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On

CHALLENGES OF HIGHER EDUCATION IN INDIA TO COMPETE WITH GLOBAL LEVEL

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CONTENTS

Morphometric Analysis of Linear Aspects of Sina River Basin, Maharashtra

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Abstract

Watershed managers require understanding and synthesizing hydrologic response of river basin for which they have started looking into its basin characteristics or morphologic features and establish connection of fluvial geomorphology to hydrology. According to Strahler (1968), the science of geomorphology treats the origin and systematic development of all types of landforms and is a major part of Physical Geography. Drainage basin is an ideal unit of the earth surface for the study of its landform. Therefore the present study deals with the quantitative analysis of selected drainage basin. Using drainage basin as a basic unit in morphometric analysis is the most logical choice because all hydrologic and geomorphic processes occur within the drainage basin. Measurement of shape, or geometry, of any natural form- be it plant, animal, or relief feature- is termed as morphometry (Strahler, 1957). Systematic description of the geometry of a drainage basin and its stream channel system requires measurement of linear, areal and relief aspect of drainage network. In current research paper only linear aspects are analyzed such as stream order, Stream numbers, bifurcation ratio, stream length, mean stream length and stream length ratio.

***Keywords** : Morphometric, drainage network, linear aspects.*

Introduction

Watershed and its characteristics are controlled by nature and its hydro-climatic parameters are mostly interrelated with each other. Watershed managers require understanding and synthesizing hydrologic response of such basin for which they have started looking into its basin characteristics or morphologic features and establish connection of fluvial geomorphology to hydrology. Geomorphology is the study of landforms (valley, gorge, waterfall, cavity, sand-dunes). Worcester defines geomorphology, the interpretative description of relief features. (Worcester, 1948) Drainage basin is an ideal unit of the earth surface for the study of its landform (Singh S. a., 1974). Therefore the present study deals with the quantitative analysis of selected drainage basin. (Singh S. a., 1974). Using drainage basin as a basic unit in morphometric analysis is the most logical choice because all hydrologic and geomorphic processes occur within the drainage basin. The landscape as well as relief features play a dominant role to influence source of transportation, location of cities and agriculture field so their study is great importance and interest to geomorphologist. The aim of the watershed management is to conserve the soil and water resources, so as to achieve improvement in the agriculture. So the emphasis is on the development of regional resources.

Study Area

The basin used in this study is the drainage area of the *Sina* River. It's catchment area of about 12365.3 sq. km. (approximate). Topographically the basin shows low degree of slopes, less dissection index and typical features of Western Ghats at the origin region of river. The *Sina* River basin is part of the upper Bhima river basin situated in the North part of Krishna River Basin. Actually, Sina river have two main tributaries which are arises from two opposite side, one from (West) Village Jamgaon (height 844 m) and another from (East) Village Sasewadi (height 970 m), and meet at Village Sawedi. River Bhogawati, river Upla, river Mehkari, river Kheri are the major tributaries which join Sina river. The latitudinal and longitudinal extension of the entire basin is from 17^0 21' 25.92" N to 19^0 15' 49.32" N and 74^0 28' 46.56" E to 76^0 05' 52.44" E respectively (fig. 1). The eastern part of the basin is comparatively less rugged and possesses flat rolling topography. The region experiences tropical type of climate. The rainfall pattern in the area is highly variable. About 85% of the rains occur in the months of June to September. The rainfall is below 800 mm.

The entire river basin area rather the Deccan plateau portion is mainly formed during the Late Cretaceous to Palaeogene age. The prolonged weathering of these trap rocks gave rise to residual sedimentary rock known as Laterite. Banks of stream are covered with alluvium patches. The upper part is mainly covered with red-brown soil and at places lateritic soils while the lower most portions is known for black cotton soil. The middle part of the basin mostly comprises of coarse shallow soils and alluvium. The lateritic soil is rich in Iron and Alumina.

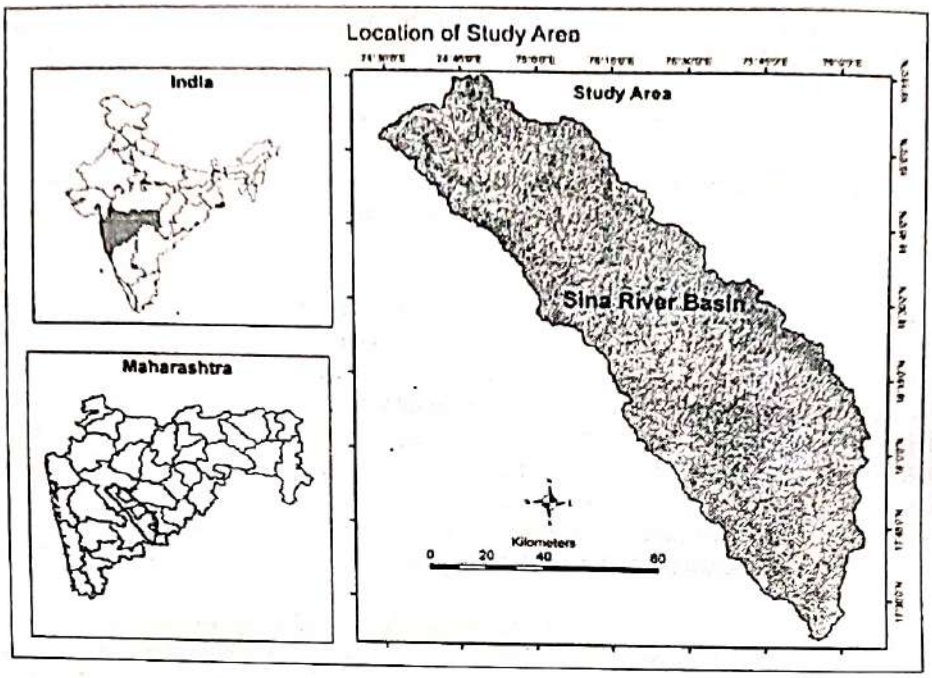

Fig – 1: Location of Study Area

Objectives

The goal of the present study is "to understand the morphometric linear aspects of the drainage basin". In order to understand this goal following objectives were outlined,

1. To examine fluvial environment under different morphometric attributes and the role of lithology upon their development processes.
2. To judge the impact of topography upon the drainage basin.
3. To adopt various statistical techniques to standardize the morphometric parameter and to define statistically the association between morphometric variable.

Methodology

In the present investigation, the form approach has been mainly used to interpret and study the various kinds of landform. This method follows the form approach very common quantitative and empirical method. Such investigation is usually based on a natural unit – the drainage basin being the most frequently selected and the relationship that can be established between the variables have been referred as the laws of morphometry (Chow, 1965). The above mentioned laws of morphometry based on measurable quantities such as number of stream, length ratio, drainage density, stream frequency and basin circularity ratio which can be related to one another quantitatively and dimensionlessly (King, 1966).

1. Fluvial environment is examined under following aspect.
   a. Linear Aspects: Stream order, Stream number, bifurcation ratio, Stream length ratio etc. The linear aspects are studied using the methods of Horton (1945), Strahler (1952), and Chorley (1957).
2. Quantitative measurement: Central tendency measurement, dispersion, quartile deviation, standard deviation, correlation coefficients and regression models are computed by computer. The variables of fluvial morphometry are interrelated with the help of correlation analysis.

The base map and drainage map of the basin was prepared with the help of Survey of India topographic sheets on 1:50000 scale. The toposheets and digital data were geometrically rectified and geo-referenced to world space coordinate system using digital image processing software (ERDAS Imagine 9.1 and Arc GIS software ver. 9.3). The orders were designated to each stream following Strahler (Chow, 1965) stream ordering technique. The fundamental parameters namely stream length, area, perimeter, number of stream, order and basin length were derived from the drainage layer. Drainage network map, Contour map, Stream ordering map, Location map of study area prepared with the help of Arc GIS software ver. 9.3, software was used for computing morphometric parameter.

Table-1 Formula adopted for computation of morphometric parameters

Sr. No.	Morphometric Parameters	Formula	Reference
1	Stream order (μ)	Hierarchical rank	Strahler (1964)
2	Stream Number (Nμ)	Hierarchical rank	Strahler (1964)
3	Bifurcation ratio (Rb)	Rb=Nμ/Nμ+1	Schumn(1956)
4	Stream length (Lμ)	Length of the stream	Horton (1945)
5	Mean stream length (Lsm)	Lsm=Lμ/Nμ	Strahler (1964)
6	Stream Length Ratio (Rl)	$Rl=Lsm^1/Lsm^2$	Horton (1945)
7	Mean bifurcation ratio (Rbm)	Average of bifurcation ratios of all orders	Strahler (1957)

Discussion and Results

Linear aspects of the basins are related to the channel patterns of the drainage network wherein the topological characteristics of the stream segments in terms of open links of the network system (streams) are analyzed. The drainage network, which consists of all of the segments of streams of a particular river, is reduced to the level of graphs, where stream junctions act as points (nodes) and streams, which connect the points (junctions), become links or lines wherein the numbers of all segments are counted, their hierarchical orders are determined, the lengths of all stream segments are measured and their different interrelationships are studied. The nature of flow paths in terms of sinuosity is equally important in the study of linear aspects of the drainage basins.

The liner aspects of drainage network such as Stream Orders (μ), Stream Number (Nμ), bifurcation ratio (R_b), Stream Length (Lu), Mean Stream Length (Lsm) and Stream Length Ratio (RL) results have been presented in the present study.

Stream Orders (μ)

'Stream order is defined as a measure of the position of a stream in the hierarchy of tributaries' (Leopold, 1964). Out of the four systems of ordering the streams that are available (Horton, 1945) (Strahler, 1957) and (Scheidegger, 1968), Strahler's system, which has in fact slightly modified Horton's, was followed because of its simplicity.

In the present study, the stream segments of the drainage basin have been ranked according to Strahler's stream ordering system (Strahler, 1968). According to Strahler's method of ordering the Sina River Drainage basin with a drainage area of 12365.3 sq. km. has a 8th order. 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.

Stream Number (Nμ)

The order wise total number of stream segment is known as the stream number. Horton states that the number of stream segments of each order form an inverse geometric sequence with order number, (Horton, 1945) (Table 2). The total number of 26857 streams were identified and information is given in Table 2. These figures show that, the number of the streams decreases as the stream order increases.

Table 2: Stream Order and Number of Stream

Stream Order	1st	2nd	3rd	4th	5th	6th	7th	8th	**Total Number of Stream**
Number of Stream	20615	4861	1071	233	58	14	4	1	**26857**

Bifurcation Ratio (R_b)

Horton defined the bifurcation ratio (R_b) as the ratio between the numbers of streams of any given order to the number in the next lower order (Horton, 1945). The term bifurcation ratio (R_b) is used to express the ratio of the number of streams of any given order to the number of streams in next higher order (Schumm, 1956). Bifurcation ratio characteristically ranges between 3.0 and 5.0. For basins in which the geological structures do not distort the drainage pattern (Chow, 1965). Strahler demonstrated that bifurcation ratio shows a small variation for different regions or for different environment dominates (Strahler. 1957). The higher values of R_b (>10) indicate strong structural control in drainage pattern while the lower values are indicative of not affected by structural disturbances. According to Strahler the theoretical minimum possible ratio is 2, whereas the natural drainage systems are generally characterized by bifurcation values between 03 and 05.

Bifurcation ratio is defined as a ratio of the number of streams of a given order to the number of streams of the next higher order and is expressed in terms of the following equation

$R_b = \frac{N\mu}{N\mu+1}$ Where $N\mu$ = number of stream of a given order

$N\mu + 1$ = number of streams of the next higher order

For the present study, bifurcation ratio of the Sina river basin calculated and tabulated as follows

Table 3: Stream Order, Stream Number and Bifurcation ratio

Stream Order (μ)	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	6^{th}	7^{th}	8^{th}	**Mean Bifurcation Ratio (Rbm)**
Number of Stream (Nμ)	20615	4861	1071	233	58	14	4	1	-
Bifurcation ratio (R_b)	4.2409	4.5387	4.5966	4.0172	4.1429	3.5	4	-	**4.1480**

The mean bifurcation ratio (Rbm) of the Sina river basin is 4.148, which indicates that geological structure are less disturbing the drainage pattern.

Stream Length (Lμ)

Stream length is one of the most significant hydrological features of the basin as it reveals surface runoff characteristics. Streams are relatively smaller length are characteristics of areas with larger slopes and finer textures, longer lengths of streams are generally indicative of flatter gradients. Generally, the total length of the stream segment is maximum in first order streams and decreases as the stream order increases.

Relationship between logarithm of number of stream versus stream order and logarithm of length of stream versus stream order were measured (fig. 2 and 3) and calculated in Table 4. Plot of logarithm of stream length versus stream order (fig 3) showed the linear pattern which indicates the homogenous rock material subjected to weathering erosion characteristics of the basin. Deviation from its general behavior indicates that the terrain is characterized by variation in lithology and topography.

Table 4: Stream Order, Number of Stream and Length of Streams

Stream Order (μ)	**Number of Stream (Nμ)**	**Length of Streams in km. (Lμ)**	**Mean Stream Length in km. (Lsm)**
1^{st}	20615	13221.9	0.64
2^{nd}	4861	4876.9	1.00
3^{rd}	1071	2533.3	2.37
4^{th}	233	1353.4	5.81
5^{th}	58	731	12.60
6^{th}	14	279.6	19.97
7^{th}	4	116.1	29.03
8^{th}	1	250.3	250.3
Total	**26857**	**23362.5**	**321.72**

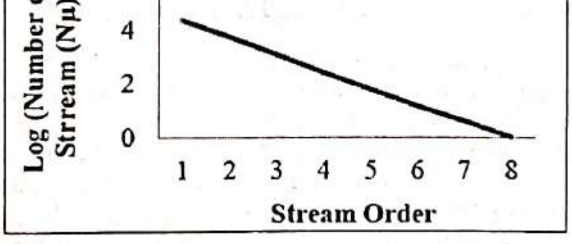

Fig 2: Relationship between Logarithm of Number of Streams versus Stream order

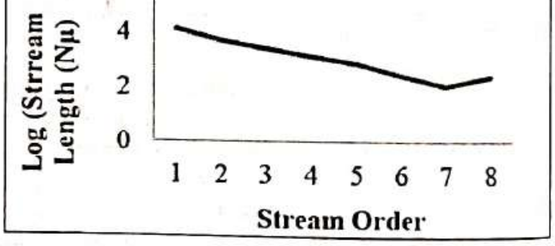

Fig 3: Relationship between Logarithm of Length of Stream versus Stream order

Mean Stream Length (Lsm)

The mean length of a channel is a dimensional property and reveals the characteristic size of drainage network components and its contributing basin surface (Chow, 1965). The mean stream lengths (Lsm) have been calculated by dividing the total stream of order (μ) and number of stream of segment of order (Nμ). Table 4 indicates that an Lsm value of the basin is total 321.72 respectively

Table 5: Relationship between logarithm of number of stream versus stream order and logarithm of length of stream versus stream order

River Basin	Stream Order (μ)	Number of Stream (Nμ)	Log. Number of Stream (Nμ)	Total Length of Streams in km. (Ls)	Log (Ls) Stream Length
Sina River Basin	1	20615	4.3142	13221.9	4.1213
	2	4861	3.6867	4876.9	3.6881
	3	1071	3.0298.	2533.3	3.4037
	4	233	2.3674	1353.4	3.1314
	5	58	1.7634	731	2.8639
	6	14	1.1461	279.6	2.4465
	7	4	0.6021	116.1	2.0648
	8	1	0	250.3	2.3985

Stream Length Ratio (RL)

The stream length ratio is the ratio of the mean length of the streams of a given order to the mean length of the streams of the next lower order (Horton, 1945). Horton's law of stream lengths refers that the mean stream lengths of stream segments of each of the successive orders of a drainage basin tend to approximate a direct geometric sequence in which the first term (stream length) is the average length of segments of the first order (Table 6). Changes of stream length ratio from one order to another order indicate that their late youth stage of geomorphic development (Singh S. a., 1997).

Table 6: Stream Order and Stream Length Ratio

Stream Order (μ)	Number of Stream (Nμ)	Length of Streams (Ls)	Mean Stream Length km. (Lsm)	Stream Length Ratio (RL)
1st	20615	13221.9	0.64	--
2nd	4861	4876.9	1.00	0.64
3rd	1071	2533.3	2.37	0.4219
4th	233	1353.4	5.81	0.4079
5th	58	731	12.60	0.4611
6th	14	279.6	19.97	0.6310
7th	4	116.1	29.03	0.6879
8th	1	250.3	250.3	0.1160
Total	26857	23362.5	321.72	3.37
Mean				0.48

Conclusion:

Stream order and Stream number; In the present study the study area Sina river basin is a 8th order drainage basin (Fig 1). The total numbers of 26857 streams were identified.

Bifurcation ratio of Sina river basin was 4.15 which indicate that geological structure is less disturbing the drainage pattern. Suresh has shown the high bifurcation ratio (Rb) is expected in the regions of steeply dipping rock strata, where narrow strike valleys are confined between the ridges (Suresh, 2000). According Kale and Gupta (Kale, 2001), the results of the present study ranged from 3 to 5 for the drainage basin indicating natural drainage system characteristics.

Stream length: Plot of logarithm of stream length versus stream order (fig. 3) showed the linear pattern which indicates the homogenous rock material subjected to weathering erosion characteristics of the basin. Deviation from its general behavior indicates that the terrain is characterized by variation in lithology and topography.

Table 7: Linear aspects of the drainage network of the study area

Sr. No.	Morphometric Parameters		Sina Basin
1	Stream order (μ)	I	20615
		II	4861
		III	1071
		IV	233
		V	58
		VI	14
		VII	4
		VIII	1
2	Total Number of Stream (N μ)		26857
3	Stream length (Lμ)	I	13221.9 km
		II	4876.9 km
		III	2533.3 km
		IV	1353.4 km
		V	731 km
		VI	279.6 km
		VII	116.1 km
		VIII	250.3 km
4	Total stream length		23362.5 km
5	Mean Stream Length (Lsm)		321.72 km
6	Bifurcation ratio (Rb)	I/II	4.2409
		II/III	4.5387
		III/IV	4.5966
		IV/V	4.0172
		V/VI	4.1429
		VI/VII	3.5
		VII/VIII	4
		VIII	-
7	Mean Bifurcation Ratio (Rbm)		4.15
8	Stream Length Ratio (RL)		3.37
9	Mean Stream Length Ratio		0.48

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