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Morphometric Analysis of Sitamou Area, Mandsaur District, Madhya Pradesh, India

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ABSTRACT

The morphometric analysis of the Chambal River Basin of Sitamou area located in Mandsour district of Madhya Pradesh,India, has been conducted. The morphometric analysis of a part of Chambal River drainage basin covering an area of 309.48 km^2 in Sitamou block has been conducted based on Survey of India toposheet No 46 M/5 on 1:50,000 scale. The drainage basin is divided into four A, B, C and D sub -basins. The quantitative morphometric analysis has been carried out for linear, areal and relief parameters denote a moderately good variation range and their importance has been discussed. The inter-relationship between morphometric parameters such as number of streams and stream order and length of stream and stream orders have been illustrated. An attempt has been made using geomorphic evidence to delineate the groundwater potential sites within the vicinity of Chambal River Basin, Sitamou area.

Introduction

The present study area has been selected in a part of Chambal River Basin located in South Eastern Part of Sitamau area, Mandsaur district of Madhya Pradesh within Longitude 75^0 20' to 75^0 25'E and Latitude 23^{0}50' to 24^{0}0' N (Survey of India, Toposheet No.46 M/5; Figure 1). The present study area is located in Mandsaur district of the Malwa Plateau in Madhya Pradesh. The study area in Sitamau block is located at a distance of 128 km from Ujjain, city, Madhya Pradesh. Geomorphology deals with the Study of evolution of landforms and Surface process. The nature of the landforms can be Studied with a background Knowledge of lithology, geological stracture, stratigraphy tectonic History and Climatology of a particular region. The landforms are resulted due to erosional and depositional Earths relief feature. The description of the landforms was first attempted by Davis (1909) on the basis of genesis. Russel (1949) recognized different stages in the development of landforms.

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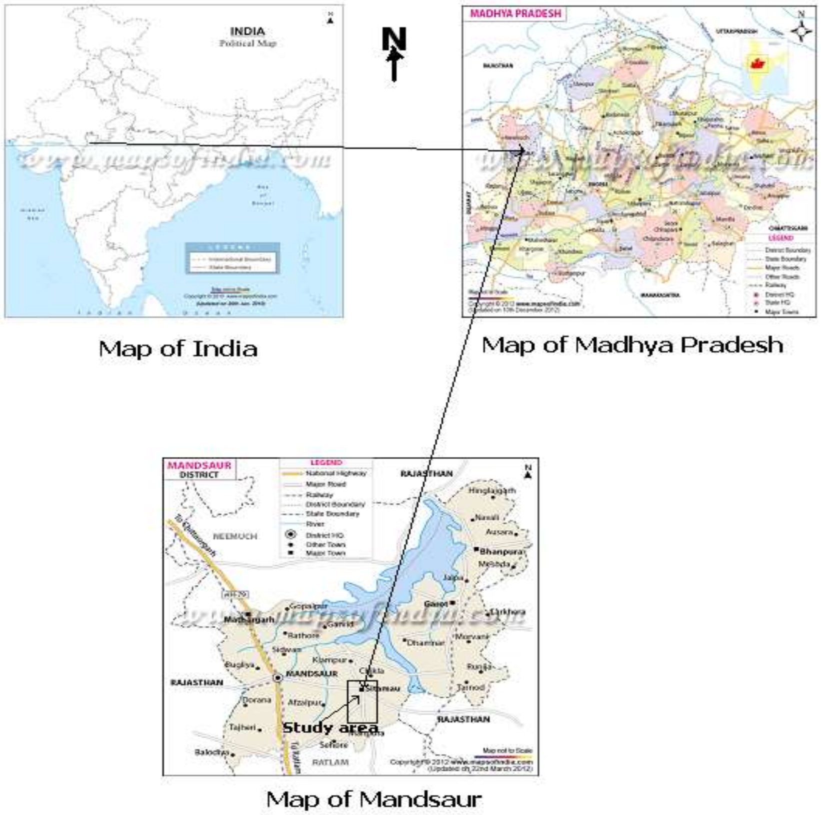

Fig: 1 Location Map of Sitamou Area, Mandsaur District, M.P.

Geology of Study Area

The study area forms a part of the Deccan Traps volcanic province and its located in Mandsaur District. Based on the work of Geological Survey of India prepared the geological tectonic and other types of maps for the county. They have covered the present area by systematic geological mapping on the large scale in recent years.

The area is chiefly occupied by the middle trap flow locally known as "Malwa Trap" each flow has different sub unit consisting of massive basalt, vesicular basalt Geological basalts. The geological succession has been established in the area.

Quantitative Geomorphic Analysis

The established work of Horton (1945), a renowned hydraulic engineer, laid the foundation of Quantitative Geomorphology that enables a logical approach to the analysis of a complex landscape of several size and origin (Sharma, 1986). In recent years, there has been a emphasis on the study of quantitative geomorphology of erosional drainage basins as a basic morphologic unit.

The morphometric analysis study area has been carried out by author preparing a drainage map of the Chambal River basin on the basis of Survey of India toposheet No. 46 M/5 (Figure 2). The stream length has been measured with the help of rotameter.

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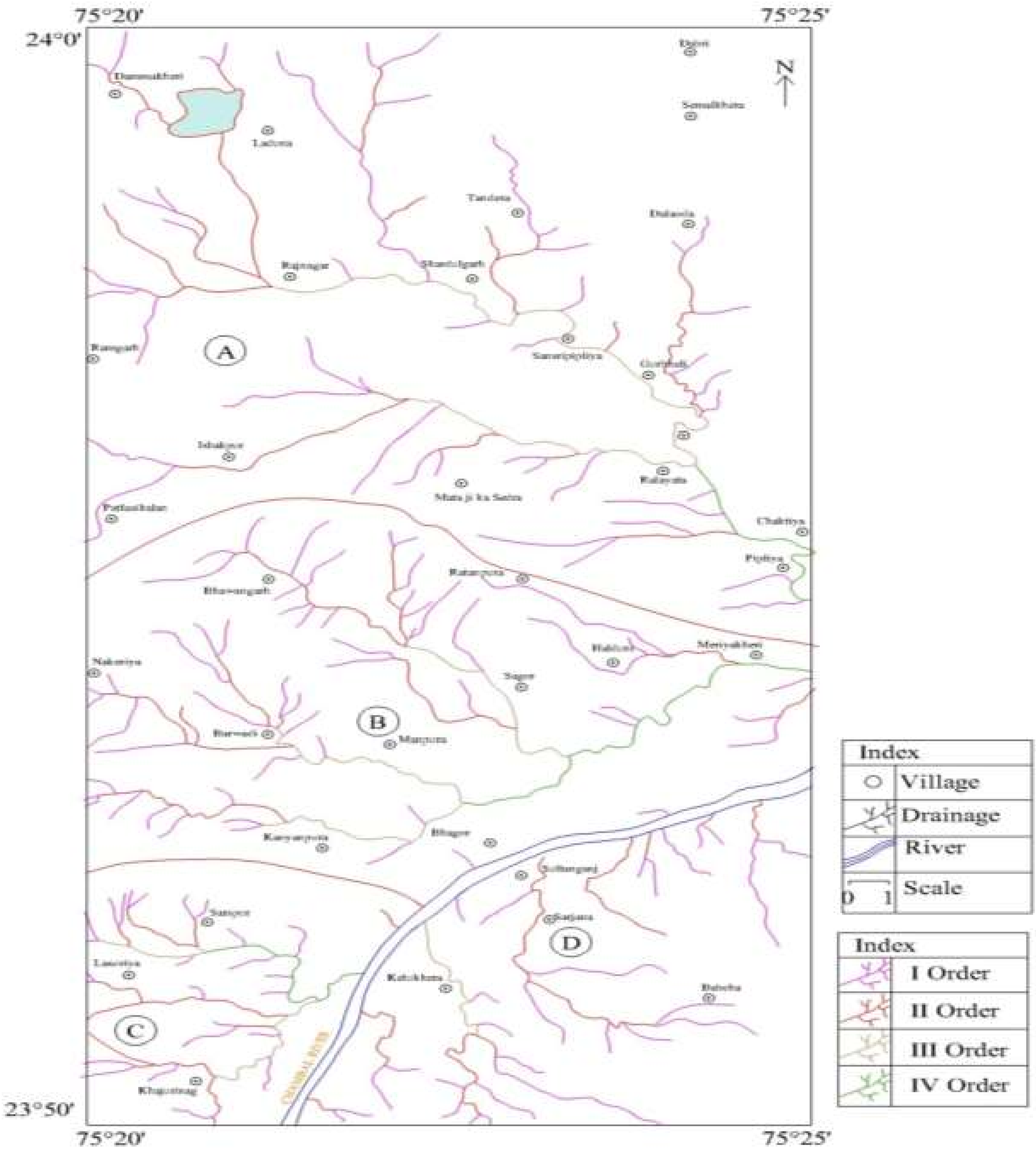

Figure: 2 Drainage Map of Sitamou Area, Mandsaur District M.P.

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Table 1 Showing details of the Morphometric variables in respect of Chambal River basin of study area, Mandsaur district, M.P.

SNO.	Morphometric variables	Chambal River Basin in Study Area, Sub-Basin			
		A	B	C	D
1	Number of first-order stream	51	56	29	29
2	Number of second-order stream	12	11	8	8
3	Number of third-order stream	2	3	3	1
4	Number of Fourth-order stream	1	1	1	-
4	Total number of stream	66	71	41	38
5	Length of first order stream(km)	88	74	26	47
6	Length of second-order stream(km)	43	35	14	21
7	Length of third-order stream(km)	26	18	7	5
8	Length of Fourth -order stream(km)	7	12	8	-
9	Total length of stream(km)	164	139	55	73
10	Highest elevation within the sub-basin(m)	480	440	460	431
11	Lowest elevation within the sub-basin(m)	425	425	425	422
12	Basin perimeter(sq.km)	74	52	32	42
13	Length of basin(km)	10	6.3	4.3	5.6
14	Width of basin(km)	8.6	8.6	3.7	5.9
15	Area of basin(sq.km)	86	54.1	15.9	33.04

(A) Linear aspects:- Stream order, Stream number, and bifurcation Ratio are linear aspects that were determined.

Stream order :- The computation of stream order has been conducted by following by methods of Horton (1932, 1945) and Straler (1957) and the determined values of sub – basin wise order are displayed (Table 1). Number of first-order stream ranges from 29 to 56, Number of second-order stream ranges from 8 to 12 and Number of third-order stream various from 1 to 3, Number of fourth-order stream ranges from 0 to 1(Table 1).

Stream number :- All the stream have been assigned to their respective orders and all segments of orders are connected to yield the number 'Nu' of the stream in the basin. that the number of stream segments of sequentially lower orders in a given basin tend to form a geometric series opening with the single segment of the highest order and ever-increasing according to continuous bifurcation ratio in the study area highest number of streams 71 is observed in sub-basin B and lowest number of streams 38 is observed in sub-basin D (Table 1).

Bifurcation Ratio :- According to Horton (1932), the bifurcation ratio can be defined as the "ratio between the number of the channel segments of a particular

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order (Nu) to the number of the channel segments of the next higher order (Nu+1)". It can be expressed by the equation. Rb = Nu / Nu+1, Where, Rb = Bifurcation ratio, Nu = Number of channel segment, Nu+1 = Number of channel segment of next higher order. The Bifurcation ratio of Chambal River Basin the study area varies from 1 to 4.66 with on average value of 2.888.

(B) Areal Aspects :- Areal aspects of the drainage basin include the study of basin parameter-Drainage Density, Circularity Ratio, Form Factor, Stream Frequency, Elongation Ratio, Leminiscate Ratio, Basin Relief, Relief Ratio, Length of over land flow.

Drainage Density:- The drainage density is expressed by the symbol "Dd". It has been considered as the ratio of cumulative lengths of channel segments of the all orders with in a basin to the basin area. It can be expressed by the following formula: Dd = L/A, Where, Dd = Drainage Density in Kms / Kms^2, L = Sum of total length of stream of all orders in Kms, A = Total area of drainage basin in square Kms. It has been observed that the drainage density range from 1.90 to 3.45.The average density has been computed to be 2.527.

Circularity Ratio:- The Circularity ratio has been defined by Miller (1953) as "the eatio of area of a basin to the area of a circle with same perimeter of the basin". It is denoted by the expression:

$$R_c = \frac{4\pi A}{P^2}$$

Where, R_c = Circularity Ratio, A = Area of basin, P^2 = Area of circle with some perimeter as of the basin. The Circularity ratio varies from 0.1950 to 0.2512 with an average value of 0.219 in the study area of sitamau in Mandsaur district.

Form Factor:- It provides an idea of the shape of Basin. Horton (1932) defined it as "the ratio between the basin area and square of the length" The form factor can be determined by the following formula: $F = A/L^2$, Where, F = Form Factor, A = Basin area, L = Basin Length. The form factor varies from 0.85 to 1.36 with an average value of 1.03 in the study area of sitamau in Mandsaur district.

Stream Frequency:- Stream frequency also known as the drainage frequency. It has been defined as the ratio of the total number of Channels of all orders in a basin to the area of the whole basin. The stream frequency is given by the formula: $S_f = N/A$, Where, S_f = Stream frequency, N = Sum of all streams in a basin, A= Total area of drainage Basin in km^2, The unit of stream frequency is given by number/ Km^2, The relief ratio of sub basin of the area from 0.76 to 2.57 with average value of 1.447.

Elongation Ratio:- It is also known as basin Elongation. Schumm (1956) has defined the elongation ratio as the ratio between the diameter of the circle with same area as basin and basin length. It is generally expressed by symbol 'Re' or E. E = Diameter of circle with same area basin / basin length. E = 2 / L / $\sqrt{A}$ / π, Where, E = Elongation ratio, A = Area of Basin, L = Length of Basin The relief ratio of sub basin of the area from 0.06 to 0.36 with average value of 0.185.

Leminiscate Ratio:- Chorley et al (1957) proposed the parameter Leminiscate Ratio which is based upon the expression of the basin with Leminiscate curve. K = L^2 / 4a, Where, K = Leminiscate, L = Basin length, A = Area of the basin. The Leminiscate of sub basin of the area from 3.43 to 5.45 with average value of 4.132.

Basin Relief:- Strahler (1952) defined the Basin Relief as the difference between the highest and lowest point in the basin. The basin relief has been defined by Schumm (1956) as the measure of the longest dimension of the basin parallel to the principal drainage line. It is expressed by the symbol 'H' or 'Hb'. In the area of investigation the highest elevation point is observed as 480.00 meters M.S.L. and the lowest elevation point is of 422 meters M.S.L. Basin Relief = H – L, Where, H = Highest point of Basin, L = Lowest point of Basin. The Basin relief of sub basin of the area from 9 to 55 with average value of 28.5.

Relief Ratio:- Schumm (1956) described it as Ratio between horizontal distance along the longest dimension of basin parallel to the principal drainage line and maximum basin relief. It is expressed by the following formula. Rh = H / L, Where, Rh = Relief Ratio, H = Maximum basin relief, L = Horizontal distance along with longest dimension of Basin. The relief ratio of sub basin of the area from 0.0016 to 0.0055 with average value of 0.0175.

Length of over land flow:- For a particular area length of overland flow is the most significant variable which, effects the hydrologic development of drainage basin. The length of the overland flow is denoted by the expression. Lo = 1 / 2 Dd, Where, Lo = Length of overland flow, Dd = Drainage Density. The relief ratio of sub basin of the area from 0.144 to 0.263 with average value of 0.207.

(C) Aspects: The relief aspects of drainage basin can be expressed as the Ruggedness number.

Ruggedness Number:- The ruggedness number is product of maximum basin relief and drainage density (Strahler,1953). It can be expressed as HD = H X D_d, Where, HD= Ruggedness Number, H = Maximum Basin Relief, D_d = Drainage density.

Conclution

Quantitative morphometeric analysis of the study drainage basin indicates that there are streams of four orders that decrease in number as the order increases. The geomorphic analysis of the study drainage basin indicates that there are streams of Fourth orders including main Chambal River. The significance of various morphometric parameters is discussed. Bifurcation Ratio of the study drainage basin ranges from 1 to 4.66 with an average value of 2.888 suggesting that the drainage of the study basin is mainly governed by lithological characters. The impacts of geological structures are rashers insignificant.

The drainage density of the present area has been calculated to be ranging from 1.90/ km to 3.45/ km with a average value of 2.527 indicating low value of drainage density that points out presence of a flat study area. The circularity ratio for the present drainage basin under investigation has been calculated to be ranging in between 0.1950 to 0.2512, with average of 0.219. It is suggested that the study area characterized by the presence of a more or less circular basin. The form factor ranges from 0.85 to 1.36 with a average 1.03.

The stream frequency of the study area varies from 0.76/ km^2 to 2.57/ km^2 with a average value of 1.447/ km^2. The Elongation Ratio of the study area varies from 0.06 to 0.36 with an average value of 0.185 pointing out that the drainage basin is nearly circular in shape. The lemniscates for the study area has been determined as revealing values ranging from 3.43 to 5.45 with a average value of 4.132 .In the study the length of overland flow ranges from 0.144 to 0.263 with an average value of 0.207 suggesting that the water covers rather a small distance before emerging into the drainage channel.

The Ruggedness number for different sub basins varies from 19.8 to 120.75 with an average value of 70.86, that is suggestion of the development of fairly uneven topography. The geomorphic analysis of the present study area a reveals dendritic to sub-dendritic drainage pattern that is more possible for differentiation of groundwater probable sites.

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