GEOMORPHOLOGICAL STUDY OF THE KABINI RIVER BASIN, SOUTH INDIA

H. C. VAJRAPPA and G. SRINIVAS, Bangalore

ABSTRACT: The Kabini river basin covers an area of 7040 sq. km. It rises on the western ghats in North Wayanad district and flows in north-eastern direction over a length of 230 kms. The over all slope of the basin is in a north-easternly direction. The basin exhibits a dendritic pattern of drainage with a number of segments controlled by lineaments present in the basin. Quantitative studies have been carried out to correlate the geomorphic parameters with runoff and other hydrological characters. Two dimensional random sampling technique has been employed to derive the morphometric parameters. The Kabini basin is an elongated, seventh order basin. The bifurcation ratio is 4.7 indicating a mature stage of development. The length and area ratio is found to be 2.1 and 4.3. The number of streams, mean length and mean areas follow the Horton's exponential relationships. The mean drainage density is 1.97 km/sq km. The stream frequency of the basin is 1.78 per sq. km. The slope and hypsometric analysis have been carried out for the basin. The low slope regions are potential zones of ground water accumulation and should be considered for detailed exploration. The hypsometric analysis indicates the mature stage of development of the basin.

INTRODUCTION : The Kabini river is a tributary to the river Cauvery. This river basin covers an area of 7040 sq. km. and lies in Karnataka, Tamil Nadu and Kerala. Kabini river rises in North Wayanad district of Keral and flows in north eastern direction over an eastern direction over a length of 230 km, and joins the Cauvery river at T. Narasipura. It lies between 75°45'-77°0' longitudes and 11°30'-12°30' latitudes. The South-Western part of the area is occupied by the hill tracts, while the southern and eastern parts of the area are plain. The highest point of this hill range is Chittamala (1659 m) towards western part of the basin. In the present paper the geomorphological parameters are studied in detail for a qualitative as well as quantitative investigation of the basin.

Geology: The Kabini river basin is a part of the Archacan Cration of South India.

The main units are the Sargur supracrustal rocks, the Peninsular gneissic complex, younger granites and post tectonic dykes. The Sargur supracrustal rocks trending NNW, generally occur as enclaves and disrupted units within the Peninsular gneissic complex. The peninsular gneissic complex is fractured and generally trends towards NNW to NNE with an easterly dip and consists of heterogeneous polyphase gray gneisses with foliation. Besides, a few younger granitic bodies are found in the study area. A number of E-W running dykes cut across the older units. The rocks are highly weathered, and in general the thickness of weathering zone varies from 3 to 18 m. where as the thickness upto 25 m. are also observed around H. D. Kote and Nanjangud taluks.

Soil: The Soils of Kabini basin are represented by red gravel and sandy soils, medium black soils, red loamy soils and

mixed red and black soils. The thickness of soil cover generally varies from 1 to 12 m. The infiltration and moisture retentivity rate is moderate to good. The red loamy and black soils range from acidic to alkaline respectively in nature. The texture of the soil is medium to a coarse grained.

Drainage pattern : The Kabini basin is elongated along N-S direction, while it is narrower in the NE, SW portions and wider in the middle. The basin exhibits dendritic pattern of drainage in general which is typical of homogeneous crystalline rocks (Fig-1). The drainage segments in the northern part of the basin are long and widely spaced. The straight channels are to be controlled by lineaments present in the basin.

Methodology: Toposheets on the scale 1;50,000 are used for the morphometric analysis of the Kabini basin. The linear measurements are carried out with opisometer, areal measurements are carried out with planimeter and elevations with in the basin are pickedup from the toposheets for hypsometric analysis. For convenience, the fluvial morphometric analysis of the basin is divided into three aspects linear, areal and relief (gradient).

Linear Aspects of the basin: a) Stream order:- There are different methods of designating the stream order, however, the modified method of Strahler (1952) is adopted for the present analysis, and the number of segments of each order are tabulated in table-I. The Kabini basin is a seventh order basin with 9864, 2259, 507, 121, 32, 7 and 1 segments in first, second, third, fourth, fifth, sixth and seventh order respectively.

It is further observed that there are more number of channels of a particular order than the next higher order. This observation leads to the recognition of bifurcation ratio (Rb), which is the ratio between the number of a given order (Nu) to the number of segments of the next higher order (Nu+1). Mathematically it is designated as:

$$Rb = \frac{Nu}{Nu+1}$$

The bifurcation ratio for each set of streams has been calculated and presented in table-I. The bifurcation ratio of the Kabini basin is 4.7 (fig-2), which indicates the mature stage (Horton, 1950). which is aso further confirmed by the hypsometric curve.

b) Stream lengths:- The stream length has an imporant relationship with the surface flow discharge, longer the length slower the appearance of flood and larger the surface flow. Horton observed that mean lengh of channel segments of a given arder is smaller than that of higher order in a particular ratio called "length ratio", which is defined as the ratio of mean channel length of an order (Lu) to that of lower order (Lu+1), Mathematically the length ratio (RL) is given by the following formula:

$$R_L = \frac{\overline{Lu}}{\overline{Lu}+1}$$

The length ratio of the Kabini basin is 2.1 (fig-3) and tht values are presented in table-I.

The study of stream lengths which states that the cumulative mean legths of stream segments of successive orders of a basin tend to form a direct geometric sequence in which the first term is the average length of first order segments.

DRAINAGE MAP OF KABINI RIVER BASIN

FIG:1

FIG:6   Hypsometric curve for Kabini Basin
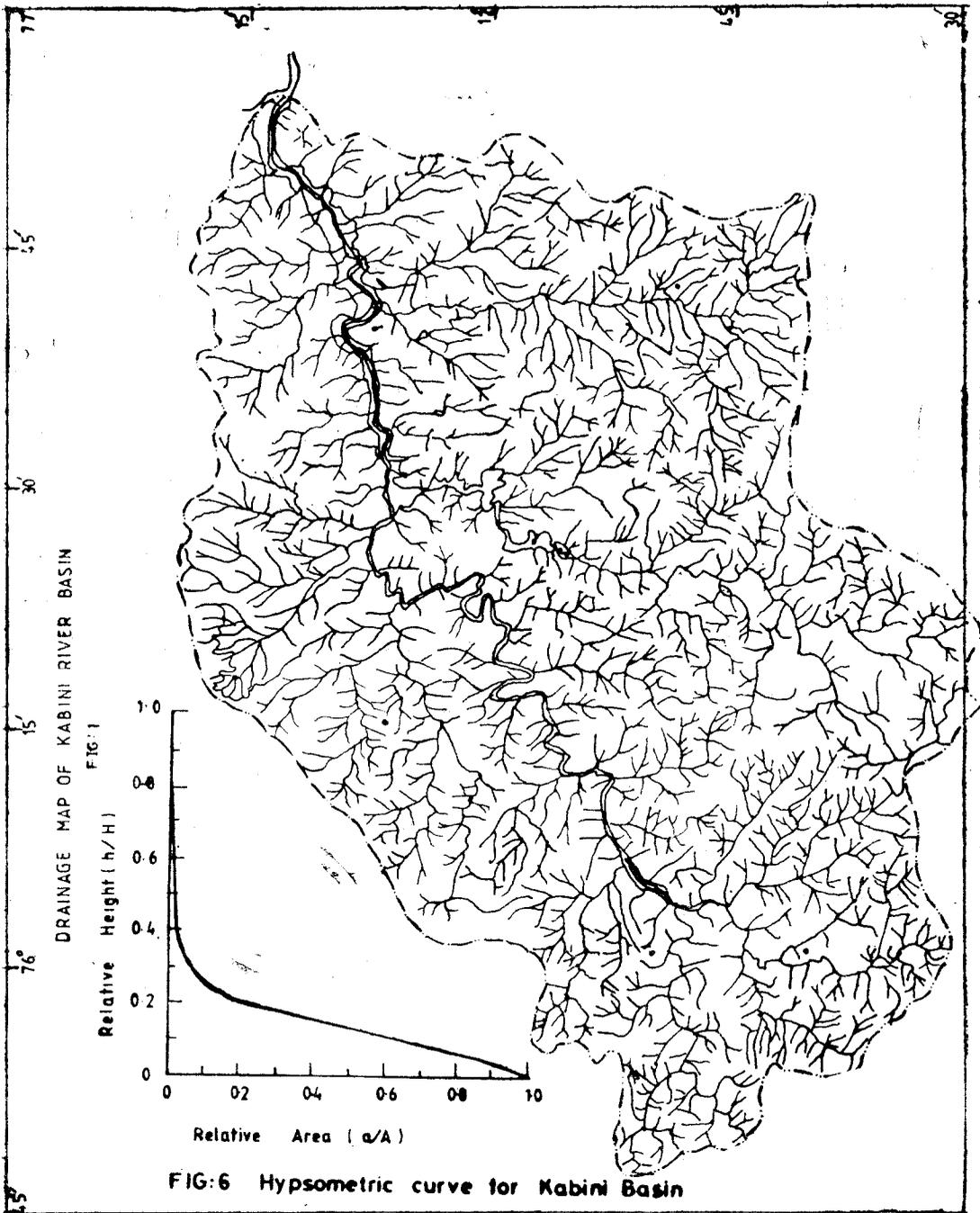
Thus the law is presented mathematically in the following way

$$\overline{Lu} = \overline{L}_1 \cdot R_L^{(u-1)}$$

In the case of the Kabini basin when the order of streams plotted against the cummulative mean length of streams follows the Horton's law.

Table - I

Table giving Different Morphometric Characters of the Kabini River Basin

Stream Order "u"	Total No. of Segments "Nu"	Bifurca- tion ratio "Rb"	Mean length of segment "Lu" in kms.	Length ratio "RL"	Mean area "Au" in Sq. kms.	Area ratio "Ra"
1.	9864		0.8		0.5	
		4.4		1.7		3.6
2.	2259		1.4		1.8	
		4.5		2.1		6.8
3.	507		3.0		12.2	
		4.2		2.5		3.2
4.	121		7.5		39.4	
		3.8		1.8		3.3
5.	32		13.4		128.7	
		4.6		2.2		5.0
6.	7		30.0		644.5	
		7.0		5.9		10.9
7.	1		177.0		7040.0	

Areal Aspects of the basin: a) Law of stream areas are governed by the mean basin areas of successive stream orders, that tend to form a direct geometric series begining with the mean basin area of first order basins and increases with the constant area ratio (Schumm, 1956). The law can be stated mathematically as under :-

$$\overline{A}u = \overline{A}_1 . R a^{(u-1)}$$

where, 'A' is mean area of basin of 'u' order, A_1 is the mean basin area of first order basin and R is an area ratio similar to the length ratio RL. The basin of different orders from 1–7 have been

calculated and the corresponding area ratios are determined as 4.8 for the Kabini basin (fig-4). The mean area plotted against stream orders exhibits a positive relation.

Basin Shape: The shape or form of a drainage basin, may have effect on the discharge characteristics of a basin. A flood takes a longer time to travel in an elongated basin when compared to a circular basin. Different values obtained using methods suggested to quantify this parameter of a basin are presented in table-II. The parameters like elongation ratio, circular ratio etc. are also presented in the table-IIa.
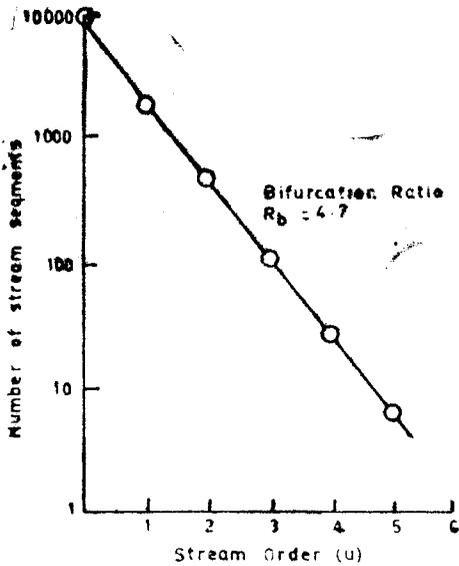
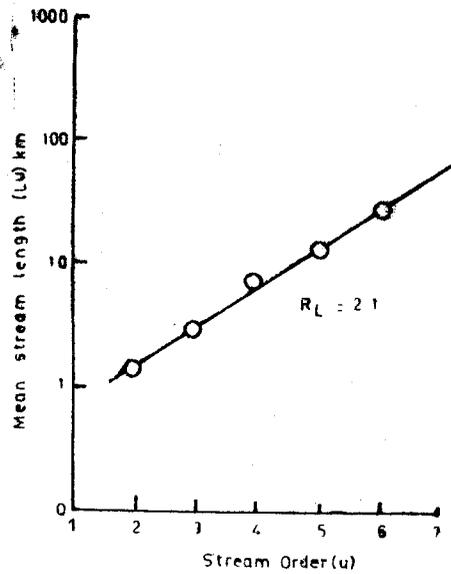FIG:2 RELATION OF NUMBER OF STREAMS
TO STREAM ORDER

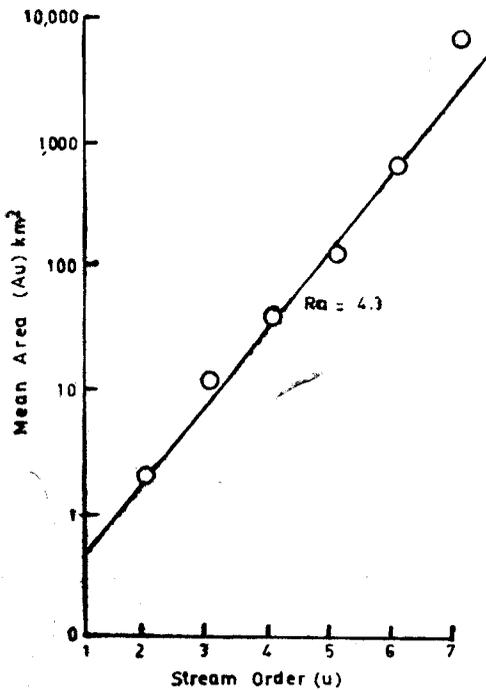FIG:3 RELATION OF MEAN LENGTH
TO STREAM ORDER

FIG:4 RELATIONSHIP BETWEEN MEAN AREA
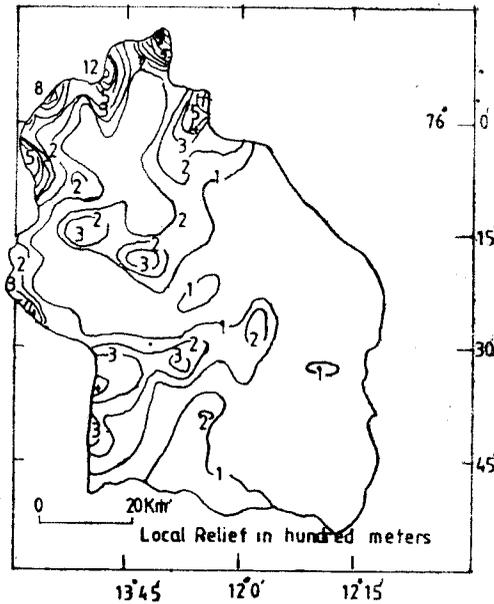& STREAM ORDER

FIG.5 Kabini River Basin Slope map

Table - II

Table Showing some of the Important Basin Parameters

1.	Basin area	7040 sq. kms.
2.	Maximum length of the basin	230 kms.
3.	Maximum Width of the basin	181 kms.
4.	Perimeter of the basin	390 kms.
5.	Diameter of Circle of the same area of the basin	124.08 kms.
6.	Area of the circle with same basin parameter	12085.74 kms.
7.	Trunk channel length	177 kms.
8.	Cumulative channel length	14298.1 kms.
9.	Drainage density	2.03 km/km^2
10.	Bifurcation ratio (Rb)	4.7
11.	Length ratio (RL)	2.1
12.	Area ratio (R$_a$)	4.3

Drainage density: Drainage density is an important factor affecting the flow, infltration capacity etc. It is defined as the ratio of the total Channel lengths within a basin to the total basin area. The unit is miles per sq. mile or km/sq. km. The drainage density of the Kabini basin is 2.03 km/sq. km. The Kabini basin is graded as coarse textured basin (Singh, 1967).

Inverse of drainage density a parameter termed as constant of channel maintenance 'C' (Schumm, 1952). The unit of 'C' is sq. km. per km. It indicates the number of square kilometers of watershed surface required to sustain 1 linear km. of channel. The 'C' for the Kabini basin is 0.58 sq. km/km.

Stream frequency: It is defined as the number of channels ir sream segments per unit area. It is of 1.78 per sq. km. as obtained for Kabini basin. Melton (1958) after analysing several drainage basins found the following universal relation $F = 0.694 D^2$ where 'F' is the stream frequency and it is 2.86 for the Kabini basin.

Relief Aspects of Kabini basin:

a) Slope analysis:-- Slope analysis is an important aspect of geomorphic studies. In the present analysis, the smith's (1953) Grid pattern method has been employed, and isopleths are drawn on the basin to indicate areas having same local relief (fig. 5). The low slope values are indicated in the northern, central and eastern part of the basin. The over all slope of the basin is in north-easterly direction. The slope map correlated wtih lithological map shows that the gneissic terrain is

TABLE — IIa

BASIN SHAPE MEASURES

Shape factor	Definition	Values	Source
1) Form S	$\dfrac{\text{Basin area}}{(\text{Basin length})^2}$	0.13	Horton (1932)
2) Shape S =	$\dfrac{(\text{Basin length})^2}{\text{Basin area}}$	7.51	Corps of Engineers (U.S.A)
3) Shape S =	$\dfrac{(\text{Basin length})}{\text{Basin Width}}$	1.27	Horton (1932)
4) Circularity ratio "C" =	$\dfrac{\text{Basin area}}{\text{Area of circle with same perimeter as the basin}}$	0.58	Millers (1953)
5) Elongation ratio "E"	$\dfrac{\text{Diameter of circle of the basin perimeter}}{\text{Maximum length}}$	0.54	Schumm (1956)
6) Lemniscate ratio "K"	$\dfrac{(\text{Basin length})^2}{4 \ (\text{basin area})}$	1.88	Chorley (1957)

characterised by a lower slope compared to the granitic region. The low slope areas are potential zones for ground water accumulation.

b) Hypsometric analysis :- Strahler (1952 and 1957) demonstrated the advantages of hypsometric analysis and has drawn type curves for different stages of erosion. Hypsometric curve involves two ratios relative height (h/H) and relative area (a/A), where the former is the ratio of height of a given contour 'h' to the total height 'H' and the later is the ratio of horizantal cross-sectional area 'a' to entire basin area 'A'. The relative height is plotted on the 'Y' axis and the relative area is plotted on the 'X' axis. The hypsometric curve of the basin compares very well with that of the type curve depicting mature stage of the cycle of erosion (fig–6). This conclusion is in conformity with the conclusion arrived based on the study of bifurcation ratio.

Conclusions : Kabini basin exhibits a dendritic pattern of drainage with a number of segments controlled by lineaments present in the basin. The basin obeys the laws of the stream numbers, the stream length, and the stream areas of Horton. It is a seventh order basin, wth a drainage density of 2.03 km/sq. km, which is a coarse textured basin.

The over all slope of the basin is in a north-easternly direction and the low slope regions are potential zones of ground water accumulation. The bifurcation ratio of 4.7 and the hypsometric analysis indicate that the basin has reached a mature stage of erosion, which is in conformity with the hypothetically accepted general view concerning the river basins of south India.

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Addresses of the authors

H. C. Vajrappa, Research Assistant, Department of Geology, Bangalore University, Jnana Bharathi, Bangalore-560 056.

Dr. G. Srinivas, Reader, Department of Geology, Bangalore University, Jnana Bharathi, Bangalore-560 056.