VOLUME-6 | ISSUE-1 | JANUARY-2017 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 78.46

Original Research Paper

MORPHOMETRIC ANALYSIS OF SUB BASINS OF BOLI- PATHRALA WATERSHED IN LOWER SHIWALIK HILLS, INDIA

Geography

KEYWORDS: Watershed, Morphometry, Bifurcation ratio, Drainage Texture

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ABSTRACT

Rivers are dynamic and increasingly important part of the physical environment, and the geomorphic regions have been made by the drainage system pattern, texture, density etc. Basin morphometry is one of the factor controlling river regimes. Morphometric studies are related to the quantitative description of the basin geometry. The purpose of present study is to assess the drainage characteristics of Boli-Pathrala watershed using the topographical maps on a scale of 1:50000.

Introduction

A watershed is a natural hydrological entity, which allows surface run-off to a defined channel, drains, stream or river at a particular point. Watershed morphometry is a technique of analysing linera, aeral and relief aspects of the drainage network. In this paper the morphometric analysis of sub-basins of Boli-Pathrala watershed (Map-1) has been done, which is a hydrologically important basin as it is a part of Haryana Water Resources Consolidation Project prepared by the Haryana Irrigation Department.

Study Area

The Boli-Pathrala watershed is a sub-watershed of Somb river, which is a tributary of Yamuna river, flow in Yamunanagar district of Haryana (India). Boli river arises from the outer slope of the lower part of Shiwalik range in the Sirmaur district of Himachal Pradesh (India) and takes a southerly course, which drains the plain land of the Yamunanagar district. The Boli river joined Pathrala river near Kotra Khansingh village in the Bilaspur thesil of the Yamunanagar district after about a course of 28.5 kms from its origin. The Pathrala River is also a tributary of Somb river. The total catchment area of the Boli- Pathrala watershed is 235km^2 (Map-1).

Data Source and Research Methodology

The morphometric elements of Boli-Pathrala watershed has been measured with the help of topographical sheets no. 53F/7, F/8, and F/11 published by the Survey of India on 1:50,000 scale. The variables for the study of morphometric aspect are analysed using standard techniques followed by several pioneers in the field such as Strahler, Horton, and Schumn etc. The parameters worked out include linear and aerial aspects measured by rotometer and digital plannimeter respectively. A few aspects of morphometry, which seems to have special relevance in the geomorphological and hydrological studies are considered for analysis.

Morphometric analysis of the basin

The morphometric analysis of Boli-Pathrala watershed has carried out in seven sub watersheds of the basin as well as whole watershed.

The seven sub-watersheds are
1. Nagil ki khol
2. Nimbuwala khola
3. Palasi khola
4. Chikenkhol-Kansil Khol
5. Khilonwala-khol-Nakunda nala
6. Boli nadi
7. Pathrala nadi.

Stream Number (S_N) and Stream Order (S_O)

The first step in the drainage basin analysis is a designation the stream orders. Strachler's low (1964) of stream ordering has been adopted in the present analysis. The total number of order wise stream segments is known as stream number. It is concluded that the Boli-Pathrala drainage basin is found to have upto sixth order (Table-1). Out of the seven-selected drainage basin, Pathrala nadi has designated a 6th order stream, whereas Boli nadi sub-watershed is a 5th order drainage basin and another five are 4th order sub-watersheds. The physiographic and structural conditions affect the stream number in the basin (table-1)

Stream Length (S_L)

The total stream lengths of various orders have been measured with the help of rotameter. It is clear that the total length of the stream segments is maximum in case of first order stream. The values of stream length decrease as the order increase (Table-1).

Mean Stream Length (MS_L)

The MS_L is calculated by dividing the total length of streams of an order by the total number of stream segments in the same order. Table 1 shows that in all cases the MS_L increases as the order of segment increases, but there is little variation in mean stream length of Pathrala nadi, this is due to local variations in relief conditions.

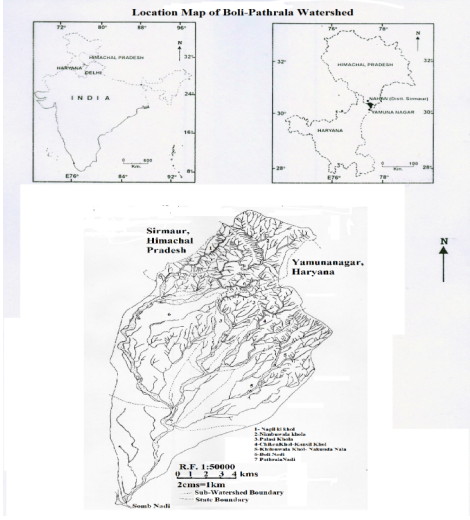
Stream Length Ratio (SL_R)

It is the ratio of mean length of the streams of one order to that of the next lower order of stream segments, which tends to be constant throughout successive orders of a watershed and each of the successive orders of basin tend to approximate a direct geometric series (Horton, 1945).

The SL_R of sub basin Nagil ki khol shows a direct geometric series, whereas all the sub basin and main basin register variations to this law (Table 1). This change may indicate the lithological differences and varied pattern at the slope of the area.

Bifurcation Ratio (R_B)

Bifurcation ratio is the ratio between the total number of streams of one order to that of the next higher order (Schumm, 1956). The R_B varies from 2 to 6 for Boli-Pathrala watershed (Table-1). There are some irregularities in the values of R_B from one order to next higher order, which indicates the lithological and geological development of the watershed.



Map-1

VOLUME-6 | ISSUE-1 | JANUARY-2017 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 78.46

Table-1 Stream order, Stream number, Stream length, Mean stream length, Stream length ratio, Bifurcation ratio and Mean bifurcation ratio

No. of sub watersheds →	1	2	3	4	5	6	7	Boli-Pathrala watershed	
S_N	1st	96	149	55	71	109	84	9	575
	2nd	23	36	12	14	21	19	2	127
	3rd	06	06	2	03	04	5	-	27
	4th	01	01	1	01	01	2	-	07
	5th	-	-	-	-	-	1	2	03
	6th	-	-	-	-	-	-	1	01
	Total	127	192	70	89	135	113	14	740
S_L	1st	27	49.5	23.7	26	44.5	39.7	21	231.5
	2nd	8	18.5	7	8	22	18	4	79.5
	3rd	5	12	7.2	7.5	17	7.7	-	56.5
	4th	7.7	9	5	7	11.5	4	-	44.2
	5th	-	-	-	-	-	16.5	4	20.5
	6th	-	-	-	-	-	-	10	10
	Total	47.7	89	43	48.5	89	86	39	442.2
MS_L (kms)	1st	0.28	0.33	0.43	0.36	0.40	0.47	2.3	0.4
	2nd	0.34	0.51	0.58	0.57	1.04	0.94	2.0	0.6
	3rd	0.83	2.0	3.6	2.5	4.25	1.54	-	2.1
	4th	7.7	9.0	5.0	7.0	11.5	2.0	-	6.3
	5th	-	-	-	-	-	16.5	2.0	6.8
	6th	-	-	-	-	-	-	10.0	10
	Total	0.37	0.46	0.61	0.54	0.65	0.76	2.78	0.59
SL_R	½	0.82	0.64	0.74	0.63	0.38	0.5	1.15	0.66
	2/3	0.40	0.25	0.16	0.22	0.24	0.61	-	0.28
	¾	0.10	0.22	0.72	0.35	0.36	0.77	-	0.33
	4/5	-	-	-	-	-	0.12	-	0.92
	5/6	-	-	-	-	-		0.2	0.68
R_B	1st	4.0	4.1	4.4	5.07	5.19	4.5	4.5	4.5
	2nd	4.0	6.0	6.0	4.6	5.25	3.8	-	4.7
	3rd	6.0	6.0	2.0	3.0	4.0	2.5	-	3.8
	4th	-	-	-	-	-	2.0	-	2.3
	5th	-	-	-	-	-	-	-	3.0
	6th	-	-	-	-	-	-	2	-

Source- Measured and calculated by author

Stream frequency (S_F)

Stream frequency indicates the number of stream segments per unit area, which along with drainage density gives the character of underlying lithology in a particular area. S_F of the watershed is 3.15 streams/km^2 (Table-2). The frequency of sub-basin Nagli ki khol is 7.9 streams/km^2 is highest stream frequency in the basin, which indicate this as the highest relief area of the watershed, whereas the stream frequency of sub-basin Pathrala nadi have 0.28 streams/km^2 which signifies the area of low relief.

Drainage Density (D_D)

Drainage density is the length of streams per unit area. D_D is low in resistant rock and under high permeable and is a characteristic feature of the course textural drainage. Here, sub-basin Nimbuwala khol has highest D_D i.e. 3.42 kms./km^2., whereas sub-basin Boli nadi and Pathrala nadi have 1.49kms/km^2 and 0.8kms/km^2 drainage density respectively, which indicate the permeable surface and have a comparatively plain area (Table-2).

Drainage Texture (D_T)

It can be expressed by the equation suggested by Smith (1950)-

$$D_T = D_D \times S_F$$

Based on the values of D_T, it is classified as Below 4- Corase , 4 to 10- Intermediate, 10 to 50- Fine and Above 50- Ultra fine (bad land topography)On the basis of above category the Boli-Pathrala watershed (5.91) have intermediate texture. The sub-basin Boli nadi (2.92) and Pathrala nadi (0.23) have coarse texture, Palasi khola (8.5), Chiken khol- Kansil khol (9.72), and Khilonwala khol- Nakunda Nala (5.42) have intermediate texture and Nagil ki khol (23.63) and Nimbuwala khol (25.23) have fine texture (Table-2).

Table-2 Stream Frequency, Drainage Density, Drainage Texture, Form factor, Elongation ratio and Circulatory ratio

No. of sub watersheds →	1	2	3	4	5	6	7	Boli-Pathrala watershed
Area (km^2)	16	26	18.75	21	47	57.5	48.75	235
S_L (kms)	47.75	89	43	48.5	89	86	39	442.2
S_N	127	192	70	89	135	113	14	740
S_F	7.93	7.38	3.73	4.23	2.87	1.96	0.28	3.14
D_D(km/km^2)	2.98	3.42	2.29	2.3	1.89	1.49	0.8	1.88
D_T	23.63	25.23	8.5	9.72	5.42	2.92	0.23	5.91
C_R	0.45	0.48	0.42	0.54	0.49	0.39	0.28	0.55
F_F	0.16	0.23	0.14	0.23	0.22	0.14	0.06	0.16
E_R	0.45	0.54	0.42	0.54	0.52	0.42	0.27	0.45

Circularity Ratio (C_R)

It is the ratio of the area of the basins to the area of circle having the same circumference as the perimeter of the basin. Miller (1953) suggests following formula for this-

$$C_R = 4 \times Pi \times A / P^2$$

Pi = 'Pi' value (3.14), A = Area of the basin (km^2), P^2 = Square of the basin perimeter (km)

The value of C_R less than 0.5 indicating the elongated shape of the watershed. The C_R of sub-basin Chiken khola-Kansil khol is highest i.e. 0.54 (Table-2), which indicates the late maturity stage of topography. The value of other sub-watersheds lies between 0.28 to 0.48, indicating the elongated shape. The C_R of Boli-Pathrala watershed is 0.55, suggesting that watershed have a less circular shape.

Form Factor (F_F)

it expresses the ratio of basin area to the square of basin length.

$$F_F = \text{Area of basin} / (\text{Lenght of basin})^2 \text{ (Horton, 1932)}$$

The value of F_F would always be greater than 0.78 for a perfectly circular basin. The smaller the value of F_F, more elongated will be the basin. The F_F of Boli- Pathrala watershed is 0.16, while the form factor of other seven sub-basin lies in between .06 to 0.23 (Table-2), which indicate the less circular shape of the basin.

Elongation Ratio (E_R)

It is the ratio between the diameter of the circle of the same area as the drainage basin and the maximum length of the basin. Schumn (1956) suggests following formula to calculate this

$$E_R = 2\sqrt{A/Pi} / Lb$$

A = Area of the basin, Pi = 'Pi' value i.e., 3.14, Lb = Basin length

The value of E_R varies from 0 (in highly elongated shape) to unity i.e. 1.0 (in the circular shape) (Strahler, 1964). The E_R of the Boli-Pathrala watershed is 0.45 indicating less elongated shape. The E_R of the seven sub-basins vary from 0.27 to 0.54 (Table-2). These low values represent the elongated basin with low relief.

Conclusion

On the basis of the preceding discussion, it may be noted that the Boli-Pathrala watershed can be divided into two broader divisions; one is rugged, highly dissected elevated hilly surface lies in the northern and eastern part of the basin and second is elongated plain area of the south. The streams of lower order mainly dominated and form the major part of the basin. The Bifurcation ratio indicates the mountainous, hilly dissected basin mainly in the north of the basin. The Nature of Boli drainage basin is permeable have less circular shape and drainage texture is fine.

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