CHAPTER IV
MORPHOMETRIC ANALYSIS

MORPHOMETRIC ANALYSIS

INTRODUCTION

Various morphometric parameters are useful to understand the drainage characterstics of any area. These different parameters give systematic measures of any drainage basin and also help to know the terrain texture. The evolutionary changes which are taking places throughout the geologic past in a particular area can be interpreted by computing different dimensionless parameters. With this view, various drainage parameters have been calculated for the area under investigation and are discussed in the following paragraphs.

Drainage analysis

In order to know the drainage characterstics and to have a set of systematic measures for drainage basins of different orders, various parameters have been computed. These parameters have been used to know the terrain texture of the area under study.

The area covered during present investigation is drained by the streams which originate in the Sahyadri ranges of the Western ghats and follow short tumultuous courses. Majority of the streams follow East-West course while some follow NW-SE and NE-SW courses. Most of the streams are characterised by straight segments with acute angle turns, indicative of structural control. This structural control has given rise to drainage anamolies. Most of the streams in their upper reaches exhibit the presence of rapids, which occur generally at elevations of 60-70 m. Rapids range in height from 1 m. to 15 m. The Majority of the streams have been controlled by lineaments as has been inferred from topographic sheets and LANDSAT-1 imageries. The same has already been pointed out from the rosette diagrams (Figs. 3.1 and 3.2).

Major rivers present in the area are Kajali, Machakandi, Kodavli, and Vaghotan that originate to the eastern part of the area and flow in a western direction. River Kajali takes a turn at $73^{\circ}, 25'$ from NE-SW direction and takes a 'U' turn and bends at $73^{\circ}, 22'$ from SE to NW direction ultimately joining the sea. Nearly similar trend has been followed by river Machakandi whereas, river Kodavli after flowing towards west turns from SE to NW ultimately joining the sea. It is observed that the drainage pattern in the eastern part is dendritic, which gradually gives way to sub parallel type in the western part of the area. Stream network decreases graduallyfrom East to West. The sub-parallel drainage pattern of many streams having their sharp and active meanders at places might be due to the deep seated lineaments. The river system in the area predominantly reflect two slope zones, i.e. from NE to SW and SE to NW directions. As is stated earlier in the lineament analysis, the river courses have been controlled by the trends of the

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lineaments.

On the basis of the stream flow characters, the drainage basins are classified into exorheic, endorheic and archeic types. The area studied reveals the drainage basins to be of exorheic type because many basins debouch directly into the sea. The river valleys from the area are generally short and are ranging between 6 to 30 km. in length. These rivers have generally steep valleys and are narrow in their upper reaches.

The dissection of the area is carried out by the streams. Study of the stream pattern therefore in terms of the drainage reveals the extent to which the dissection of the topography has taken place. The importance of these studies was pointed out by Horton (1945), Strahler (1952,1957) and Scheidegger (1965).

In the present study, an analysis of the stream ordering has been carried out by the method suggested by Horton (1945). This method has an advantage over other methods because it bears close relationship with the structural elements of the area. Analysis of the stream ordering has been presented in Table nos. 4.1, 4.2 a,b,c,d,e,f,g, and h, 4.3 a, b, c, d, e, f, g, h, i, j, k and l and 4.4 a, b, c, d, e, f, g, h, i, j, k and l.

Following drainage parameters have been worked out for the area under investigation to understand the terrain texture.

Abbriviations used, for different morphometric parameters.

Nu : Number of streams of order ´n´

Lu : Total length of streams of order ´n´

$\overline{Lu}$: Mean length of streams of order ´n´

Rb : Bifurcation ratio

R : Stream length ratio

Au : Area of basin

DD : Drainage Density

CM : Constant of channel maintainance

Table 4.1 : Bifurcation Ratio, Length ratio, Drainage Density and constant of channel maintainance of sixth order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	401	209.807	0.5232	3.487	0.382	9.128	--	--	--	--
II	115	549.28	4.776	4.1071	6.964	0.590	87.937	637.037	7.244	0.13804
III	28	78.875	2.816	2.8	1.353	2.070	73.987	202.625	2.739	0.36515
IV	10	58.3	5.83	2.5	1.614	1.549	114.375	239.600	2.095	0.47735
V	4	36.125	9.031	4.0	0.990	4.042	170.184	273.325	1.606	0.6227
VI	1	36.5	36.5	--	--	--	290.438	968.887	3.336	0.2998

Table 4.2 a and b : Bifurcation Ratio, Length ratio, Drainage Density and constant of channel maintainance of fourth order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	13	8.375	0.644	13	11.17	01.16	--	--	--	--
II	01	0.750	0.750	01	00.50	02.00	0.375	9.125	24.33	0.041
III	01	1.500	1.500	01	04.17	04.17	1.250	10.625	8.50	0.120
IV	01	6.250	6.250	--	---	--	8.875	16.875	1.90	0.530

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	80	44.50	00.56	4.21	1.58	2.66	--	--	--	--
II	19	28.25	01.49	2.38	1.19	1.99	13.66	044.50	3.26	0.30
III	08	23.75	02.97	8.00	1.36	5.89	23.43	060.50	2.58	0.39
IV	01	17.50	17.50	--	--	--	54.25	114.00	2.10	0.48

Table 4.2 c and d : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of fourth order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	12	5.625	0.469	04	1.324	3.021	--	--	--	--
II	03	4.250	1.417	03	2.429	1.235	1.613	5.875	3.643	0.274
III	01	1.750	1.750	01	0.411	2.429	1.563	7.625	4.880	0.204
IV	01	4.250	4.250	--	--	--	10.063	11.875	1.180	0.847

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	22	10.875	0.494	4.40	1.38	3.189	--	--	--	--
II	05	7.875	1.575	1.67	0.90	1.852	4.250	12.25	2.882	0.347
III	03	8.750	2.917	3.00	1.59	2.502	8.925	25.75	2.885	0.347
IV	01	5.500	5.500	--	--	--	15.813	33.00	2.087	0.479

Table 4.2 e and f: Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of fourth order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	10	6.25	0.625	05	2.50	2.00	--	--	--	--
II	02	2.50	1.250	02	0.90	2.20	1.188	3.50	2.947	0.339
III	01	2.75	2.750	01	1.38	0.72	2.938	11.50	3.914	0.255
IV	01	2.00	2.00	--	--	--	9.063	13.50	1.490	0.671

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	26	12.00	0.462	5.20	1.548	0.359	--	--	--	--
II	05	7.75	1.550	5.00	4.428	1.129	3.938	13.75	3.492	0.286
III	01	1.75	1.750	1.00	0.233	4.286	2.375	21.50	9.053	0.110
IV	01	7.50	7.500	--	--	--	14.875	29.00	1.950	0.513

Table 4.2 g and h : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of fourth order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	43.00	23.88	0.556	5.375	2.032	2.642	--	--	--	--
II	8.00	11.75	1.469	2.000	1.146	1.744	08.25	18.750	2.273	0.44
III	4.00	10.25	2.563	4.000	1.000	3.999	10.50	32.625	23.107	0.322
IV	1.00	10.25	10.250	--	--	--	29.56	56.125	--	1.899

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	7	3.13	0.45	2.33	0.71	3.27	--	--	--	--
II	3	4.38	1.46	3	1.25	2.40	1.44	5.00	3.48	0.29
III	1	3.50	3.50	1	0.61	1.64	2.31	8.75	3.78	0.26
IV	1	5.75	5.75	--	--	--	8.13	16.75	2.06	0.49

Table 4.3 a and b : Bifurcation Ratio, Length ratio Drainage Deñty and constant of channel maintainance of third order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	05	2.25	0.45	05	1.50	3.33	--	--	--	--
II	01	1.50	1.50	01	0.42	2.33	0.688	3.75	5.45	0.183
III	01	3.50	3.50	--	--	--	3.125	7.25	2.32	0.430

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	05	2.00	0.40	05	1.60	3.13	--	--	--	--
II	01	1.25	1.25	01	0.38	2.60	0.563	3.25	5.777	0.173
III	01	3.25	3.25	--	--	--	1.438	6.75	4.700	0.212

Table 4.3 c and d : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of third order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	08	3.625	0.45	08	4.88	1.67	--	--	--	--
II	01	0.750	0.75	01	0.33	3.00	0.188	4.375	23.33	0.042
III	01	2.250	2.25	--	--	--	2.750	7.625	02.77	0.360

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	02	0.25	0.125	02	0.20	10.00	--	--	--	--
II	01	1.25	1.250	01	0.56	1.80	0.425	1.50	3.53	0.283
III	01	2.25	2.250	--	--	--	1.625	3.75	2.31	0.433

Table 4.3 e and f : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of third order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	14	8.75	0.625	07	1.52	4.60	--	--	--	--
II	02	5.75	2.875	02	1.045	1.913	2.813	14.50	5.15	0.194
III	01	5.50	5.500	--	--	--	10.575	20.00	1.89	0.529

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	02	0.50	0.125	02	1.00	4.00	--	--	--	--
II	01	0.50	0.500	01	0.40	2.50	0.375	1.00	2.67	0.375
III	01	1.25	1.250	--	--	--	0.563	2.25	4.00	0.250

Table 4.3 g and h : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of third order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	7	5.375	0.768	3.50	2.389	1.465	--	--	--	--
II	2	2.250	1.125	2.00	0.600	3.333	0.625	3.125	5.00	0.20
III	1	3.750	3.750	--	--	--	4.250	11.375	2.68	0.37

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	12	4.50	0.375	12	7.50	1.60	--	--	--	--
II	01	0.60	0.60	01	0.19	5.42	0.563	1.10	1.96	0.511
III	01	3.25	3.25	--	--	--	2.500	8.35	3.34	0.299

Table 4.3 i and j : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of third order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	05	4.50	0.375	5	1.30	3.85	--	--	--	--
II	01	0.60	0.600	1	0.56	1.80	0.375	2.8750	7.667	0.130
III	01	3.25	3.250	--	--	--	3.250	5.1250	1.577	0.634

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	8	3.75	0.47	4	3.00	1.33	--	--	--	--
II	2	1.25	0.63	2	0.26	7.60	0.775	1.875	2.419	0.413
III	1	4.75	4.75	--	--	--	7.500	9.750	1.300	0.769

Table 4.3 k and l : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of third order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	7	3.88	0.55	07	3.100	2.26	--	--	--	--
II	1	1.25	1.25	01	0.385	2.60	0.44	1.375	3.143	0.318
III	1	3.25	3.25	--	--	--	3.00	8.375	2.792	0.358

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	9	4.125	0.458	4.50	3.30	1.37	--	--	--	--
II	2	1.250	0.625	2.00	0.23	0.80	0.625	1.625	2.60	0.385
III	1	5.500	5.500	--	--	--	5.375	10.875	2.02	0.494

Table 4.4 a and b : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of second order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	1.00	0.50	0.50	1.00	0.20	--	--	--	--	--
II	1.00	2.50	2.50	--	5.00	--	1.563	3.00	--	--

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	01	0.25	0.25	01	0.1	10.00	--	--	--	--
II	01	2.50	2.50	--	--	--	1.80	--	--	--

Table 4.4 c and d : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of second order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	02	1.25	0.625	02	0.55	3.6	--	--	--	--
II	01	2.25	2.250	--	--	--	1.375	3.50	--	--

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	01	1.75	1.75	01	0.778	1.29	--	--	--	--
II	01	2.25	2.25	--	--	--	0.375	4.00	--	--

Table 4.4 e and f : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of second order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	01	0.75	0.75	01	0.5	2.00	--	--	--	--
II	01	1.50	1.50	--	--	--	1.125	2.25	--	--

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	05	4.75	0.95	5.00	1.06	4.74	--	--	--	--
II	01	4.50	4.50	--	--	--	2.988	9.25	--	--

Table 4.4 g and h : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of second order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	02	1.75	0.875	02	1.40	1.43	--	--	--	--
II	01	1.25	1.25	--	--	--	0.357	3.00	8.403	0.119

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	04	2.50	0.625	04	0.90	4.40	--	--	--	--
II	01	2.75	2.750	--	--	--	3.25	5.25	1.62	0.619

Table 4.4 i and j : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of second order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	01	1.25	1.25	01	0.416	2.40	--	--	--	--
II	01	3.00	3.00	--	--	--	3.688	4.25	1.15	0.868

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	03	1.50	0.50	3.00	0.50	6.00	--	--	--	--
II	01	3.00	3.00	--	--	--	2.813	4.50	1.60	0.625

Table 4.4 k and l : Bifurcation Ratio, Length ratio Drainage Density and constant of channel maintainance of second order basin

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	02	2.00	1.00	2	1.0	2.00	--	--	--	--
II	01	2.00	2.00	--	--	--	1.75	4.00	2.29	0.44

Order	Nu	Lu	$\overline{Lu}$	Rb	R		Au	Channel length	DD	CM
I	01	0.50	0.50	01	0.4	2.50	--	--	--	--
II	01	1.25	1.25	--	--	--	0.63	1.75	2.80	0.36

1. Bifurcation ratio.
2. Stream length.
3. Drainage density.
4. Constant of channel maintainance.
5. Hypsometric analysis.
6. Altimetric analysis.
7. Slope analysis and
8. Stream gradient Index.

These are dimensionless parameters which have been determined separately for all the basins of fifth order present in the study area.

1. Bifurcation ratio

It is the ratio of number of streams of any given order to the number of streams in the next lower order (Horton, 1945). The bifurcation ratio explains branching probability in a particular region. It depends mainly on different geological and environmental factors. It is the common observation that unless there is a strong geologic control prevalent in the region, bifurcation ratio does not show any significant variation.

Bifurcation ratio for the basins of the fifth order within the area have been determined and is presented in table 4.5. From the table, it can be seen that each basins of fifth order shows much variations in the values of bifurcation ratio. In basins 1 and 8, there is a decrease in

TABLE 4.5 : Bifurcation ratio for the basins of fifth order

SR. NO.	STREAM ORDERS ->	I	II	III	IV	AREA IN SQ.KMS.
	BASIN NOS.					
1.	1	4.35	4.00	3.30	3.00	130.325
2.	2	5.00	3.50	4.00	1.00	049.387
3.	3	6.00	2.50	4.00	1.00	030.375
4.	4	4.80	6.00	1.00	1.00	025.125
5.	5	2.28	7.00	1.00	1.00	066.375
6.	6	7.66	1.50	2.00	1.00	048.437
7.	7	4.93	3.75	4.00	1.00	096.060
8.	8	5.80	3.00	2.50	2.00	039.500

TABLE 4.6 : Drainage density for the basins of fifth order

SR. NO.	STREAM ORDERS ->	II	III	IV	V	AVERAGE
	BASIN NOS.					
1.	1	5.50	2.92	2.02	2.48	3.23
2.	2	1.31	1.47	1.22	1.01	1.25
3.	3	3.06	4.07	3.90	2.33	3.34
4.	4	3.20	8.23	3.53	1.58	4.13
5.	5	3.02	2.76	6.56	0.99	3.33
6.	6	3.72	6.87	5.03	2.18	4.45
7.	7	3.30	6.24	1.68	1.26	3.12
8.	8	1.52	1.22	1.17	0.88	1.20

Table 4.7 : Constant of channel maintenance for the basins of fifth order

SR. NO.	STREAM ORDER ->	II	III	IV	V	AVAERAGE
	BASIN NOS.					
1.	1	0.18	0.34	0.50	0.40	0.36
2.	2	0.76	0.68	0.82	0.99	0.81
3.	3	0.33	0.24	0.26	0.43	0.32
4.	4	0.31	0.12	0.28	0.63	0.34
5.	5	0.33	0.36	0.15	0.99	0.46
6.	6	0.27	0.42	0.20	0.46	0.34
7.	7	0.30	0.16	0.60	0.80	0.47
8.	8	0.66	0.82	0.85	1.13	0.87

the values of the bifurcation ratio with respect to the stream order segments while in basins 2,3,6 and 7, there is a decrease in the values of the bifurcation ratio from lower to higher order, again increases and ultimately decreases to the higher order basin. Whereas, in basin 4 and 5, there is an increase in the values of the bifurcation ratio from first to second and a decrease in the values of the bifurcation ratio for higher order basin. The values of the bifurcation ratio for the higher order stream segments are less than those for the lower order stream segments, indicating that branching probability is less for the higher order stream segments.

Values of the bifurcation ratio, reveal a geometrical similarity in the drainage basins. The ratio for higher order basins are low, indicate strong geological control in their development. Values of the bifurcation ratio lie between 3 and 5, indicating the homogenity in the geological characters of the area. Decrease in the values of the bifurcation ratio for higher order stream segments appears to be due to the development of the drainage on the Quaternary Sediments.

2. Stream length

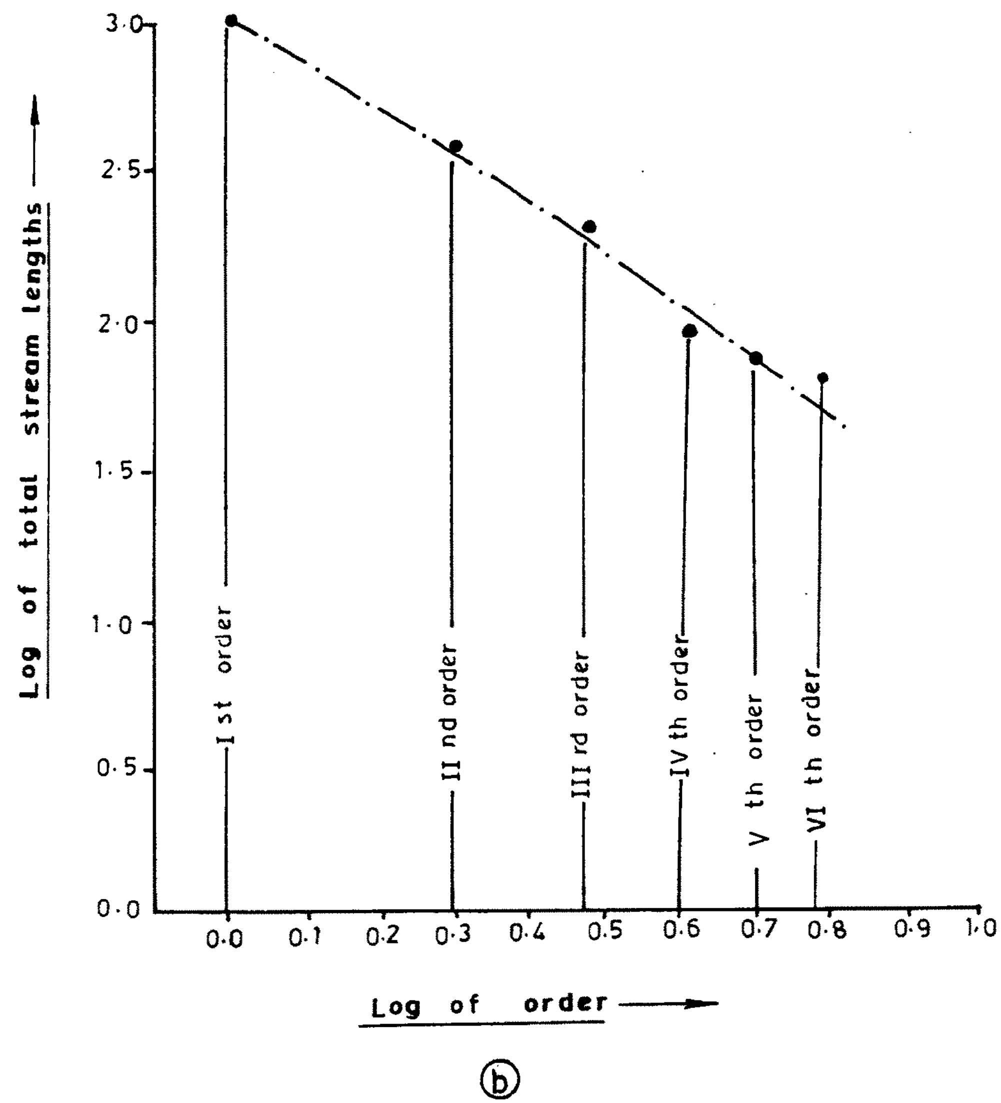
Study of the stream length with respect to the stream order is of significant importance. Stream length for the basin of the given order is inversely proportional to the stream order (Strahler, 1957). Plot on the double log paper of total stream length of each order VS. the Stream order results in a straight line, indicating that the relation between the two is a power function.

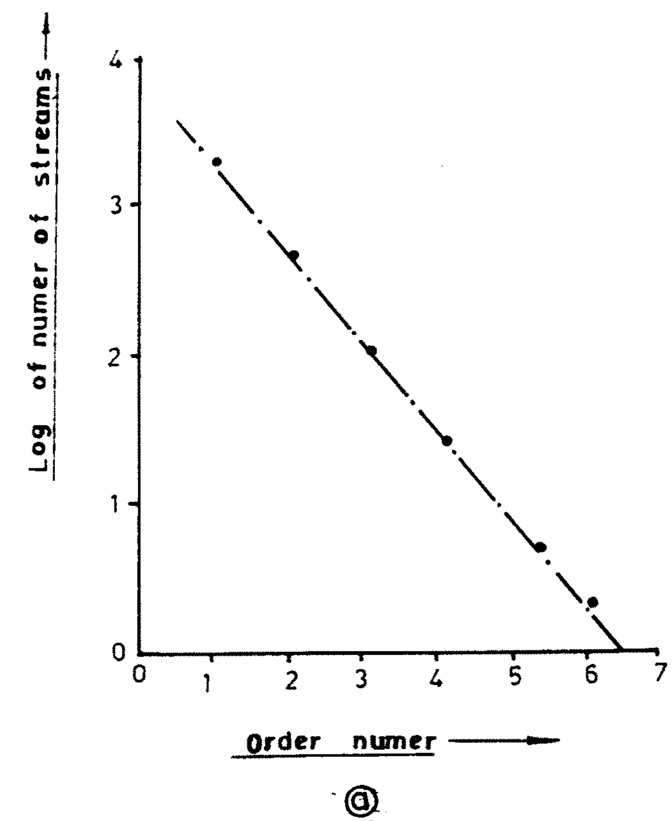
In the present studies, plots of the logarithm of total stream length for each order against logarithm of the stream order have been made for the basins from the total area. The stream length analysis of these basins have been carried out by following the method suggested by Horton(Op.cit.). Accordingly, separate graph has been prepared and presented in fig. 4.1. The plots yield a regression which is not a straight but a curved line convex upwards. Increase in the slope of the line with increase in the stream order suggests that the length of higher order streams are greater than what should normally be expected. This could be due to the headward erosion of higher order streams which has been guided by the structurally weaker zones.

3. Drainage density

It is a linear scale measurement of a basin. With the help of the drainage density, texture of a topography can be explained. Frequency of the change in the ups and downs of the landscape can also be expressed by drainage density. Texture can be expressed by the relative closeness of the drainage network.

Ratio of sum of the channel length to the basin area gives the drainage density (Strahler, 1957). Drainage density has been calculated for second and higher order basins.





Regression coefficient b , $rb = \log^{-1} b$.

Regression coefficient	Bifurcation ratio
b	rb
0·6500	4·467

FIG. 4·1 : REGRESSION COEFFICIENT OF a) STREAM SEGMENTS ON STREAM ORDER.
b) TOTAL STREAM LENGTH ON STREAM ORDER FROM THE AREA.

Values of the drainage density for all the eight basins of the fifth order have been presented in Table 4.6. It can be seen that the values of the higher order basins are low compared to the lower order basins. The lower values of the drainage density for the higher order basins might be due to the streams flowing in more or less low elevated area. Average values of the drainage density of the basins 2 and 8 are low, show that these basins have been developed on low elevated area. Average values of the drainage density for basins 1, 3 and 7 are slightly higher probably because of the basins originating relatively at higher elevation, ultimately joining the sea.

4. Constant of channel maintenance

Drainage characterstics can also be described by another linear scale measurement, i.e. Constant of channel maintenance. It is the inverse of the drainage density (Schumm, 1956). The constant of channel maintenance has been calculated from the values of the drainage density. The values obtained are presented in Table 4.7. It can be seen from this table that the constant of channel maintenance is more or less same for the basin 2, it is 0.81 and for the basin 8 it is 0.87. Whereas, for basins 1, 3, 4, and 6 the values are more or less same except for basins 5 and 7, it is 0.46 and 0.47 respectively. From the observations made earlier, regarding basin numbers 2 and 8, it appears that the geomorphic evolution of these two basins is more or less identical and therefore the degree of dissection of topography is also same.

It has been observed that there appears to be no strong geologic control in the geomorphic evolution of these basins. Study of stream length with respect to the stream order indicates that the headward erosion of the higher order streams have probably been guided by the structurally weaker zones.

5. Hypsometric analysis

In order to evaluate the amount of dissection brought about by the fluvial processes, the area-altitude analysis i.e. Hypsometric analysis, has been carried out by following the method suggested by Strahler, (1952). It is the study of the distribution of the horizontal cross sectional area of the landmass with respect to elevation. This is represented graphically by plotting cross sectional area of the basin under investigation VS. the respective elevation. This plot results in the form of a smooth curve. The percentage hypsometric method has been used to estimate the amount of dissection that the individual drainage basin has undergone (Strahler, op.cit). In the hypsometric analysis, two ratios are involved, viz,

a. Ratio of the area between a contour and the upper perimeter to total drainage basin area and
b. Ratio of the highest of the contour above the base to the total height of the basin.

While plotting, the first ratio is represented on an abscissa and second on an ordinate. The resulting curve is termed as the percentage hypsometric curve. The curves for the basins of second, third, fourth and fifth orders have been prepared and presented in Figs. 4.2 a, b, c, d, e, f, g and h.

According to Strahler (1952), hypsometric curves exhibit different forms with wide range in the sequence of drainage basins, which commence with youthful stage, termed as an inequilibrium stage, progressing through a stage of full maturity, termed as equilibrium stage finally attaining an old stage, termed as monadnock phase. The area below the curve in each stage, therefore, varies, which is termed as the hypsometric integral. According to Strahler, there is a critical value of the hypsometric integral for each phase. According to him the transition from inequilibrium to equilibrium stage corresponds approximately to a value of 0.60 of hypsometric integral; whereas, monadnock becomes conspicious feature, when hypsometric integral drops down to 0.35. Accordingly, the hypsometric integral for the basins of different orders within the fifth order basin, from the area of investigation has been determined. The hypsometric integral values are the ratio of the area below the hypsometric curve to the total area which have been calculated for representative basins of different orders within the fifth order basins from the area investigated. The values so obtained are presented in Table 4.8.

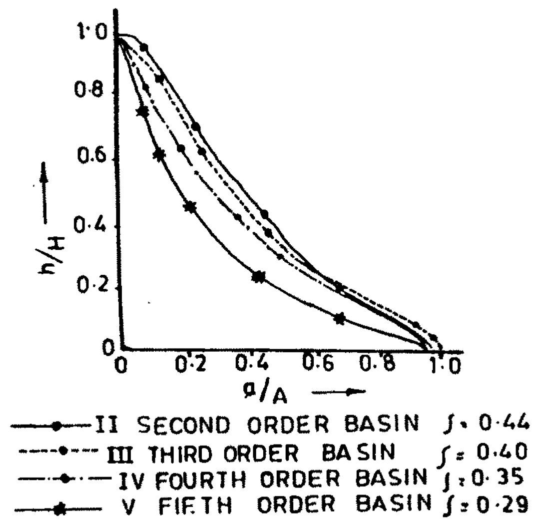


FIG. 4·2 a : HYPSOMETRIC CURVES FOR THE 5th ORDER BASIN No. 1.

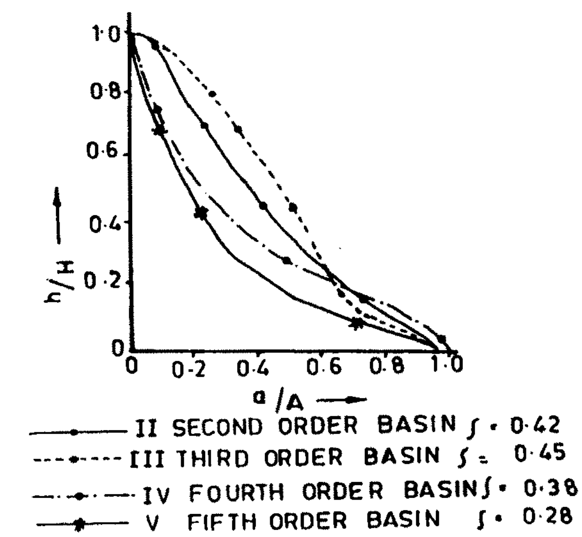
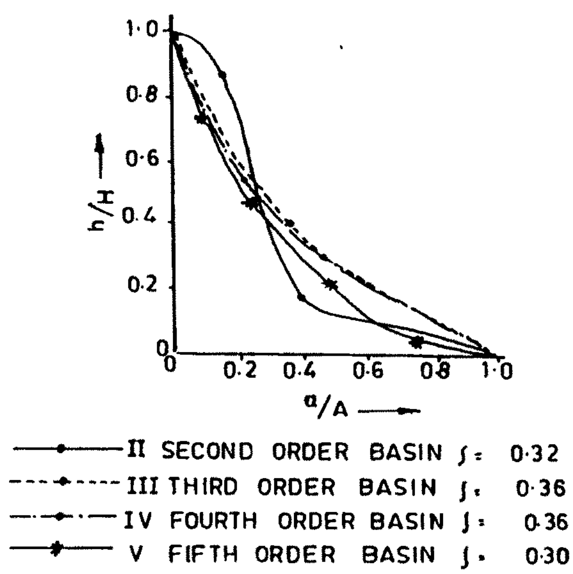


FIG. 4·2 b: HYPSOMETRIC CURVES FOR THE 5th ORDER BASIN No. 2.



FIC. 4·2 c : HYPSOMETRTIC CURVES FOR THE 5th ORDER BASIN No. 3

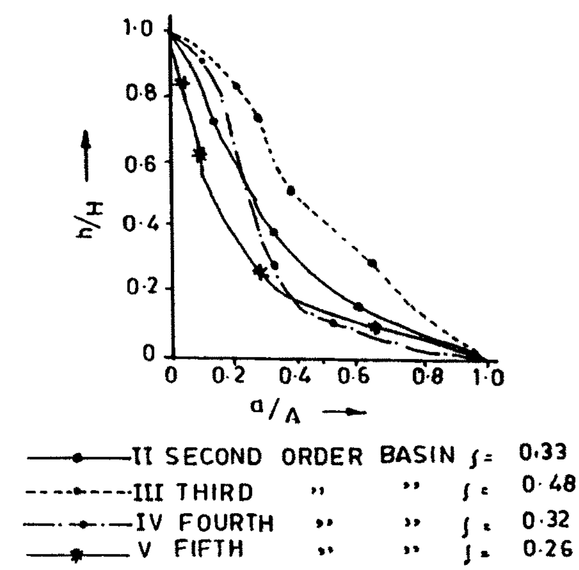
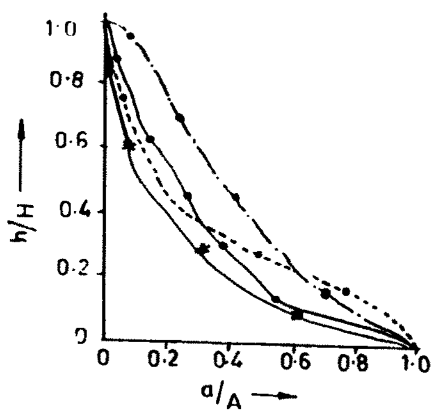
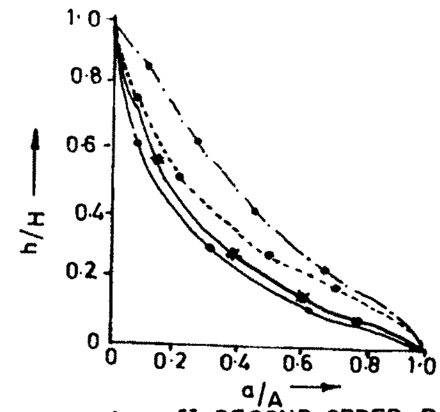


FIG. 4·2 d : HYPSOMETRIC CURVES FOR THE 5th ORDER BASIN No. 4.



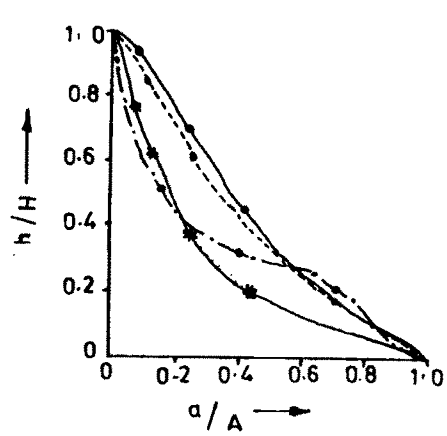
II SECOND ORDER BASIN ∫ = 0·29
III THIRD " " ∫ = 0·34
IV FOURTH " " ∫ = 0·41
V FIFTH " " ∫ = 0·24

FIG. 4·2 e: HYPSOMETRIC CURVES FOR THE 5th ORDER BASIN No. 5.



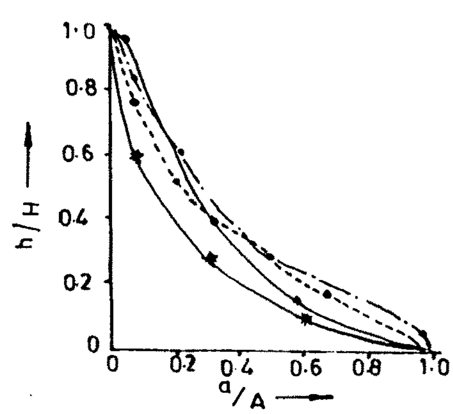
II SECOND ORDER BASIN ∫ = 0·25
III THIRD " " ∫ = 0·37
IV FOURTH " " ∫ = 0·39
V FIFTH " " ∫ = 0·21

FIG. 4·2 f: HYPSOMETRIC CURVES FOR THE 5th ORDER BASIN No. 6



II SECOND ORDER BASIN ∫ = 0·41
III THIRD " " ∫ = 0·40
IV FOURTH " " ∫ = 0·21
V FIFTH " " ∫ = 0·28

FIG. 4·2 g: HYPSOMETRIC CURVES FOR THE 5th ORDER BASIN No. 7



II SECOND ORDER BASIN ∫ = 0·32
III THIRD " " ∫ = 0·35
IV FOURTH " " ∫ = 0·37
V FIFTH " " ∫ = 0·25

FIG. 4·2 h: HYPSOMETRIC CURVES FOR THE 5th ORDER BASIN No. 8

Table 4.8 : Hypsometric integral values for the basins of fifth order

BASIN NOS.	BASIN ORDERS II	III	IV	V
1	0.44	0.40	0.35	0.29
2	0.42	0.45	0.38	0.28
3	0.32	0.36	0.36	0.30
4	0.33	0.48	0.32	0.26
5	0.29	0.34	0.41	0.24
6	0.25	0.37	0.39	0.21
7	0.41	0.40	0.31	0.28
8	0.32	0.35	0.37	0.25

Table 4.9 : General slope directions of the fifth order basins in area

BASIN NOS.	SLOPE TREND	HIGHEST ELEVATION IN BASIN	LOCATIONS
1	NW to SE	272 m.	Dombal Tek Dongar
2	NE to SW	183 m.	N of Kalkarwadi about 1.5 km.
3	NE to SW	205 m.	E of Lavgan about 3 km.
4	SE to NW	344 m.	W of Khawaddi about 100 m.
5	NW to SE	300 m.	E of Run about 1 km.
6	SE to NW	259 m.	Bhityakwadi
7	NW to SE	190 m.	W of Dhopeshwar about 2 km.
8	NE to SW	207 m.	NE of Nanarkewadi about 2.5 km.

It can be seen that the hypsometric integral for higher order streams in all basins indicates monadnock phase, whereas, the values around 0.40 indicates the maturity stage of the development. The values of the hypsometric integral for basins 1, 2 and 7 have reached to an equilibrium stage, thereby suggesting the maturity stage of development.

From the hypsometric analysis, it can be said that the area under investigation indicates the monadnock stage of aeration, represents the residual hills.

6. Altimetric analysis

Preliminary field studies conducted in the study area indicate the presence of few planar surfaces. In order to establish their presence, an altimetric analysis of survey of India topographic sheets was undertaken. The toposheet area was divided in to square at regular grid interval of 2 cms. and the values of the highest contour within each square area was recorded. From the data obtained the altitude frequency curve for the area has been drown (Fig. 4.3.). From this figure it is clear that 30 m., 90 m., 120 m., 180 m. and above 260 m. levels are the prominant ones.

Altimetric analysis yields the nature of relative relief in the area is a significant morphometric tool for the determination of degree of dissection and assesment of the stage of terrain development. The relative relief also helps to know the morphological characteristics of the region. For

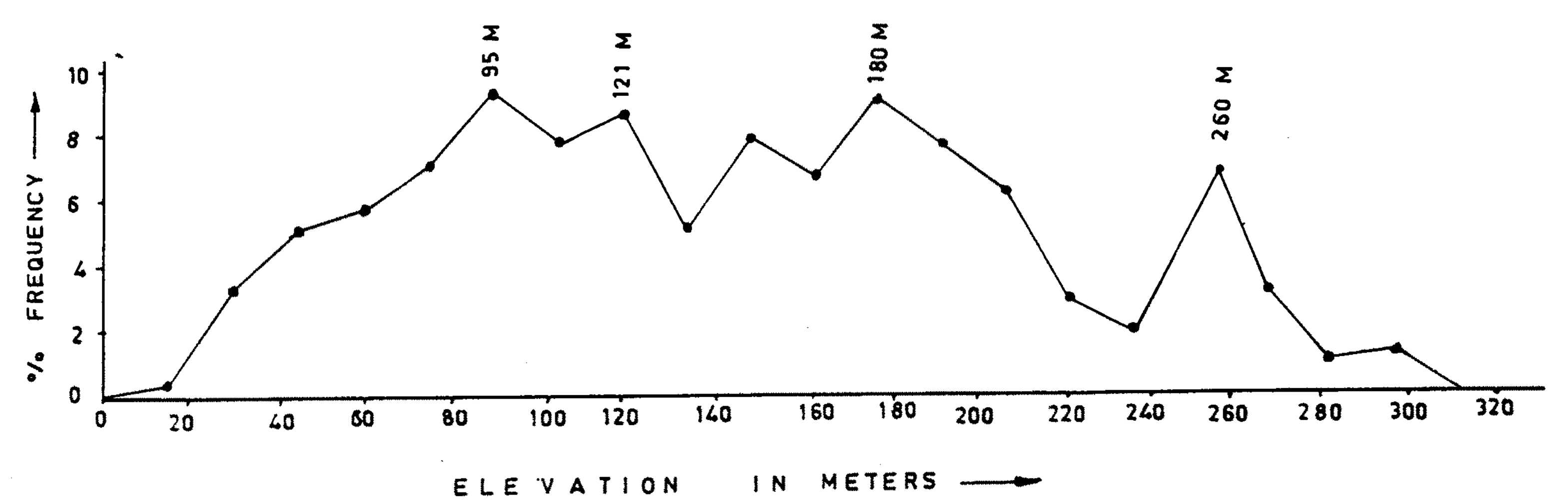


FIG. 4·3 : ALTITUDE FREQUENCY CURVE, FOR THE BHATYA - VIJAYDURG AREA.

the purpose of the relative relief study, the method suggested by Dubey, (1986) has been followed. The difference in heights between the highest and the lowest point in one cm. square grid has been considered. For the purpose, fifth order basins within the area can be divided into six categories of relative relief, as very low (0 to 20 m.); low (20 to 80 m.);moderate (80 to 140 m.); moderately high (140 to 200 m.); high (200 to 260 m.), and very high (above 260 m.).

The altimetric analysis of the area under investigation reveals that the area generally slopes from NE to SW; NW to SE and SE to NW directions. The general slope direction along with the localities of all the basins of the fifth order have been presented in Table 4.9. In order to simplify the prominent relative relief categories are grouped on the basis of percent frequency and are shown in Table 4.10. From this table it can be seen that major part of the area under investigation falls under the category of moderate to moderately high category in terms of percent frequency, whereas, a small part of the basin falls under the category of very low and very high relative relief.

The frequency polygons for all the fifth order basins under investigation have been prepared. (Figs. 4.4 a,b,c,d,e,f,g, and h) From the figures, it is seen that basins 1, 7 and 8 reveal negative skewness, basins 2, 3, and 6 are symmetrically skewed, whereas, basins 4 and 5 are

Table 4.10 : Relative Relief categories and frequency percentage (fifth order basins) of the Bhatya-Vijaydurg area (one Km^2 grid)

SR. NO.	VERY LOW BELOW 20 M.	LOW BELOW 80 M.	MODERATE BELOW 140 M.	MODERATELY HIGH BELOW 200 M.	HIGH BELOW 260 M.	VERY HIGH ABOVE 260 M.
1.	---	---	120-140 12.16 %	180-200 10.44 %	---	260-280 5.22 %
2.	---	70-80 20.98 %	---	150-170 23.08 %	---	---
3.	---	---	120-140 19.02 %	160-180 23.81 %	---	---
4.	---	---	140-160 5.26 %	---	240-260 21.05 %	---
5.	---	---	---	200-220 16.67 %	240-260 13.89 %	280-300 11.11 %
6.	---	---	---	160-180 18.60 %	---	---
7.	---	60-80 15.07 %	---	160-180 23.29 %	---	---
8.	---	40-60 10.30 %	100-140 27.89 %	---	---	---
AVG. %	---	15.69 %	16.09 %	19.31 %	17.47 %	8.17 %

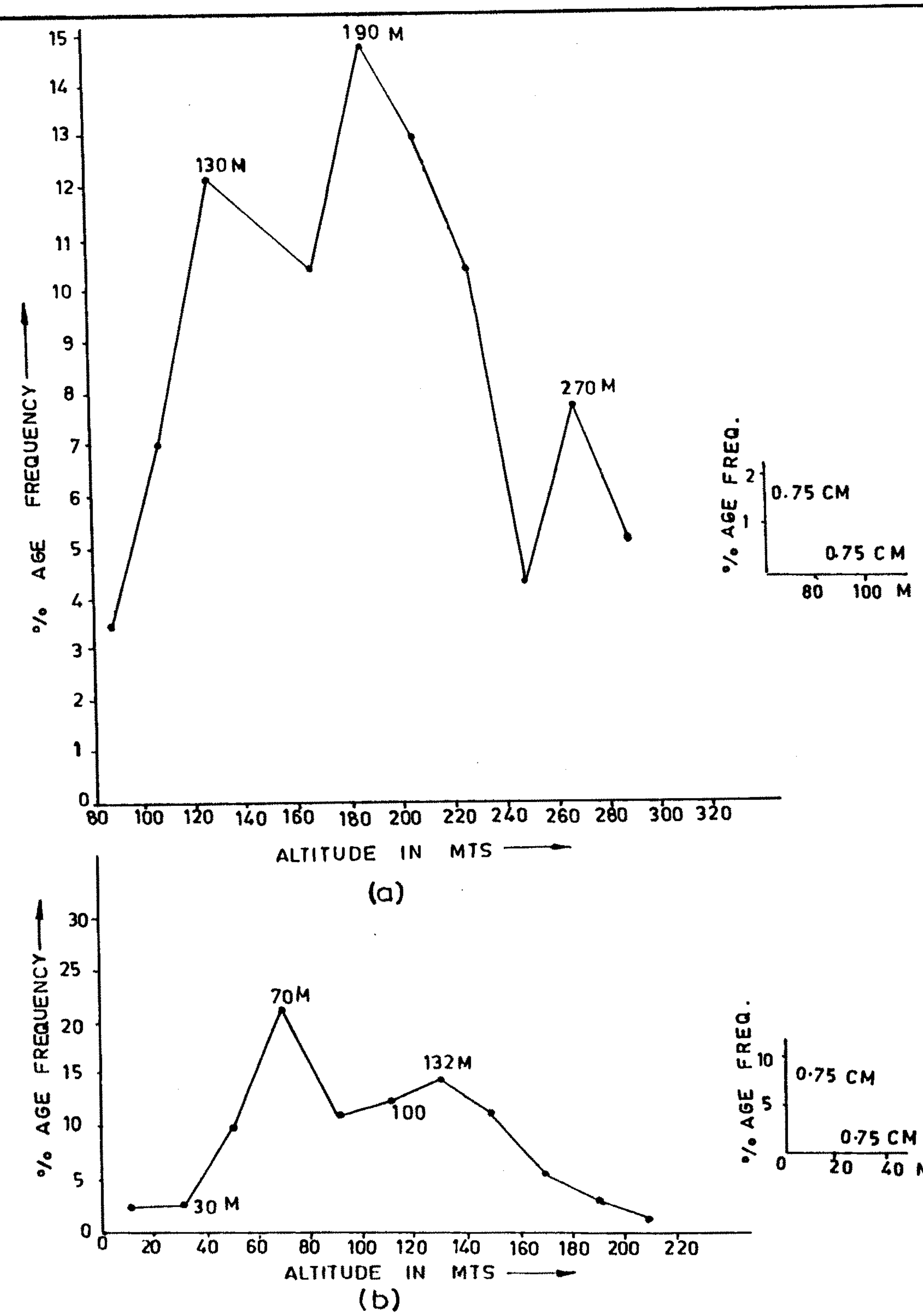


FIG. 4.4 a & b) : ALTITUDE FREQUENCY CURVES OF THE 5th ORDER BASIN Nos.1 & 2.

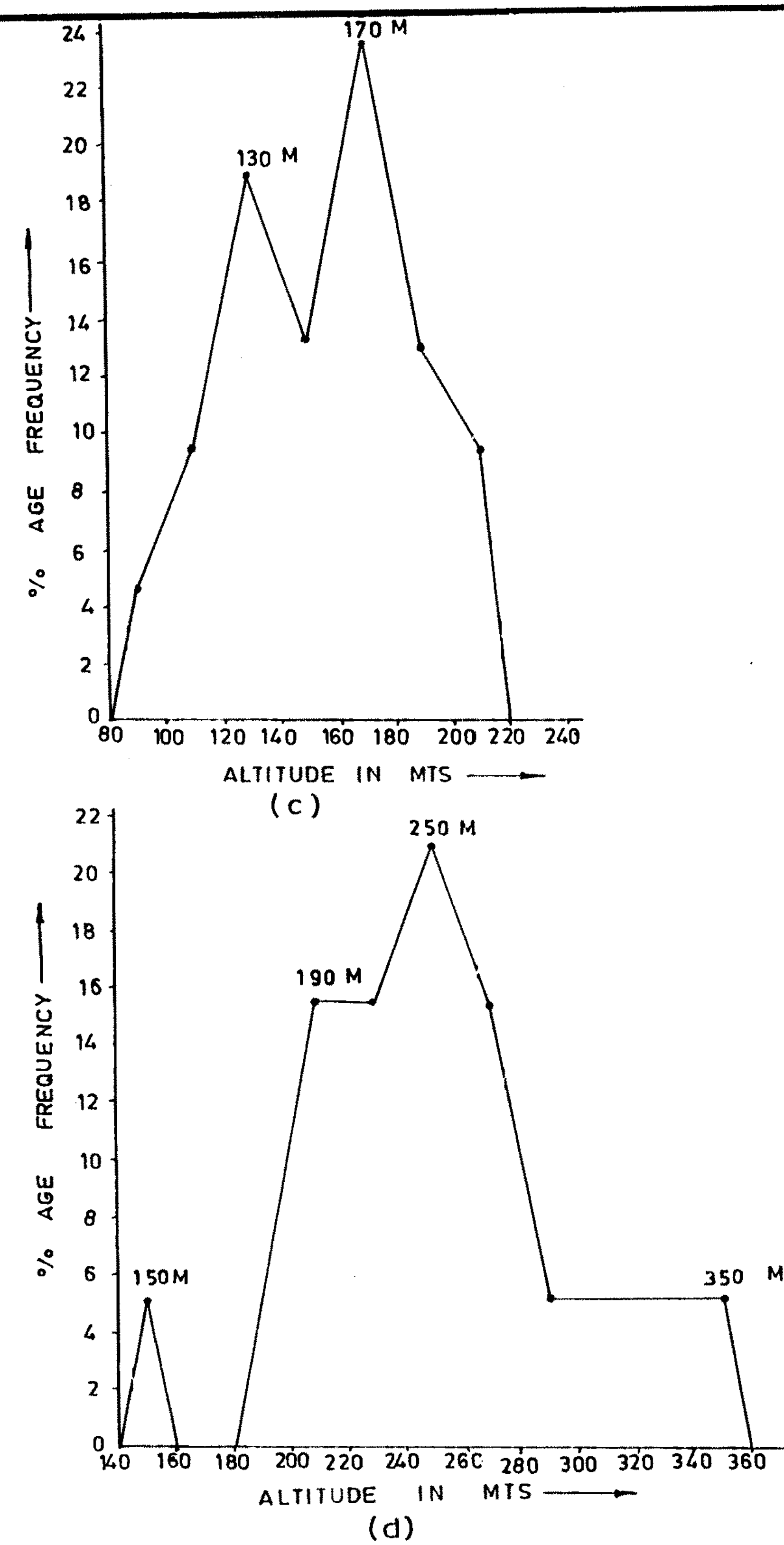
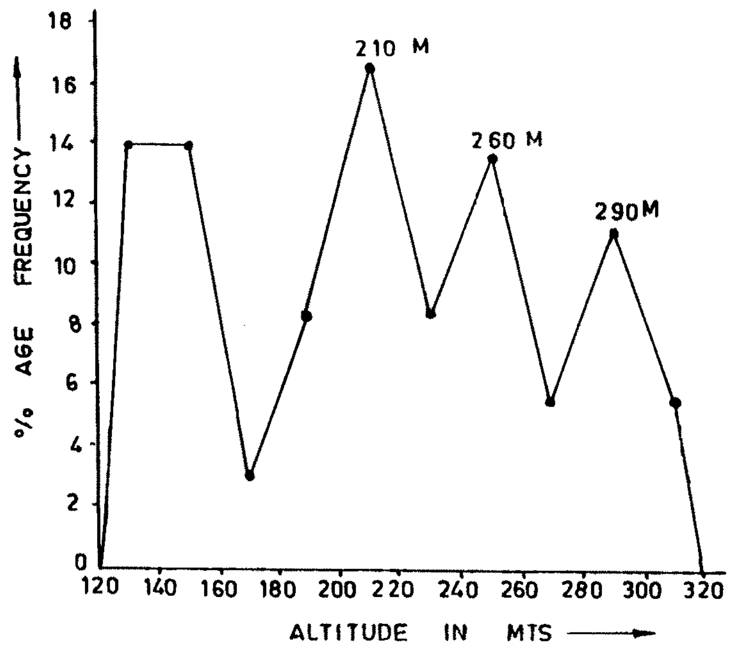
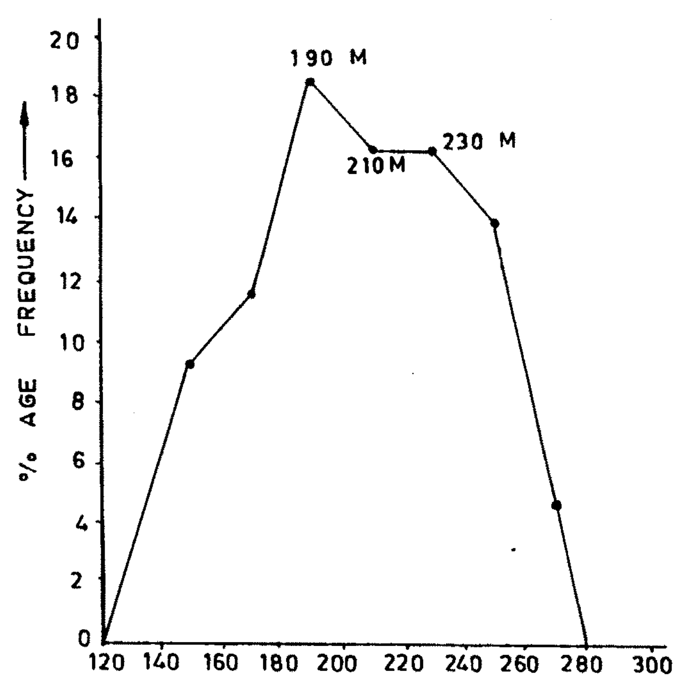


FIG. 4.4 c & d) : ALTITUDE FREQUENCY CURVES OF THE 5th ORDER BASIN Nos.3 & 4.

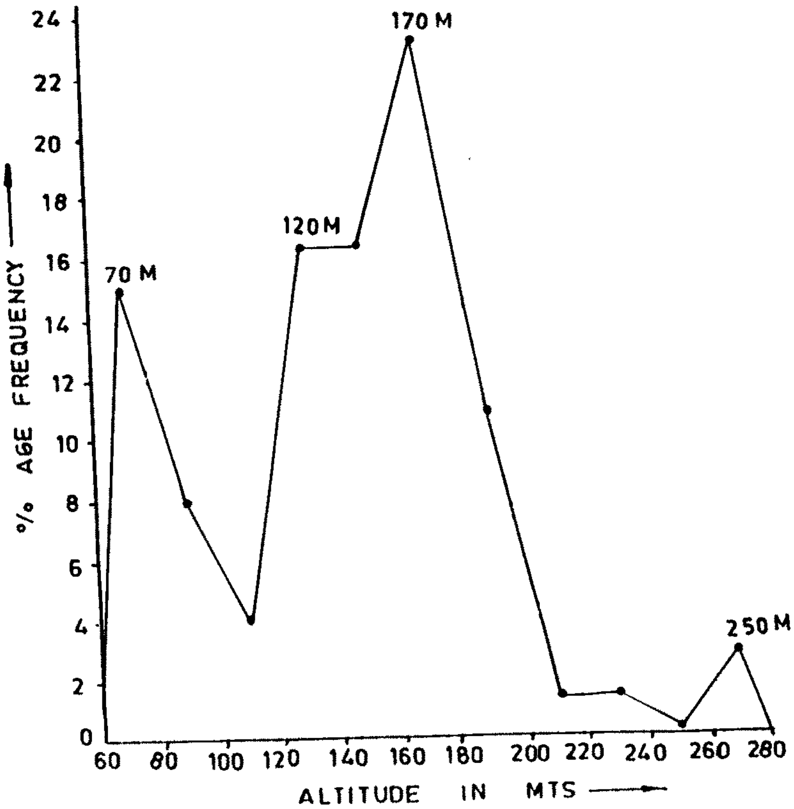


(e)

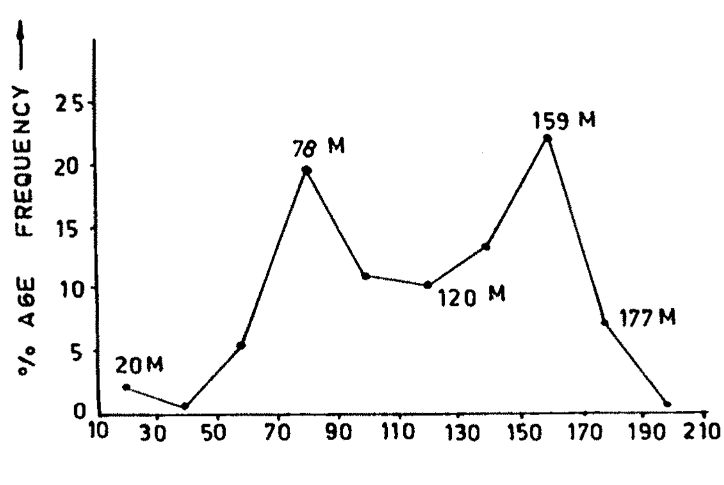


(f)

FIG. 4·4 e & f) : ALTITUDE FREQUENCY CURVES OF THE 5th ORDER BASIN Nos.5 & 6.



(g)



(h)

FIG. 4·4 g & h) : ALTITUDE FREQUENCY CURVES OF THE 5th ORDER BASIN Nos.7 & 8.

positively skewed. The negative skewness means that the maximum concentration of frequencies is in a low relative relief category. The symmetrically skewed basins mean that the maximum concentration of frequencies is in moderate relative relief category, while positive skewness indicates that the maximum concentration of frequencies is in a high relative relief category.

The axial extent of moderate absolute relative relief over about 35.62 percent of all the basins of fifth order suggests about the highland topography of the area under investigation. Such a highland topography can result due to the presence of high hills or hillock or more commonly to be due to the isolated hillock that generally give rise to a feature, termed as ´butte´. In the area under study, such a ´topography´ represented by buttes is observed at about 250 m. due west of Wada-Kombha village and about 500 m. due West of Golap village indicating the final phase of scarp retreat Gray, (1973).

7. Slope analysis

Slope analysis of all the eight fifth order basins have been carried out, with the help of the topographic sheets. The difference in heights between the highest and the lowest points in one cm. square grid has been considered. The general slope directions within the grids for all these basins have been shown in figs. 4.5 a,b,c,d,e,f,g and h. The fifth order basins have been selected for the study as it

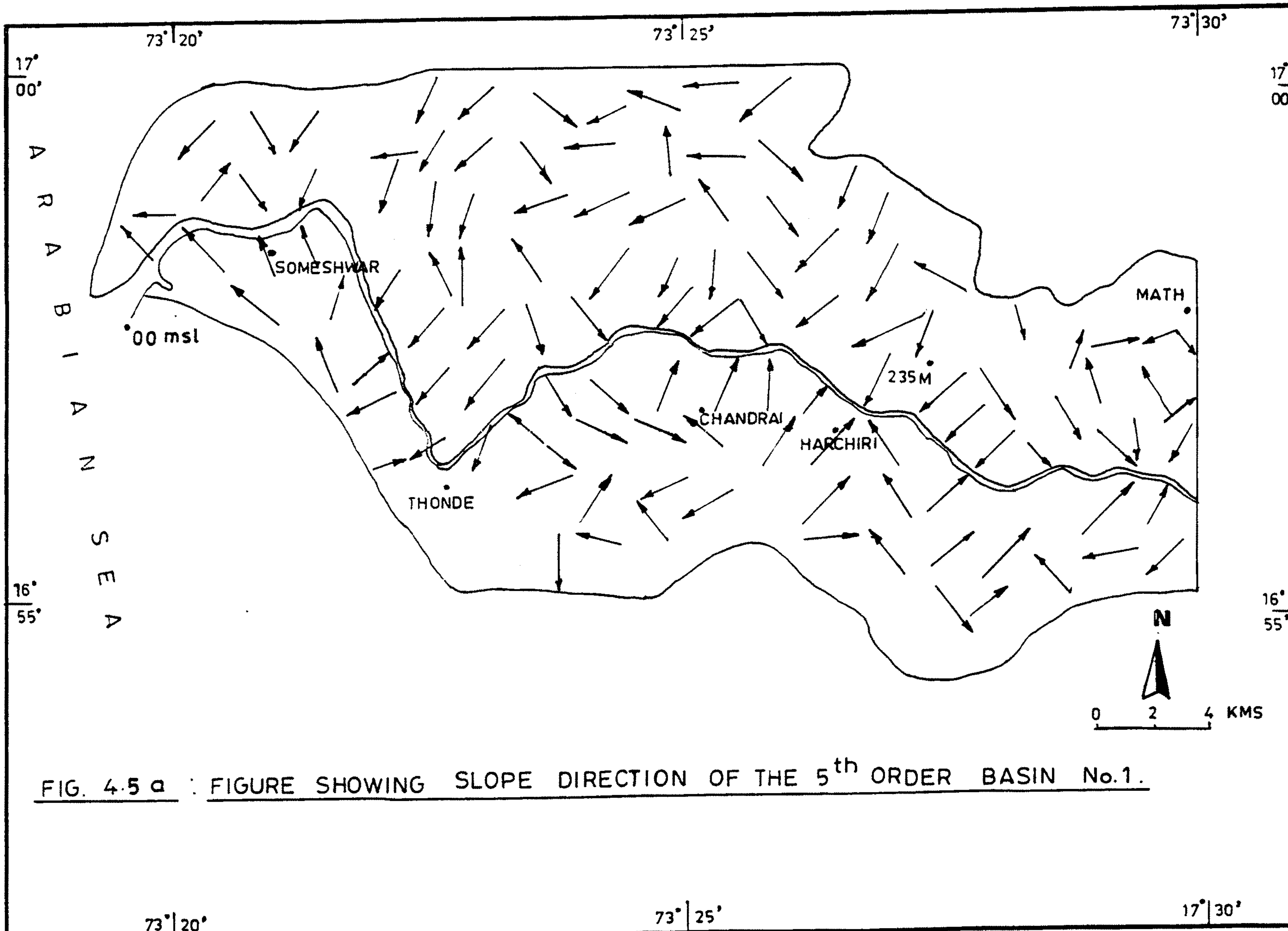


FIG. 4.5 a : FIGURE SHOWING SLOPE DIRECTION OF THE 5th ORDER BASIN No.1.

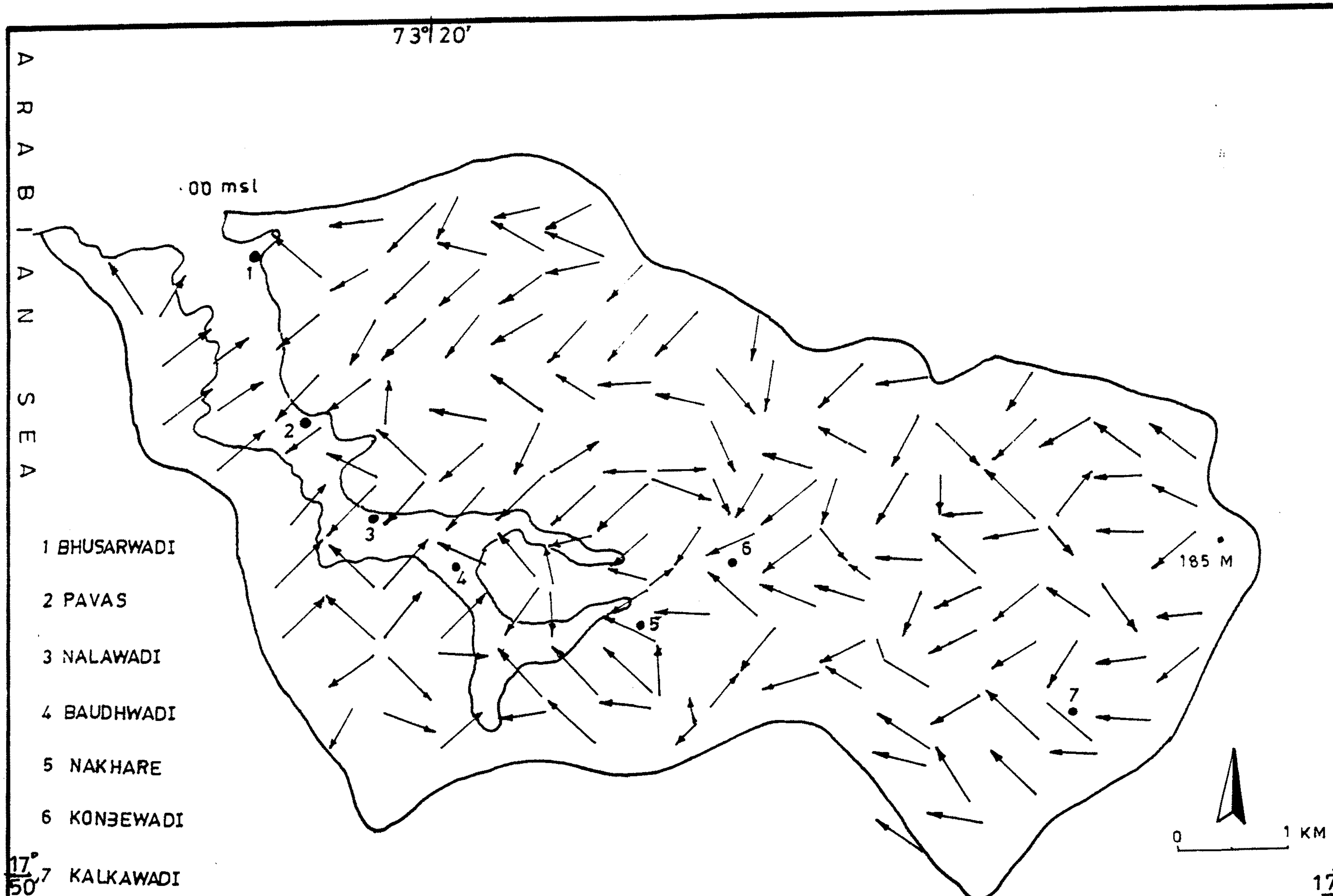


FIG. 4.5 b : FIGURE SHOWING SLOPE DIRECTION OF THE 5th ORDER BASIN No. 2.

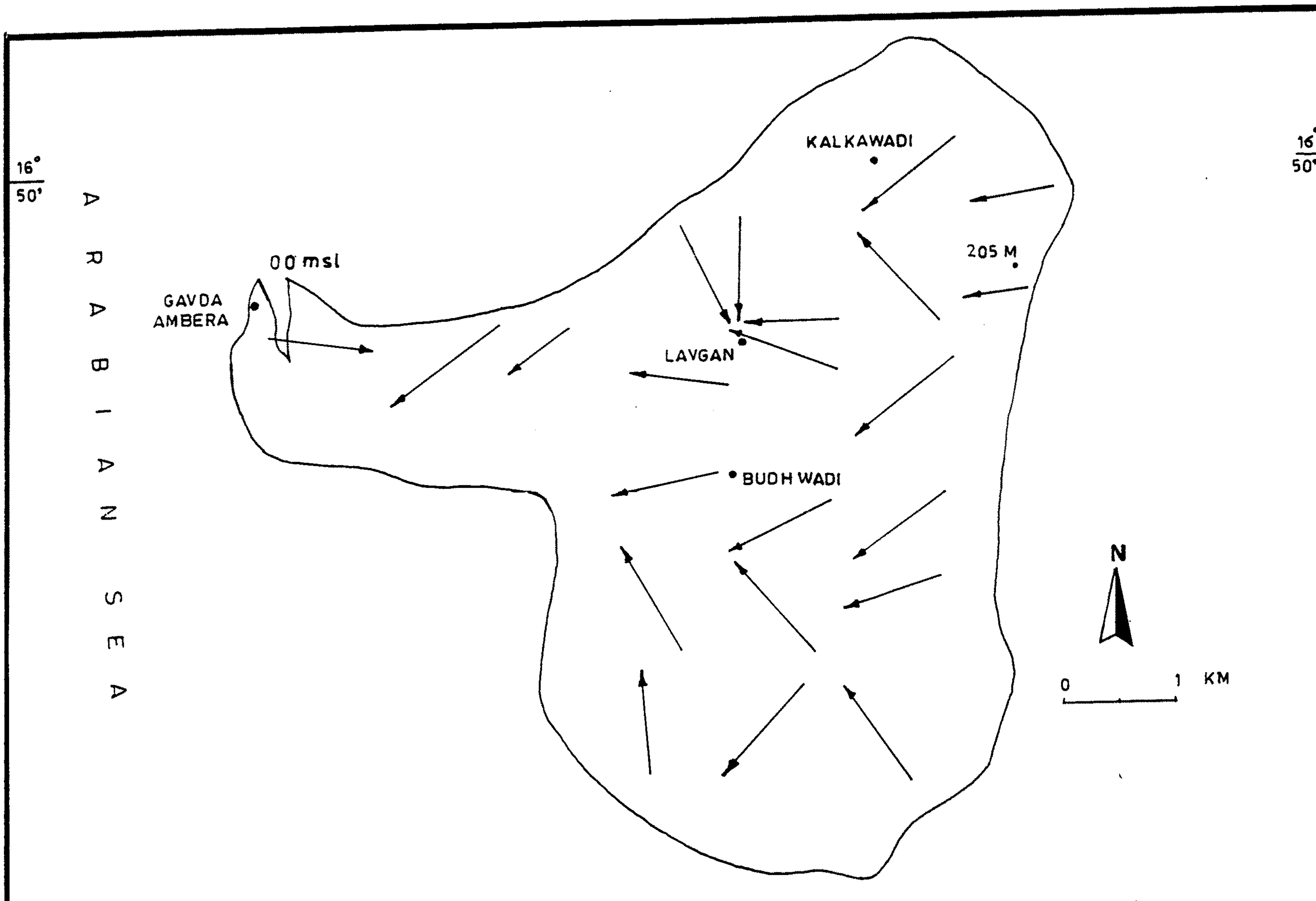


FIG. 4·5 c : FIGURE SHOWING SLOPE DIRECTION OF 5th ORDER BASIN No. 3.

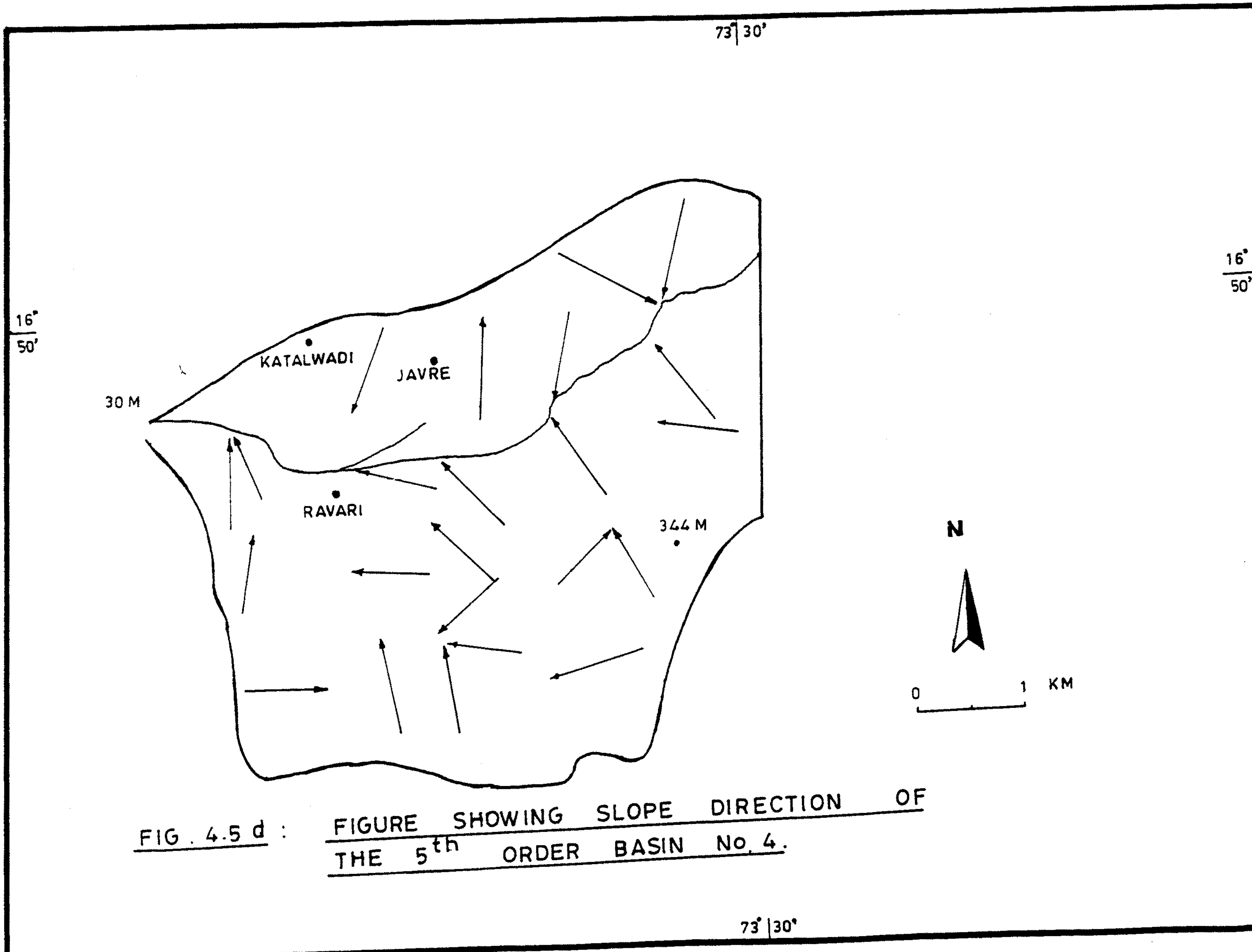


FIG. 4.5 d : FIGURE SHOWING SLOPE DIRECTION OF THE 5^{th} ORDER BASIN No. 4.

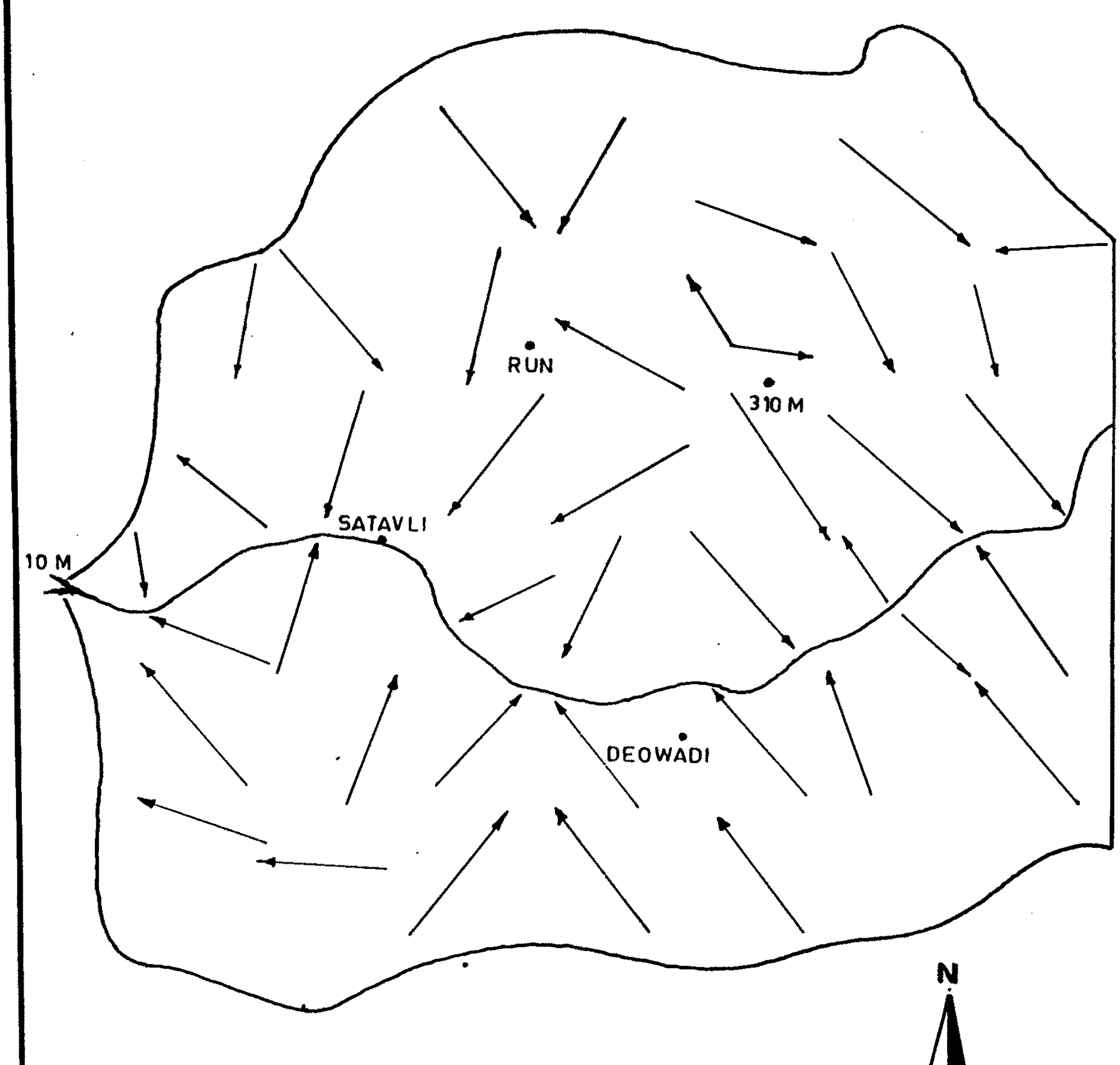


FIG. 4.5e : FIGURE SHOWING SLOPE DIRECTION OF THE 5^{th} ORDER BASIN No. 5.

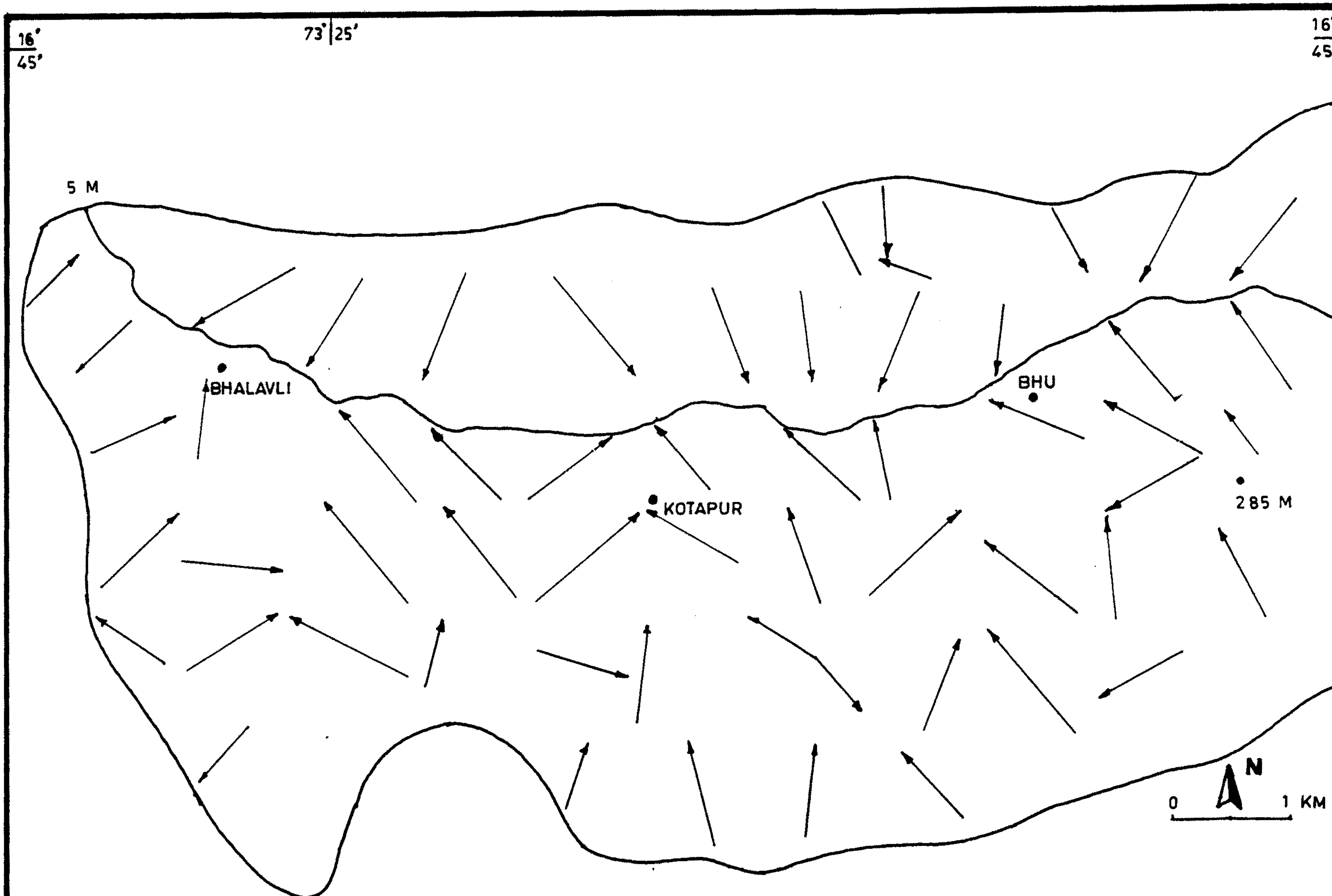


FIG. 4.5 f : FIGURE SHOWING SLOPE DIRECTION OF THE 5th ORDER BASIN No. 6.

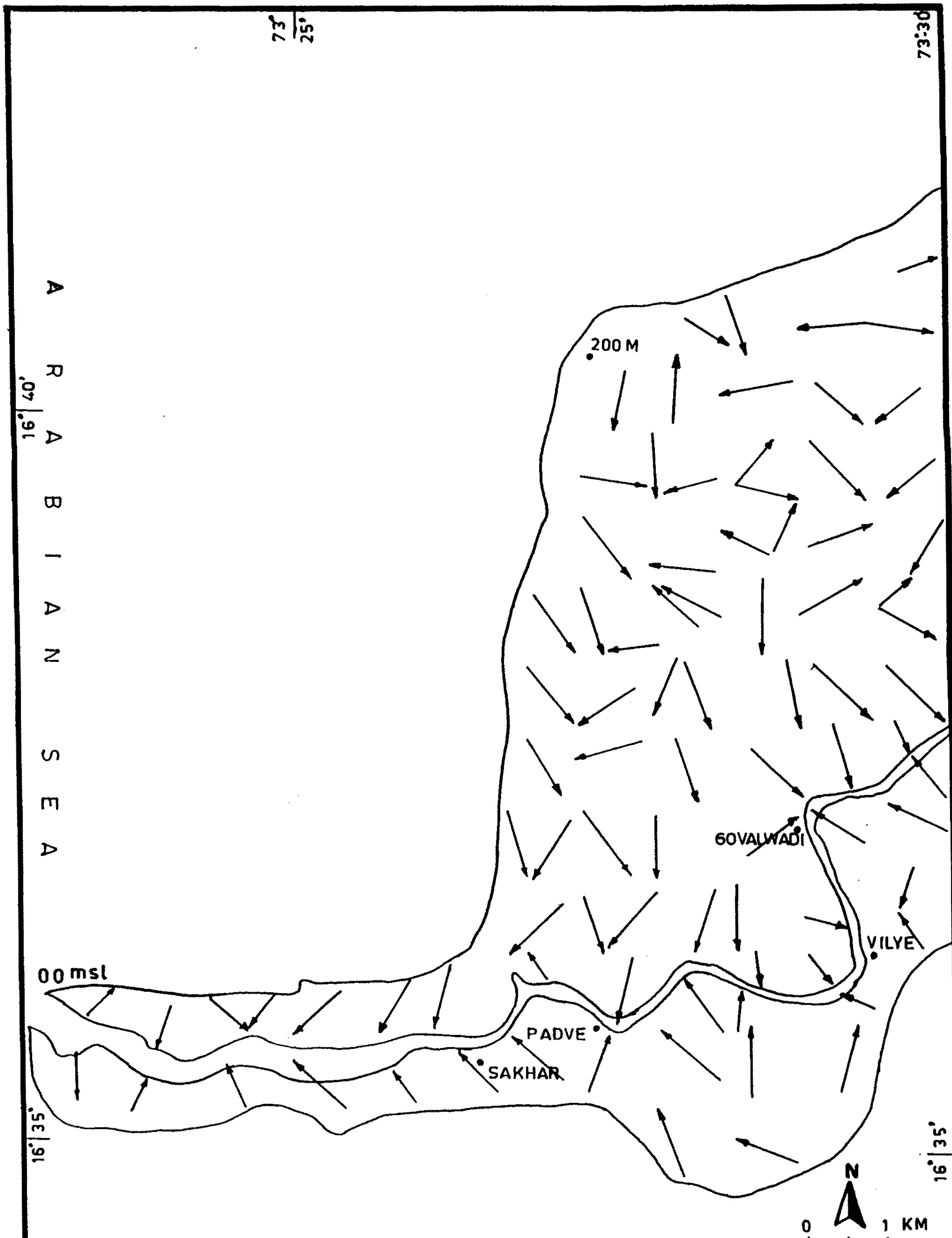


FIG. 4·5g : FIGURE SHOWING SLOPE DIRECTION OF THE 5th ORDER BASIN No. 7.

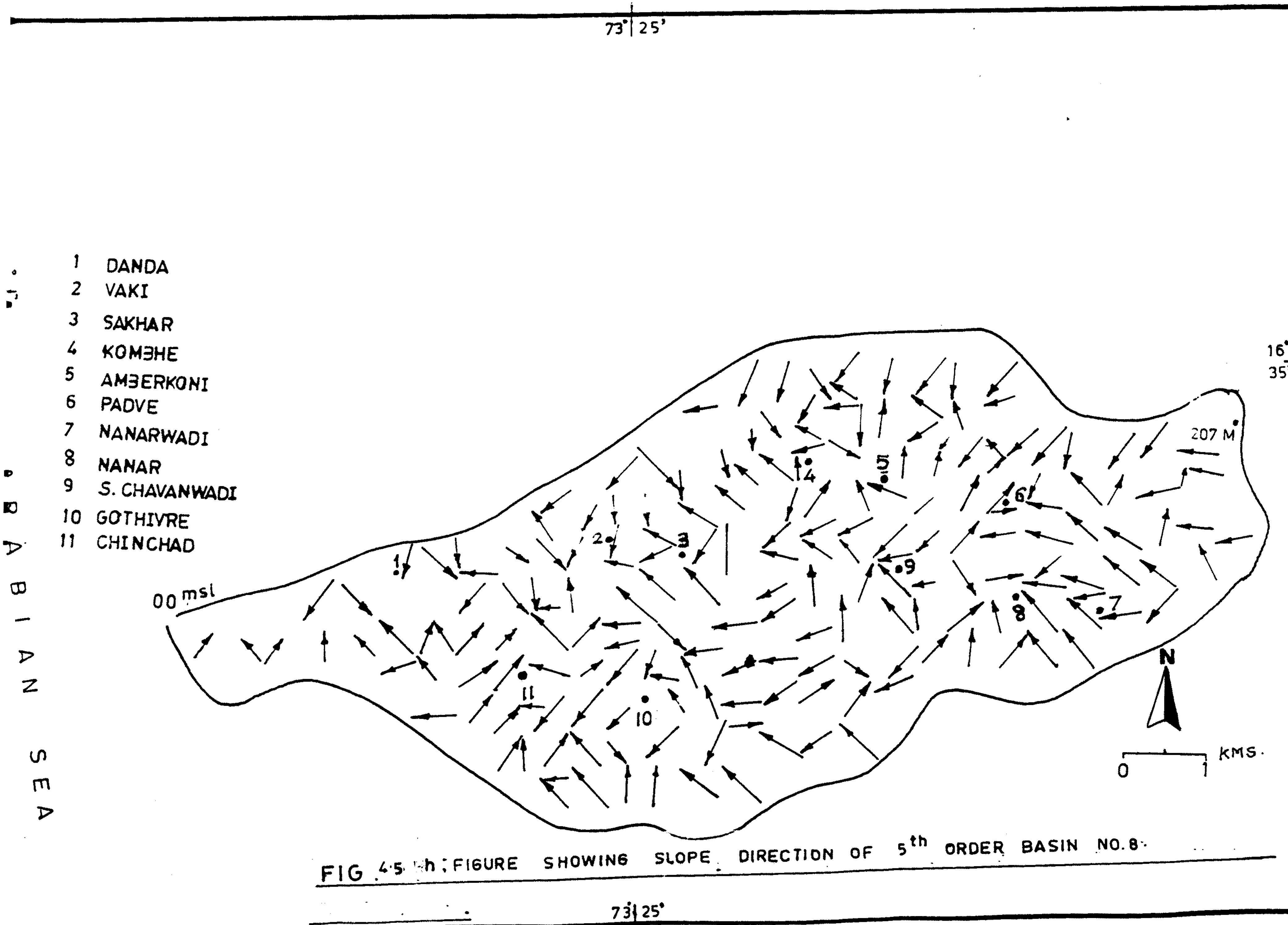


FIG 4.5 h: FIGURE SHOWING SLOPE DIRECTION OF 5th ORDER BASIN NO. 8.

represents the area between the highest elevation and the lowest plains within the area. For the slope analysis, the basins and the valley sides have been selected. This is because the development of the slopes in basins are regarded to be due to the mass movement of the material under the action of gravity. Whereas, the slopes of the valley sides are supposed to be determined by the relative rates of uplift of a landmass.

The data so obtained have been categorised in five classes, viz; level (0^{o} - 10^{o}) gentle (11^{o} - 20^{o}), moderate (21^{o} - 30^{o}), moderatly steep (31^{o} - 40^{o}) and steep (41^{o} - 50^{o}). The cumulative percentage curves, frequency polygons and frequency histograms for each basin of fifth order have been shown in Figs. 4.6 a,b,c,d,e,f,g and h.

For the numerical analysis of slope angles, their frequencies and characterstics like -ve and +ve skewness have been identified. From Table 4.11 it can be seen that the basins 2, 3 and 7 belons to frequencies in gentle slope category. Whereas, basins 1, 4, 5, 6 and 8 belong to frequencies in moderate slope category. This indicates that the whole of the area under investigation is composed of hills of residual type. Detailed analysis of slope studies from table 4.11 it is observed that the frequencies of average slope decreases with increasing steepness of slope. Taking into consideration, the average slope of all the eight basins of fifth order, it is evident that more than 37.49 %

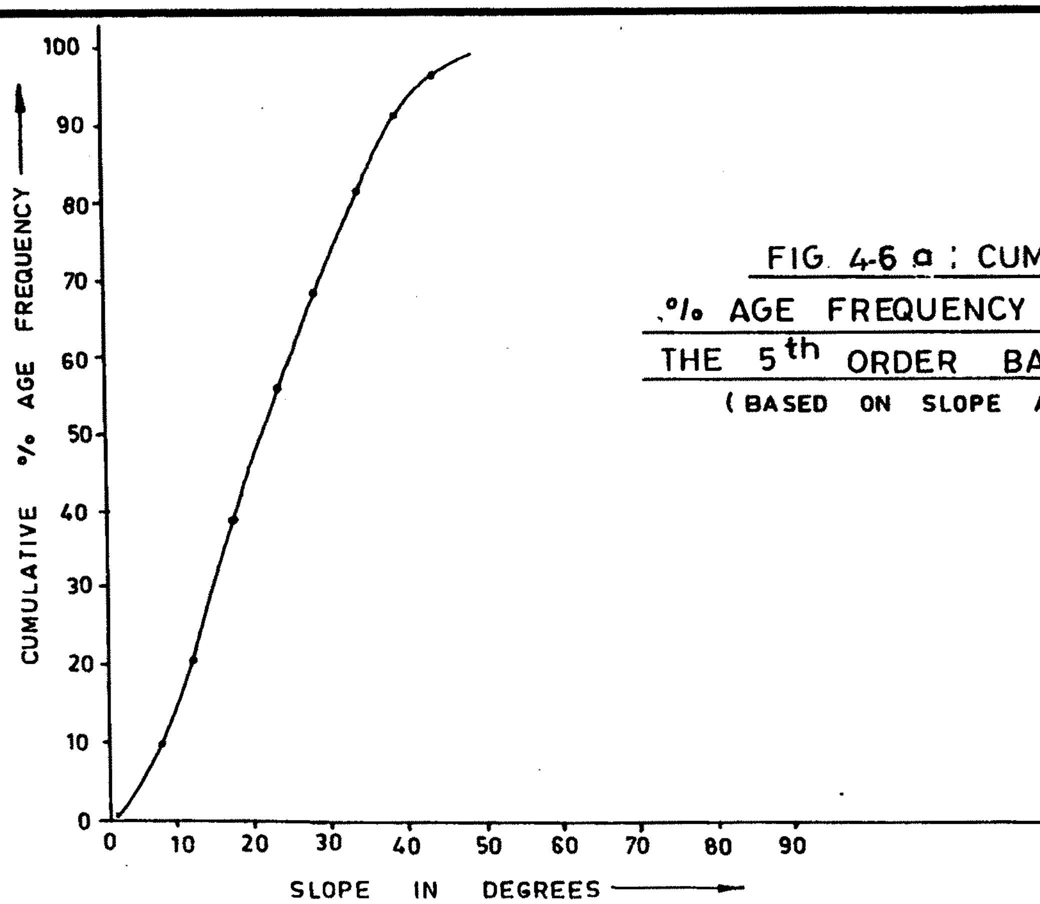


FIG. 4·6 a : CUMULATIVE % AGE FREQUENCY CURVE OF THE 5th ORDER BASIN No. 1. (BASED ON SLOPE ANALYSIS)

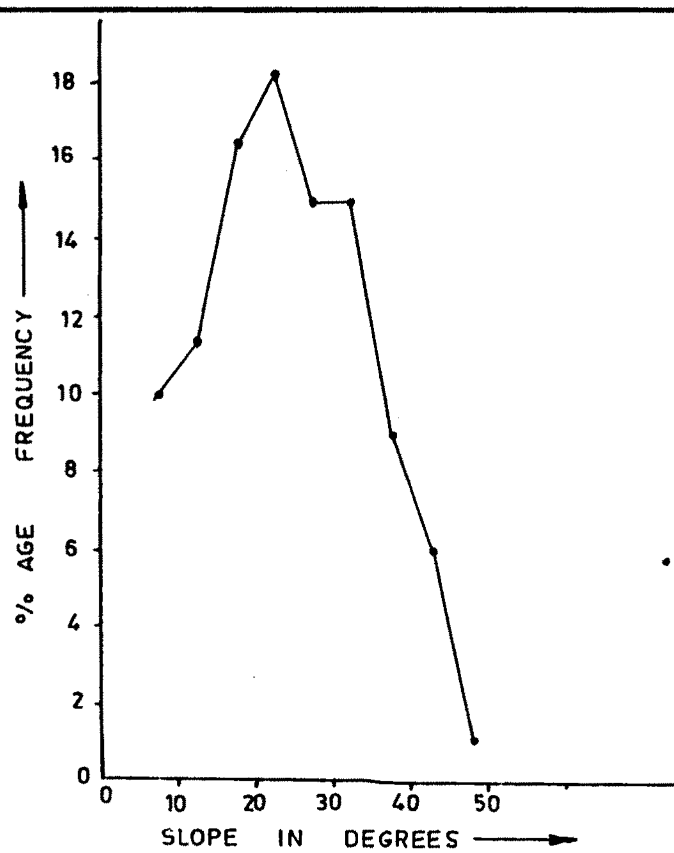


FIG. 4·6 a : FREQUENCY POLYGON OF 5th ORDER BASIN No. 1. (BASED ON SLOPE ANALYSIS)

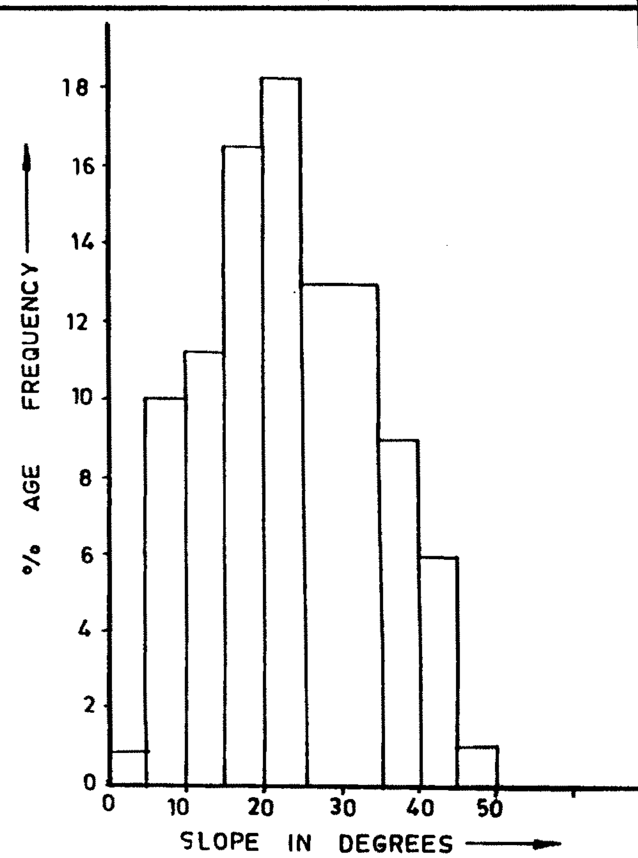


FIG. 4·6 a : FREQUENCY HISTOGRAM OF 5th ORDER BASIN No. 1. (BASED ON SLOPE ANALYSIS)

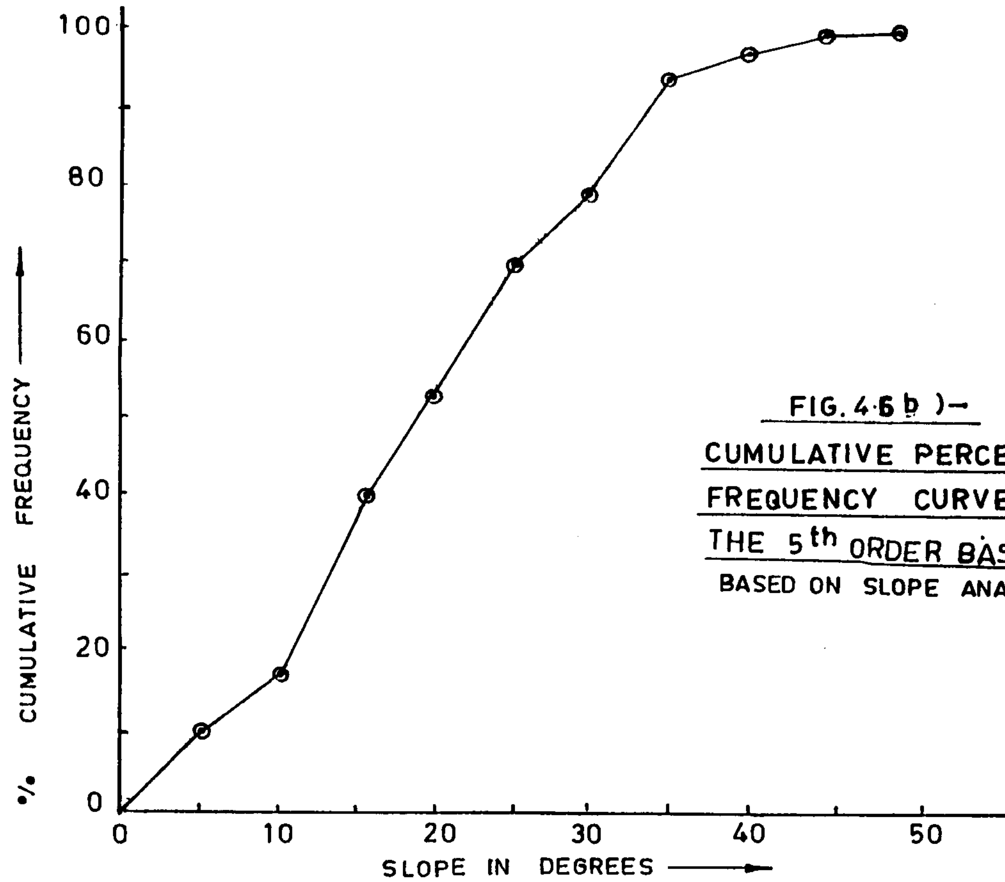


FIG. 4.6 b)–
CUMULATIVE PERCENTAGE FREQUENCY CURVE FOR THE 5th ORDER BASIN No.2
BASED ON SLOPE ANALYSIS.

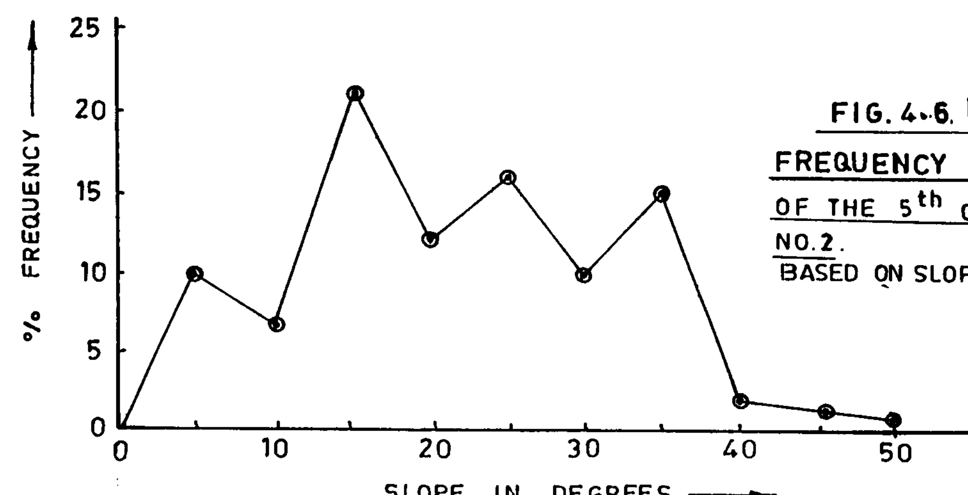


FIG. 4.6. b :) –
FREQUENCY POLYGON. OF THE 5th ORDER BASIN NO.2.
BASED ON SLOPE ANALYSIS.

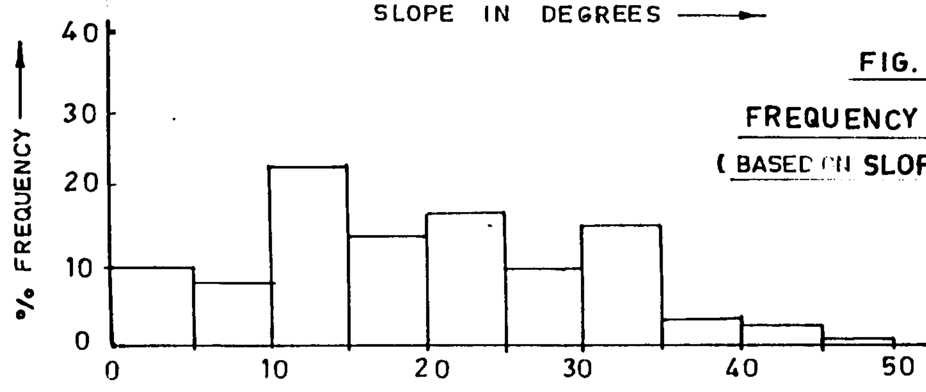
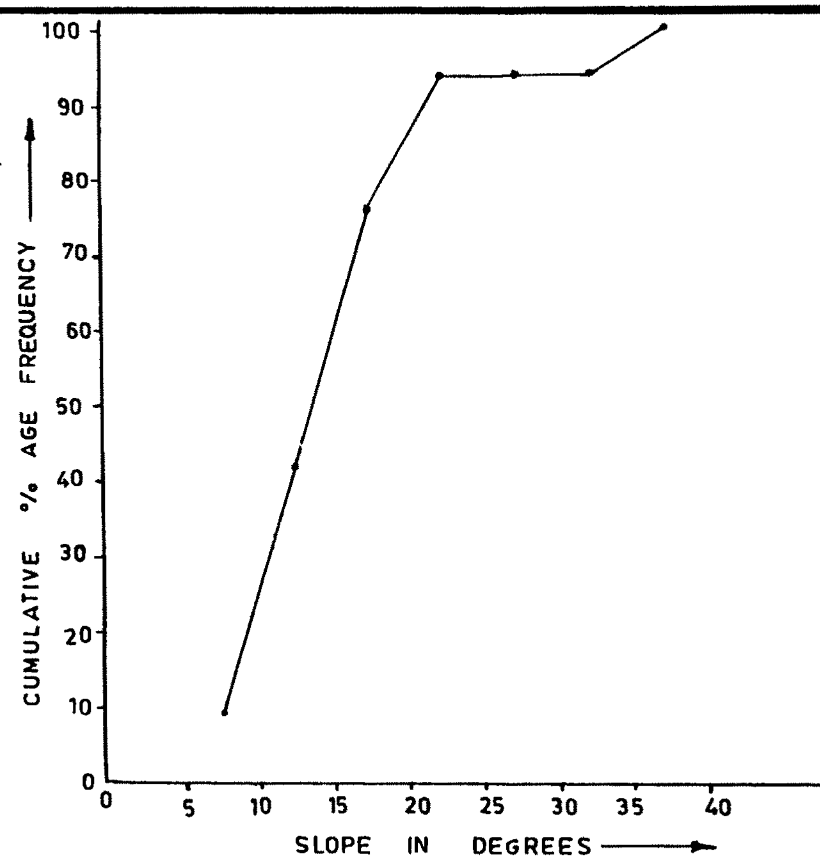


FIG. 4.6 b) –
FREQUENCY HISTOGRAM.
(BASED ON SLOPE ANALYSIS)

FIG. 4.6c : CUMULATIVE % FREQUENCY CURVE OF THE 5th ORDER BASIN No. 3.

(BASED ON SLOPE ANALYSIS)



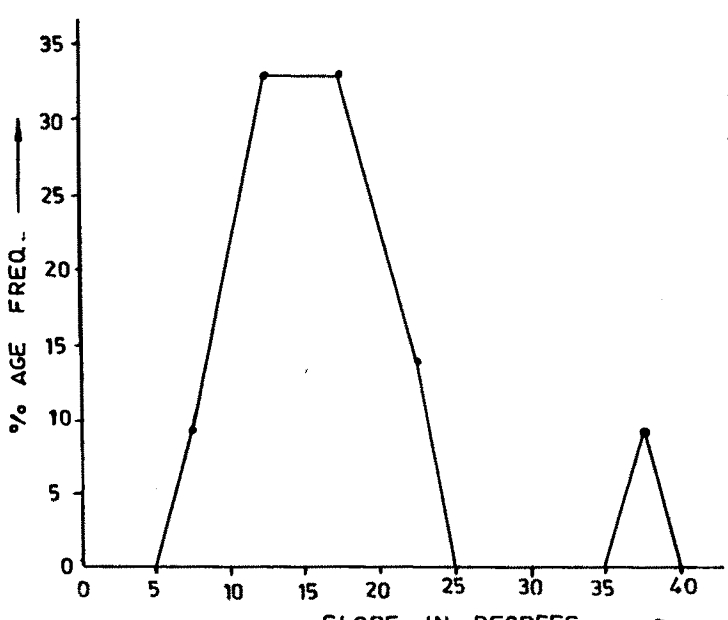


FIG. 4.6c : FREQUENCY POLYGON OF THE 5th ORDER BASIN No. 3

(BASED ON SLOPE ANALYSIS)

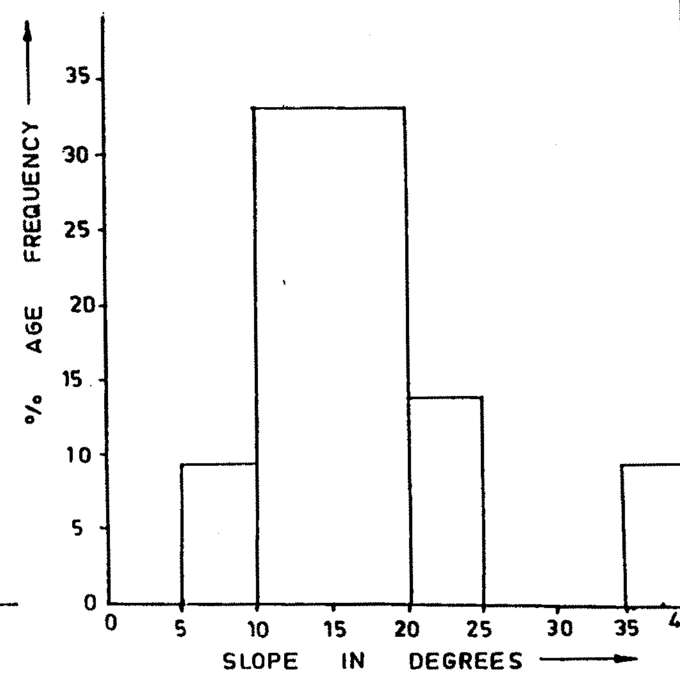


FIG. 4.6c : FREQUENCY HISTOGRAM OF THE 5th ORDER BASIN No. 3.

(BASED ON SLOPE ANALYSIS)

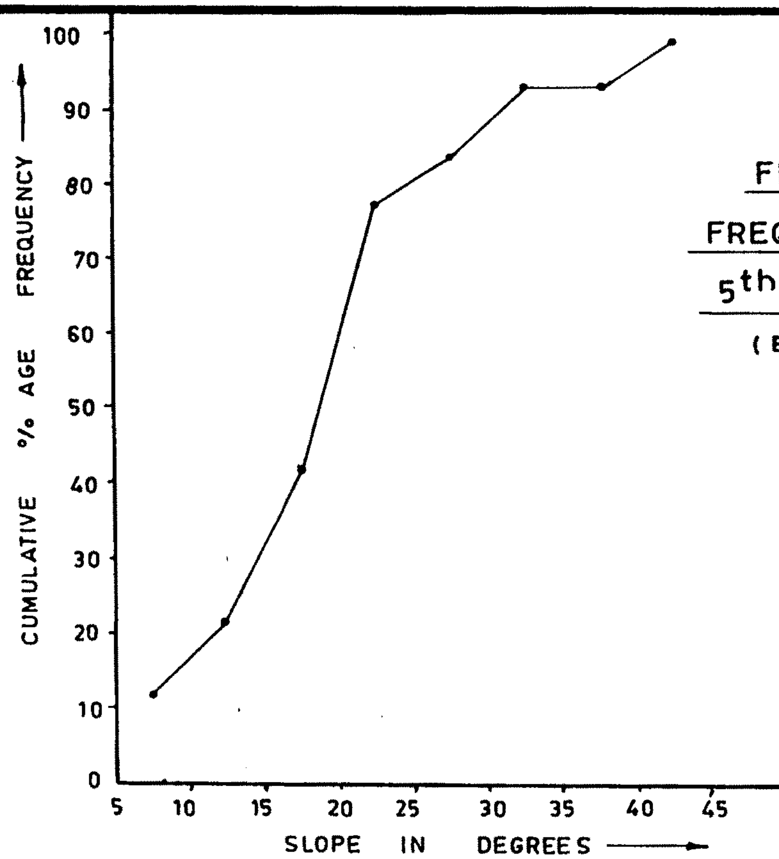


FIG. 4.6 d : CUMULATIVE %AGE FREQUENCY CURVE OF THE 5^{th} ORDER BASIN No. 4.

(BASED ON SLOPE ANALYSIS)

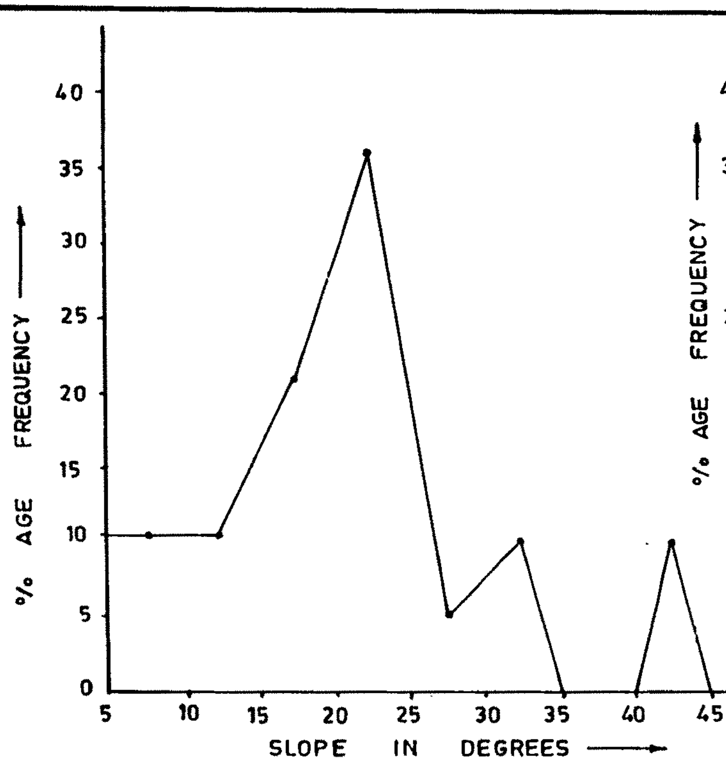


FIG. 4.6 d : FREQUENCY POLYGON OF 5^{th} ORDER BASIN No. 4.

(BASED ON SLOPE ANALYSIS)

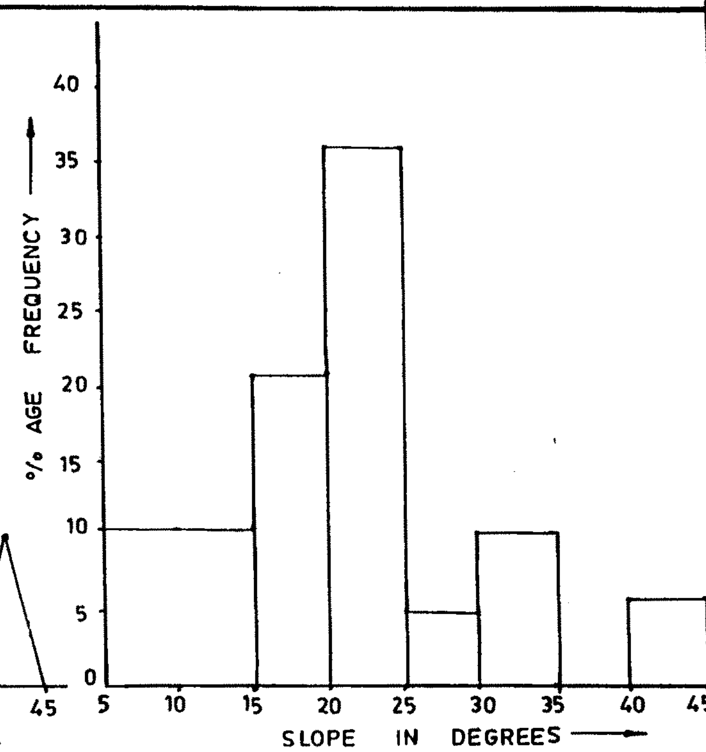


FIG. 4.6 d : FREQUENCY HISTOGRAM OF THE 5^{th} ORDER BASIN No. 4.

(BASED ON SLOPE ANALYSIS)

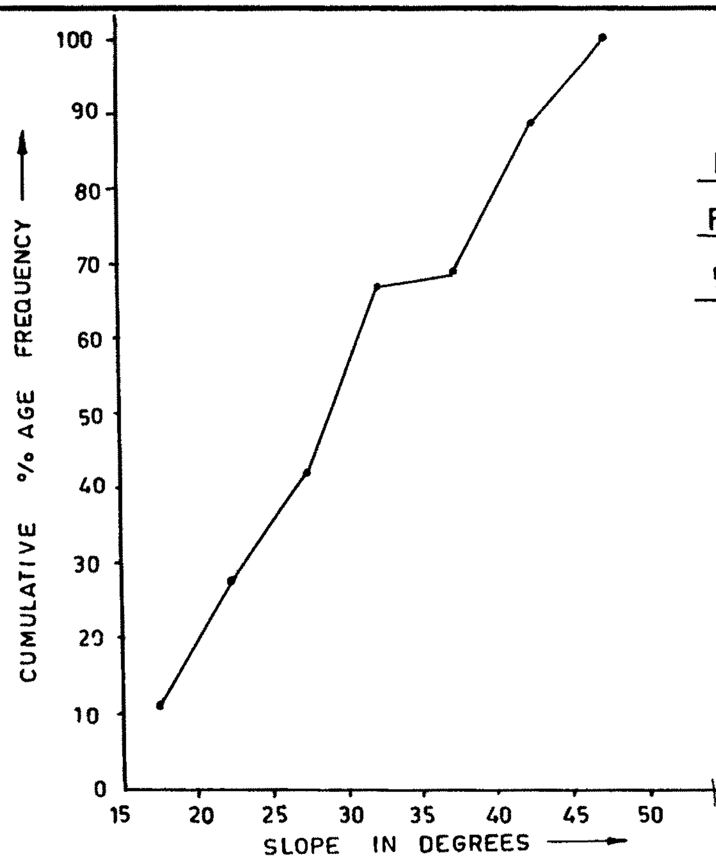


FIG. 4.6 e : CUMULATIVE % AGE FREQUENCY CURVE OF THE 5th ORDER BASIN No. 5.
(BASED ON SLOPE ANALYSIS)

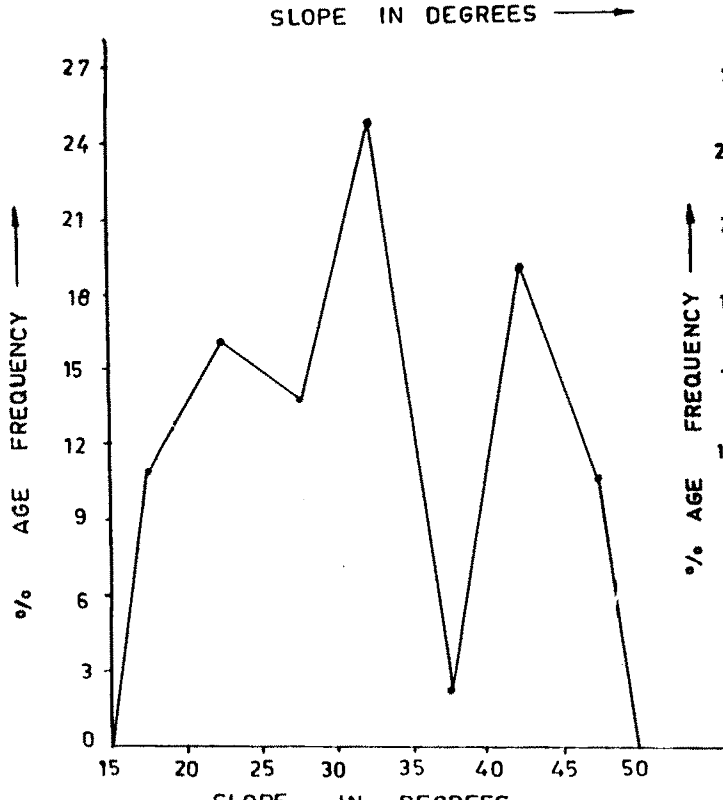


FIG. 4.6 e : FREQUENCY POLYGON OF THE 5th ORDER BASIN No. 5.
(BASED ON SLOPE ANALYSIS)

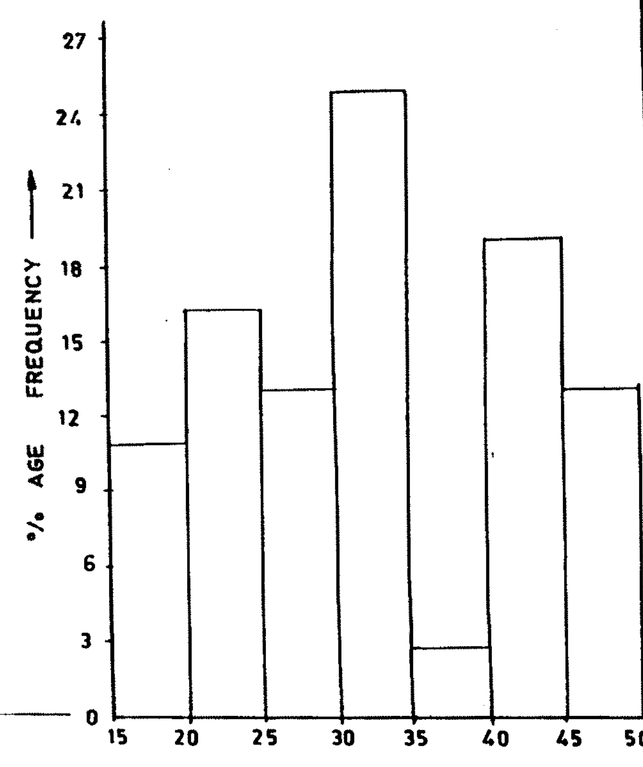


FIG. 4.6 e: FREQUENCY HISTOGR-AM OF THE 5th ORDER BASIN No. 5.
(BASED ON SLOPE ANALYSIS)

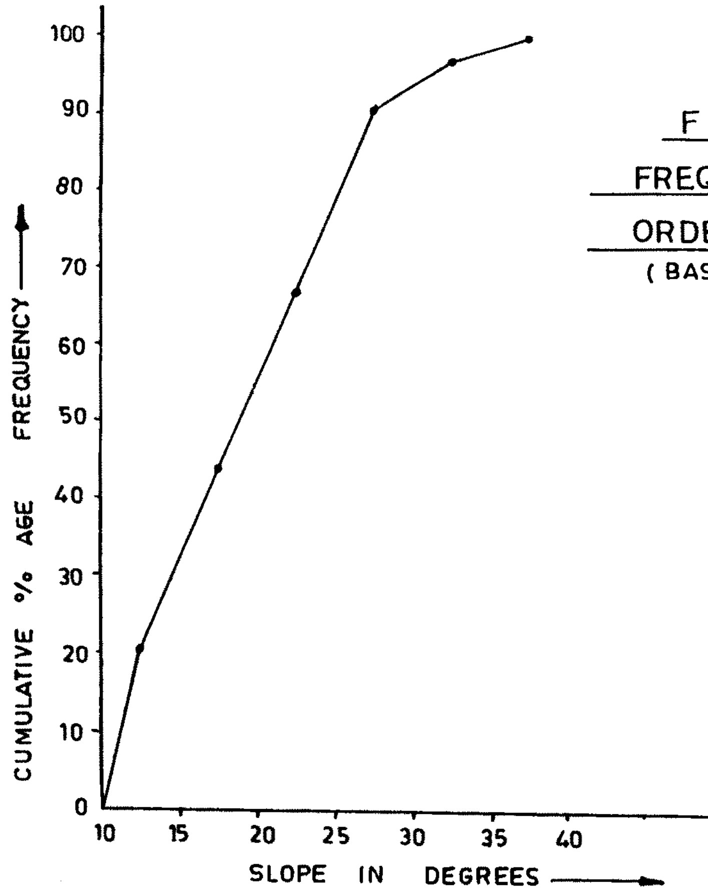


FIG. 4.6 f : CUMULATIVE % AGE FREQUENCY CURVE OF THE 5th ORDER BASIN No. 6.

(BASED ON SLOPE ANALYSIS)

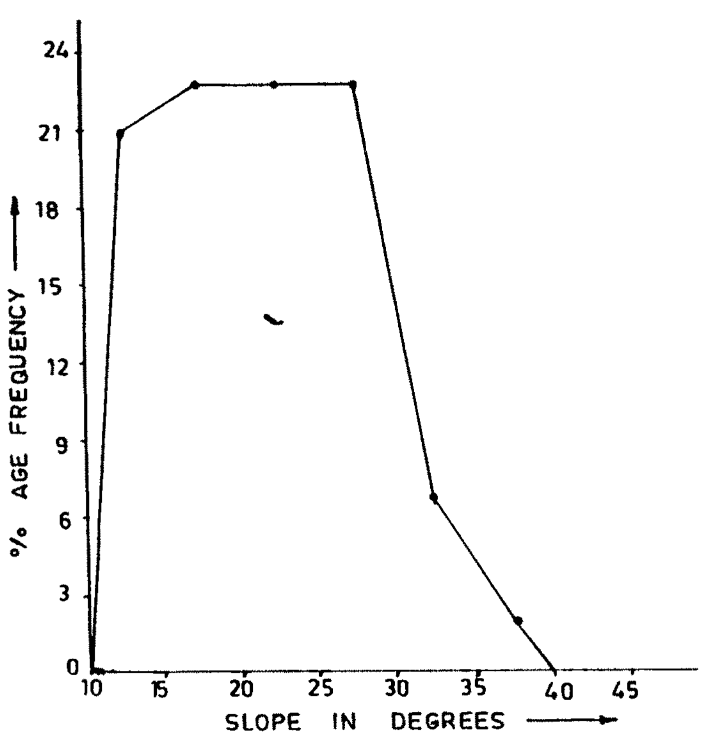


FIG. 4.6 f : FREQUENCY POLYGON OF THE 5th ORDER BASIN No. 6

(BASED ON SLOPE ANALYSIS)

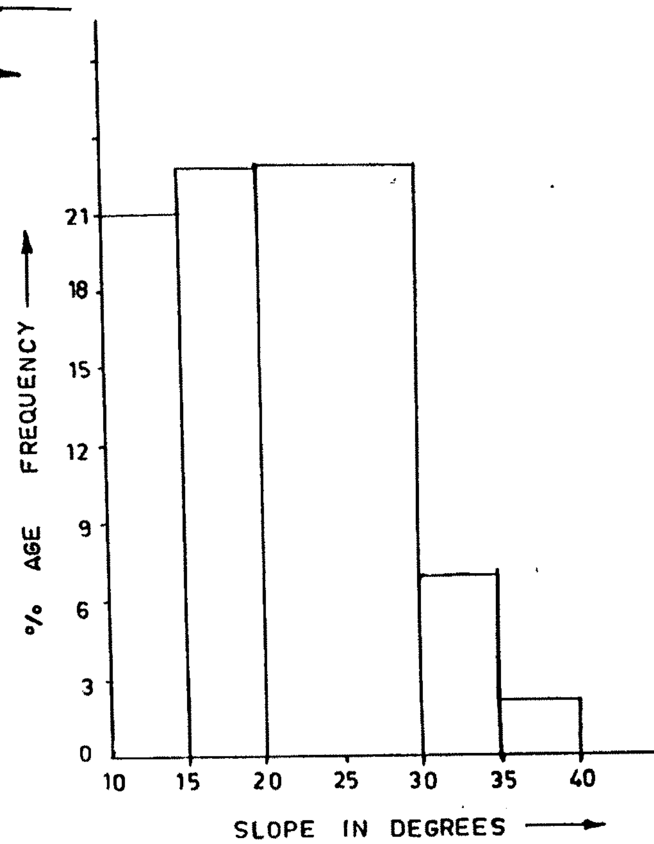


FIG. 4.6 f : FREQUENCY HISTOGRAM OF THE 5th ORDER BASIN No. 6

(BASED ON SLOPE ANALYSIS)

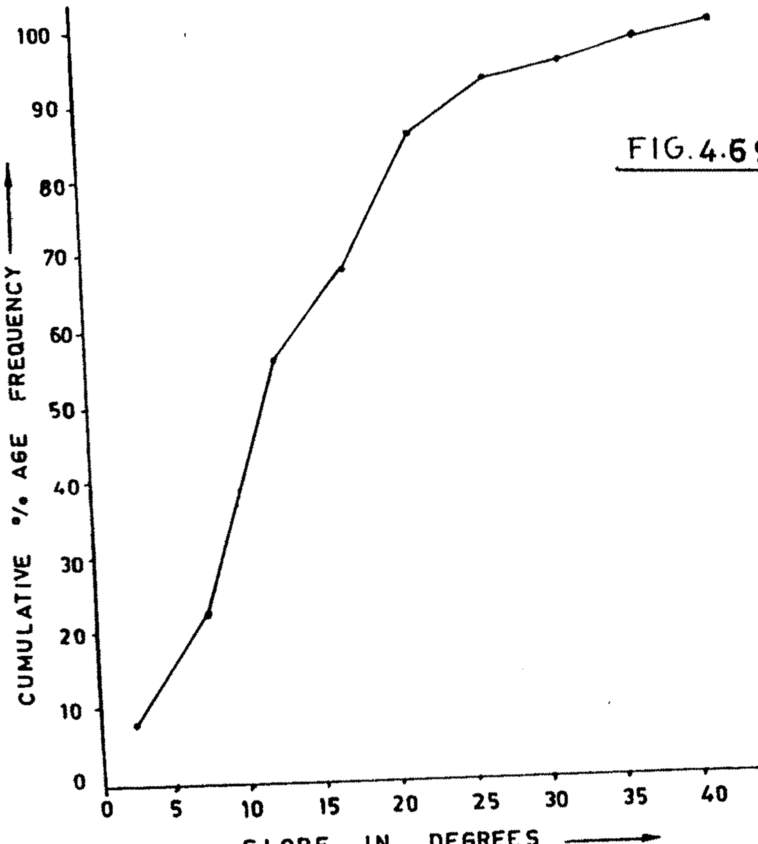


FIG. 4.69 : CUMULATIVE % AGE FREQUENCY CURVE OF THE 5th ORDER BASIN No. 7.
(BASED ON SLOPE ANALYSIS)

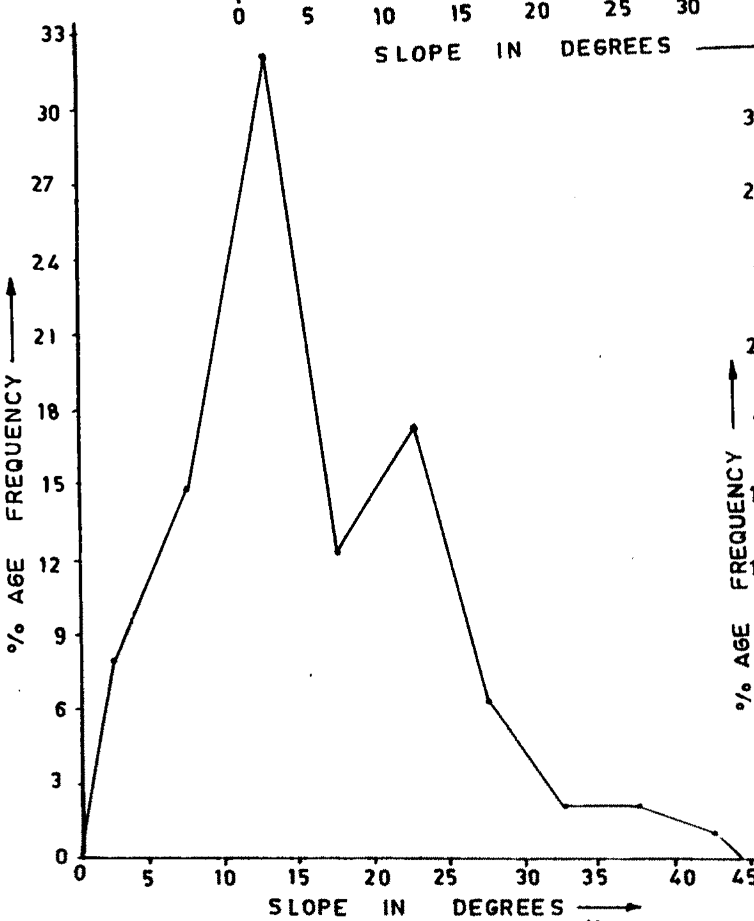


FIG. 4.69. FREQUENCY POLYGON OF THE 5th ORDER BASIN No.7 (BASED ON SLOPE ANALYSIS)

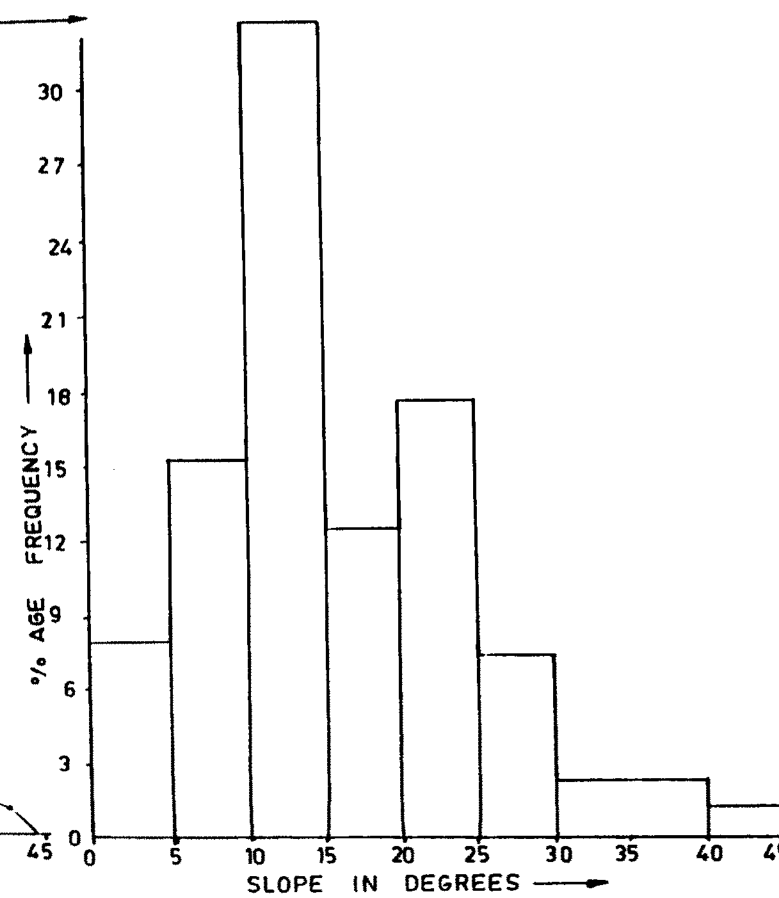


FIG.4.69 : FREQUENCY HISTOGRAM OF THE 5th ORDER BASIN No.7 (BASED ON SLOPE ANALYSIS)

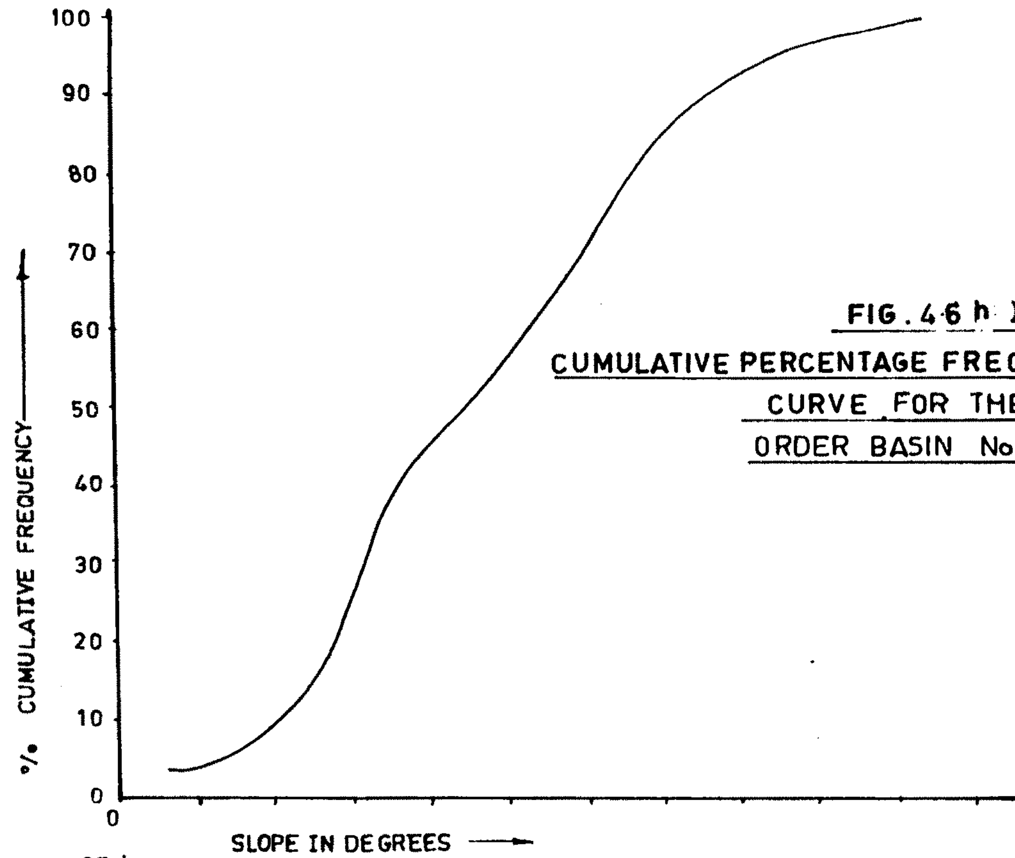


FIG. 4.6 h) –
CUMULATIVE PERCENTAGE FREQUENCY CURVE FOR THE 5th ORDER BASIN No. 8.

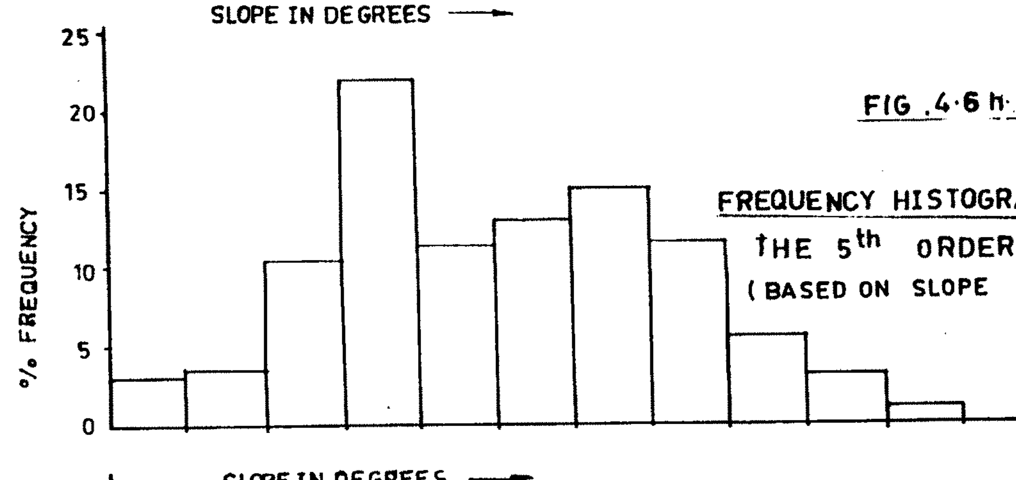


FIG. 4.6 h) –
FREQUENCY HISTOGRAM OF THE 5th ORDER BASIN No. 8
(BASED ON SLOPE ANALYSIS)

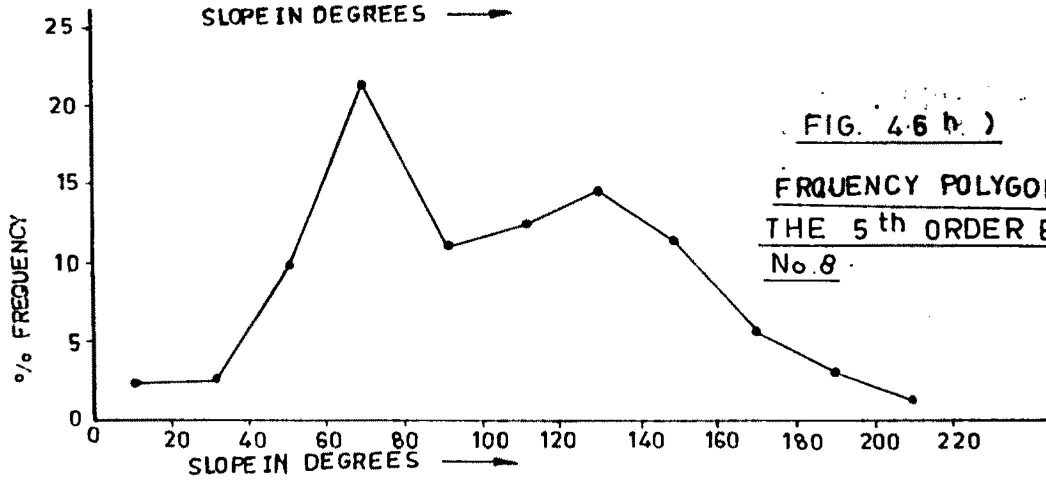


FIG. 4.6 h)
FRQUENCY POLYGON FOR THE 5th ORDER BASIN No. 8.

Table 4.11 : Average slope frequency percent of fifth order basins of the area

SLOPE IN DEGREE ->	LEVEL	GENTLE	MODERATE	MODERATELY STEEP	STEEP
BASIN NOS.	0 - 10 IN %	11 - 20 IN %	21 - 30 IN %	31 - 40 IN %	41-50 IN %
1	10.44	27.83	31.30	22.61	7.83
2	16.08	36.37	25.87	18.17	3.50
3	9.52	66.66	14.28	9.52	--
4	10.52	31.57	42.10	10.52	5.26
5	--	11.11	30.57	27.78	30.55
6	--	44.19	46.52	9.31	--
7	23.29	45.21	24.66	5.48	1.37
8	21.40	37.01	32.44	8.67	--
AVERAGE PERCENTAGE	11.41	37.49	31.03	14.00	6.06

Table 4.12 : Stream gradient index (G.I.) and geomorphic provinces of fifth order basins

NAME OF THE STREAM	ORDER	SL	G.I. UPPER	G.I. MID	G.I. LOWER	GEOMORPHIC PROVINCE
1 Panval	4	357.67	290	638	145.00	Upland
2 Pavas	5	100.00	50	175	75.00	Lowland
3 Lavgan	5	118.83	201.5	108.5	46.50	Combined
4 Jaure	5	43.52	27.5	34.37	68.75	Lowland
5 Satavli	4	350.00	437.5	262.5	371.88	Upland
6 Tervan	5	95.63	38.25	51.0	191.25	Lowland
7 Padve	4	181.21	356.25	75.0	112.50	Combined
8 Gothivare	4	65.25	67.5	74.25	54.00	Lowland

of frequencies lie in gentle slope category, whereas, on an average 6.06 % of all of the fifth order basins are of steep slope category. The moderate slope covers 31.03 % of frequencies, while concentration of only 11.41% of the total frequencies are of level category.

From the above, it can be said that the area is a hilly terrain of residual type. From figs. 4.6 a, b, c, d, e, f, g, and h it is inferred that all the basins are negatively skewed in frequency of slope. The gentle and moderate types of slopes are present in the area. These hills are the skeletal ridges of the Sahyadri ranges, which are completely denudational in genesis and originated due to neo-tectonic activity, simultaneously followed by various erosional agents. The valley side slopes of the area are impressive as slip of slope rises abruptly from the channel, forming the vertical cliffs upto 20 m. in elevation. The gentle slope is found to be generally overlain by fluvio-colluvial and coastal Quaternary deposits.

8. Stream gradient index

The high and low stream gradient index that throw light on the existence of diverse geomorphic provinces in the coastal tract and in the hinterlands has been shown by Raghavan and Murthi (1991). On this basis, the stream gradient index (GI) can be useful in understanding the drainage adjustment mainly in the area that has been affected by tectonism Hack, (1981). The stream gradient index has been calculated for all the fifth order basins from the area. The area exhibits the rugged topography. The basins under consideration mainly consist of basaltic hills and show high to moderate relief. The drainage pattern of the basins is dendritic, and at places also sub-parallel. As is already stated the sub-parallel drainage pattern is suggestive of the structural control. The valleys are characterised by the development of various geomorphological features related mainly to fluvial and marine activities.

For the purpose of the stream gradient index study, representative basins of fifth order from lowland, upland and from combined region have been selected. Such a selection has been made mainly to represent the different basins with the following aspects ;

a. basins which are structrually controlled,
b. basins which include hilly or flat-topped topography,
c. basins which include mainly plain, low-level areas and do not exhibit obvious structural control and
d. also to examine the effect of neo-tectonism, if any.

Such a categorisation for selection of basins has been made, as suggested by Ramarao and Vaidyanadhan (1974).

These basins have been studied for comparing the stream gradient index. It is computed by taking into consideration the distance from the mid-point of the given stream to the source of the stream in km. and the channel slope of stream in m./km. The results obtained for the representative basins are shown in Table 4.12. From the table it can be seen that basins 1 and 5 are of the upland type, whereas, the low-land depicts extremly low values. These lower values are the outcome of channels being influenced by low relief and the sand-sized bed material (Hack, 1981). The intermediate values shown by basins 3 and 7 are generated due to the influence of the combination of diverse lithological entities and the constrasting geomorphic provinces alongwith the homogenety of the size of dominent bed material.

In order to understand the behaviour of the individual streams within the selected basins; three segments namely upper reach, mid-reach, and lower reach are subjected to stream gradient analysis. Variations in the slopes are observed on the arthmetic longitudinal profiles, which are shown in Figs. 4.7 a,b,c,d,e,f,g and h. The values so obtained are given in the table 4.12. From this table, inconsistancy in the values are seen in any of the three reaches of every streams. Higher value nearly demarcates upland river basin while lower value delineates the low-land river basins. But it is seen in case of basins 3 and 7, the values are combined which suggest the dynamic nature of high energy regime of upland geomorphic environment. Whereas, low relief and low energy regime represents low-land geomorphic environment. The high gradient index value is due to the presence of resistant rock and it can be a zone of uplift and

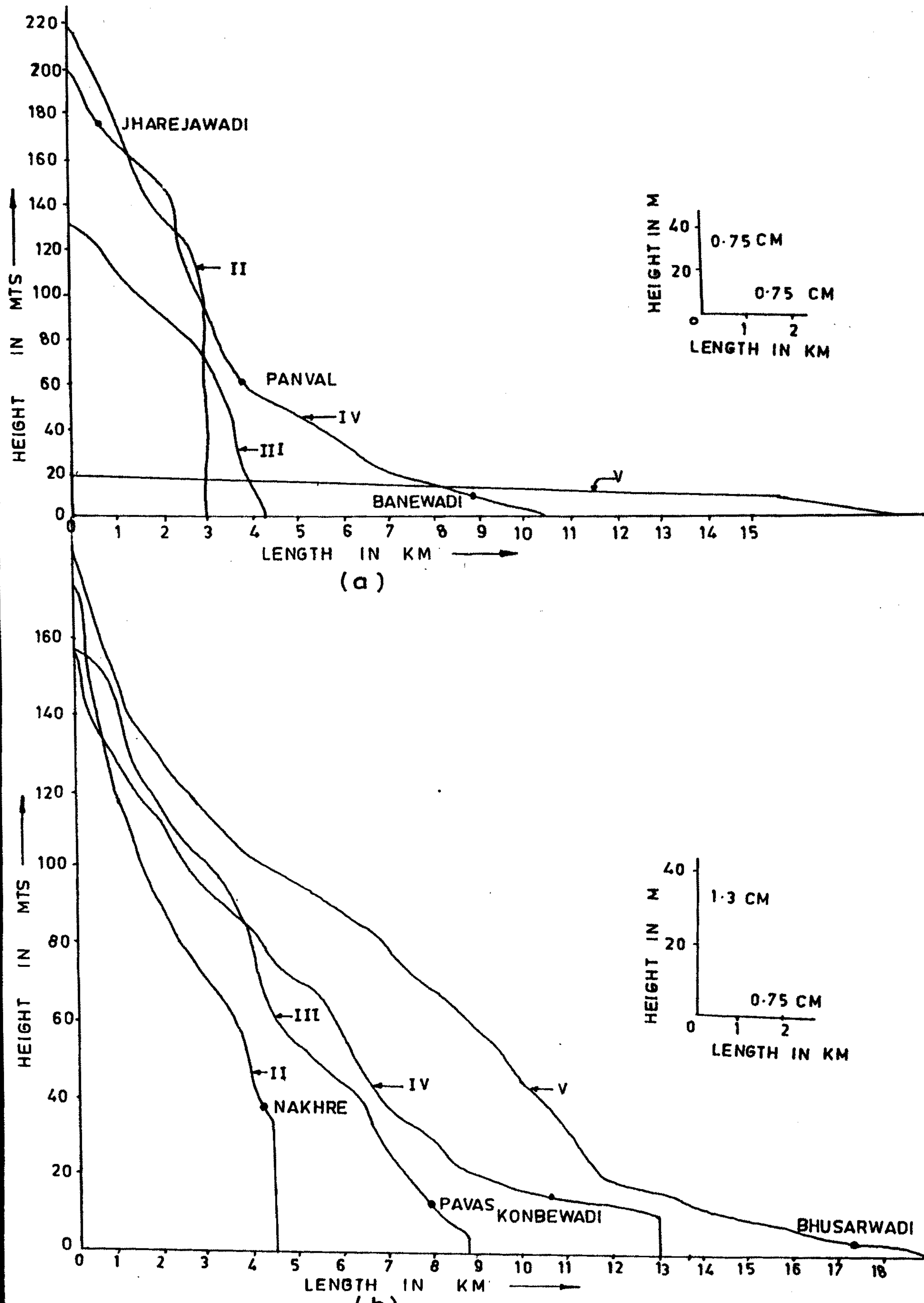


FIG.4·7 a & b) : LONGITUDINAL PROFILES OF THE 5th ORDER BASIN Nos.1 & 2.

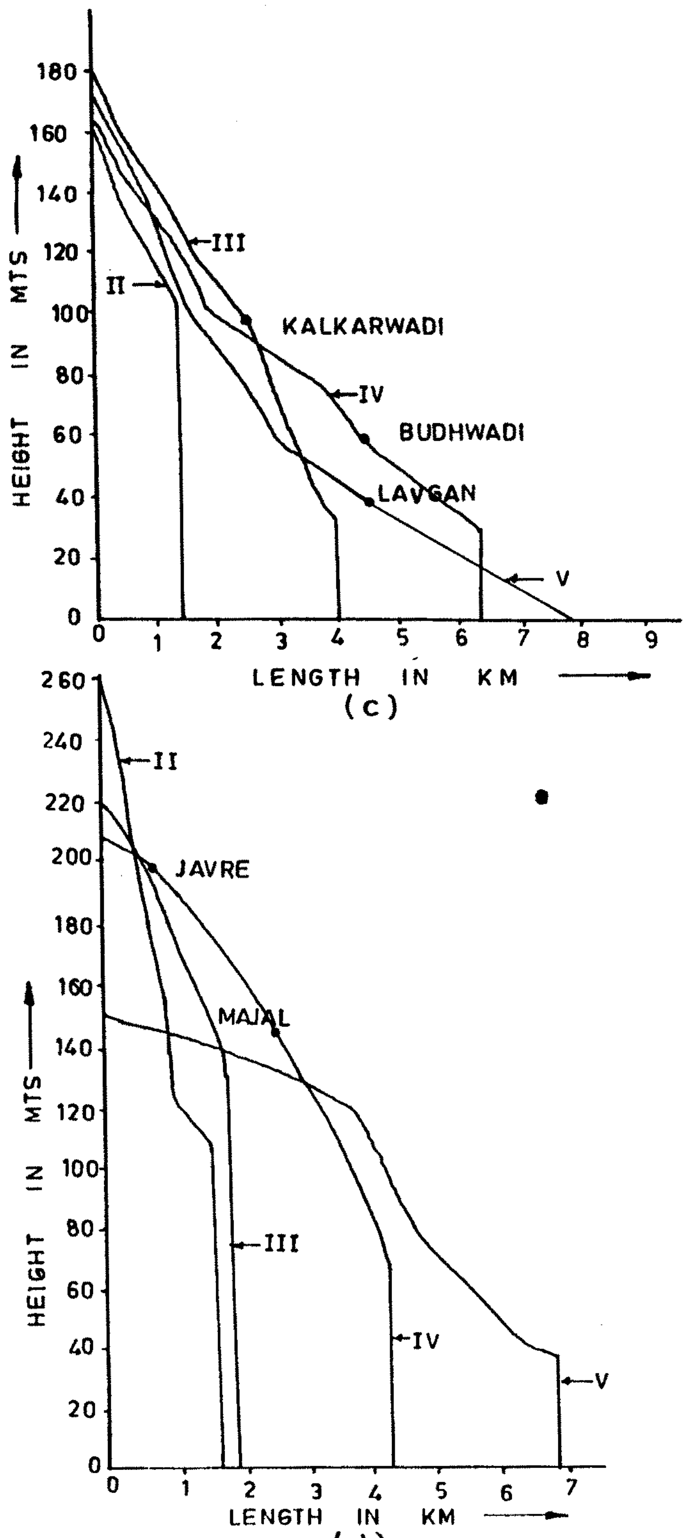


FIG.4·7 c & d) : LONGITUDINAL PROFILES OF THE 5[th] ORDER BASIN Nos.3 & 4.

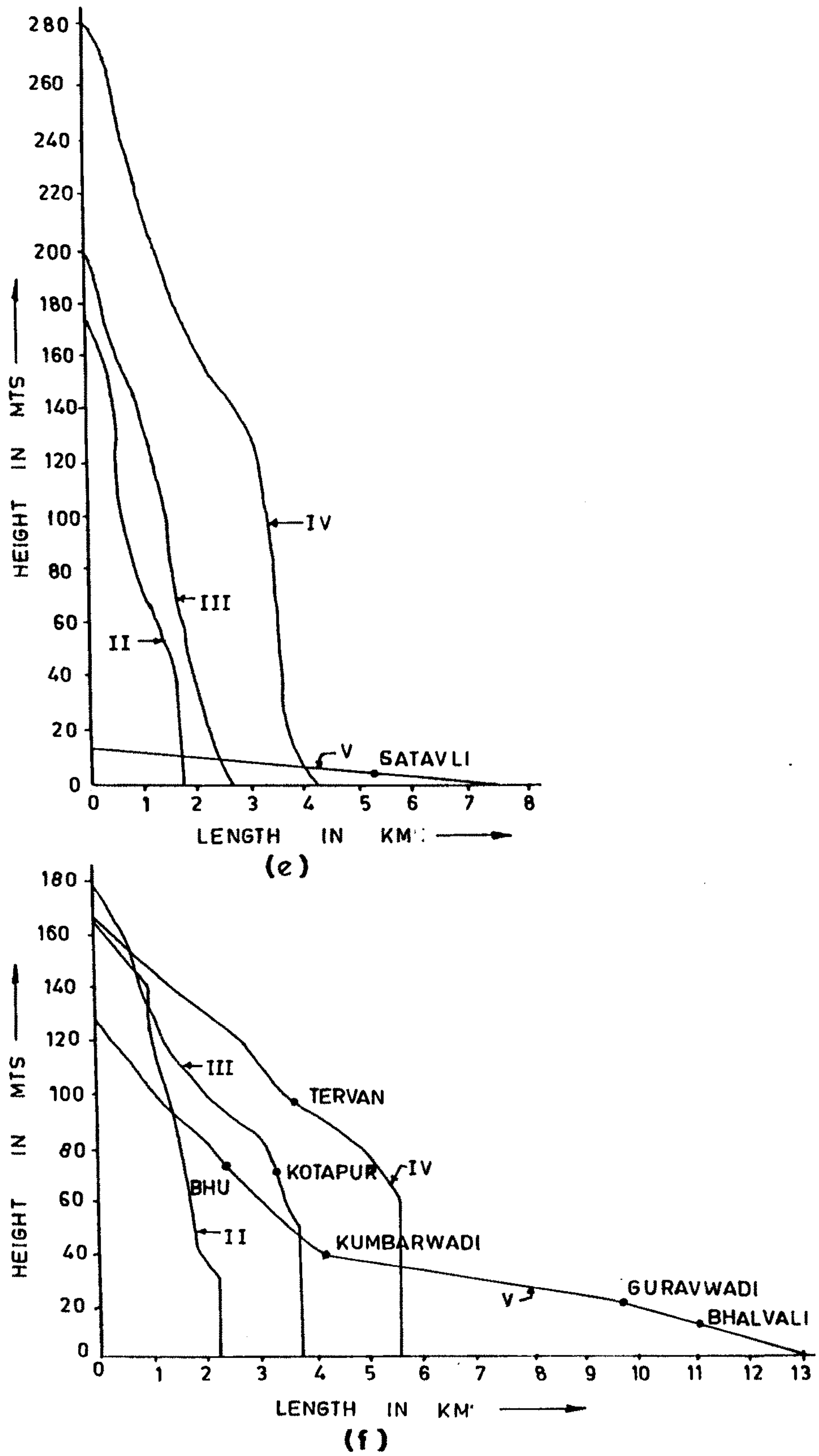


FIG. 4·7 e & f): LONGITUDINAL PROFILES OF THE 5th ORDER BASIN Nos. 5 & 6 .

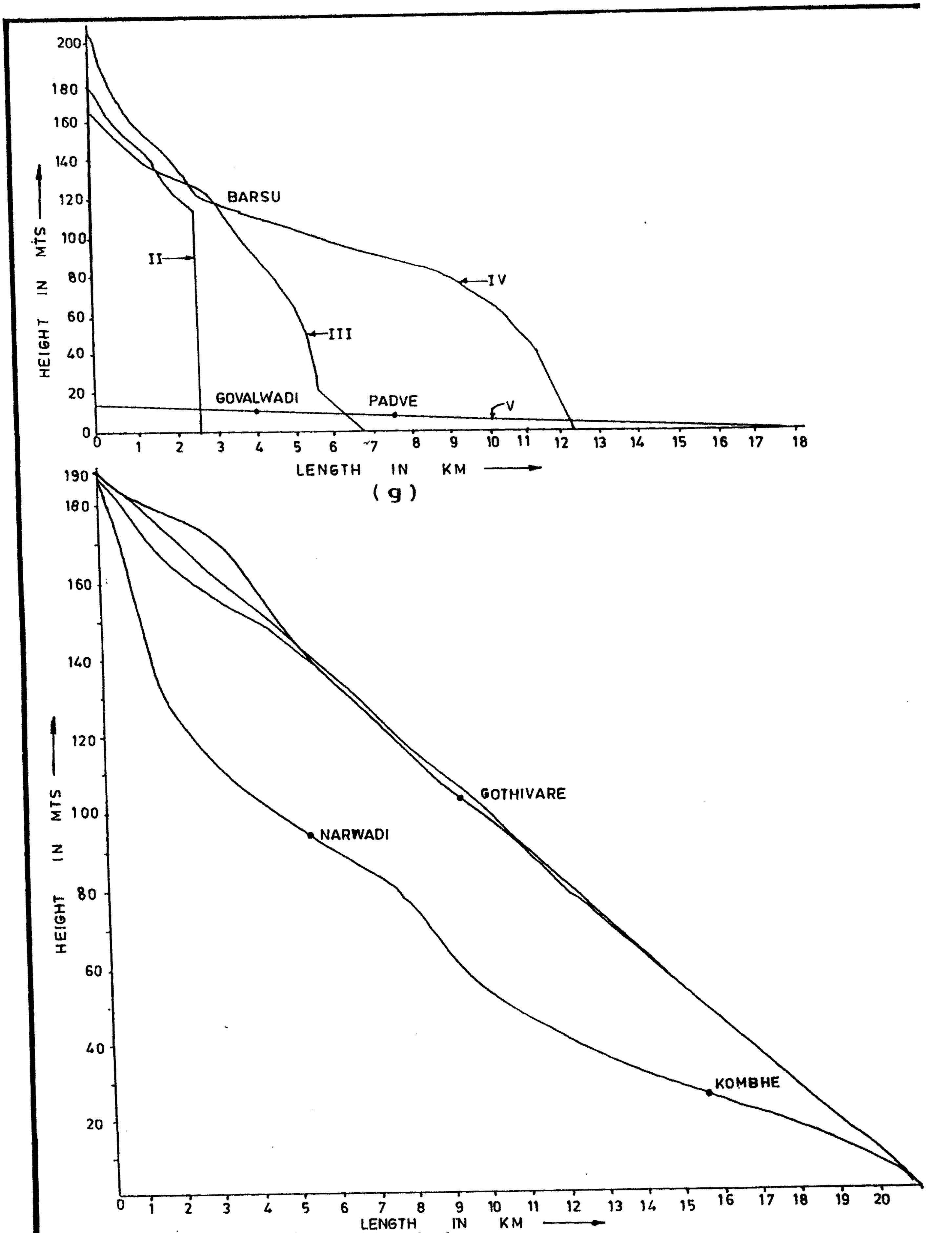


FIG. 4·7 g & h) : LONGITUDINAL PROFILES OF THE 5th ORDER BASIN Nos.7 & 8.

erosional disequilibrium between the two drainage systems (Hack, 1981).

DISCUSSION

To understand the drainage characterstics and to get the systematic measures for the drainage basins, different morphometric parameters have been calculated. These parameters help to know the terrain texture. The different dimensionless parameters from the drainage analysis also suggest the evolutionary changes which have taken place because of the various geological agents in a particular area.

From the values of the bifurcation ratio, it is evident that there appears to be no strong geologic control in the development of the drainage, but more or less similar values of the bifurcation ratio suggest that this could be mainly due to the homogeneous nature of the lithology of the area under study. It has been observed that wherever the drainage is developed on the low-lying areas, constituting the Quaternary sediments, there is a decrease in the values of the bifurcation ratio, particularly for the higher order streams. The graph of logarithm of total stream length for each order against the logarithm of stream order indicates that the headward erosion of higher order streams has been guided by structurally weaker zones.

Stream length analysis of the basins shows that the length of higher order stream is greater than what should normally be expected, suggesting thereby that it is due to the headward erosion of the higher order streams. The lower values of the drainage density indicate that the stream has reached more or less to low elevated areas, while slightly higher values of the drainage density are due to higher elevation of the basin.

Considering the values of the constent of channel maintenance it is inferred that out of the eight fifth order basins, only basins 2 and 8 are more or less identical having similar topography and effect of the degree of dissection. From these values, it can be concluded that there is no strong geological control in the geomorphic evolution. However, the stream length values indicate that the headward erosion of the higher order streams probably have been guided by structurally weaker zones.

From the hypsometric values, it is inferred that the higher order streams in all the fifth order basins within the area show monadnock phase, whereas, the hypsometric values around 0.40 indicate the maturity stage. For basins 1, 2 and 7, from the value obtained, it is suggested that these basins have reached to an equilibruim stage thereby implying the maturity stage of develement. From these observations, it can be said that the area under study indicates monadnock phase of aeration which represents the residual hills. From altimetric analysis, it is observed that in general the area slopes from NE to SW, NW to SE and SE to NW directions.

From the altitude percent frequency, the entire area fall under the category of moderately high relief. The frequency polygons of all the fifth order basins reveal -ve skewness, while, basins 4 and 5 are +vely skewed. The values of the absolute relative relief over 35.62 % of all the basins of fifth order indicate the high land topography.

From the slope angles, it is observed that the basins 2, 3 and 7 belong to the gentle slope category, while basins 1,4,5,6 and 8 belong to the frequencies of moderate slope categories. Majority of the basins under investigation belong to the frequencies in the moderate slope and therefore whole of the area can be classfied as of residual hill type. The slope frequency percentage values obtained, support the above observation.

The stream gradient index values obtained for the basins of the fifth order exhibit relatively higher values, for basins 1 and 5, which are of upland type. Basins 3 and 7 are of combined type, while the low values for basins 2,4,6 and 8 are of low-land type.