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Morphometric Analysis of Gadwal Watershed, Jogulamba Gadwal District, Telangana, India

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***Abstract*— *Quantitative measurements and measurements of the earth's surface and volume, called morphological analysis, are important for understanding the geohydrological behavior of rivers. Remote sensing and GIS has revolutionized the field of morphometry by providing a solid foundation for in-depth studies of soils and their properties. This technique, which can analyze the morphological landscape and define basins, provides important information about the climate, geology, topography and history of the study region. Current research emphasizes the importance of surface permeability in groundwater development. The drainage pattern is sub-dendritic to dendritic, RB value indicates that the study area is structural control. The low DD revels that the studied region is highly permeable subsurface and thick vegetation cover. The aerial parameters are indicating that the shape of the basin is elongated*.

I. Introduction

Groundwater has emerged as the important for agriculture in semi-arid climates [1], particularly in India [2]. The unregulated and unauthorized exploitation of aquifers has led to a reduction and the availability of groundwater, which is now confined to deeper regions [3]. the acute warmth climate conditions caused the premature reduction of surface water bodies, forcing use of groundwater for irrigation as the simplest option [4]. the prospective groundwater resources are distributed in a sporadic manner, making it tough to pick them out, moreover, the geological conditions within watershed complicate the comprehension of potential groundwater regions. Exploring groundwater without enough understanding of the subsurface lithological composition can lead to inefficiency in terms of time, electricity, and finances. Thorough knowledge of geology and geomorphology is required to classify regions with abundant groundwater assets. in this research, we aim to utilise hydro geomorphological facts and the data integrated in GIS to assess groundwater.

The importance of morphometric evaluation, which entails a quantitative evaluation of the basin's geometry. The attributes of physiographic facts are defined by using [5], [6], [7], [8], [9], [10], [11]. a number of researchers have carried out drainage morphometry on watersheds. A number of the researchers who've contributed to this discipline are [10], [12], [13], [14]. Presently, remote sensing and GIS strategies are used to carry out autonomous evaluation of drainage systems and their traits [15]. several scholars in southern India have performed studies on the morphometric capabilities of drainage basins [16], [17]. The study presents a complete evaluation of the correct morphometric features of the drainage network making use of the hydrology tool on the ArcGIS platform. We performed an assessment and produced exclusive thematic maps of geological, geomorphological, topographic, and drainage density.

Study area

The study area is bounded by $77^0$44'36" - $78^0$15’12”.and $15^0$54'44"- $16^0$18’02” in the Survey of India toposheets D43F13, D44A1, D44A5, E43X12, E43X15, E43X16 and E44S4. The total geographical area is 644 sq.km. The lithological composition of schist belts is indeed diverse and complex, reflecting a rich geological history (Figure 2). These belts typically contain a variety of rock types, including basic and intermediate volcanics, as well as significant bands of iron formations.

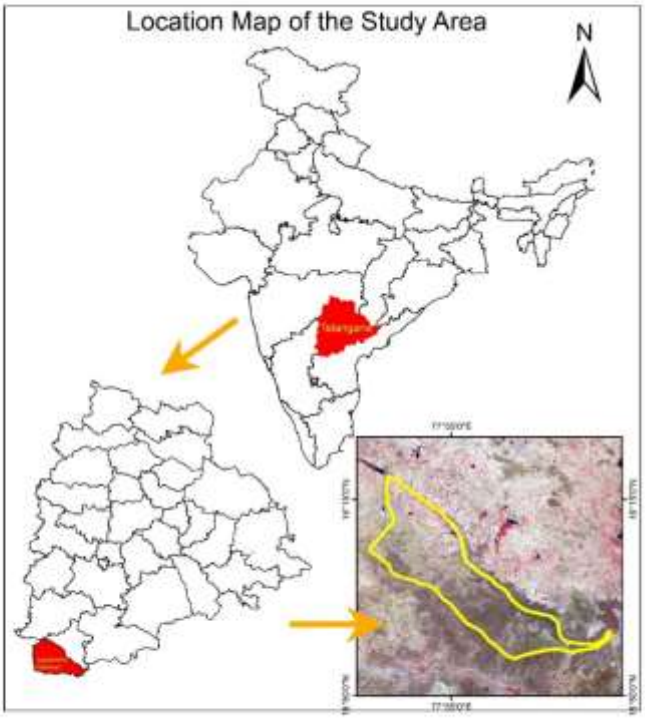

Figure 1: Location map of the study area

The presence of basic dykes, quartz veins, and pegmatites within these belts indicates a dynamic geological environment with multiple phases of intrusion and mineralization. Granites and gneisses are predominant, often accompanied by distinctive pink granites. The South Eastern part of the study area is covered by Limestones and Shales of Kurnool Group. Figure 3 indicates the Geomorphology of the study area, i.e., 86.17% is occupied by the PPC (Pediment Pediplain Complex). Alluvial plain and flood plain occur mainly along the Krishna River.

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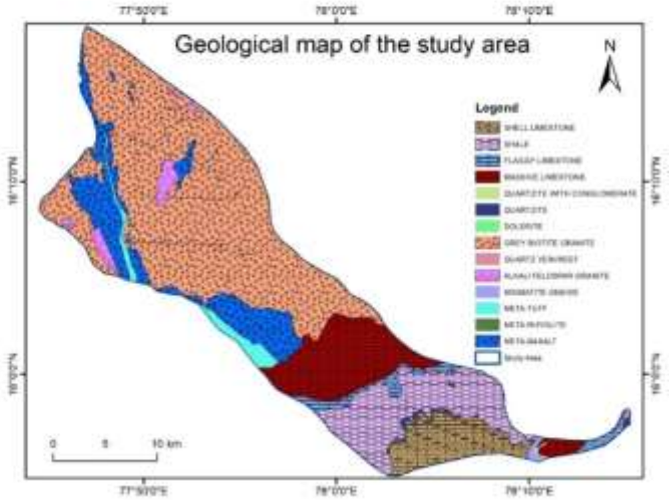

Figure 2: Geological map of the study area

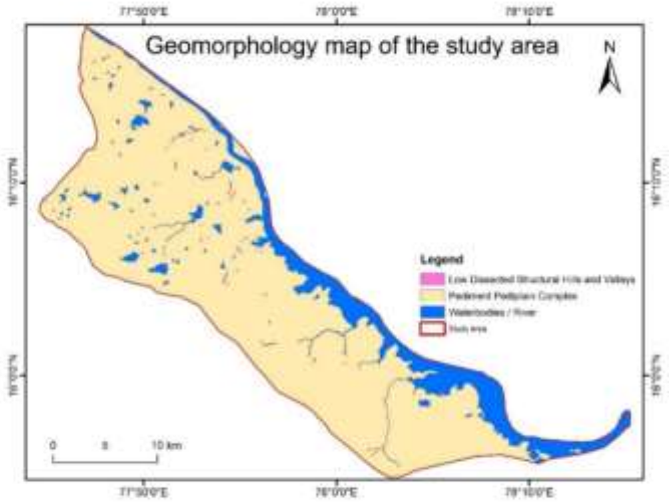

Figure 3: Geomorphology of the study area

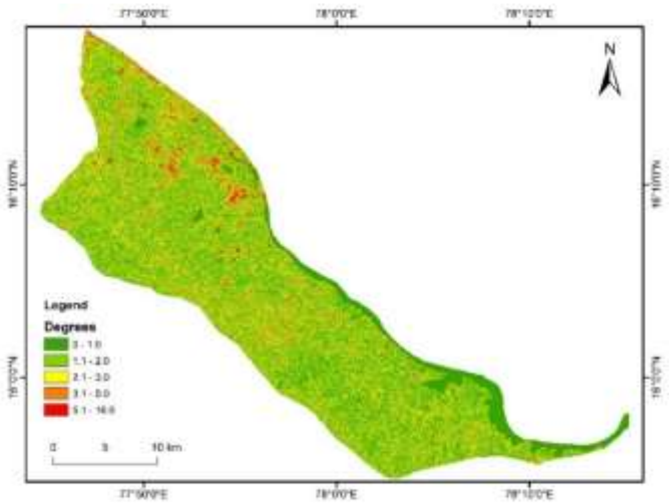

Figure 4: Slope map of the study area

The slope of the terrain plays a crucial influence in the infiltration of the area. As the slope increases, the recharge area decreases. The slope map depicted in Figure 4 was partitioned into five distinct categories based on the degree of inclination: flat (0–1), mild (1.1–2.0), moderate (2.1–3.0), steep (3.0–5.0), and extremely steep (5.1–16.0). The northern part of the area exhibits highly inclined slopes, while the remaining component of the research area displays predominantly level to gently sloping terrain characteristics. The variations in slope within a certain area directly impact the lithological characteristics of the land's surface.

II. MATERIALS AND METHODS

Remote sensing techniques facilitate the examination of drainage morphometry by offering a comprehensive view of large areas. In this present study Landsat-9 remote sensing data from USGS Earth explorer and Survey of India toposheets on 1:50000 used for extraction of various thematic layers Utilizing image interpretation techniques and digital image processing, detailed maps can be created integrating in Arc GIS software. These maps are further refined by ground truthing. ensuring a high level of accuracy in depicting the distribution of landforms, stream orders, and lineaments. This meticulous process aids in the comprehensive understanding of terrain and landscape evolution, which is essential for morphometric analysis. The integration of geomorphological units and stream order into digital mapping represents a significant advancement in the field of geospatial analysis. Morphometric analysis and morphometric parameters allows for a comprehensive assessment of linear, aerial, and relief aspects, which are essential for understanding the hydrological behavior and potential flood risks of an area.

III. RESULTS & DISCUSSIONS

Morphometric analysis is a numerical method for describing and analyzing topography or drainage basin in large regions. It helps to delineate potential zones of the groundwater in a watershed. The physiographic parameters of a drainage basin, such as its size, slope, and drainage density, are also associated with numerous hydrologic phenomena. Morphometric study of a basin relies on three essential characteristics (i) Liner parameters; (ii) Aerial Parameters & (iii) Relief Parameters

Liner Parameters

Stream Order (U): According to [10], “the connection of two same order rivers generates a higher-order stream”. The highest order in this study area is fifth order stream. Figure 5 depict the order of the streams in the study area.

Stream Number (NU): The NU refers to the total quantity of streams within a given sequence. As the stream order increases, we observe a corresponding decrease in the NU parameter within these sub-basins. specifically, the basins contain the following stream counts: 1storder streams: 1863; 2ndorder streams: 436; 3rdorder streams: 93; 4thorder streams: 22; & 5thorder streams: 8

Table 1 provides the numerical values associated with each stream order.

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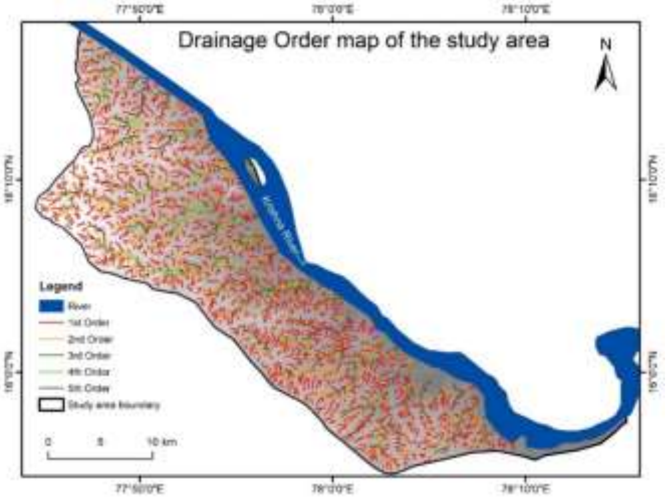

Figure 5: Drainage Order map of the study area

TABLE 1: Morphometric analysis results for the study area.

Liner parameters					
Stream order	**No_of_Streams**	**Stream_length (km)**	**Mean Stream Length (MSL)**	**Stream Length Ratio (SLR)**	**Bifurcation Ratio (BR)**
1	1863	807.89	0.43	1.84	4.27
2	436	347.81	0.80	2.32	4.69
3	93	172.45	1.85	2.43	4.23
4	22	99.11	4.51	1.00	5.50
5	4	18.03	4.51		
	2418	1445.29	Mean bifurcation ratio (Rbm)		4.67

Area parameters	
Basin area(sqkm)	644.62
Perimeter (km)	158.65
Basin length (km)	62.29
Drainage density (Dd)	2.24
Stream frequency (SF)	3.75
Drainage Texture (DT)	15.24
From factor (FF)	0.17
Circularity Ratio (CR)	0.32
Elongation ratio(ER)	0.61
Length of over flow (Lg)	0.22

Relief Parameters	
Total relief (m)	117
Relief ratio(Rh)	1.88

Stream Length (LU): The LU refers to the cumulative length of all stream segments within a given order. According to [11], streams of different orders in a drainage basin tend to exhibit a direct geometric ratio in their average lengths. Specifically, as the stream order increases, the length of the stream decreases exponentially. Here are the lengths of streams for each order:

- 1^{st}order streams: 807.89 km
- 2^{nd}order streams: 347.81 km
- 3^{rd}order streams: 172.45 km
- 4^{th}order streams: 99.11 km
- 5^{th}order streams: 18.03 km

For detailed data on individual stream lengths, please refer to Table 1.

Mean Stream Length (LSM): The LSM value of the study area varies between 0.43 km and 4.51 km. Specifically, the LSM value for a water segment (U) lies between the value associated with the lowest flow in the river and the value of the next higher order.

Stream Length Ratio (RL): The value of RL varies between 1.00 and 2.43. It varies little due to slope and terrain difference.

Bifurcation Ratio (RB): The number of the next higher streams is called the bifurcation ratio. Geological and lithological changes in the basin lead to changes in Rb as it progresses from one level to the next ([10). Rb varies between 4.23 and 5.50. High values of Rb indicate that the study area is affected by characteristic structural effects.

Aerial Parameters:

Areal aspect parameters are crucial in geographical analysis as they provide quantitative measures of a region's characteristics. These parameters include Area (A) and Perimeter (P), which are fundamental in describing the size and shape of a region. Additionally, Basin area, Drainage density (Dd), Basin length (Lb), Stream frequency (Fs), Elongation ratio (Re), Circularity ratio (Rc), and Form factor (Rf) are essential in understanding the topography and hydrological potential of a landscape.

Basin Area (A): A Basin area is an area where precipitation accumulates in an outlet such as a river, bay, or other body of water. The geographical area of this study is 644.62 square kilometers**.**

Perimeter (P): Perimeter is a simple concept in geometry that refers to the total length around two sides. It is calculated by adding the length of each side of the polygon. The perimeter of the study area is 158.65 km.

Basin Length (LB): Basin length is an important measure in hydrology and represents the maximum length from the basin boundary to the flow point. It is important to calculate the length of water, which is an important indicator of water flow and water conditions. The length of the basin to the study area is 62.29 km.

Drainage Density (DD): Density is the total length of each stream in a stream. This density is affected by many factors such as weather, rock formation, topography, permeability, vegetation, material roughness and water flow. The amount and type of precipitation directly affects the amount of runoff. In our study area, the Drainage density (DD) is 2.24 km/km² (shown in Table 1), indicating a low water level (Figure 6). This low DD is attributed to the high permeability and dense vegetation in the subsurface.

Stream Frequency (FS): As a rule, basins with the same flow frequency may see different flows and create others. The FS results (value 3.75) shown in Table 1 show that there is a good relationship between the calculation of the flow and the higher the liquid.

Drainage Texture (DT): An important concept in topography is the natural flow of water, which refers to the length of the stream. Table 1 gives the properties of DT (15.24). Regular inspection shows much liquid separation.

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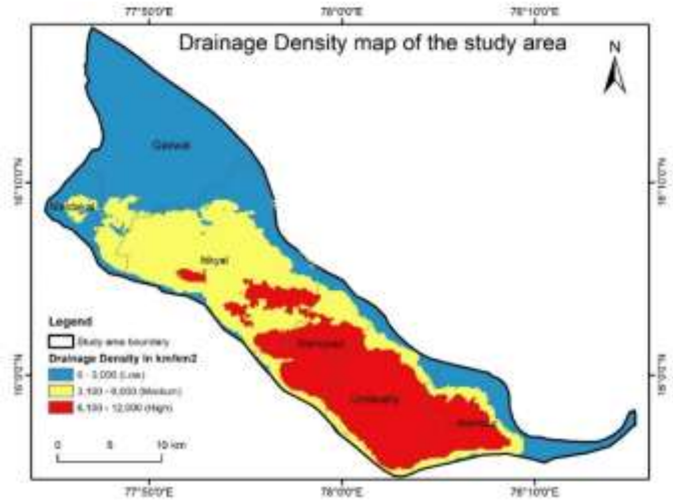

Figure 6: Drainage Density map of the study area

Form Factor (RF): The RF value of the study area is 0.17, it indicates the site has an elongated shape with relatively low form factor values.

The Circularity Ratio (RC): The RC is affected by many factors such as river length, frequency, climate, land use and land cover (LULC), geological formations, basin topography and slope. In our current study, the RC value is 0.32, which indicates the non-circular shape, spatial difference and optimization process.

Elongation Ratio (RE): An elongation ratio close to one indicates a very flat terrain, whereas a value between 0.6 and 0.8 suggests a moderately steep ground slope ([10]). The RE values can be categorized as follows:

- Values greater than 0.9 are considered round.
- Values between 0.9 and 0.8 are considered oval.
- Values less than or equal to 0.7 are considered elongated.

In the study area, the RE (elongation ratio) is 0.61, indicating that it falls within the lower range and has an elongated shape.

Relief Parameters:

Basin Relief (BR): More precisely, it is used to gain an understanding of the physical characteristics of the land and the changes that occur in the shape and structure of the river basin being studied. The most prominent impact of BR is shown in the peak run-off rates and sediment delivery in the research area. The present relief of the area measures 117 m, suggesting that the erosion forces and average denudational rates are quite low compared to the surrounding landscape.

Relief Ratio (RH): The RH increases as the drainage area decreases and the overall size of the drainage network expands. A higher RH value signifies a steep slope with significant elevation changes, while a lower RH value suggests a gentle slope with minimal elevation variations. In our studied region, the RH is 1.88. Furthermore, the basin exhibits a lesser degree of slope compared to the surrounding area.

IV. CONCLUSION

The assessment of drainage basin characteristics, including drainage density and stream frequency, is crucial for understanding the hydrological behavior of a region that is highly permeable and thick vegetation cover. High drainage density often indicates a landscape with less permeable substrates, whereas lower values suggest better infiltration and more permeable soils. The study's findings, which highlight favorable conditions for surface permeability, point towards the potential for effective infiltration measures. The aerial aspects of the studied region indicate, elongation shape of the basin and the relief of the study area is flat region with lesser degree of the slope.

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