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Morphometric Analysis of Irang River Watershed, Manipur, India using Remote Sensing and GIS

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Abstract: Remote sensing (RS) and GIS is considered to be a very effective tool for interpretation of high resolution satellite data for understanding and managing the nature of a drainage basin.
The morphometric analysis of the drainage basin and channel network plays a significant role in comprehension of the geohydrological nature of drainage basin and expresses the prevailing climate, geological setting, geomorphology and structural antecedents of the catchment area.
Keywords: Morphometry, Geomorphology, Remote sensing and GIS, Watershed.

I. INTRODUCTION

Geomorphology is the science of origin and evolution of topographic features or attributes caused by physical and chemical processes operating at or near the earth surface. Geomorphology determines the variation in earth's surface from past to present and its causative factors.
Whereas, the term Morphology is a science and measurement of forms or structures which is quantitative determination of landform.
Morphometry is the measurement and mathematical analysis of the configuration of the earth surface, shape and dimensions of its landforms (Clarke, 1966).
Morphometric analysis of a river basin provides a quantitative description of the drainage system, which is an important aspect of the basins (Strahler, 1964). River drainage morphometry plays vital role in comprehension of soil physical properties, land processes and erosional features.
A watershed is an area of land that drains or "sheds" water into a specific waterbody. Every body of water has a watershed. Watersheds drain rainfall and snowmelt into streams and rivers. These smaller bodies of water flow into larger ones, including lakes, bays, and oceans. Gravity helps to guide the path that water takes across the landscape.

II. STUDY AREA

The present study area of Irang river watershed lies between 24°12'00" N to 25°00'00" N latitude and 93°09'00" E to 93°48'00" E longitude with an area of about 2794.55 km^2. Irang river is a tributary of Barak River originated in Manipur. Tuipi is a small tributary of Irang river.
The rivers are distributed in four basins which are the Barak river basin to the west, the Manipur river basin in the central, the Yu river basin in the east and the Liyai river basin in the north. The study area lies within the Tamenglong, Noneh Churachandpur and Pherzawe district.

A. *Significance of the Study*

The area under study has remained unexplored in the field of channel morphology. Hence the study has been a great significant one in the applied geomorphology of the basin.
The major task lies with understanding and indentifying the morpholgical characteristics of the Irang river and its basin related to fluvio-geomorphology.
Study of the geomorphological characteristics of the watershed using remotely sensed data for land use identification/land of the watershed helps to understand about the geological and hydrological potential of an area.

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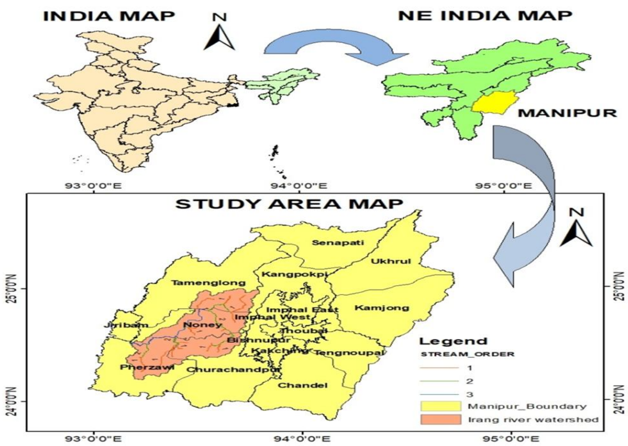


Fig: Location map of study area.

III. METHODOLOGY

The data preparation for the drainage basin analysis of the Irang river was done using CartoSat-1 DEM data with 90m resolution downloaded from https://earthexplorer.usgs.gov/.The stream network is generated by Arc Hydro tools in ArcGIS 10.8.

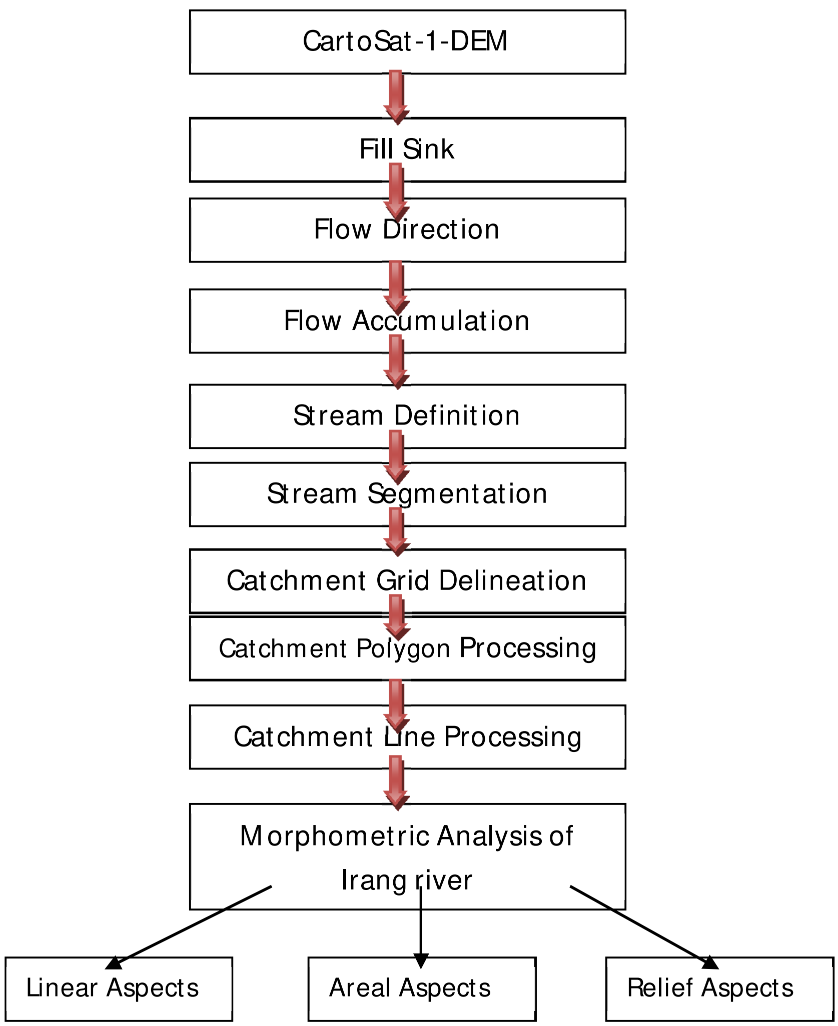


Fig : Flowchart of methodology.

IV. RESULTS AND DISCUSSION

Morphometric analysis of a basin describes characteristics of basin based on quantitative evaluation of different parameters. Parameters are allocated according to their dimensional aspects; linear aspects, areal aspects, and relief aspects. Morphometric parameters such as relief, shape, and length also influence basin discharge patterns strongly through their varying effects on lag time (Gregory and Walling, 1973).

A. *Linear Aspects*

Linear aspects give the information about one-dimensional parameter like Stream Order, Stream Number, Bifurcation Ratio, Stream Length, Sinuosity Index. This indicates channel patterns of the drainage network with the topological characteristics of the stream segments and analysis are based on open links of the stream network.

Table.1: Stream order, streams number, stream length and bifurcation ratios in Irang river watershed.

Stream Order	Stream Number	Stream Length (Km)	Bifurcation Ratio (Rb)
1st	16	179.08	
2nd	5	111.88	3.2
3rd	1	72.63	5

B. *Areal Aspects*

Areal aspects deal with two-dimensional parameters like basin shape and area, drainage density, drainage texture, stream frequency, elongation ratio, circularity ratio, and form factor. The area of the basin is defined as the total area flowing to a given outlet, or pour point upon a horizontal plane contributing to cumulate of all orders of a basin which are delineated by ridgelines which are called water divides. Perimeter is the length of the outline of a basin that can be plot and calculate in the GIS software.

Table 2: Areal aspects.

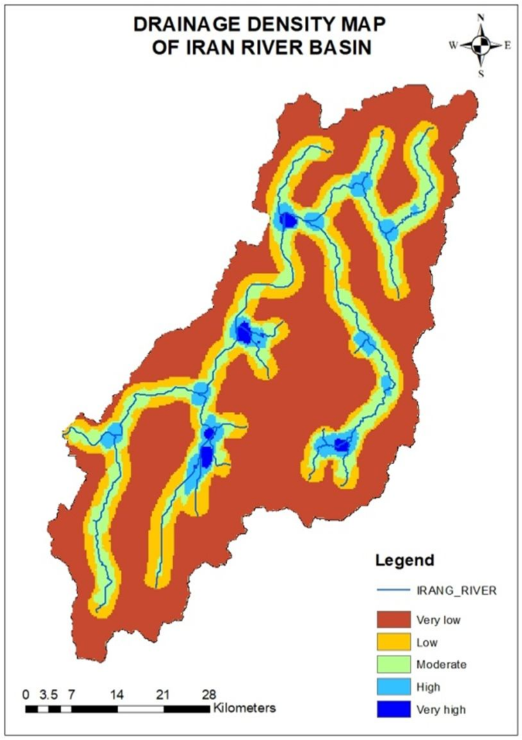
AREAL ASPECT			
Morphometric parameters	Formula	Reference	Results
Max length of Basin	L	GIS Analysis	106.009
AREA	A	Schumm (1956)	2794.55
Perimeter (P)	P	Schumm (1956)	442.92
Stream length	LU	GIS Analysis	365.19
Drainage Density(Dd)	LU/A	Horton (1932)	0.130679358
Stream Frequency (FS)	NU/A	Horton (1932)	0.018249808
Drainage Texture (T)	DD*FS	Horton (1945)	0.002384873
Elongation Ratio (RE)	(2/L)√(A/P)	Schumm (1956)	0.096118702
Form Factor Ratio (Ff)	A/L^2	Horton (1932)	0.248671726
Length Overland Flow (Lg)	1/DD*2	Horton (1945)	3.826158986

C. *Form Factor Ratio (Rf)*

Form factor (Rf) is defined as the dimensionless ratio of the basin area to the square of the basin length. This factor indicates the flow intensity of a basin of a defined area (Horton, 1932).

D. *Drainage Density (Dd)*

Drainage density is a measurement of the sum of the channel lengths per unit area. Dams are constructed in those areas where river density is higher. The drainage density is an expression of the closeness of spacing of channels (Horton, 1932). Dd is suggested that the low drainage density indicates the basin is a highly permeable subsoil and thick vegetative cover (Nag & Chakraborty, 2003). High drainage density is the result of weak or impermeable subsurface material, sparse vegetation, and mountainous relief. Low drainage density leads to coarse drainage texture while high drainage density leads to fine drainage texture.



E. Elongation Ratio (Re)

Elongation ratio (Re) is defined as the ratio of the diameter of a circle of the same area as the drainage basin and the maximum length of the basin (Schumm, 1956).

F. Relief Aspects

Relief Aspects deals with three-dimensional parameters like Relief, Relief Ratio, Ruggedness Number, Slope, River profile, Gradient Ratio and Hypsometric Curve.

Table 3: Relief aspects.

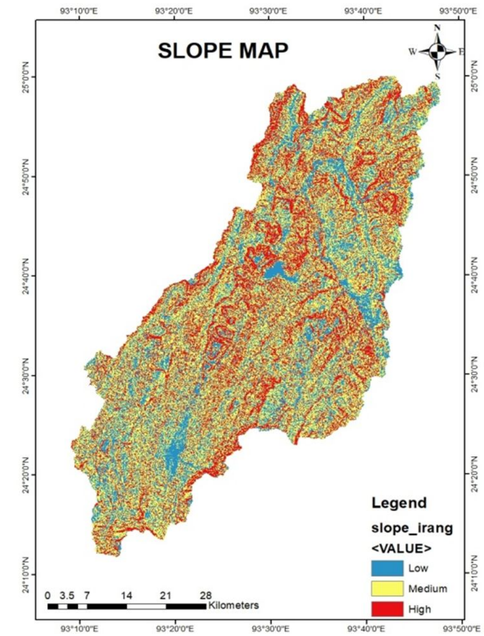
RELIEF ASPECT			
Max Height	H	Height	2285
Min Height	h	Height	6
Total Basin Relief	H/h	Strahler (1952)	380.8333333
Relief Ratio	H/L	Schumm (1956)	3.592462275

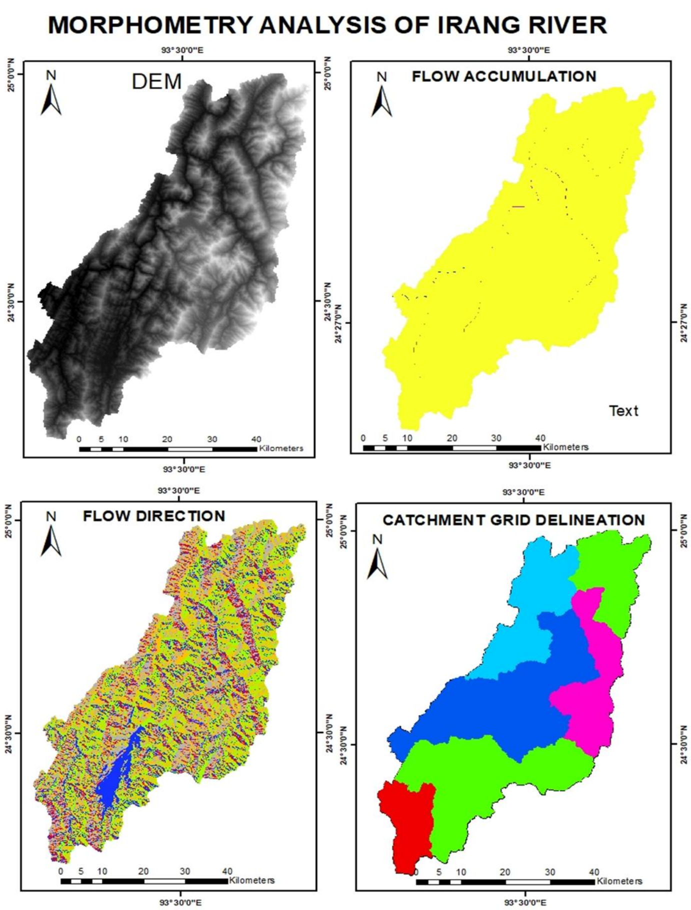
G. Relief ratio (Rh)

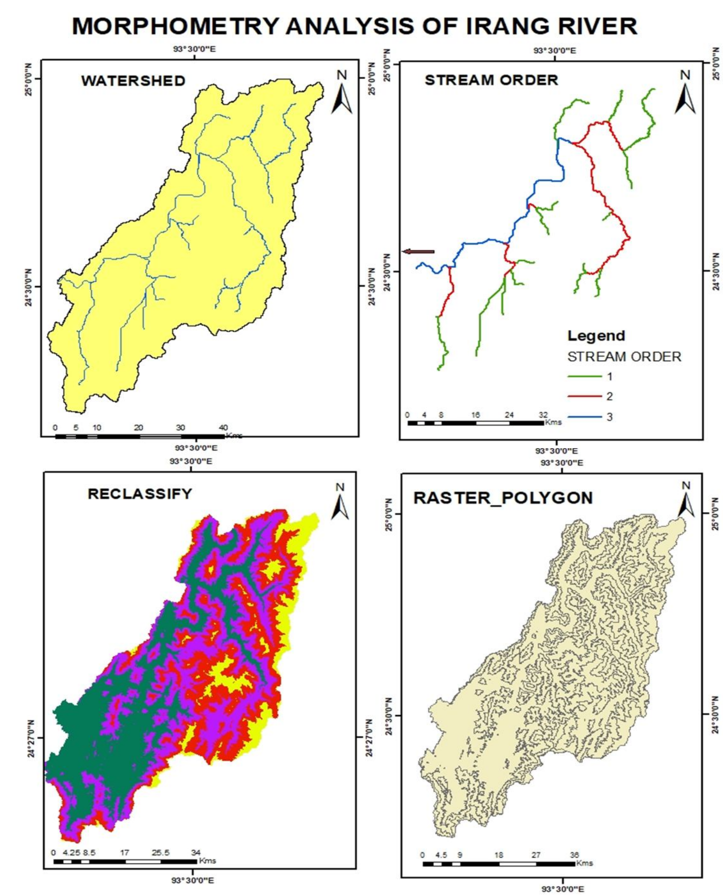
Relief ratio is defined as the ratio between the total relief of a basin i.e., elevation difference of lowest and highest points of a basin, and the longest dimension of the basin parallel to the principal drainage line (Schumm, 1956). It is a dimensionless ratio.

H. Slope

Slope is a crucial terrain parameter that has an effect on groundwater potential and recharge. Slope governs the amount of infiltration and runoff.







V. CONCLUSION

The measurement of linear, areal and relief aspects based on DEM generated from contour and spot height are really useful to identify physical and meteorological characteristics of the particular basin area. In this study, it is observed that the value indicated by bifurcation ratio, elongation ratio, drainage density, stream frequency, length of overland and relief ratio. After the study of morphometry, drainage density and slope pattern of the Irang river watershed is found that the area where slope are steep runoff takes in those places. From the study the river morphometry we can understand about the slope pattern of an area, as water flows from high to low relief. Remote sensing and GIS help to select the suitable drilling area for groundwater extraction.

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