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Geomorphometric Analysis to Deduce Groundwater Potential of Kumbhi River Basin, Kolhapur District, M.S. India

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Abstract

Various factors like geology of the area, soil type, hydrological setting of the area etc. have an impact on drainage basin characteristics. Morphometric study of these features of a particular area is helpful to throw light on, geomorphological features, lithology, structural features, and ground water conditions of the area. Lineaments and hydrological setting of the area which in turn throws light on ground water conditions and movement of groundwater. The study area is Kumbhi River Basin. The study area is bounded by latitudes 16° 28' 20.77"N to 16° 44' 0.35" N and longitude 73°07' 13.74" E to 74 °49' 31.91" E on Survey of India (SOI) toposheet numbers 47H/14, 15 and 47L/2. Morphometric analysis has been carried out. Kumbhi River Basin is of 6th order. There is total 1571 streams. The Rb value of Kumbhi River Basin indicates minimum structural disturbances. The basin has coarse texture and elongated shape Hence runoff is high and infiltration is low. These low values of rho coefficient indicate that the basin is likely to be less affected during the time of floods and elevated discharge. The relief of the basin is moderate to high and it indicates low to moderate infiltration rate and high run off conditions. The frequency of lineaments in the KRB indicates large number of sub-surface openings which can act as conduits for underground water. The area has moderate to good groundwater potential.

Keywords: Drainage basin, morphometric characters, lineaments, relief, drainage density, ground water potential

Introduction

Morphometric analysis of a drainage basin can provide valuable insight into the hydrological properties of the rocks within the basin, including how topography, geology, and climate influence the organization and shape of the drainage network [3, 4, 5, 6, 12, 19]. According to Clarke (1996) [1], basin morphometry deals with the measurement and mathematical analysis of earth's surface configuration, landform dimensions, and drainage characteristics. Evaluation of the hydrological nature of rocks exposed within a basin, using quantitative morphometric analysis in relation to geomorphological features-which can provide useful information on yield potential for the watershed-is a reliable index of rock-permeability [13, 21]. The study of basin morphometric parameters helps understand basin processes and compare their characteristics. Anthropogenic activities have had a serious impact on the physical structure of rivers, streams, biotic communities, and ecological functioning of aquatic ecosystems throughout the world [20].

GIS strategies have rapidly grown in popularity among scientists and researchers in India, and they have been tried on different hydrological regimes [2, 6, 7, 8, 14, 6].

Study Area

The study area is bounded by latitudes 16° 28' 20.77"N to 16° 44' 0.35" N and longitude 73°07' 13.74" E to 74 °49' 31.91" E on Survey of India (SOI) toposheet numbers 47H/14, 15 and 47L/2. Kumbhi River is one of the main tributaries of the Panchganga River. Kumbhi River originates near Lakhmapur Village (Taluka-Gaganbawada), Kolhapur District, Maharashtra. The location map of Kumbhi River Basin is shown below. (Fig.1)

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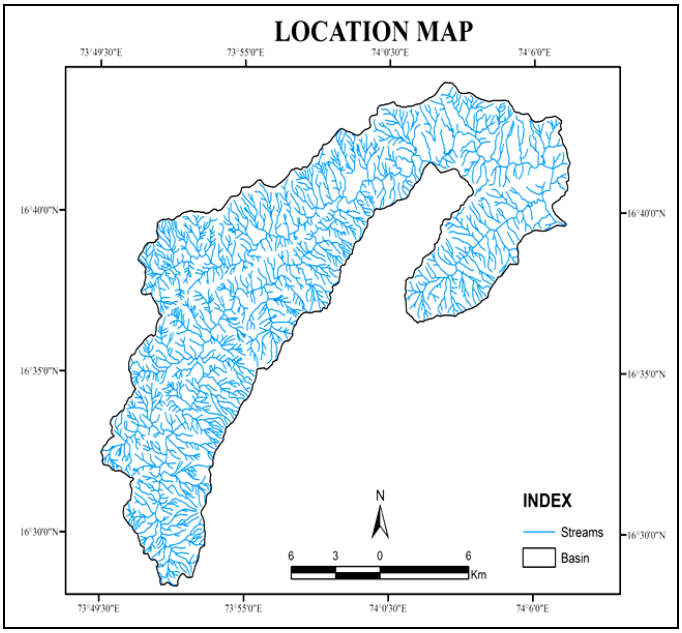

Fig 1: Location map of Kumbhi River Basin

Methodology

Survey of India Toposheets on 1: 50,000 scales were used to prepare location map (Fig. 01) and drainage map (Fig. 03). To prepare the location map and drainage map Shuttle Radar Topographic Mission (SRTM) is also used. DEM-1-arc-30 meters resolution is used for preparation of contour map and DEM map. Toposheets were scanned, geo referenced and projected to UTM WGS (1984) datum and then digitized using the capabilities of ArcGIS software. Streams of 1st and 5th order were marked by using Strahler method [19].

Morphometric Parameters

The study of basin morphometry of Kumbhi River Basin comprises: linear-, areal-and relief-aspects.

Table 1: Areal Aspects

Parameters	Kumbhi
A	315
P	133
L	56
Ff	0.10
Rc	0.22
Re	0.36
K	7.54
Dd	3.09
Fs	4.99
Di	1.61
N	15.42
Cc	2.11
C	0.32

Table 2: Linear Aspects

Basin	Stream length ratio (Rl)						Bifurcation Ratio (Rb)						Rho Coefficient (σ)							Length of Overland Flow (Lg)
	I	II	III	IV	V	VI	1/2	2/3	3/4	4/5	5/6	Avg	1	2	3	4	5	6	Avg	
Kumbhi	0.37	0.43	0.27	1.52	0.66	-	4.11	4.56	5.82	5.50	2.0	3.75	0.09	0.09	0.05	0.28	0.33	-	0.15	0.16

Table 3: Relief aspects

Basin/Sub-basin	Basin Relief (H) in meters	Relief Ratio (R_r) in m/km	Ruggedness Number (R_n)	Melton's Ruggedness Number (Mrn)	Sinuosity Index (SI)
Kumbhi	449	0.008	0.145	0.025	1.83

Slope

Analysis of slope of any basin helps to understand the rainfall pattern, runoff, and flooding. The degree of slope is a factor deciding the inflow and outflow, infiltration rate and soil transportation. Also, an understanding of the slope distribution is essential, as it provides information during planning of settlement, agriculture, afforestation, deforestation, engineering structures, etc. From the analysis of map, it was found that the basin varies in slope from 0° to 46°. The slope has been classed into ten classes with respect to its influence on slope in degrees and its areal extent. This has been tabulated in Table 4.

Table 4: Slope classification of Kumbhi River Basin along with their respective area.

Slope Class	Degrees	Area in Km	Slope Class	Degrees	Area in Km
1	0-1.5	25.17	6	7.5-9	23.56
2	1.5-3	40.29	7	9-11.5	34.23
3	3-4.5	39.43	8	11.5-14	28.80
4	4.5-6	31.10	9	14-15.5	14.44
5	6-7.5	26.05	10	15.5-46	51.89

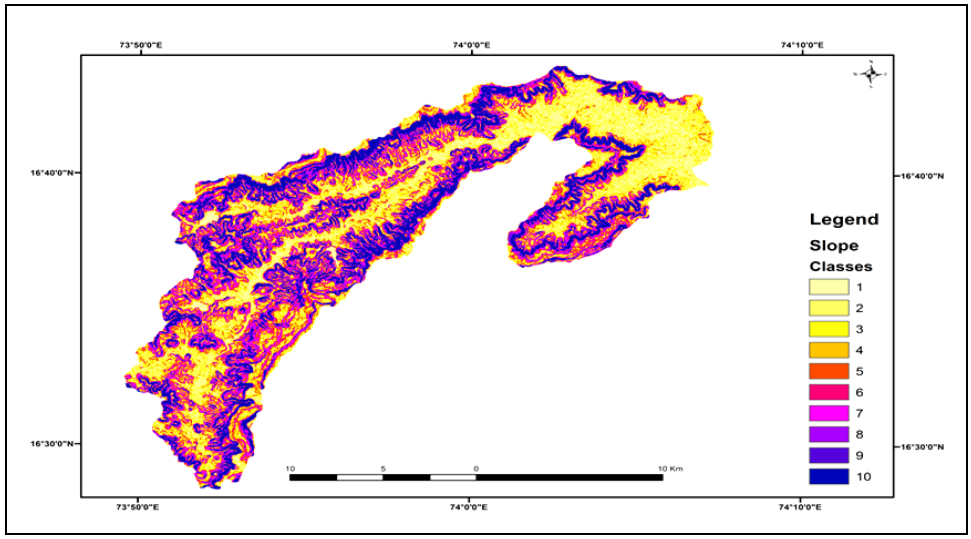

Fig 2: Slope map of Kumbhi River Basin

Lineaments

A lineament represents surficial reflection of the underlying structural features and is the surface traces of fractures in bedrock, which are projected, on the erosion of surface by various mechanisms. Structural features such as joints, fractures, and lineaments etc., which are ideal localization points of groundwater accumulation, channel for movement of groundwater and good location for exploration of groundwater[15]. The inferred lineaments in the study area are mapped with the aid of remote sensing data and toposheets. The relationship of lineaments on groundwater systems and occurrence of groundwater in carbonate rocks has been signified by[11]. The number of major and minor lineaments (Fig. 3) in the Kumbhi River Basin are marked distinctly. which clearly indicates main stream and its sub-streams. The trends of these lineaments are NNE to SSW.

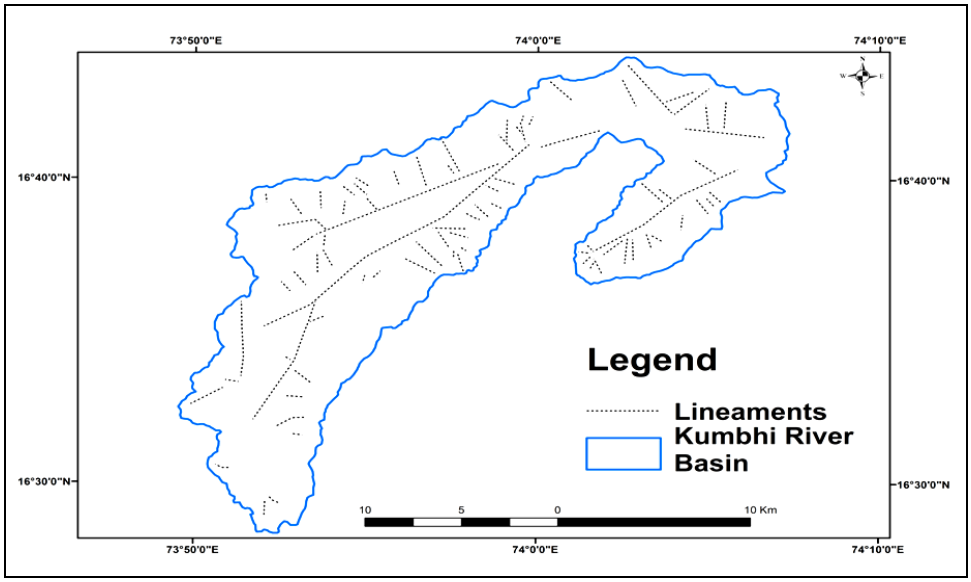

Fig 3: Lineament map of Kumbhi River Basin

Hypsometric Analysis

Hypsometry is the measurement of elevation of land with respect to sea level. It represents the relationship between elevation and basin area of any watershed, or catchment [10, 18]. The term hypsometric analysis was first time coined by Langbein (1947) [10] to define the overall slope and the forms of drainage basin. By studying hypsometric analysis, one can generate Hypsometric Curve and Hypsometric Integral, which are very useful to evaluate erosional stage and flood response of a basin. Hypsometric curves (HC) and hypsometric integrals (HI) are important indicators of watershed conditions[16]. Many researchers have studied hypsometric analysis of different drainage basin to monitor condition of basin with respect to its water resources and landscape [9, 17].

In the Kumbhi River Basin, hypsometric analysis was performed to determine its runoff, recharge, and storage conditions. HC plotted for present study area show the relationship between relative heights (h/H) and relative areas (a/A). Further, HI values were calculated using contour map of study area in arc GIS software and generated data of relative area and relative height were tabulated in Table 5. Strahler (1952)[18] classed values of HI and HC into three important classes. HI values > 0.6= Youthful stage; 0.35 < HI < 0.6= Mature stage and HI < 0.35= Monadnock stage.

Table 5: Relative area and relative height calculated for Kumbhi River Basin

Contour interval		Relative area	Relative height
From	To	a/A	h/H
536	580	0.269461	0.566954
580	625	0.248445	0.612538
625	670	0.160707	0.658122
670	715	0.106121	0.703706
715	760	0.068874	0.759289
760	805	0.063800	0.794873
805	850	0.057843	0.820457
850	895	0.019042	0.886041
895	940	0.004286	0.931624
940	985	0.001257	0.977208

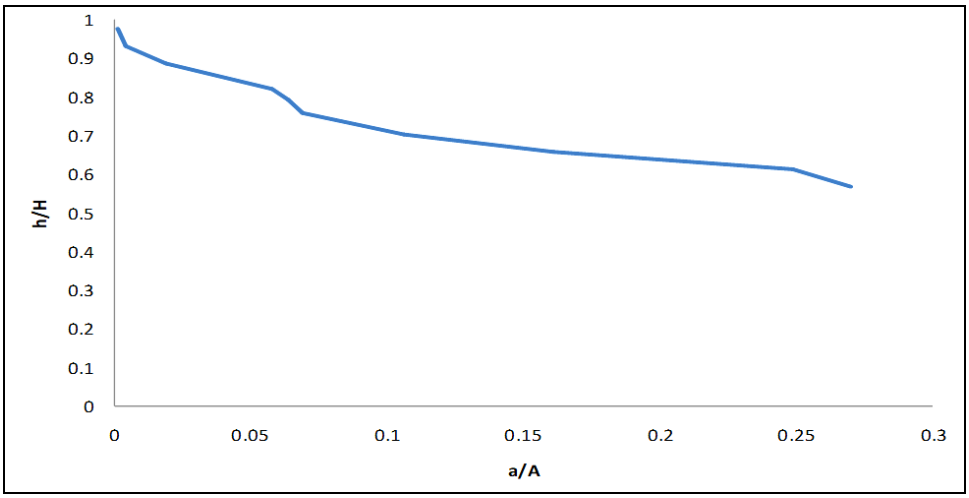

Fig 4: Hypsometric curve of Kumbhi River Basin

Discussion and Conclusion

The average (Rb) bifurcation ratio value of 4.4 (Table 3) suggests that the basin is not much affected due to structural disturbances. Rho **(ρ)** value in the present study area 0.113. This low value of rho coefficient indicates that the basin is likely to be less affected during the time of floods and elevated discharge. Length of Overland Flow value of Kumbhi River Basin is 0.16 indicating normal to medium ground slopes, flow-path, run-off, and infiltration. The calculated value of form factor ratio for Kumbhi River Basin 0.10 indicating the sub-basin to be in elongated in shape and experiencing lower peak flows of longer duration. The circularity ratio value of the present study area is 0.22 indicate elongated shape of the basin. Elongation ratio value of Kumbhi River Basin is 0.36**.**

Lemniscate ratio (K) value for whole Kumbhi River Basin is 7.54 Km/Km2 These values of lemniscate ratio indicate moderate slope and moderate permeability. The watershed has a drainage density value of 1.81, which falls under very course texture category. Stream frequency (Fs) value of the study area is 4.99; while the Constant of Channel Maintenance (C) value of Kumbhi River Basin is computed as 0.32, indicating moderate slope, high permeability, and less run-off. The computed value of Compactness coefficient **(**Cc) in the Kumbhi River Basin is 2.11, indicating elongated shape and moderate slope.

The value obtained for infiltration number of Kumbhi River Basin is 15.42, This value of infiltration number indicates moderate to high infiltration and high relief. Relief value indicates the basin to be having moderately high relief. The relief ratio (Rr) value of the present study area is 0.008, it implies basin have valleys.

The lower values of Ruggedness Number (Rn) in the present study indicate terrain is less prone to erosion. From the study it was found that Kumbhi River Basin has Melton's Ruggedness Number **(**Mrn) value of 0.025, the above result signifies that the basin is prone to debris floods due to flooding. According to the present study, Kumbhi River Basin shows the sinuosity value (SI) of 1.83 (Table 5), signifying that river Kumbhi is at meandering stage.

Region of low slopes is observed in North-eastern part of study area indicating high infiltration while in area of greater slopes indicate less infiltration and more runoff. The lineament map analysis clearly indicates main stream and its sub-streams. The trends of these lineaments are NNE to SSW. Hypsometric analysis of Kumbhi River Basin using above method signifies the basin is in its youthful stage (Fig. 4).

The frequency of lineaments in the study area indicates large number of sub-surface openings which can act as conduits for underground water. After studying and analysing the above parameters, it can be concluded that study area has overall moderate to good potential of surface and sub-surface water.

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