.46	0.72	0.085	0.08	0.09

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Co. QD	0.67	0.48	0.35	0.61	0.31	0.26	0.52	0.76	0.73	0.18	0.266	0.14	0.15
CV	82.04 %	55.07 %	77.14 %	65.81 %	37%	37.19 %	85.86 %	100%	123.7 9%	29.62 %	37.08 %	19.35 %	23.10 %
skew	+ 0.51	-0.07	-0.25	+ 0.29	-0.53	+0.13	+0.48	+0.56	+0.73	+0.24	-0.427	-0.18	- 0.47

Statistical measurement third order basin: upper Pindar river basin

Aspect	**SL**	**LU**	**Lr**	**br**	**H**	**Rh**	**Rg**	**Dd**	**Sf**	**Tr**	**F**	**Cr**	**Re**
M	33.32	0.84	5.54	4.92	2953	358.25	3.32	1.40	1.97	3.35	0.364	0.66	0.69
Md	27.04	0.89	3.37	4.16	3240	334.23	2.81	1.03	1.42	3.59	0.370	0.68	0.72
Mo	50.5	0.89	1.46	2.26	3345	300.13	2.61	0.60	1.27	3.75	0.374	0.71	0.73
MD M	18.76	0.11	4.57	2.83	546	90.37	1.15	0.75	1.33	0.73	0.055	0.07	0.06
MD md	18.29	0.09	3.85	2.84	457	87.27	1.03	0.72	0.67	0.69	0.052	0.08	0.05
MD mo	21.13	0.09	4.21	3.25	471	81.16	1.07	0.86	1.11	0.67	0.051	0.08	0.05
Co.MD M	0.56	0.13	0.82	0.57	0.18	0.25	0.35	0.54	0.78	0.22	0.150	0.11	0.09
Co.MD md	0.68	0.12	1.14	0.68	0.14	0.26	0.37	0.63	1.17	0.19	0.141	0.11	0.08
Co.MD mo	0.42	0.12	2.88	1.45	0.14	0.27	0.41	1.43	0.92	0.18	0.136	0.11	0.08
SD	20.02	0.14	5.37	2.97	668	112.63	1.42	0.95	1.79	0.84	0.073	0.09	0.08
Co.SD	0.60	0.16	0.97	0.60	0.23	0.31	0.43	0.68	0.91	0.25	0.200	0.14	0.11
Q1	15.31	0.77	1.54	2.13	2383	272.63	2.31	0.66	0.82	2.48	0.314	0.60	0.63
Q2	54.31	0.94	14.02	8.04	3406	416.02	3.85	1.71	1.96	3.88	0.396	0.74	0.74
QD	19.5	0.08	6.24	2.95	511	71.69	0.77	0.52	0.57	0.70	0.041	0.07	0.05
Co. QD	0.56	0.09	1.62	0.58	0.18	0.21	0.25	0.44	0.41	0.22	0.115	0.10	0.08
CV	60.08 %	16.21 %	96.89 %	60.55 %	23%	31.44 %	42.77 %	67.86 %	90.86 %	25.07 %	20.05 %	13.64 %	11.17 %
skewness	+ 0.39	–0.07	+ 1.08	+ 0.31	-0.67	+0.14	+0.35	+0.10	-0.05	-0.57	-0.366	- 0.14	- 0.52

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