International Journal of Current Research and Modern Education (IJCRME)
Impact Factor: 6.725, ISSN (Online): 2455 - 5428
(www.rdmodernresearch.com) Volume 2, Issue 2, 2017

MORPHOMETRIC ANALYSIS OF THE SANDRAN WATERSHED SOUTHEAST OF KASHMIR VALLEY, NORTHWEST HIMALAYAS

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Cite This Article: Tariq Ah Tahir, Dr. Bikram Singh Bali & Arshid Ahmad Dar, "Morphometric Analysis of the Sandran Watershed Southeast of Kashmir Valley, Northwest Himalayas", International Journal of Current Research and Modern Education, Volume 2, Issue 2, Page Number 235-240, 2017.

Abstract:

The Morphometric analysis consisting of linear and areal aspects of Sandran watershed has been determined to understand the nature, landscape development and Geo-hydrologic responses of sandran watershed. the sandran watershed has an basin area of 368.21km^2.The drainage pattern of stream network in the upper reaches of the basin have been observed as mainly dendritic to trellis while in lower reaches the basin represent parallel pattern indicating that topographical features are dipping downwards with uniform slopes and less resistant bedrock. Bifurcation Ratio (Rb) value of 4.5 reflects less structural disturbances and less disturbed drainage. Drainage density (Dd) of the basin is 2.91, which is the result of impermeable subsurface material, sparse vegetation and mountainous relief. Calculated values of Circularity Ratio (Rc) 0.27, Elongation Ratio (Re) 0.41 and Form Factor (F) 0.26 depict that the shape of the basin is elongated. Drainage Texture (Dt) values of the 1st order to 6th order suggests that the study area falls into very coarse to coarse texture category and indicates good permeability of sub-surface material in the study area except the first order streams.

Key Words: Morphometry, Linear Aspects & Areal Aspects

Introduction:

Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape and dimension of its landforms (Agarwal, 1998). A major emphasis in geomorphology over the past several decades has been on the development of quantitative physiographic methods to describe the evolution and behavior of surface drainage networks (Horton, 1945; Strahler, 1952). The source of the watershed drainage lines have been discussed since they were made predominantly by surface fluvial runoff has very important climatic, geologic and biologic effects. Morphometric analysis of a watershed provides a quantitative description of the drainage system, which is an important aspect of the characterization of watersheds (Strahler, 1964). The quantitative measurements of landforms are accomplished on the basis of calculation of geomorphic indices by the use of topography maps, digital elevation model, satellite images, aerial photographs and field works.

Study Area:

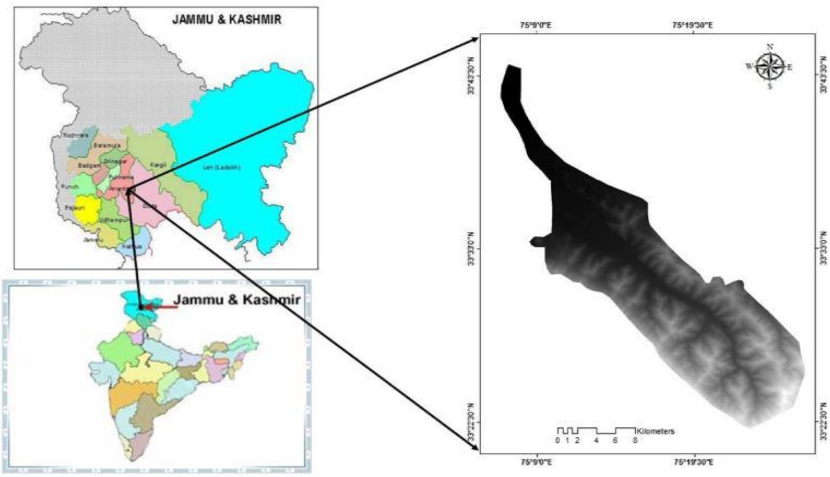

Figure 1: showing location map of the study area

The Sandran drainage basin occupies the south eastern part of the Kashmir valley (Fig.1) and is situated between 33^{0}20' to 34^{0}15' north latitude and 74^{0}15' to 75^{0}15' east longitude. The Sandran stream is the important right bank perennial tributary of the Jhelum River, Having its birth from the Sarbal lake (2592m) on the gentler southern slopes of the Pir Panjal range of Kashmir Himalayas below the Kaukut peak, it receives several branches at Cheard (2306m) and Anganmando (2362m) passing through a deep carved channel, studded with big boulders from its source to a point close to Vernag. It merges with the Jhelum a little above Khanabal near Anantnag town after traversing a course of about 52 kms (Raza *et al.,* 1978). Extending over a total catchment area of about 368.21 km2 (i.e., about 3 percent of the total drainage basin of Jhelum stream), it flows in the direction of north-west and irrigates most areas of Dooru Shahabad.

The study area is elongated in shape and has varied topography. The soils of the Sandran catchment belong to the groups of the brown forest soils, lacustrine (Karewa) soils and alluvial soils. Lithologically, the alluvium consists of blue, grey/silts and clay shales and sands of different textures and structures. The size of the grain varies from fine, medium to coarse. The valley possesses distinctive climatic characteristics because of its high altitude location and its geophysical setting, being enclosed on all sides by high mountain ranges. The valley is characterized by sub-Mediterranean type of climate with nearly 70% of its annual precipitation concentrated in winter and spring months (Meher, 1971).

Lithology of the study area: The study area comprises of various types of rock formations ranging in age from Upper Carboniferous to Plio-Pleistocene. In the study area, the oldest rock formation present are Agglomeratic Slates, which are light grey to dark in colour and are highly crushed, the age of Agglomeratic Slate is Upper Carboniferous, the Agglomeratic Slates are followed by Panjal Volcanics ,which are of Carboniferous age. The Panjal Volcanics contain series of bedded andesitic and basaltic flows, the Panjal traps are followed by Triassic Limestones which are of light blue or grey tint, compact and heterogeneous in composition. The grain Lower part of the study area consists of Lower Karewas of Plio-Pleistocene age. The Lower Karewas (Hirpur Formation) of the study area comprises of Methowian Member, which mostly consists of succession of sand, sandy clay and clay.

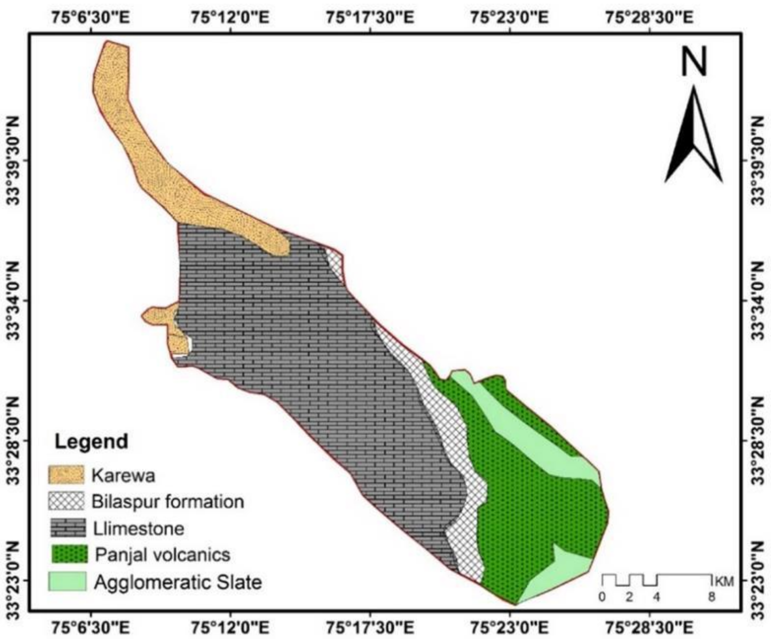

Figure 2: Showing lithological map of the study area

Material and Methods:

Drainage network is a significant indicator of the process of landform development in a geographical unit. Horton (1932) advocated in a drainage basin is an ideal unit for understanding the geomorphological processes and for evaluating the runoff pattern of the streams. The geological settings of the area as portrayed by the main streams and their tributaries generally control the drainage of the watershed. The drainage network found in the study area is dendritic to sub- dendritic drainage pattern. The drainage map of the study area is shown in the fig3 In young orogens, fast sedimentation can cover young structures, in these cases geomorphic indices are very useful for the type of processes that make of landforms especially analysis of drainage pattern and rivers can help to the recognition of the position of active structures (Burbank and Anderson, 2001). One of the most important landforms on the ground are rivers that are extremely sensitive to tectonic movements. In fact they are the fundamental units of fluvial landscape and a great amount of research has focused on their geometric characteristics including the topology of the stream networks and quantitative description of drainage texture, pattern and shape (Abrahams, 1984). Morphometric data combined with geomorphic data seem to be a valuable tool in determining relative levels of tectonic activity. The drainage characteristics of Sandran watershed has been examined to understand the tectonic geomorphology of the area with particular reference to Stream order (u), Stream number (Nu), Stream length (Lu), Drainage density (Dd), Drainage frequency (Fs), Bifurcation ratio (Rb), Form factor (Ff), Drainage intensity (Di), Circulatory ratio (Rc), Elongation ratio (Re), Relief ratio (Rr), Ruggedness number (Rn), Drainage texture (Dt), Basin area (A), Basin shape (Bs), Basin relief (Br).The calculated morphometric parameters are described below:

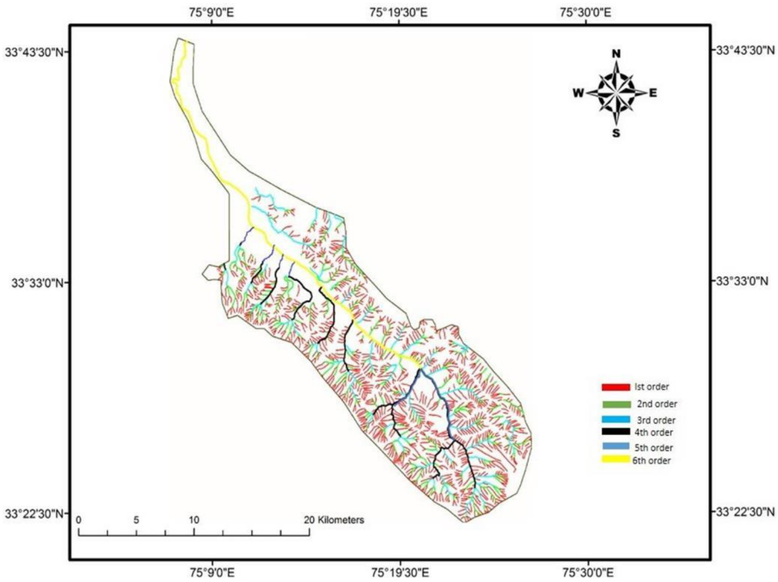

Figure 3: Showing Drainage map of Sandran stream

Linear Aspects of the Basin:

Stream Order (Su) and Stream number (Nu):

The designation of stream orders is the first step in drainage basin analysis and expresses the hierarchical relationship between segments. The stream ordering systems has been first advocated by Horton (1945) but Strahler (1952) has proposed this ordering system with some modifications. In the present study, stream ordering is carried out using the method given by Strahler (1964). According to Strahler (1964), the smallest fingertip tributaries are designated as order 1. Where two first order channels join, a channel segment of order 2 is formed The trunk stream through which all discharge of water and sediment passes is therefore the stream segment of highest order. The stream ordering for the study area is given in table 1. Drainage patterns of stream network in the upper reaches of the basin have been observed as mainly dendritic pattern to trellis, characterized by a tree like or fernlike pattern with branches that intersect primarily at acute angles and in trellis pattern branches meet at right angles. While in lower parts of the basin represent parallel pattern indicating that the topographical features are dipping downwards. A parallel drainage pattern consists of tributaries that flow nearly parallel to one another and all the tributaries join the main channel at approximately the same angle. Parallel drainage suggest that the area has a gentle, uniform slopes and with less resistant bed rock. It has observed that the maximum frequency is in the case of first order streams. It has also noticed that there is a decrease in stream frequency as the stream order increases. The order wise total number of stream segment is known as the stream number. Horton's (1945) laws of stream numbers states that the number of stream segments of each order forms an inverse geometric sequence when plotted against order, most drainage networks show a linear relationship, with small deviation from a straight line.The number of streams in each order are shown below in table 1

S.NO	Stream Order	No. of streams	Stream Length(Km)
01	1st order	1028	64.14
02	2nd order	294	14.37
03	3rd order	126	10.32
04	4th order	18	5.04
05	5th order	2	1.58
06	6th order	1	4.53
Total	6 orders	1469	100

Table 1: Showing order wise stream number and stream length.

Stream Length (Lu):

Stream length is an indicative of the chronological development of the stream segments including tectonic disturbances. Generally, the total length is maximum in the 1st order streams and decreases as the stream order increases (4). This is also true for the Sandran basin. Since the 1st order streams are usually smaller in length in the study area, this is due to the reason a large number of streams of smaller length have developed in the study area and the controlling factors are the presence of hard rocks and availability of weak zones.

Bifurcation Ratio (Rb):

Bifurcation ratio is defined as the ratio between the total number of stream segments of one order to that of next higher order. It is calculated by the formula: The stream segments of different orders were digitized from the topographic map in GIS environment to determine the bifurcation ratio for various orders using the above equation. It is a dimensionless property and shows the degree of integration prevailing between streams of various orders in a drainage basin. Horton (1945) considered Rb as an index of relief and dissection while Strahler (1957) demonstrated that Rb shows only a small variation for different regions with different environments except where powerful geological control dominates. The drainage density, lithology and climatic conditions prevalent in the area influence the Bifurcation ratio. Bifurcation ratios characteristically ranges between 3.0 and 5.0 for basins in which the geologic structures do not distort the drainage pattern (Strahler, 1964). The lower values of bifurcation ratio reflect less structural disturbances and less disturbed drainage whereas the higher values indicate high structural complexity and low permeability of the terrain. The average bifurcation ratio of the Sandran watershed is 4.5 which reflects less structural disturbances and less disturbed drainage. The bifurcation ratios of the study area are given below in table 2

S.NO	Order ratio	Values	Mean Bifurcation ratio
1	1st &2nd	4.9	4.54
2	2nd&3rd	3.1	
3	3rd&4th	3.7	
4	4TH&5th	9.0	
5	5TH&6th	2.0	

Table 2: Showing Bifurcation ratio between different orders

Areal Aspects of Drainage Basin:

Drainage Density (Dd):

Drainage density is an important parameter in knowing the level of dissection of a landscape due to the action of the fluvial systems and is a good measure of the fineness of the basin topography. Drainage density is the ratio of the total length of all streams in a given sub-basin to the drainage area of the same sub-basin. Rock types, vegetation cover, amount of slope are some of the parameters which influence drainage density. The drainage density value for the study area is 2.91. According to Nag (1998), low drainage density (< 2 per km) generally results in the areas of highly permeable subsoil material, dense vegetation and low relief. Whereas high drainage density (> 2.5 per km) is the result of impermeable sub- surface material, sparse vegetation and mountainous relief. The values of drainage density and other parameters are given in table 3

Stream Frequency (Fs):

Drainage frequency or Stream frequency is the total number of stream segments of all orders per unit area (Horton 1932). A higher value of stream frequency in hard rock and sloppy mountainous region is caused by a higher number of discontinuities present in the area and also due to structural control of drainage in the area. Table 3 shows the high value of stream frequency (Fs = 4.08) in the study area which suggests that the drainage pattern is structurally controlled.

Circularity Ratio (Rc):

Circularity ratio is defined as the ratio of the area of basin to the area of a circle having the same circumference as the perimeter of the basin. It is expressed by the formula:

$$Ka = 4\pi A / P^2$$

Where Ka is the circularity ratio, A is the area of basin and P is perimeter of the basin. Miller et al. (1960) has described that the circularity ratio of the basin ranges from **0.4 to 0.7,** which indicates strongly elongated and highly permeable homogenous geologic materials. The calculated 'Ka' value for Sandran watershed is 0.27 indicates that basin is elongated and is tectonically active circularity ratio value (0.27) of the watershed corroborates the Miller's range, indicating that the watershed is elongated in shape. The tectonics of the area overcomes the erosion activity of the basin. This is because tectonics on one hand creates elongate basins but at the same time erosion reshapes it into circular.

S.no	parameter	calculated value
1	Drainage Area (A)	368.21km
2	Drainage Density(D_d)	2.91km/km2
3	Drainage Frequency (F_s)	4.08/km
4	Drainage Texture (D_t)	8.3 1-0.008
5	Form Factor Ratio (R_f)	0.26
6	Elongation Ratio (Re)	0.41
7	Circulatory Ratio (R_c)	0.27

Table 3 showing calculated areal aspects of Sandran stream

Elongation Ratio (Re):

According to Schumm (1956) elongation ratio is defined as the ratio of diameter of a circle of same area as the basin to the maximum basin length. A circular basin appears more efficient in the discharge of run-off than that of an elongated basin (Singh 1997). Strahler states that this ratio runs between 0.5 and 1.0 over a wide variety of climatic and geologic types. The varying slopes of watershed can be classified with the help of the index of elongation ratio, i.e. circular (0.9-0.10), oval (0.8-0.9), less elongated (0.7-0.8), elongated (0.5-0.7), and more elongated (less than 0.5). Basin elongation ratio < 0.5 are characteristic of tectonically active basins, values ranging from 0.5 to 0.7 reflect slightly active basins, and values > 0.7 reflect inactive basin settings (Cuong and Zuchiewi 2001) The calculated elongation ration value of Sandran watershed is 0.41, which represents that the watershed is highly elongated in shape.

Basin Area (A):

The area of the watershed is another important parameter like the length of the drainage streams. Basin area is the direct outcome of the drainage development in a particular basin. It is usually seen that the basin are pear shaped in early stages, but as the cycle advances, the shape tends to become more elongated . The shape of the basin is significant since it affects the stream discharge characteristics(Schumm (1956) established an interesting relation between the total watershed areas and the total stream lengths, which are supported by the contributing areas. The basin area is computed by using Glober mapper, which is 368.21 Sq Kms.

Length of the Basin (Lb):

Schumm (1956) defined the basin length as the longest dimension of the basin parallel to the principal drainage line. Schumm (1956) defined the basin length as the length of the line from a basin mouth to a point on the perimeter equidistant from the basin mouth in either direction around the perimeter. The length of the Sandran stream is determined as 34.63Kms.

Form Factor (F):

The ratio of the basin area to the square of the basin length is called the Form Factor. Horton in 1932 describe form factor and devised certain values to infer the circularity or elongation of the basin based on these values. According to him if the value of form factor is between 0-0.5, the basin is highly elongate and if it is between 0.5-0.9, it is elongate and if the value of form factor is 1, it is perfectly of circular shape. The form factor of Sandran is 0.26 which shows that the basin is of elongated shape.

Drainage Texture (Dt):

The drainage texture is considered as one of the important concept of geomorphology which shows the relative spacing of the drainage lines (Chorley *et al*, 1957). In the present study, the drainage texture values were found as 8.31 (1^{st} order streams), 1.65 (2^{nd} order streams), 0.54 (3^{rd} order streams), 0.14 (4^{th}order streams), 0.016 (5^{th} order streams) and 0.008 (6^{th}order stream). Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture(smith 1939) . So it is clear that the drainage texture values (Table-3) are variable and suggests that the study area falls into very coarse to coarse texture category and indicates good permeability of sub-surface material in the study area except the first order streams.

Conclusion:

The morphometric parameters derived here will be of immense use in river basin evaluation, flood management, watershed prioritization for soil and water conservation, and natural resources management at micro level. Drainage texture (Dt) shows that the sub-surface material in the sandran shows good water bearing properties which could prove to be useful from Geo-Hydrological point of view for ground water exploration. ; Hence this watershed may be taken for conservation measures by planners and decision makers in the watershed management. Further, the morphometric parameters evaluated using GIS will enable us to understand various terrain parameters such as nature of bedrock, infiltration capacity, surface runoff, etc. Thus present study will immensely contribute towards watershed development and management.

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