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GEOMORPHOLOGICAL CHARACTERISTICS OF NARMADA (UPTO MANOT) BASIN

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PREFACE

The advanced knowledge of geomorphology of a basin is of importance. The different geomorphological parameters of a watershed can be employed in synthesizing and understanding its hydrological behavior. The geomorphological properties of channel network are generally referred to the basin composition which represents the topographical and geometrical properties of the basin. The linear, areal and relief aspects of the watershed are some of the important characteristics which are considered generally in the science of geomorphology and particularly in hydrological studies.

In this report an attempt has been made to present methodology to quantify various geomorphological parameters of Narmada Basin upto Manot using modern measuring techniques for use in subsequent rainfall runoff modeling studies. This study has been carried out by Sri M K Jain, Scientist B, and assisted by U.K.Singh , R.A., in the Mountain Hydrology Division , National Institute of Hydrology , Roorkee.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The geomorphological characteristics of a watershed represents the attributes of the watershed and can be employed in synthesizing and understanding its hydrological behavior. For hydrological purposes, the various geomorphological characteristics which are of importance can be broadly classified into following three groups :

(1) characteristics representing linear aspects of the basin,

(2) characteristics representing areal aspects of the basin and

(3) characteristics representing relief aspects of the basin.

In this study the above mentioned aspects of the Narmada (upto Manot) Basin are evaluated. The study may be useful at finding out effect of geomorphology on watershed runoff response and identifying those parameters which are more closely related to runoff.

1.0 INTRODUCTION

One of the most important tasks in theoretical as well as practical hydrology, is to find the laws of runoff processes in river basins. The difficulty of this task increases when there is a lack of hydrological data as is often the case in mountainous areas. It is a well known fact that the climate and geomorphological characteristics affect the basin response to a considerable extent. Thus the linking of geomorphological parameters with hydrological characteristics of the bàsin provides a simple way to understand the hydrological behavior of different basins and particularly of the ungauged basins.

Quantitative studies of geomorphological parameters is a prerequisite for taking up hydrological simulation studies by using these parameters. The geomorphological properties which are important to the hydrological simulation studies includes the linear, areal and relief aspects of the basin. Various measures have been suggested by many investigators to represent the linear, areal and relief aspects of the basin. The quantification of these measures is cumbersome and time taking if carried out manually But the task becomes comparatively easy by using electronic digitizers and computers

In this study various geomorphological aspects such as linear, areal and relief aspects of the Narmada basin upto Manot are evaluated. The toposheet maps of the scale of 1:2,50,000 covering Narmada basin upto Manot have been digitized . The digitized information is used to quantify some of the important geomorphological properties of the basin.

1.1 Application in Hydrology

A large number of studies (Brush 1961, Coulter 1961) have related indices of drainage basin composition rock and soil type, vegetation and land use hydrological behavior, especially measures of water and sediment yields and their frequency distributions. Of all the indices, the basin area, drainage density, main stream length and main stream slope appears to have been utilized most frequently.

Synder (1938) employed basin area, mean stream length, and main drainage length to the centroid of the area to synthesize unit hydrograph lag, peak flow and peak time. Taylor and Schwartz (1952) used these as well as mean stream slope to synthesize the runoff hydrograph. A large number of studies (Laten et al. 1940; US Army Corps of Engineers, 1954; O'kelly, 1955; Gray, 1962; Morgan and Johnson, 1962; Mirajgaonkar and Chitambaran, 1963; Askew, 1963; Hopkins and Kachis, 1964; Schulz et al., 1971; Bc'. et al.,1979) have since appeared on synthesis of unit nydrographs in ungauged areas. Recently, Rodriguez-Iturbe (1982); Rodriguez-Iturbe et al.(1982); Rodriguez-Iturbe and Valdes (1979); Gupta et al. (1980), Singh (1983), Pristochova (1990) employed bifurcation ratio, length ratio, area ratio, stream lengths and stream areas for synthesizing unit hydrograph. Ros;o (1984) gave relation between Nash model parameters and Horton's order ratios Zelazinski (1986) applied GIUH theory to evaluate parameters of two conceptual models.

White (1975) classified 112 basins in Pennsylvania and surrounding states according to drainage density, Channel slope, shape factors, and geometric factors for the purpose of evaluating their flood potential. Clang and Body 91977) wed watershed and climate factors for estimation of low floods.

Ebisemiju (1979) used drainage density, stream numbers, steam lengths, and relief for identifying morphologically and hydrologically uniform basins. A study by Patton and Baker (1976) concluded that drainage density, steam magnitude and relief ratio are practical measures of flood potential in basins smaller than 100 mi^2 in area.

Melton (1957) found a strong correlation of drainage density with the ratio of average annual precipitation to average annual evaporation. A comprehensive account of potential application of drainage density was given by George (1977, 1979) and Gurnell (1978).

1.2 Problem Definition:

The various geomorphological parameters are required to be quantified for taking up studies using these parameters. The estimation of such parameters gains further importance in case of hilly catchments because direct measurement of hydrologic data is difficult in such areas. Quantification of these parameters is cumbersome and time taking. This report is aimed at development of a suitable methodology for quantifying commonly used geomorphological characteristics. In this study, various geomorphological parameters of Narmada Basin upto Manot are being evaluated. The parameters thus evaluated will be used to test hydrological models using these parameters.

2.0 METHODOLOGY

This section describes the different geomorphological parameters and the methodologies to quantify these parameters.

2.1 Geomorphological Characteristics

Systematic description of the geometry of a drainage basin and its stream channel system requires the following measurements (i) linear aspect of drainage network, (ii) areal aspect of drainage basin, and (iii) relief aspect of channel network and contributing ground slopes. Here, the first two categories of measurement are planimetric (i.e. treat properties projected upon a horizontal datum plane) and the third category treats the vertical inequalities of the drainage basis forms.

2.1.1 Ordering of the streams

For all practical purposes, the quantitative study of channel networks used to begin with Horton's (1945) methods of ordering of channels. Later on, Strahler (1952) proposed a modification of Horton's ordering scheme. Strahler's method is now generally preferred due to its simplicity and greater freedom from subjective decisions. In this report, the Strahler's method will be employed. There are three steps in Strahler's ordering procedure.

i) Channels that originate at a source are defined to be first order streams;

ii) When two stream of order w joins, a stream of order (w+1) is created; and

iii) When two streams of different order joins, the channel segment immediately downstream has the higher order of the combining streams.

2.2 Linear Aspects

The linear aspects proposed by various investigators which are of importance in hydrological studies, are described below. The methodology used to quantify them is also stated.

2.2.1 Number of streams of given order (N_w)

The quantity N_w represent total number of all streams, counted as the stream segments, having the order, w present in the watershed. Since a watershed of a given order can be modelled as a collection of elements of lower orders, the number of streams of each order is an important concept in hydrologic synthesis.

2.2.2 Bifurcation ratio (R_b)

The bifurcation ratio (R_b) for a given channel network can be obtained by determining the slope of the fitted regression of the plot of the logarithm of number of stream on ordinate versus order on abscissa. The regression coefficient, b is identical with the logarithm of R_b. The R_b is a dimensionless quantity and shows only a small variation from region to region. The value of R_b varies normally between 3 to 5 and is a useful index for hydrograph shape for watersheds similar in other respect.

The R_b computed using Horton's law of stream number which states, "The number of stream segments of each order form an inverse geometric sequence with order number" or

$$N_w = R_b^{k-w}$$

where k is the order of trunk segment

N_w is the number of segments of order w

$$\log N_w = (k-w) \log R_b$$

or $$\log N_w = a - b\,w$$

where

$$a = k \log R_b \quad \text{and}$$

$$b = \log R_b$$

or $$R_b = \log^{-1}(b)$$

For computing R_b, a subroutine for linear regression REG based on least square approach is used. This value of R_b is used to compute the total number of streams of all order (N) in a given network.

$$N = \sum_{w=1}^{k} N_w = \frac{R_b^{k} - 1}{R_b - 1}$$

2.2.3 Length of main channel (L)

This is the length along the longest water course from the outflow point of designated sub basin to the upper limit of the catchment boundary. For computing the length of the main channel (L), the data file was prepared by tracing the cursor of analog to digital converter along with the main channel . The coordinates of the closely spaced points were stored in a data file and distance between two points was obtained by

$$\text{Distance} = [(\Delta x)^2 + (\Delta y)^2]^{1/2}$$

For the length of the channel, distances of all the small segments were added using a subroutine LENGTH.

2.2.4 Stream lengths (L_w)

Stream length L_w is the total length of all streams of order w in a given drainage basin.

$$L_w = \sum_{i=1}^{N_w} L_i$$

Where L_i is the length of the i th segment of order w and N_w is the number of streams of order w . Stream lengths are employed in development of simplified geometric configurations required in hydraulic modeling of watershed response. The length of all streams of each order was calculated in the same way as of main channel length using the subroutine LENGTH.

2.2.5 Stream length ratio (R_L)

This is the ratio of mean stream segment length of order w to the mean stream segment length of order (w-1),

$$R_L = \frac{\bar{L}_w}{L_{w-1}}$$

The value of R_L ranges normally between 1.5 to 3.5 in natural networks. The R_L is calculated by using Horton's law of stream lengths and stream numbers, or

$$L_w = \sum_{i=1}^{w} \sum_{j=1}^{N_i} L_{ij} = \bar{L}_1 R_b^{w-1} \frac{R_{Lb}^{w} - 1}{R_{Lb} - 1}$$

Here, L_w, L_1 and R_b are known. The above equation is solved for R_{Lb} by using Newton-Rapson non-linear optimization technique. The R_L is calculated by

$$R_{Lb} = \frac{R_L}{R_b}$$

2.2.6 Length of overland flow (L_o)

The length of over land flow can be defined as the length of flow of water over the ground before it becomes concentrated in defined stream channels. It can be measured as the length of flow path, projected to horizontal, of non channel flow from a point on the drainage divide to a point on the adjacent stream channel. Horton recommended using half the reciprocal of drainage density D for the average length of over land flow L_o for the entire watershed.

$$L_o = \frac{1}{2D}$$

2.2.7 Length of channel between outlet and a point near to C.G. (L_c)

It is the length of the channel measured from the outlet of the catchment to a point on the stream nearest to the centroid of the basin. The center of gravity is located by procedure described below,

For computing center of gravity (x_g, y_g) of the basin, it is divided into small triangles and x and y coordinates of small triangles (x_c, y_c) are calculating using formulae:

$$x_c = \frac{1}{3} (x_1 + x_2 + x_3)$$

$$y_c = \frac{1}{3} (y_1 + y_2 + y_3)$$

Where (x_1, y_1), (x_2, y_2) and (x_3, y_3) are the coordinates of the three nodes of any triangle. If catchment is divided into n parts, the x coordinate of the center of gravity of each part (x_{Gi}) is obtained by dividing sum of multiples of x_c and area of all respective triangles by the sum of areas of all the triangles. Similarly, the y - coordinates of the center of gravity (y_{Gi}) are also obtained for each parts of the catchment. The x and y coordinates of center of gravity of whole basin is calculated by

$$x_G = \frac{\sum_{i=1}^{n} x_{Gi} \cdot Area_i}{\sum_{i=1}^{n} Area_i}$$

$$y_G = \frac{\sum_{i=1}^{n} y_{Gi} \cdot Area_i}{\sum_{i=1}^{n} Area_i}$$

Where $Area_i$ represents the area of i th part of the catchment. Now a point nearest to the center of gravity can be located on a channel segment taking the minimum of perpendicular distances from the center of gravity to the different channel segments. Subsequently the length of channel from the outlet to the nearest located point from C.G. is computed.

2.2.8 Watershed eccentricity (τ):

Watershed eccentricity is given by

$$\tau = \frac{\sqrt{(L_c^2 - W_L^2)}}{W_L}$$

where

τ = watershed eccentricity, a dimensionless factor

L_c = length from the watershed mouth to the center of mass of the watershed

W_L = the width of watershed at the center of mass and perpendicular to L_c

It is to be noted that if $L_c = W_L$, $\tau = 0$, and as either L_c or W_L increases, τ increases. Thus the lower the value of τ, the greater the compactness of the watershed concentrated near to the mouth and higher the peak flood. The τ is calculated using formula described earlier.

2.2.9 Basin perimeter (P):

Basin perimeter is defined as the length of the watershed divide which surrounds the basin. The perimeter P of the basin is obtained using the same procedure as for length. The sum of lengths of segments along the catchment boundary include the length between first and last digitized point provides the estimate for perimeter of the catchment. A subroutine PARAM is used to compute the perimeter P from digitized basin boundary points.

2.3 Areal Aspects:

Various areal aspects of the geomorphological characteristics which have been evaluated include:

2.3.1 Drainage area (A):

Drainage area represents the area enclosed within the boundary of the watershed divide. The drainage area A is probably the single most important characteristics for hydrologic design.

It reflects the volume of water that can be generated from rainfall.

The catchment area is calculated by traversing digital planimeter along the boundary of the catchment. Area drained by individual stream is also measured by same procedure after properly working the drainage areas of various streams.

2.3.2 Drainage density (D):

Drainage density is defined as the ratio of total length of channels of all orders in the basin to the drainage area of the basin. The drainage density is calculated using formula.

$$D = \frac{\sum_{i=1}^{w} \sum_{j=1}^{N_i} L_{ij}}{A_w}$$

2.3.3 Constant of channel maintenance, (C):

Constant of channel maintenance is defined as the ratio between the area of a drainage basin and total lengths of all the channels expressed as square metre per metre. It is equal to the reciprocal of drainage density. This parameter indicates the number of square meters of watershed surface required to maintain one linear metre of channel. It is calculated as,

$$C = \frac{A_w}{\sum_{i=1}^{w} \sum_{j=1}^{N_i} L_{ij}}$$

2.3.4 Stream frequency (F):

Stream frequency is defined as the number of streams per unit area. Melton (1956) analysed in detail the relationship between drainage density and stream frequency and gave following relation,

$$F = 0.694\ D^2$$

Stream frequency, F is computed as the number of streams per unit area Or,

$$F = \frac{N}{A}$$

where,

N is the total number of segments of all orders in the catchment area

A is the drainage area of basin

2.3.5 Circularity ratio (R_c):

Basin circularity ratio is defined as the ratio of the basin area to the area of a circle having circumference equal to the perimeter of the basin. As the basin shape approaches to a circle, the circularity ratio approaches to 1. It is computed as the ratio of basin area to the area of a circle having same perimeter as of the basin.

2.3.6 Elongation ratio (R_e):

It is defined as the ratio between the diameter of a circle with the same area as the basin and basin length. The value of R_e approaches to 1 as the shape of the basin approaches to circle. This ratio varies from 0.6 to 1 over a wide variety of climatic and geologic regimes. Typical values are close to 1 for areas of very low relief and are between 0.6 and 0.9 for regions of strong relief and steep ground slope.

2.3.7 Form factor (R_f):

Horton defined form factor, R_f, as the ratio of basin area A, to the square of basin length, L.The R_f is a dimensionless parameter and is computed as

$$R_f = \frac{A}{L^2}$$

2.3.8 Unity shape factor (R_u):

The unity shape factor was introduced by smart and Surkan (1967) and can be defined as the basin length (L_b) to the square root of the basin area.

$$R_u = \frac{L_b}{\sqrt{A_w}}$$

2.3.9 Watershed shape factor (R_s):

The watershed shape factor, R_s was defined by Wu et al (1964) as the ratio of main stream length, L_c to the diameter D_c of a circle having the same area as of watershed.

$$R_s = \frac{L_c}{D_c}$$

2.4 Basin Relief Aspects

The following aspects have been considered.

2.4.1 Total relief (H):

The basin relief or total relief is the maximum vertical distance between the lowest (outlet) and the highest (divide) points in the watershed. It has been defined in several ways. Schumm (1956) measured it along the longest dimension of the basin parallel to the principal drainage line. On the other hand, Maxwell (1960) measured relief along the basin diameter, an objectively defined axial line, whereas Strahler (1954, 1957) obtained it by determining the mean height of the entire watershed divide above the outlet. Relief is an indicative of the potential energy of a given watershed above a specified datum available to move water and sediment down slope. In this study relief is measured as the maximum vertical distance between the outlet and the highest (divide) point in the watershed.

2.4.2 Relief ratio (R_h):

The relief ratio is a dimensionless ratio and can be defined as the ratio between the relief and the distance over which the relief is measured. It measures the overall steepness of the watershed and can be related to its hydrological characteristics.

2.4.3 Relative relief (R_p):

Melton (1957) defined relative relief as the ratio of basin relief H to the length of the perimeter, P. It is an indicator of general steepness of the basin from summit to mouth. It is computed using equation.

$$R_p = \frac{H}{P}$$

2.4.4 Ruggedness number (R_n):

Melton (1957) and Strahler (1958) defined a dimensionless number called Ruggedness number, R_n as a product of relief, H and drainage density, D. The ruggedness number combines slope and length characteristics in one expression. The areas of low relief but high drainage density are as ruggedly textured as areas of higher relief having less dissection. The ruggedness number R_n is calculated as

$$R_n = HD$$

2.4.5 Taylor and Schwartz's Slope (T_s):

Taylor and Schwartz described the slope of the main channel as parts per 10,000. Here the channel was treated as series of lengths (l) of approximately uniform slope (s), whose time of flow are considered to be proportional to ($l/\sqrt{s_i}$). The average slope of channel is therefore computed by

$$L / \sqrt{T_s} = \sum_{i=1}^{n} (l_i / \sqrt{s_i})$$

where, T_s is the Taylor and Schwartz slope of the channel of the same length and time of flow as of actual length, n is the total number of segments of the main channel, l_i is the length of i th segment and s_i is the slope of the i th segment.

3.0 DESCRIPTION OF STUDY AREA

The Narmada is a major west flowing river in central India running through the states Madhya Pradesh , Gujarat and Maharastra and finally meet Arabian Sea. The study basin i.e. Narmada upto Manot is situated in the upper reaches of the Narmada basin. The study basin lies between east longitude 80° 24' to 81° 47' and north latitudes 22° 26' to 23° 18' in Mandla and Shahdol districts of Madhya Pradesh. The river rises in Maikala range near Amarkantak in the Shahdol district of Madhya Pradesh , at an elevation of 1057 m.

Topography of the Narmada basin above Manot is hilly with forest cover , especially in upper reaches. The river has a number of falls in its head reaches. The area is covered under Survey of India toposheets nos. 64A , 64B, 64E , 64F , in 1:250,000 scale. Fig 1 shows the map of the study basin. Detailed hydrological information, network of observation stations and other details are given in NIH Case Study No. 29 (Kumar 1990.).

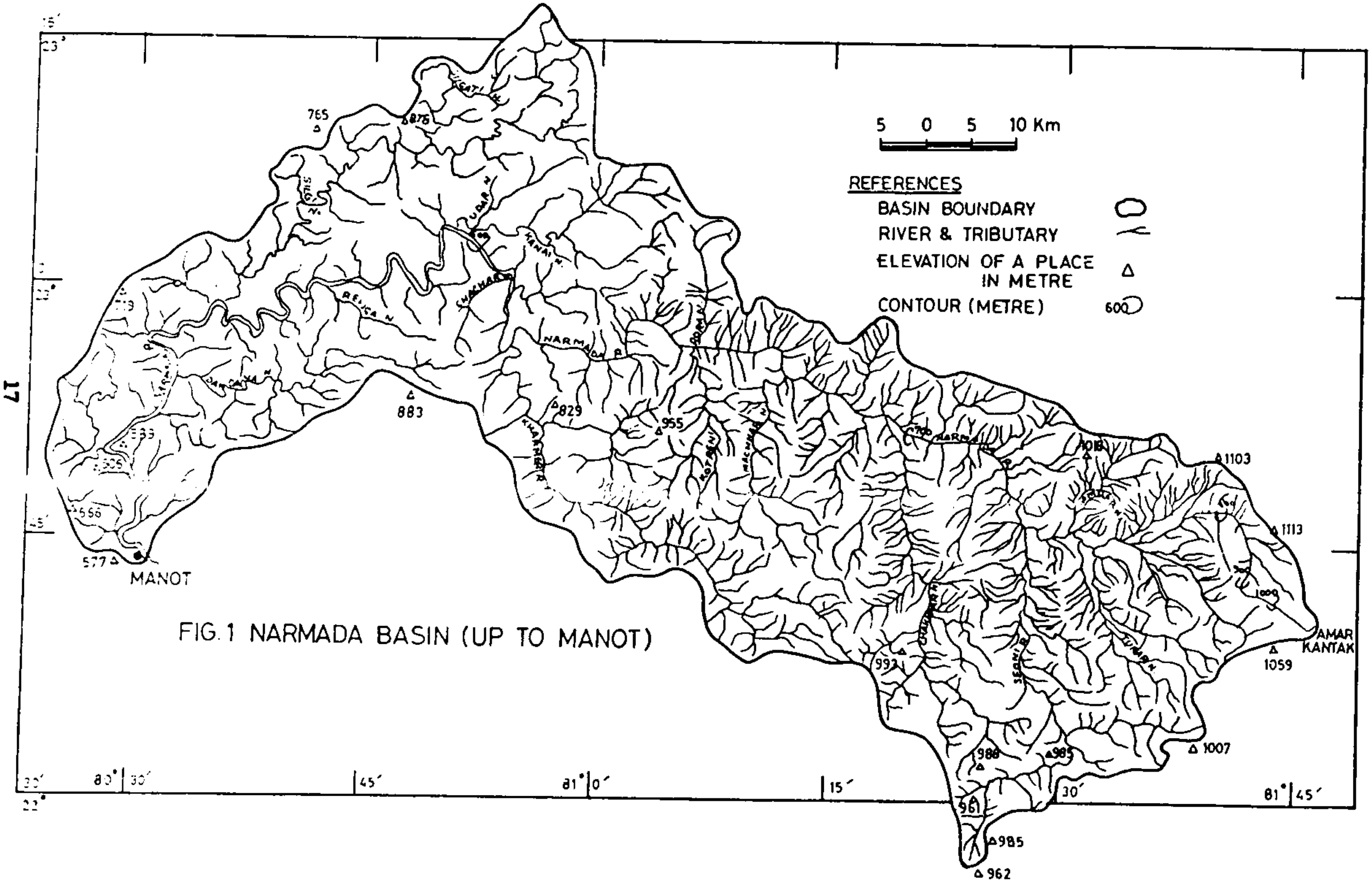

FIG. 1 NARMADA BASIN (UP TO MANOT)

4.0 ANALYSIS AND DISCUSSION OF RESULTS:

For evaluating different geomorphological parameters, the topographic map of area was drawn from the Survey of India Toposheet No.64A , 64B ,64E and 64F in the 1:2,50,000 scale. The river system of the basin was ordered according to Strahler ordering scheme discussed earlier. It is observed that the basin is sixth order basin. Map of the basin is shown in Fig.1.

Table 1 shows the linear measures of the basin. It can be seen from the table that the mean lengths, which were calculated as the ratio of total length of specific order stream to number of stream segment are 3.203 ,3.723,7.547,15.927,28.75 and 170.00km for order 1,2,3,4,5 and 6 respectively. The number of streams for different orders are 821,178.37,11,3 and 1 for order 1,2,3,4,5 and 6. respectively. Since a watershed of a given order can be modelled as a collection of sub elements, the number of streams of each order is an important concept in hydrology. It can be seen from table 1 that the number of streams of a given order decreases with the increase in order w. The stream length ratio and bifurcation ratio for the Narmada basin are 1.6020 and 3.7818 respectively. These dimensionless parameters are very useful in synthesizing hydrograph characteristics.

Table 1 : Geomorphological parameters based on linear aspect of the Narmada Basin upto Manot (Lengths are in km.)

Sl. No.	Name of parameter	Symbol	Value
1.	Basin perimeter	P	440
2.	Length of main channel	L	239
3.	Length of main channel between watershed mouth and a point near centre of mass	L_c	140
4.	Basin (or valley) length	L_b	126.25
5.	Wandering ratio		1.893
6.	Fineness ratio		0.543
7.	Stream length ratio	R_L	1.6020
8.	Bifurcation ratio	R_b	3.7818
9.	Watershed eccentricity	τ	0.796
10.	Total length of channels of each order	L_1	2629.50
		L_2	662.75
		L_3	279.25
		L_4	175.25
		L_5	86.25
		L_6	170.00
11.	Total length of all orders	L_u	4003.00
12.	Mean length of channels of each order	$\bar{L}_1$	3.203
		$\bar{L}_2$	3.723
		$\bar{L}_3$	7.547
		$\bar{L}_4$	15.927
		$\bar{L}_5$	28.750
		$\bar{L}_6$	170.000

13.	Total no. of streams of each order		
		N_1	821
		N_2	178
		N_3	37
		N_4	11
		N_5	03
		N_6	01
14.	Total no.of streams of all orders	N_u	1051

The length of channel between outlet and a point near to centre of gravity is 140 km. The other linear measures which have been computed for Narmada basin include perimeter of basin, length of main streams, watershed eccentricity etc and are given in table 1. Fig.2 shows semi log plot of stream order with stream number. Fig. 3 shows the plot of stream order vs stream length on semi log paper. Fig.4shows the semi log plot of stream order vs cumulative mean stream length. The plot shows the increasing trend in average length of the streams and it follows Horton's law of stream length.

Various areal measures evaluated for Narmada basin upto Manot are listed in table 2. The total drainage area of the basin at Gauging site at Manot is 4980 square kilometer. The drainage area of a basin is a very important geomorphological parameter and has been used widely in various hydrological simulation studies. The area drained by first, second, third , fourth, fifth and sixth order streams is 3120.30, 919.40, 329.30, 243.10, 70.50 and 297.40. sq.km. respectively. Value of area denoted here is the area from which overland flow contribute directly to the channel. Area drained by next lower stream and meeting this stream is

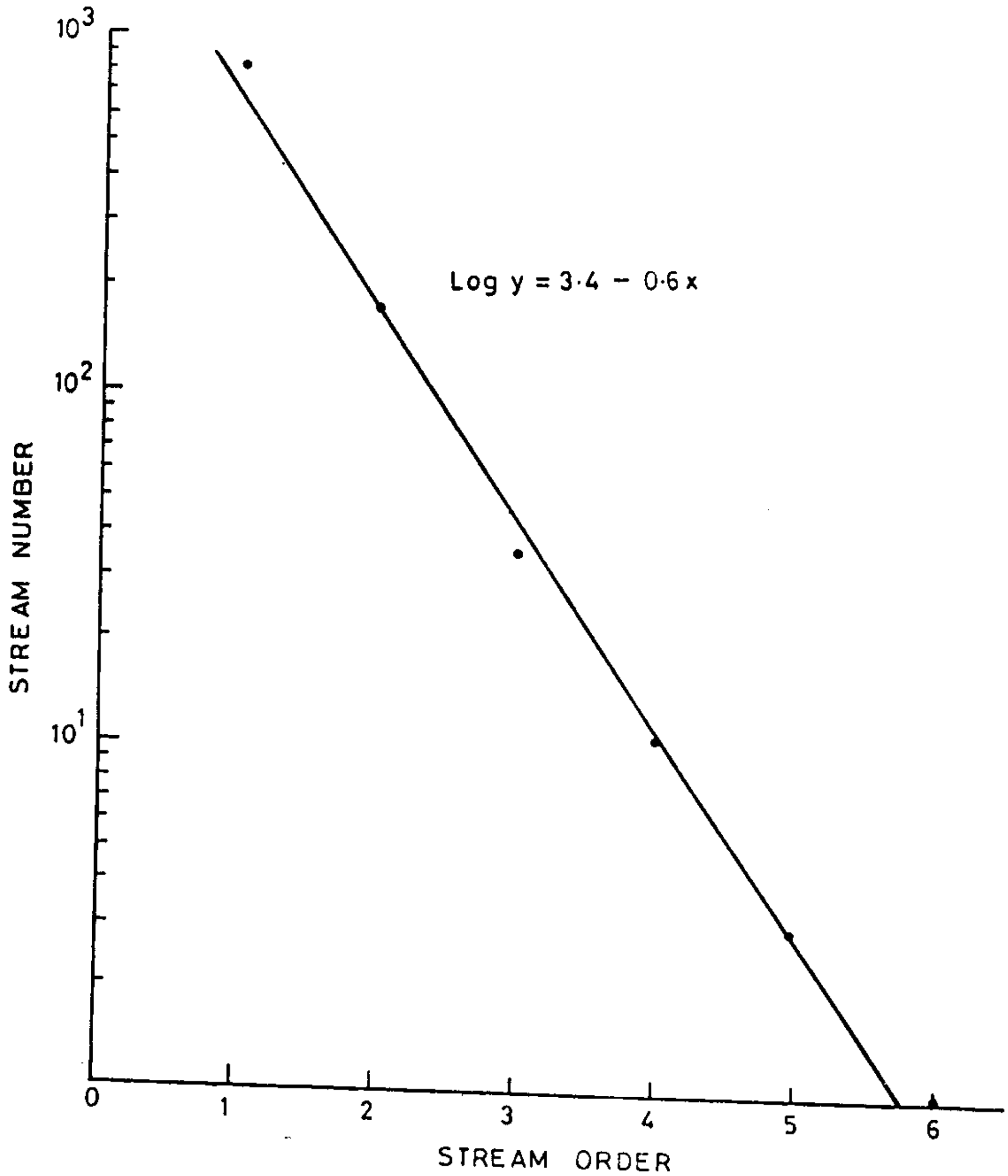

Fig.2 Semi log plot of stream order vs stream number.

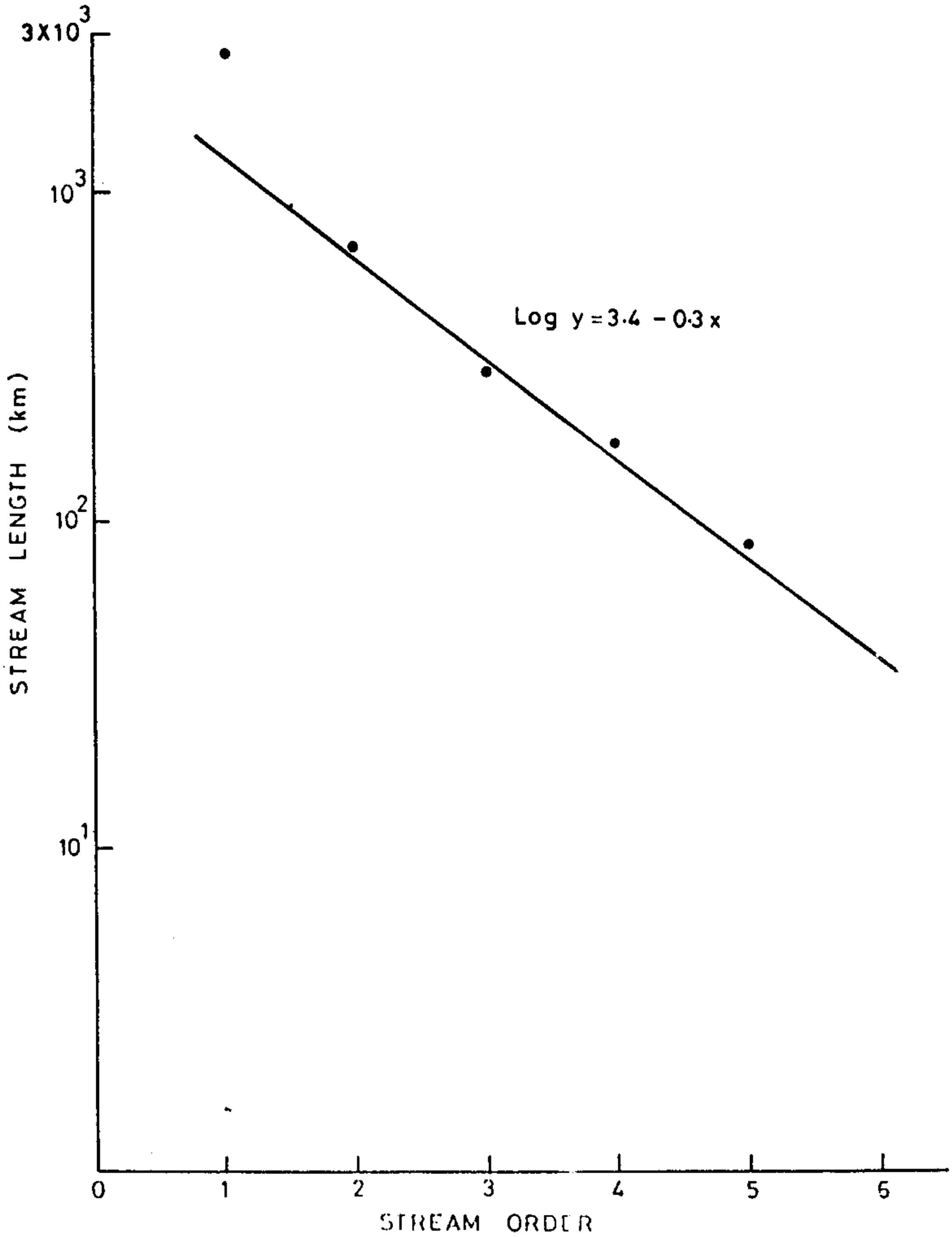

Fig.3 Semi log plot of stream order vs stream length

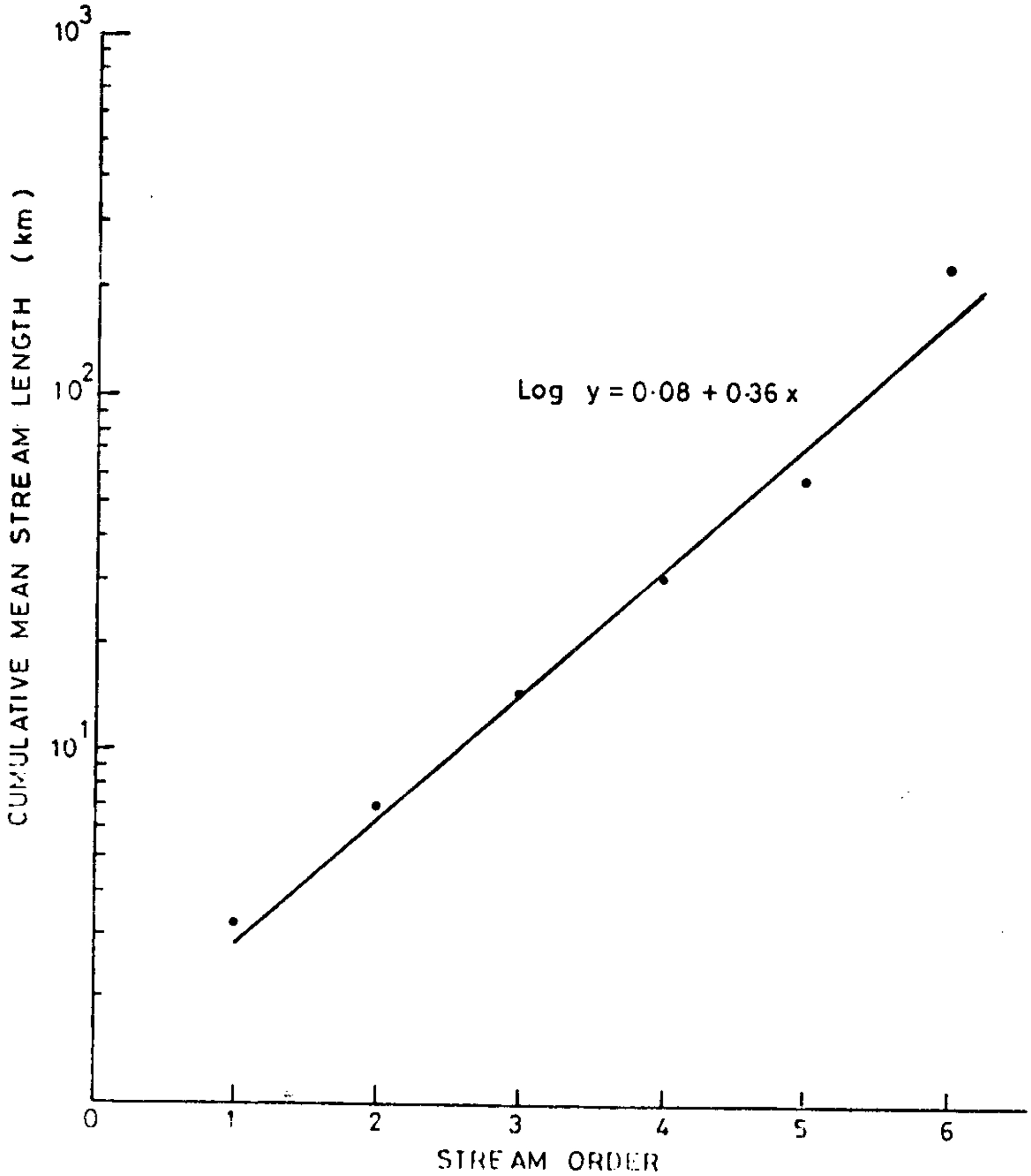

Fig. 4 Semi log plot of stream order vs cumulative mean strem length

excluded. The mean drainage area of 1st,2nd,3rd,4th,5th and 6th order streams is 3.801, 5.165, 8.900, 22.100, 23.500 and 297.400sq.km.respectively. The other areal measures which have been computed for this basin are, elongation ratio, circularity ratio, drainage density, area ratio, form factor, constant of channel maintenance and stream frequency and are listed in table 2. Fig. 5 shows the variation of mean drainage area with stream number. It can be seen from the plot that the drainage area follows the Horton's law of stream areas.

Table 2 : Geomorphological parameters based on areal aspect of the Narmada basin upto Manot (Areas are in sq. km.)

Sl. No.	Name of parameter	Symbol	Value
1.	Total drainage area	A	4980
2.	Drainage density	D	0.8038
3.	Constant of channel maintenance	C	1.244
4.	Circularity ratio	R_c	0.323
5.	Elongation ratio	R_e	0.631
6.	Watershed shape factor		3.002
7.	Unity shape factor		1.789
8.	Form factor	R_f	0.312
9.	Channel segment frequency		0.211
10.	Total drainage area of each order		
		A_1	3120.30
		A_2	919.40
		A_3	329.30
		A_4	243.10
		A_5	70.50
		A_6	297.40

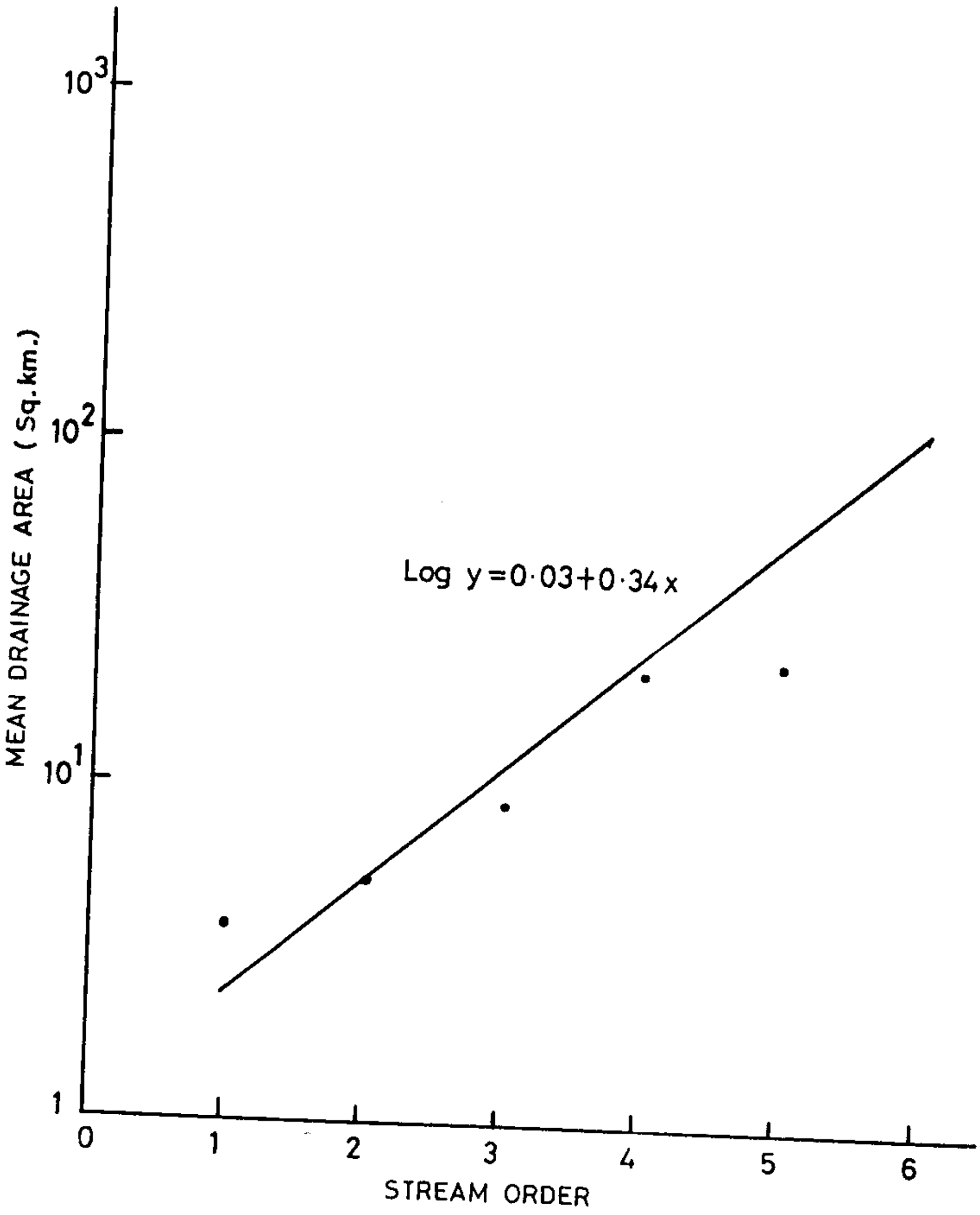

FIG. 5–SEMI LOG PLOT OF STREAM ORDER Vs MEAN DRAINAGE AREA

9.	Mean drainage area of each order		
		$\bar{A}_1$	3.801
		$\bar{A}_2$	5.165
		$\bar{A}_3$	8.900
		$\bar{A}_4$	22.100
		$\bar{A}_5$	23.500
		$\bar{A}_6$	297.400

Some of the important relief measure evaluated for the basin are listed in table 3. These measures include slope of main stream, basin relief, relief ratio, relative relief, Ruggedness number, Taylor and schawrtz slope. Fig. 6 shows the profile of the main drainage channel of the basin. The relief parameters govern the overland and stream flow processes of a basin. These parameters are of profound importance in hydrological studies in mountainous areas, and are often used in modeling hydrological responses of these areas.

Table 3 : Geomorphological parameters based on relief aspect of the Narmada basin upto Manot

Sl. No.	Name of parameter	Symbol	Value
1.	Basin relief	H	542 m
2.	Relief ratio	R_h	0.004
3.	Relative relief	R_p	0.001
4.	Ruggedness number	R_n	0.436
5.	Taylor & Schwartz slope	T_s	0.00069

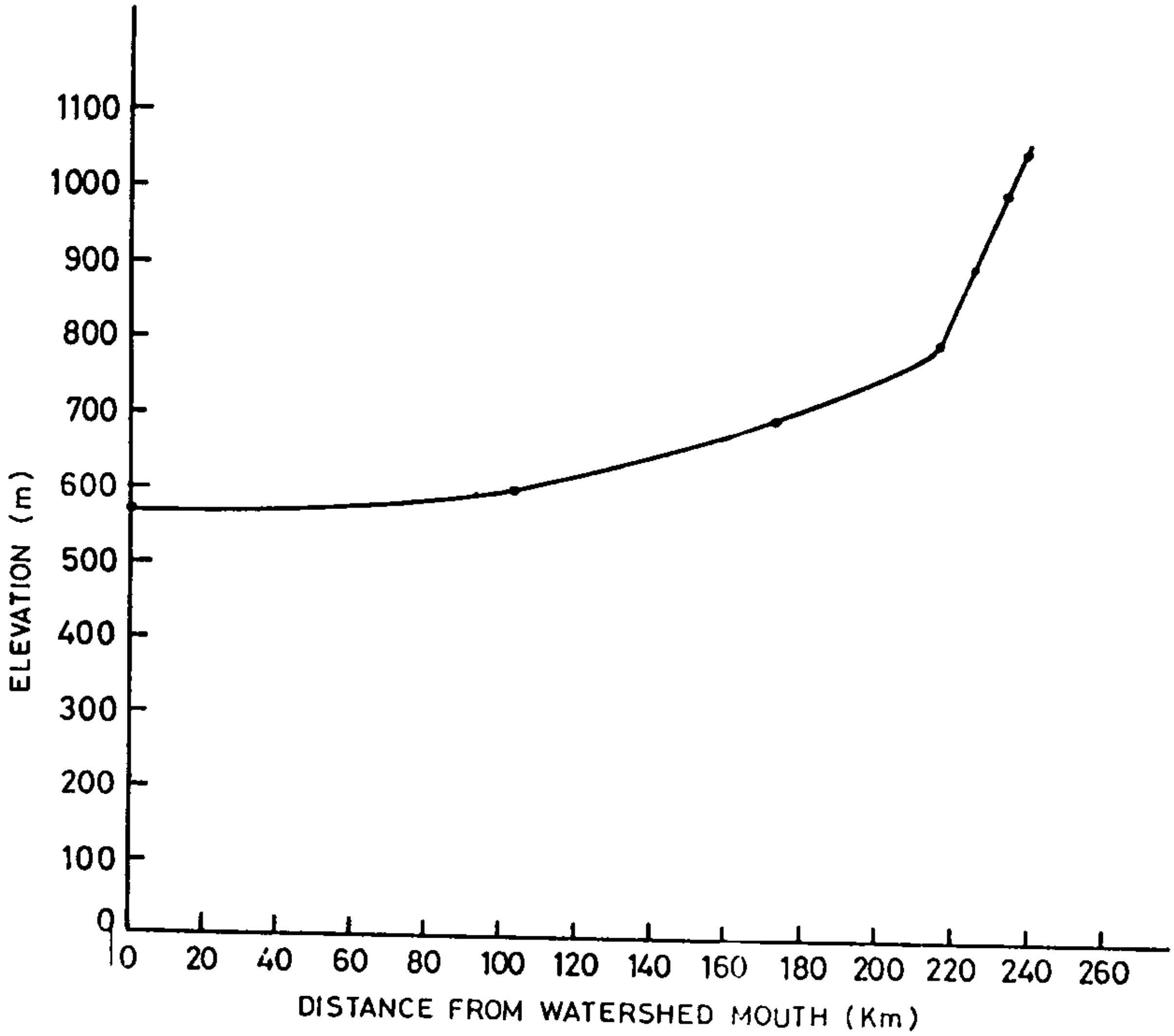

FIG. 6-MAIN CHANNEL PROFILE OF NARMADA BASIN UPTO MANOT

5.0 SUMMARY AND CONCLUDING REMARKS

In this report various geomorphological parameters covering linear, areal and relief aspects of the Narmada basin upto Manot have been evaluated using modern measuring aids. The basin under study is a sixth order basin with steep to moderate slopes. The slope is very high in its upper reaches and reduces gradually in its lower reaches. The geomorphological parameters, thus estimated, will be utilized for testing hydrological models to simulate hydrological response of the basin. Such models are very useful and are being widely used for simulating hydrological response of ungauged basin or basin with limited data.

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