Morphometric Analysis of Gostani River Basin Using Remote Sensing & GIS

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Abstract: The morphometric analysis of a river basin provides critical insights into its hydrological and geomorphological characteristics, essential for effective watershed management and planning. This study presents a detailed morphometric analysis of the Gostani River Basin using Remote Sensing (RS) and Geographic Information System (GIS) techniques. High-resolution satellite imagery and topographic data, including Digital Elevation Models (DEMs), were utilized to extract drainage networks and basin boundaries. Key linear, areal, and relief morphometric parameters such as stream order, bifurcation ratio, drainage density, stream frequency, elongation ratio, and relief ratio were computed using GIS tools. The results reveal that the Gostani River Basin exhibits dendritic drainage patterns, moderate drainage density, and a sub-mature stage of geomorphic development, indicating semi-permeable sub-surface material and moderate to low relief. The analysis highlights the usefulness of RS and GIS in deriving accurate and comprehensive morphometric parameters, facilitating better understanding of basin dynamics for sustainable water resource management and environmental planning.

Index Terms-Morphometric analysis, Remote Sensing (RS), Geographic Information System (GIS), Gostani River Basin, Drainage characteristics.

I. INTRODUCTION

The Gostani river rises in the Ananthagiri Hills of the Eastern Ghats and flows through the Borra Caves which lie near its source. It is the largest river flowing through Visakhapatnam city. It flows for 120 km before joining the Bay of Bengal throughan estuary near Bheemunipatnam. lower Gostani river basin (LGRB), a part of the Eastern Ghat Mobile Belt region is drained for a variety of agricultural fields, industrial purposes and also major source for the water supply to Vizainagram and Visakhapatnam cities. The main objective of this study, using remote sensing and GIS technology is to compute basin morphometric characteristics for various parameters.

Physiography of the Study Area

The investigated area is enclosed between latitudes 17°53′N and 18°17′N and longitudes 83°01′E and83°30′E, covering an area of 1252.39 sq. km. Geologically, the area under study is occupied by

96% khondalite group (quartz-feldspar-garnetsillimanitegneiss) of rocks. The area is well represented by structural hills, denudational hills, buriedpediments. The area enjoys tropical climate of semi arid in nature and the temperature ranges from 19 to 28º C in December and 25 to 40º C in May. The average annual rainfall in the basin is 110 cm with maximum contribution from southwest monsoon.

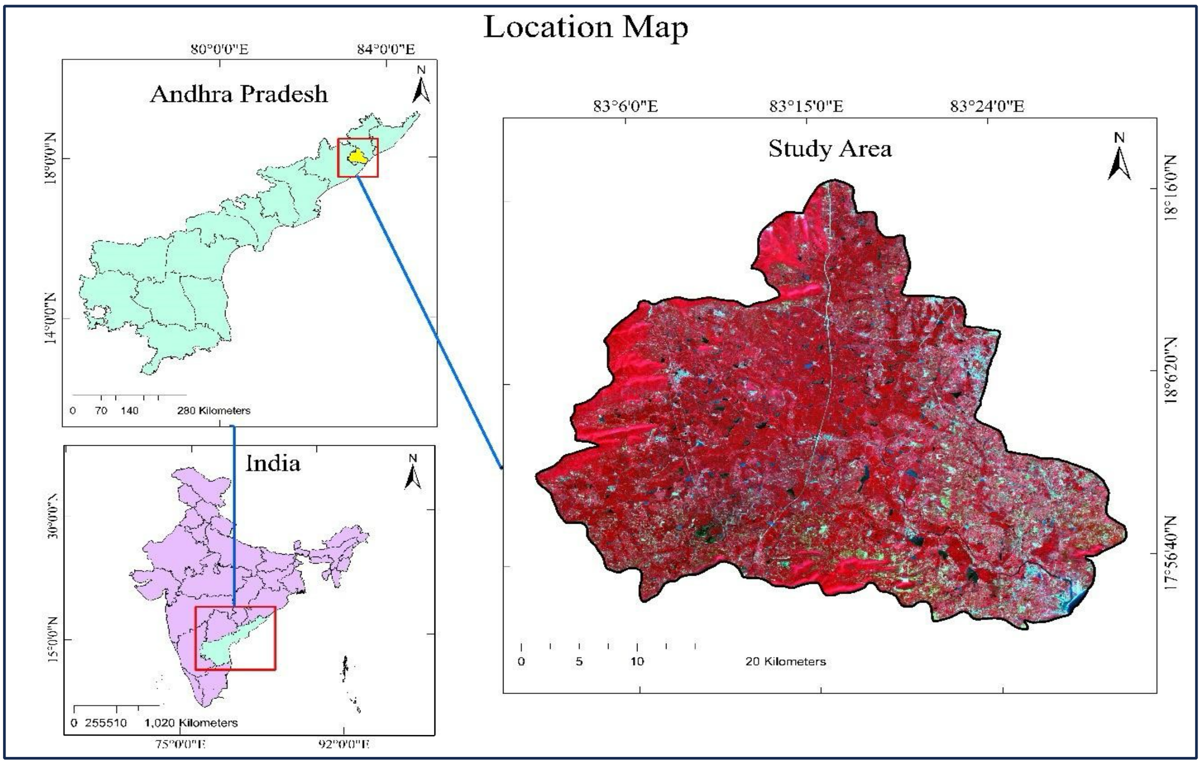
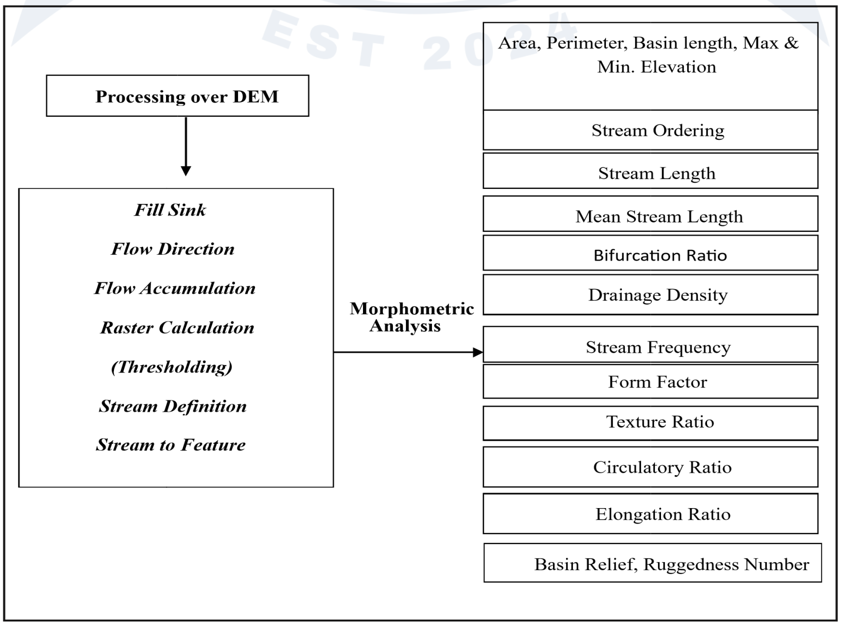


Figure: Location map of the study area

Materials and Methods

The digital data format from Google Earth Engine of Sentinel 2A with 10 m spatial resolution. ASTER DEM from NASA Earthdata with 30 m Spatial Resolution. Delineation of stream network and finding the stream order was done using GIS software (ArcGIS ver: 10.4). The order was given to each stream following Strahler (1964) stream ordering technique.



Results and Discussion

Most of the morphometric parameters are different dimension which is helpful in analysing the result regardless of scale and also shows the nature of effect on other morphometric parameter. The Morphometric Analysis of a river basin is done under following 3 heads.

• Linear Aspects: one dimension

• Areal Aspects: two dimensions

• Relief Aspects: three dimensions

Table: Method of Calculating Morphometric Parameters of Drainage basin

	Morphometric Parameters	Formula	References
LINEAR	Stream order (U)	Hierarchical order	Strahler,1964
	Stream Length (L_U)	Length of the stream	Hortan, 1945
	Mean stream length (L_{sm})	$L_{sm}=L_u/N_u$; Where, Lu=Mean stream length of a given order (km), Nu=Number of stream segment.	Hortan, 1945
	Stream length ratio (R_L)	R_L= Lu / Lu-1 Where, Lu= Total stream length of order (u), Lu-1=The total stream length of its next lower order.	Hortan, 1945
	Bifurcation Ratio (R_b)	R_b = Nu / Nu+1 Where, Nu=Number of stream segments present in the given order Nu+1= Number of segments of the next higher order	Schumn,1956
RELIEF	Basin relief (B_h)	Vertical distance between the lowest and highest points of basin.	Schumn,1956
	Relief Ratio (R_h)	R_h = Bh / Lb Where, Bh=Basin relief, Lb=Basin length	Schumn,1956
	Ruggedness Number (R_n)	R_n=Bh×DdWhere,Bh= Basin relief, D_d=Drainage density	Schumn,1956
	Drainage density (D_d)	D_d=L/A Where, L=Total length of stream, A= Area of basin.	Hortan, 1945

AERIAL	Stream frequency (F_s)	F_s=N/A Where, L=Total number of stream, A=Area of basin	Hortan, 1945
	Texture ratio (T)	T=N_1/P Where, N_1=Total number of first order stream, P=Perimeter of basin.	Hortan, 1945
	Form factor (R_f)	R_f=A/(Lb)^2 Where, A=Area of basin, Lb=Basin length	Hortan, 1945
	Circulatory ratio (R_c)	R_c=4πA/P^{2}Where A= Area of basin, π=3.14, P= Perimeter of basin.	Miller,1953
	Elongation ratio (R_e)	R_e=√(Au/π)/ Lb Where, A=Area of basin, π=3.14, Lb=Basin length	Schumn 1956
	Length of overland flow (L_g)	L_g=1/2D_d Where, Drainage density	Hortan, 1945
	Constant channel maintenance(C)	Lof=1/D_d Where, D_d= Drainage density	Hortan, 1945

River basin	**Stream order u**	**Number of streams N_u**	**Total length of streams in km L_u**
LGRB	1	780	743.4
	2	384	388.6
	3	38	190.7
	4	10	117.5
	5	4	16.6
	6	2	15.3
	7	1	32.2

Bifurcation ratio R_b						**Mean bifurcation ratio**
1st order/ 2nd order	2 nd order/ 3rd order	3rd order/ 4th order	4th order/ 5th order	5th order/ 6th order	6th ord er/ 7th or ler	
2.03	10.1	3.8	2.5	2	2	3.74

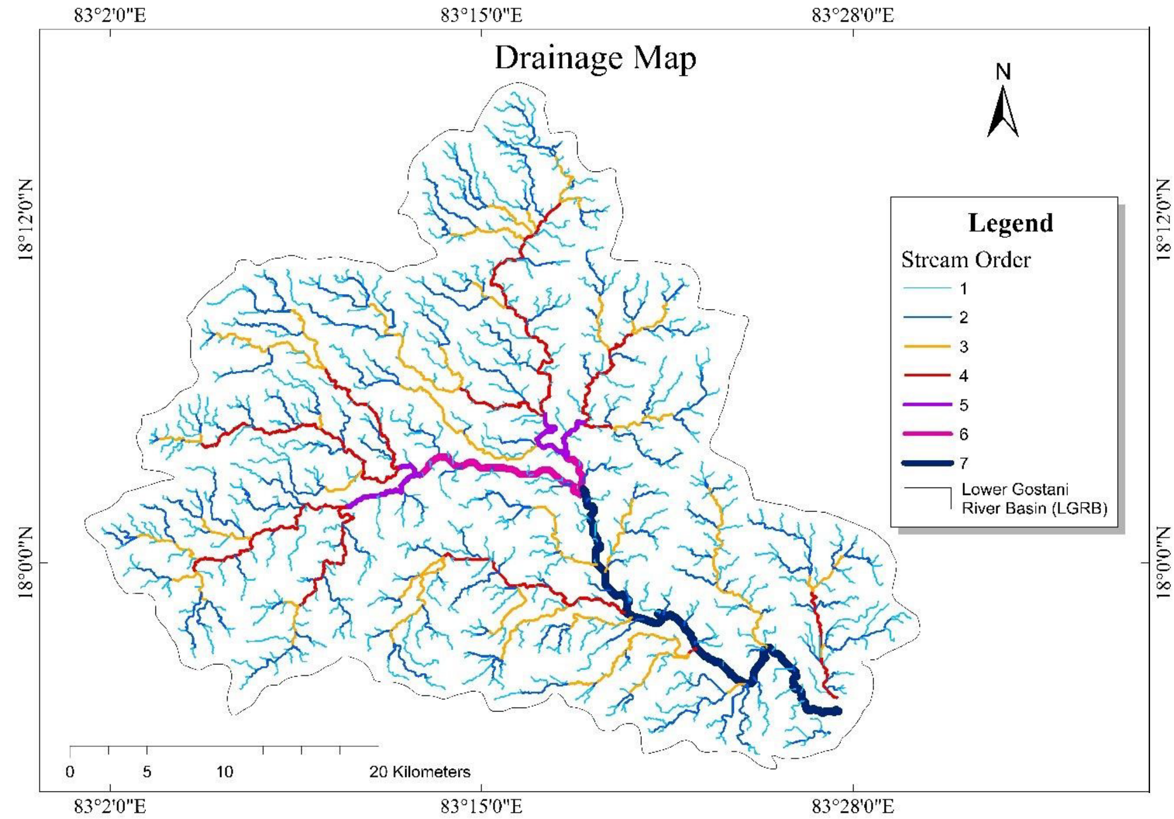
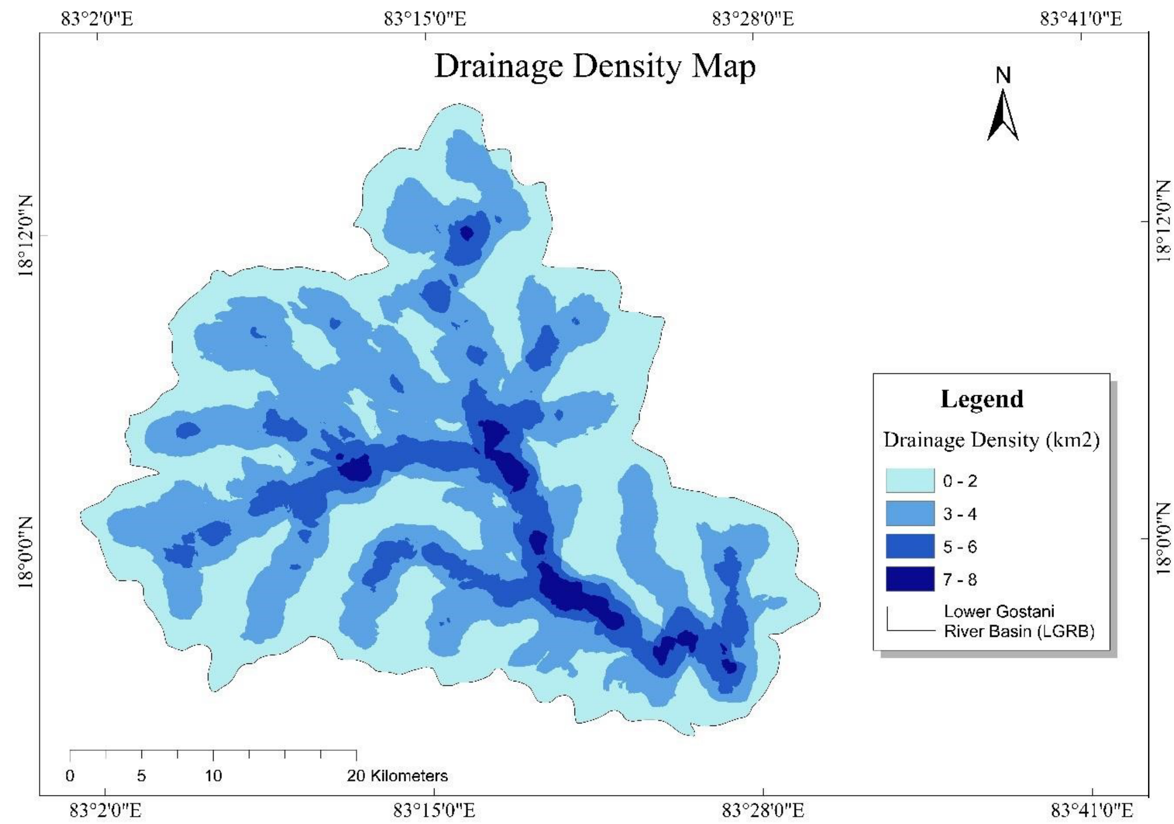


Figure: Drainage map of the river basin



Sr. No.	Parameter	Value
1	Basin Area (Km^2)	1252.4
2	Perimeter (Km)	186.2
3	Basin order	7
4	Drainage density (D_d) (Km/Km^2)	1.2
5	Stream frequency (F_s) $(Km)^2$	0.97
6	Relief Ratio (R_h)	18.1
7	Basin Length (L_b) (Km)	45
8	Basin Relief(B_h) (m)	871
9	Ruggedness number (R_n)	1045.2
10	Form Factor (R_f)	0.61
11	Circulatory ratio (R_c)	0.45
12	Elongation Ratio (R_e)	0.44

Conclusions:

The morphometric analysis carried out in the lower Gostani river basin shows that the basin is having low relief of the terrain and elongated in shape. Drainage network of the basin exhibits as mainly dendritic type which indicates the homogeneity in texture and lack of structural control. The linear pattern of the graphical representation indicates the weathering erosional characteristics of the area under study. The morphometric parameters evaluated using GIS helped us to understand various terrain parameters such as nature of the bedrock, infiltration capacity, runoff, etc. Similar studies in conjunction with high resolution satellite data help in better understanding the landforms and their processes and drainage pattern demarcations.

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