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Groundwater Potential and Sub-Watershed Prioritization in the Pokoria River Basin, Assam

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Abstract

The Pokoria River Basin covering parts of Morigaon and Nagaon districts of Assam, India, spans approximately 1,712 km². Using a river morphometric analysis, this study examines the geomorphological parameters of the basin to rank its sub watersheds for improved groundwater resource planning. SRTM (Shuttle-Radar Topography Mission) DEM data is processed in ArcGIS platform to analyze various morphometric parameters (areal, linear, and relief aspects) along with slope, LULC, and the Dissection Index for delineating groundwater potential zones. After identifying the six sub watersheds within the basin, each watershed was evaluated separately. It was found that sub watershed 4 is a priority location for water and soil conservation measures. The final results show that it has the highest drainage density and stream length, indicating a dominance of surface runoff. On the other hand, sub watershed 2 has comparatively low stream frequency and drainage density, which are better for infiltration and groundwater recharging. The results demonstrate that morphometric analysis offers a dependable and economical method of watershed prioritization when accompanied by remote sensing and GIS. For regions with limited data and a high risk of flooding, where sustainable water management is still a pressing issue, this type of study is quite helpful.

Keywords: GIS & Remote sensing, Morphometric analysis, Groundwater potential, Pokoria River Basin, Sub watershed prioritization.

1. Introduction

In the twenty-first century, managing water resources sustainably has become a major concern worldwide. Especially in regions with overuse of groundwater, changing rainfall patterns and

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increasing population pressure. Groundwater is a very important resource for various domestic, industrial, and agricultural uses in India. According to studies groundwater accounts for about 85% of rural drinking water and 62% for irrigational purposes (Central Ground Water Board [CGWB], 2021).

The Pokoria River Basin, covering parts of the Nagaon and Morigaon Districts of Assam is distinguished by its unique topography, monsoonal rainfall patterns, and rapid change in land use land cover. These unique characteristics presents both opportunities and challenges for responsible utilization of groundwater in the region. To address this, watershed prioritization and groundwater potential evaluation is very important, and morphometric analysis has become an important cost and time efficient technique in this regard, especially in settings with limited data, like northeastern states of India (Sarkar, 2017; Sarkar et al., 2022).

Morphometric analysis is a quantitative study of landform features and its characteristics obtained from topographical maps and drainage networks (Terang & Sarkar, 2025). It offers important information on hydrological behaviour of a watershed or a basin, including surface runoff, infiltration capacity, and groundwater recharge (Sarkar, 2024). These criteria allows mapping and prioritizing of sub watersheds for focused conservation and development interventions when combined with remote sensing data and geospatial technologies (Gopinath et al., 2016; Sahoo et al., 2024).

The significance of morphometric analysis in evaluating and ranking watersheds for groundwater potential and general management of land has been utilized in various studies throughout India (Terang & Sarkar, 2025). Choudhari et al. (2018) used a thorough morphometric-based strategy to prioritize watersheds in the Mula River Basin, Maharashtra. Similarly, to show how drainage morphometry can help in identifying groundwater potential, Dahiphale et al. (2024) examines the susceptibility of soil erosion in the Kandi region of Punjab, in India. The results show a significant danger of soil erosion due to intense rainfall, and limited vegetation in the region. For conducting the morphometric analysis their study, they evaluated linear, areal, relief, and shape factors in the ten identified sub watersheds within the Rupnagar watershed. Consequently, for conservation of soil measures, they prioritized the sub watersheds using morphometric assessment and Principal Component Analysis (PCA).

Morphometric analysis has also been used in several studies in northeast India to prioritize conservation efforts and to understand watershed dynamics. Barman et al. (2021) to determine the risk of soil erosion and identify groundwater potential zones, analysed the morphometric and geomorphic features of the Chite Lui basin using the TOPSIS method (Technique for Order of Preference by Similarity to Ideal Solution). Their research revealed important hydrological trends and patterns that have direct implications on the sustainable and

Table 1. Recent Studies on Morphometric Analysis and Watershed Prioritization in India

Author(s)	Year	Study Area	Methodological Approach	Key Findings	Remarks
Dahiphale et al.	2024	Rupnagar Watershed, Punjab	Morphometric analysis and Principal Component Analysis (PCA)	Identified SW-1 as highly erosion-prone using both PCA and morphometric approaches; emphasized sub-watersheds with high drainage density	PCA enhanced the robustness of prioritization; SW-1 consistently ranked high, suggesting need for immediate conservation efforts
Rao et al.	2023	Vanvate Lui Basin, Mizoram	Morphometric analysis, Compound Factor (CF), and Sediment Production Rate (SPR)	Sub-watersheds SW-1, SW-8, and SW-9 were identified as most vulnerable; strong correlation observed between CF and SPR	Integrated morphometric and sediment yield data provided a comprehensive prioritization for soil conservation planning
Barman et al.	2021	Chite Lui Watershed, Mizoram	Analytic Hierarchy Process (AHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), and morphotectonic indices	Prioritized 14 sub-watersheds based on morphometric and tectonic factors; evidence of tectonic activity supported by geomorphic indices	Demonstrated the relevance of integrating tectonic controls in watershed prioritization
Ahmed et al.	2018	Lower Barpani Watershed, Assam	Morphometric analysis and Fuzzy Analytic Hierarchy Process (FAHP)	Sub-watersheds SW2, SW4, and SW5 ranked highest for priority intervention; FAHP effectively assigned parameter weights	Established the efficacy of FAHP for morphometric-based watershed prioritization under data uncertainty
Choudhari et al.	2018	Mula River Basin, Maharashtra	Morphometric analysis using Digital Elevation Model (DEM)	Sub-watersheds with lower morphometric values were prioritized for soil conservation; five sub-watersheds delineated	Results informed spatial planning for erosion control infrastructure within vulnerable zones

Gopinath et al.	2016	Kuttiyadi River Basin, Kerala	Morphometric analysis and Analytic Network Process (ANP)	Length of overland flow emerged as the most influential factor; mature basins identified through drainage characteristics	ANP handled interdependencies among parameters effectively; check-dam sites proposed based on prioritization results

long-term watershed management. Like this, Rao et al. (2023) carried out a detailed morphometric study of the Vanvate Lui Basin in Mizoram, combining estimates of sediment production with compound factor based on Multi-Criteria Decision-Making (MCDM). They were able to conduct sub watersheds prioritization for specific soil and water conservation initiatives by establishing a correlation between the drainage characteristics and possible degradation levels in the basin.

Prioritization approaches have also been successfully improved by combining morphometric factors with land use land cover (LULC) data. During the study of Pachnoi River Basin in Northeast India, Borah and Bora (2023) stressed on the significance of integrating morphometric and LULC factors. This methodological improvement is especially beneficial for areas experiencing rapid change in land use and land cover, like the Pokoria Basin. Agricultural growth and land use dynamics may influence the groundwater recharge zones and hydrological patterns in the region. In addition to that the effectiveness of watershed prioritization has been significantly improved using geospatial techniques. To identify priority zones for groundwater recharge, Sahoo et al. (2024) demonstrated how to analyse the morphometric parameters of the Lower Satluj River Basin using satellite data and digital elevation models (DEM).

To conduct morphometric analysis in Assam, Borah and Deka (2020) offer important insights on the Jamuna River Watershed by identifying important sub watersheds that are at the risk of deterioration and thus require urgent restoration measures. Additionally, Ahmed et al. (2018) emphasized on how well the fuzzy logic-based analytical hierarchy process (Fuzzy AHP) refines morphometric analysis, enabling a successful approach for watershed prioritization,

By conducting a details morphometric assessment of the Pokoria Basin using DEM with a medium resolution of 30 meter and advanced geospatial techniques, this study aims to address the existing gap in the research domain. By utilizing both traditional geomorphological theory and contemporary geospatial technologies, this approach complements the broader goals of the integrated water resource management (IWRM) and climate resilient development. The outcomes of this study are expected to support the environmental stakeholders and planners in designing and implementing targeted measures which will help in initiating sustainable measures for the utilization of ground water in the Pokoria River Basin.

2. Description of Study Area

2.1. Geographic Location

The present study focuses on the Pokoria River Basin, which covers parts of the Morigaon and Nagaon districts in the state of Assam, India. The basin, extends over an area of approximately 1,712 square kilometers, and is a part of the larger Brahmaputra Valley which is distinguished by its active river activity, monsoonal climate, and fertile alluvial plains. This region is ecologically sensitive and agriculturally productive, making it ideal for physical and hydrological studies, especially due to the growing human pressures on the land cover of the region.

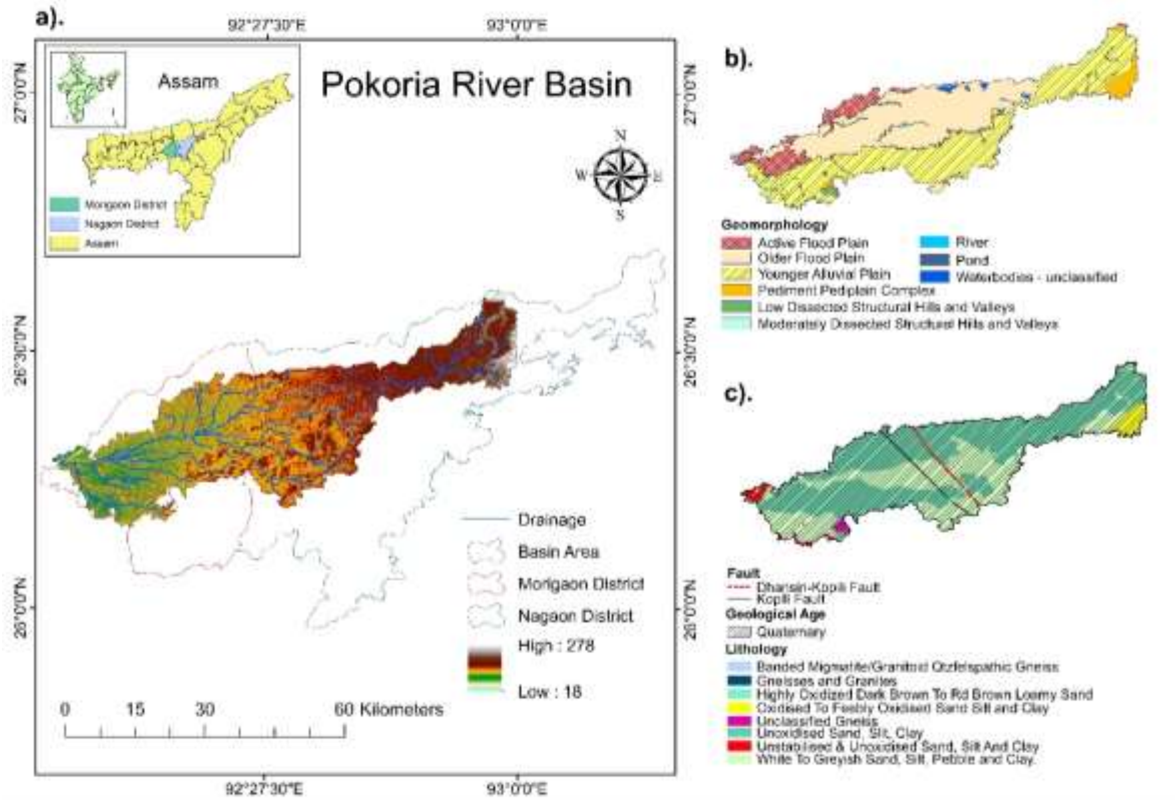

Fig. 1. Location and physical characteristics of the study area. (a) Location map of the study area; (b) Geomorphological map showing major landforms; (c) Geological map depicting lithology and fault lines.

2.2. Drainage Characteristics

Hydrologically, the River Pokoria as one of the tributaries of the Brahmaputra River contributes to the surface and subsurface water dynamics in the region. The river is a crucial part of the regional drainage system, which influences the groundwater recharge, sediment transport, and surface runoff characteristics. It eventually drains into the mighty Brahmaputra River, which rises in the Himalayan Kailash mountains and flows through Tibet (as the Yarlung Tsangpo), Arunachal Pradesh and Assam before entering Bangladesh. The river Brahmaputra is fed by numerous tributaries in Assam, from both its northern and southern banks including the Pokoria River, thereby presenting the importance of the basin in the broader hydrological framework of the region.

2.3. Topography and Climate

The Pokoria River Basin lies within the expansive alluvial plains and terrain characterized by gentle slops of the Brahmaputra Valley, a topography that can contribute to seasonal waterlogging and flooding. The region experiences a tropical monsoon climate, with the precipitation driven by the southwest monsoon occurring between May and October (Government of Assam, n.d.). These climatic conditions may contribute to substantial surface runoff and an increased risk of flooding, which can be exacerbated when peak discharge in the Pokoria River coincides with high flow conditions in the Brahmaputra.

3. Materials and Methodology

3.1. Dataset

The primary dataset utilized for this study is the Shuttle-Radar Topography Mission (SRTM) Digital Elevation Model (DEM) with a medium spatial resolution of 30 meters, acquired from the USGS Earth Explorer platform. The DEM served as the foundational dataset for deriving hydrological characteristics and conducting morphometric analysis. Additionally, Survey of India Administrative Boundary Database, was employed to delineate administrative boundaries and support locational referencing of the basin. The Basin boundary shapefile was delineated using the SRTM DEM using hydrological tools in ArcGIS and served as the spatial framework for the analysis.

To enhance the geological and geomorphological understanding of the basin, secondary datasets were obtained from Bhukosh, including layers on geomorphology, fault lines, geology, and lithology. These layers provided critical contextual information for interpreting the structural and lithological controls on drainage development and groundwater characteristics. Additionally, the Sentinel-2 dataset, which is obtained from the ESRI Land Cover Explorer

(Sentinel 2, 10m, LULC Time Series), is used for the Land Use Land Cover (LULC) data

Dataset	Resolution / Scale	Format	Source
Digital Elevation Model (SRTM DEM)	30 m	Raster (GeoTIFF)	USGS EarthExplorer
Administrative Boundary	1:50,000	Vector (Shapefile)	Survey of India
Pokoria River Basin Boundary	-	Vector (Shapefile)	Derived from SRTM DEM using ArcGIS
Geology, Lithology, Fault Lines, and Geomorphology	1:50,000	Vector (Shapefile)	Bhukosh (GSI)
Land Use / Land Cover (LULC)	10 m	Raster (GeoTIFF)	Sentinel-2 10m Land Use/Land Cover Time Series | ArcGIS Hub

needed to facilitate the evaluation of human induced impacts on the hydrological responses of the basin.

Table 2. Summary of Datasets Used in the Study

3.2. Methodology

The methodological framework employed in this study integrates morphometric analysis, and multi-criteria evaluation for sub watersheds prioritization within the Pokoria River Basin. The overall process is schematically presented in Fig. 2.

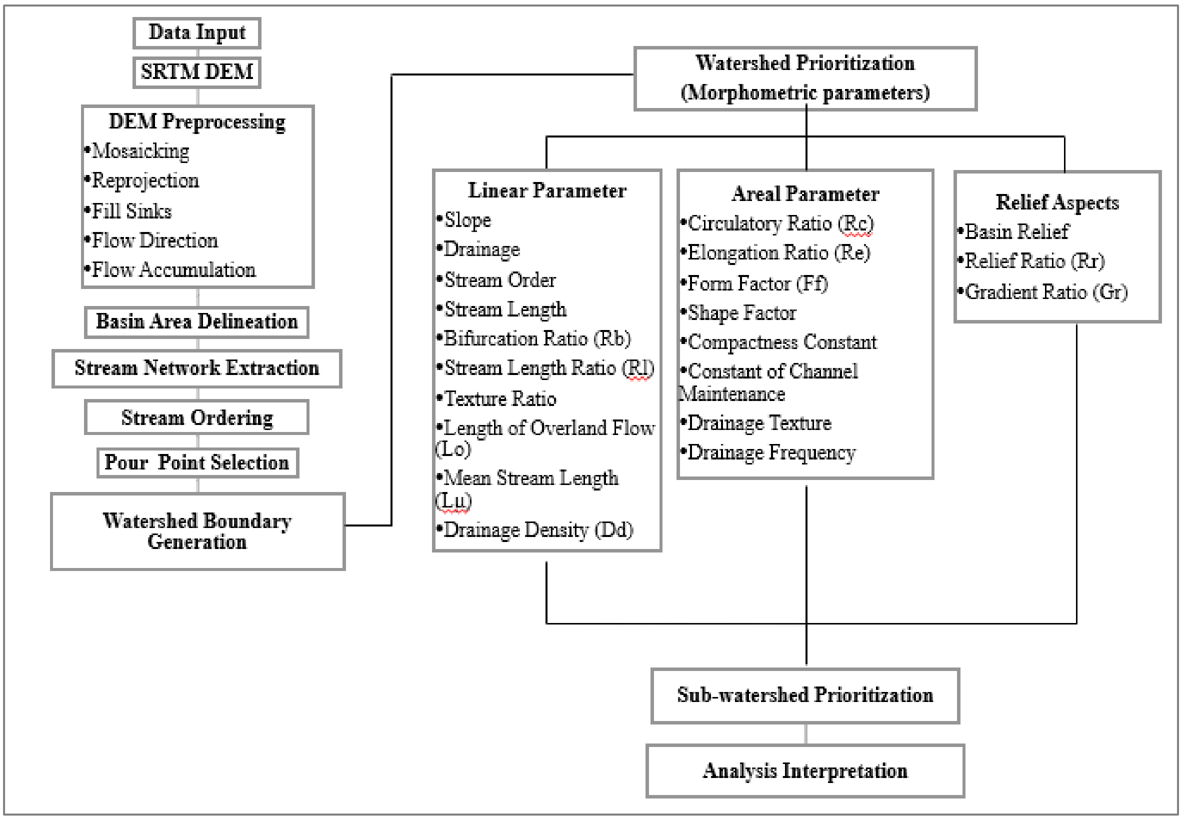

Fig. 2. Flowchart illustrating the methodology for morphometric analysis and sub-watershed prioritization

3.2.1. DEM Processing and Watershed Delineation

The analysis began with the acquisition of 30meter resolution SRTM DEM raster data from the USGS Earth Explorer. The DEM was pre-processed using standard hydrological procedures in ArcGIS, including reprojecting, sink-fill, mosaicking, flow direction, and flow accumulation generation. These preprocessing steps ensured that the surface runoff and flow paths were accurately traced.

Subsequently, the Basin area was delineated from the DEM using hydrological tools, and the drainage network was extracted by applying a threshold on flow accumulation values. The network was then classified using Strahler's stream ordering method, and the pour point (outlet) was selected to define the watershed extent. This was followed by the generation of the watershed boundaries into six sub watersheds for detailed analysis.

3.2.2. Computation of Morphometric Parameters

Morphometric parameters were computed under three broad categories:

- Linear parameters include the stream order, stream length, stream length ratio, mean stream length, bifurcation ratio, drainage density, texture ratio, and length of the overland flow. These were used to analyse the drainage network and runoff characteristics.
- Areal parameters include circularity ratio, elongation ratio, form factor, shape factor, compactness constant, drainage texture, constant of the channel maintenance and drainage frequency which helped assess basin shape, flood potential, and infiltration capacity.
- Relief aspects such as basin relief, relief ratio, and gradient ratio were computed to evaluate elevation differences, slope steepness, and erosion potential.
-

3.2.3. Subwatershed Prioritization

The morphometric parameters are computed for all six sub watersheds. The sub watersheds are then ranked on the basis relative values of each parameter. A compound value was calculated by averaging the ranks of all parameters for each sub watershed. Sub watersheds with lower compound values were prioritized as groundwater deficit zones, indicating a higher need for conservation and recharge interventions.

Table 3. Formulae used for computation of morphometric parameters

S. No.	Morphometric Parameters	Formula/Definition	References
Estimation of linear parameters			
1	Stream order (μ)	Ranking hierarchically	Strahler (1964)
2	Stream length (Lμ)	Total length of the stream segments of that particular order	Horton (1945)
3	Mean stream length (L)	$L = \sum L\mu / N\mu$	Strahler (1964)
4	Stream length ratio (Rl)	$Rl = L / L(\mu - 1)$ L = Mean length of all stream segments of a given order (μ) L(μ–1) = Mean length of all stream segments of one order less	Horton (1945)
5	Bifurcation ratio (Rb)	$Rb = N\mu / N(\mu+1)$	Schumm (1956)
6	Drainage density (Dd)	$Dd = \sum L\mu / A$	Horton (1932)
7	Texture ratio	Number of stream segments of all order per unit perimeter	Horton (1945)
8	Length of overland flow (Lo)	$Lo = 1 / (2 \times Dd)$	Horton (1945)
Estimation of areal parameters			
1	Circularity ratio (Rc)	$Rc = 4\pi A / P^2$	Miller (1953); Strahler (1964)
2	Elongation ratio (Re)	$Re = D / L = 1.128 \times \sqrt{(A / L)}$	Schumm (1956)
3	Form factor (Ff)	$Ff = A / L^2$	Horton (1932, 1945)
4	Compactness constant (Cc)	Ratio of basin perimeter to the perimeter of a circle of the same area	Horton (1945)
5	Drainage texture (T)	$T = Dd \times Fs$	Horton (1945)
6	Shape factor (BS)	$BS = L^2 / A$	Horton (1932)
7	Constant of channel maintenance (C)	$C = 1 / Dd$	Schumm (1956)
8	Drainage frequency (Fμ)	$F\mu = N\mu / A$	Horton (1932)
Estimation of relief aspects			
1	Basin relief (R)	$R = H - h$	Hadley and Schumm (1961)
2	Relief ratio (Rr)	$Rr = R / L$	Schumm (1956)
3	Gradient ratio (Gr)	$Gr = (a - b) / L$	Sreedevi et al. (2005)

3.2.4. Weighted Overlay Analysis

The thematic layers, including LULC, Slope, Drainage Intensity, and the linear and areal morphometric characteristics, were used to analysed to further improve sub watershed ranking. The impact of each layer on groundwater potential led to its standardization and reclassification. A composite groundwater potential zonation map was then created by computing the weighted sum in an ArcGIS environment.

4. Results and discussions

The six sub watersheds identified in the Pokoria River basin are then systematically analysed to highlight the morphometric features of each of the sub watersheds. To comprehend the drainage geometry and surface processes functioning in the area, quantitative evaluation has been conducted under three main aspects: the linear, areal, and relief parameters. For the purpose of planning and prioritizing watersheds, the spatial variation in the parameters provided insights on the hydrological responses, erosional stage, and geomorphic development.

4.1 Estimation of Linear Parameters

4.1.1 Stream Order (μ)

Stream ordering is a fundamental process in the analysis of a drainage basins. In this study, the stream ordering of the Pokoria River basin was conducted utilizing the Strahler method of stream ordering. Results indicate a decreasing trend in the number of streams with increasing stream order, with first-order streams exhibiting the highest frequency. The observed spatial variation in stream order and stream count reflects drainage flow predominantly originating from higher elevations, accompanied by limited lithological heterogeneity within the basin (Fig. 3).

4.1.2 Stream Length (Lμ)

Stream length is a vital parameter for characterizing drainage basins. According to Horton’s law, as the stream order increases, the average stream length also increases. In the present study, the total stream length across all six sub watersheds amounts to 644.74 km. Among these, sub watershed 4 has the longest total stream length at 293 km, while sub watershed 2 has the shortest, measuring 37.2 km (Table 4).

4.1.3 Mean Stream Length (L)

According to Strahler, 1964, the mean stream length is the average length of streams within each order. This parameter plays as an important indicator of the drainage network characteristics, typically showing higher order streams possess greater lengths, while lower order streams tend to be comparatively shorter as presented in Table 4.

4.1.4 Stream Length Ratio (Rl)

The stream length ratio refers to the proportion of the mean stream length of a given order to that of its next lower order. The computed Rl values in this study area show no consistent trend across the sub watersheds possibly due to topographical variation (Table. 4).

4.1.5 Bifurcation Ratio (Rb)

Bifurcation ratio describes the branching pattern of the drainage network and is calculated as the ratio of the number of streams of one order to the next higher order (Schumm, 1956). Natural systems typically have Rb values ranging from 3.0 to 5.0 (Strahler, 1964). The Pokoria River basin has an average Rb of 2.32, suggesting low structural disturbances and mature drainage system with natural development.

4.1.6 Drainage Density (Dd)

The drainage density, first described by Robert E. Horton (1932), quantifies the closeness of channel spacing. It reflects runoff potential, infiltration, vegetation, and rock permeability. High drainage density indicates impermeable surfaces and sparse vegetation, while low values suggest high infiltration and groundwater potential. The Dd values of the basin ranges from 0.29 to 0.57 (Table 4).

4.1.7 Texture Ratio

The texture ratio refers to the total number of stream segments occurring per unit basin perimeter. It indicates the relative spacing of drainage lines within the basin. It is influenced by various climatic conditions, relief aspects, geological characteristics, and the geomorphic stage of the basin (Horton, 1945; Smith, 1950). In this study the texture ratio lie between the range of 0.09 to 0.19 as presented in table Table 4.

4.1.8 Length of Overland Flow (Lo)

Defined by Robert E. Horton (1945), the length of overland flow refers to the distance water travels over the surface before joining a channel forming streams. It corresponds to the half of the reciprocal of drainage density. It is a key factor affecting hydrological and physiographical development. In the study the Lo values range from 0.88 to 1.40 (Table 4).

Table 4. Linear Morphometric parameters

Sub-watershed No.	Stream Length (Lµ)	Bifurcation Ratio (Rb)	Stream Length Ratio (RI)	Texture Ratio	Length of Overland Flow (Lo)	Mean Stream Length (L)	Drainage Density (Dd)
1	45.73	2.25	0.99	0.13	1.40	15.18	0.36
2	37.90	4.00	1.33	0.10	0.88	23.69	0.57
3	124.74	2.44	141.78	0.09	1.14	45.46	0.44
4	293.06	3.44	1.82	0.19	1.38	46.11	0.36
5	68.80	4.00	2.44	0.09	1.24	47.02	0.40
6	74.53	3.83	1.57	0.16	1.71	21.50	0.29

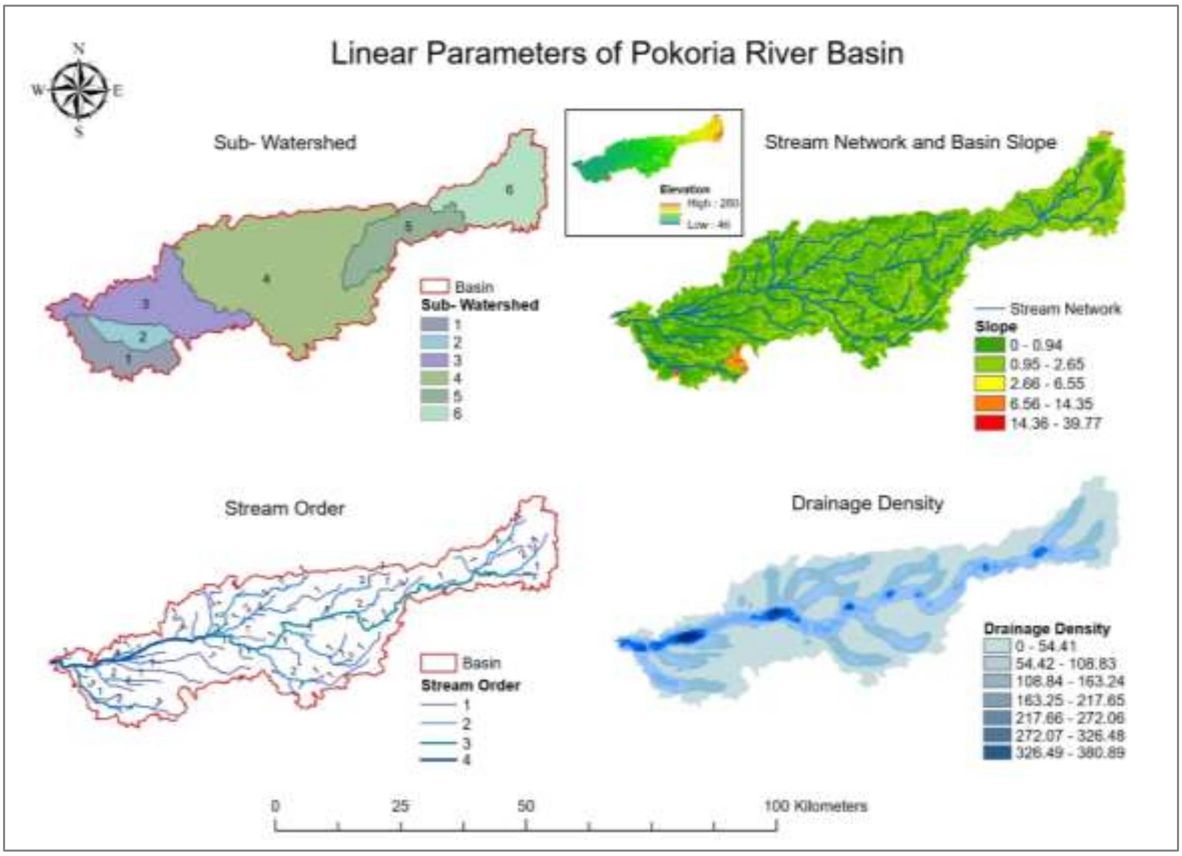

Fig. 3. Linear Morphometric Parameters of Pokoria River Basin.

4.2 Estimation of Areal Parameters

4.2.1 Circulatory Ratio (Rc)

It is is defined as the proportion of the basin area to the area of a circle having the same perimeter as the basin according to Miller, 1953. This parameter is influenced by the climatic conditions of the region, its terrain and geological structure, land cover patterns, and the length

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and gradient of streams within the basin. For the sub watersheds, the values varies between 0.14 and 0.34, indicating a mature stage of tributaries (Table 5. Fig. 4).

4.2.2 Elongation Ratio (Re)

It is the diameter ratio of a circle having an equal area as the drainage basin to the maximum length of the basin according to Schumm, 1956. Higher values suggest active denudational processes with high infiltration capacity, and minimal surface runoff characteristics, while low values correspond to higher elevations and enhanced upstream erosion along the tectonic lineaments (Reddy et al., 2004).

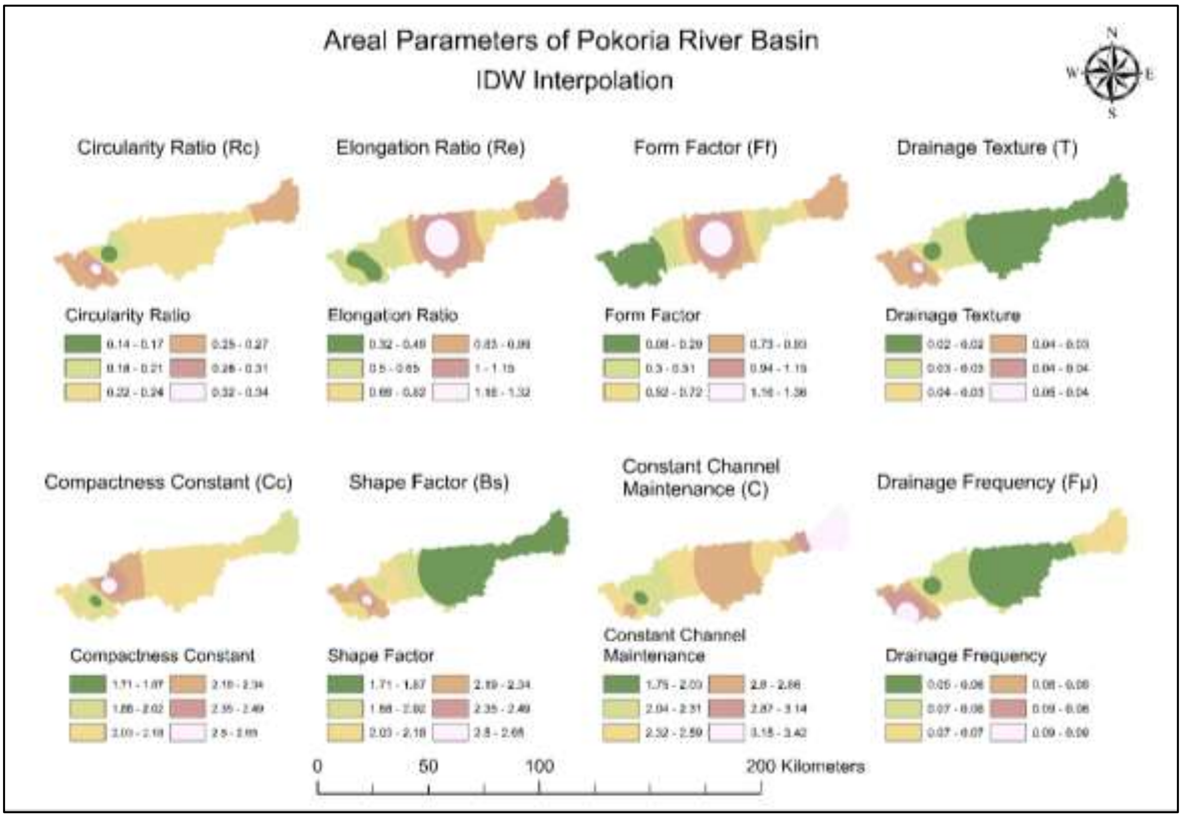

Fig. 4. Areal Parameters of Pokoria River Basin.

4.2.3 Form Factor (Ff)

Form factor is the ratio of basin area to the square of basin length and indicates the flow intensity for a given drainage basin area, Horton (1932). The lower values of the form factor signify a more elongated basin shape (Table5. Fig. 4).

4.2.4 Shape Factor (Bs)

According to Horton (1945) it is the ratio of the square of basin length (L^2) to basin area, which helps in assessment of the irregularities in the basin shape (Yadav et al., 2014). The Bs values for the sub watersheds are presented in Table 5.

4.2.5 Compactness Constant (Cc)

The compactness constant is the ratio between the perimeter of a basin and the perimeter of the circle having same area according to Horton, 1945. This parameter compares the actual hydrologic shape of a basin to an ideal circular shaped basin, providing insights into basin geometry. The compact constant in the study ranges from 1.71 to 2.65 (Table 5).

4.2.6 Constant of Channel Maintenance (C)

The channel maintenance constant is the inverse of drainage density according to Schumm, 1956. Lower value often indicates lower permeability of underlying lithology, while higher values indicate greater permeability. The sub watershed 2 accounts for the lowest C value whereas, the sub-water 6 accounts for the highest C value that is 3.42 (Table 5).

4.2.7 Drainage Texture (T)

It refers to the relative spacing and arrangement of drainage lines in an area. It can range from fine coarse based on the density of the lines which is influenced by climatic conditions, land cover, soil and lithology, infiltration capacity, topographic relief, and the geomorphic stage of the basin (Horton, 1945; Smith, 1950). Vegetation, in particular, plays a significant role in shaping both drainage texture and density (Kale and Gupta, 2001). Higher the drainage texture, the better the recharge potential.

4.2.8 Drainage Frequency (Fμ)

It refers to the occurrence of streams per unit area and reflects the surface runoff potential and terrain steepness (Horton, 1932; Yadav et al., 2014). Higher drainage frequency corresponds to increased runoff and steeper slopes (Fig. 4). In this study sub watershed 1 accounts for the highest drainage frequency (Table 5).

Sub-watershed No.	**Circulatory Ratio (Rc)**	**Elongation Ratio (Re)**	**Form Factor (Ff)**	**Shape Factor (Bs)**	**Compactness Constant (Cc)**	**Constant of Channel Maintenance (C)**	**Drainage Texture (T)**	**Drainage Frequency(Fμ)**

1	0.24	0.55	0.24	2.31	2.06	2.81	0.03	0.09
2	0.34	0.32	0.08	3.99	1.71	1.75	0.04	0.08
3	0.14	0.59	0.27	2.16	2.65	2.27	0.02	0.05
4	0.23	1.32	1.36	0.97	2.09	2.75	0.02	0.05
5	0.22	0.69	0.37	1.85	2.15	2.49	0.02	0.05
6	0.26	1.02	0.83	1.24	1.97	3.42	0.02	0.07

Table 5. Areal Morphometric parameters

4.3 Estimation of Relief Aspects

4.3.1 Basin Relief (R)

It represents the vertical variation between the highest and lowest points within a basin. It reflects denudational processes, stream gradient, surface runoff, and sediment transport. In the present study, the vertical variation varies across the sub watersheds, with values ranging from a minimum of 34 meters in Sub watershed 5 to a maximum of 256 meters in Sub watershed 1 (Table 6), suggesting that much of the basin lies within a relatively flat terrain. This topographic characteristic implies low runoff potential and a higher likelihood of water retention, which may support infiltration and groundwater recharge.

Table 6. Relief Aspects

Sub-watershed No.	Basin Relief (R)	Relief Ratio (Rr)	Gradient Ratio (Gr)
1	256	0.54	0.00013
2	172	0.17	0.00000
3	204	0.38	0.00037
4	50	0.10	0.00021
5	34	0.08	0.00033
6	180	0.24	0.00040

Note: In this study, all linear and areal parameters have been measured and reported in kilometres (km and km², respectively), whereas relief-related data have been expressed in meters (m) to maintain consistency with standard geospatial and topographic analysis conventions.

4.3.2 Relief Ratio (Rr)

It refers to the vertical variation of the basin relied to length of the basin, influenced by rock types and basin gradient. This parameter is sensitive to lithological variations and topographic gradients. In this study, the ratio ranges from 0.08 (Sub watershed 5) to 0.54 (Sub watershed 1), indicating significant variability in terrain morphology (Table 6). Higher relief ratio values, such as those in Sub watersheds 1 and 3, reflect more rugged and dissected terrain, typical of upland or hilly regions. Conversely, lower relief ratios in Sub watersheds 4 and 5 suggest flatter landscapes or pediplains (Kumar et al., 2011) (Table 6).

4.3.3 Gradient Ratio (Gr)

It is calculated as the change in elevation between the source and the mouth of the major stream divided by the maximum length of the stream. In this basin, the gradient ratio varies from 0 in Sub watershed 2 (indicating an almost flat terrain) to 0.00040 in Sub watershed 6 (Table 6) suggesting flatness of the basin terrain. While the lower gradient ratios suggests gentler slopes, less runoff, and better infiltration capacity, the higher ratios suggests steep slopes and significant runoff potential.

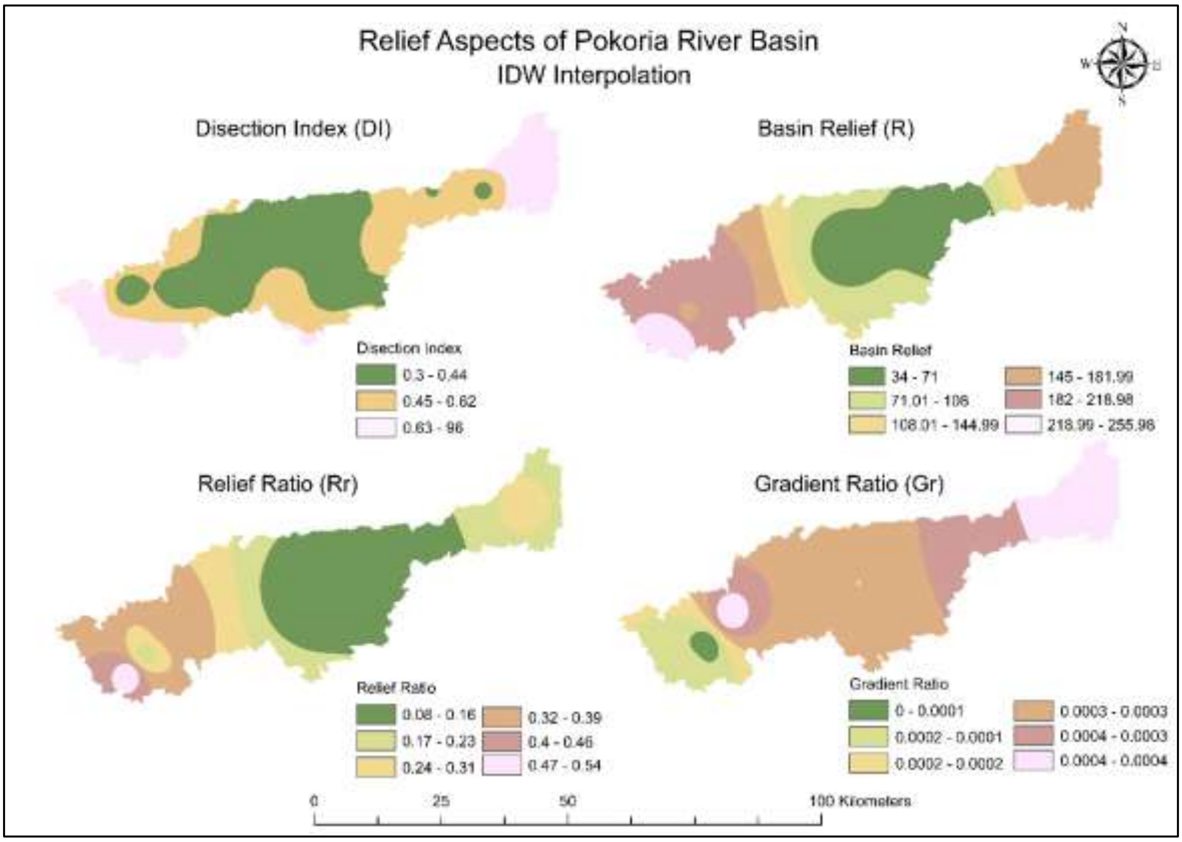

Fig. 5. Relief Aspects of Pokoria River Basin.

5. Prioritization of Sub watersheds for Groundwater Prospect

Identifying zones with significant groundwater potential and evaluating the same for the risk of soil erosion depend heavily on the analysis and assessment of morphometric parameters

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(Yadav et al., 2014). To determine areas where soil conservation measures are urgently needed to be implemented in order to improve groundwater recharge and lower the risk of soil erosion, six sub watersheds have been assessed and ranked accordingly to their morphometric

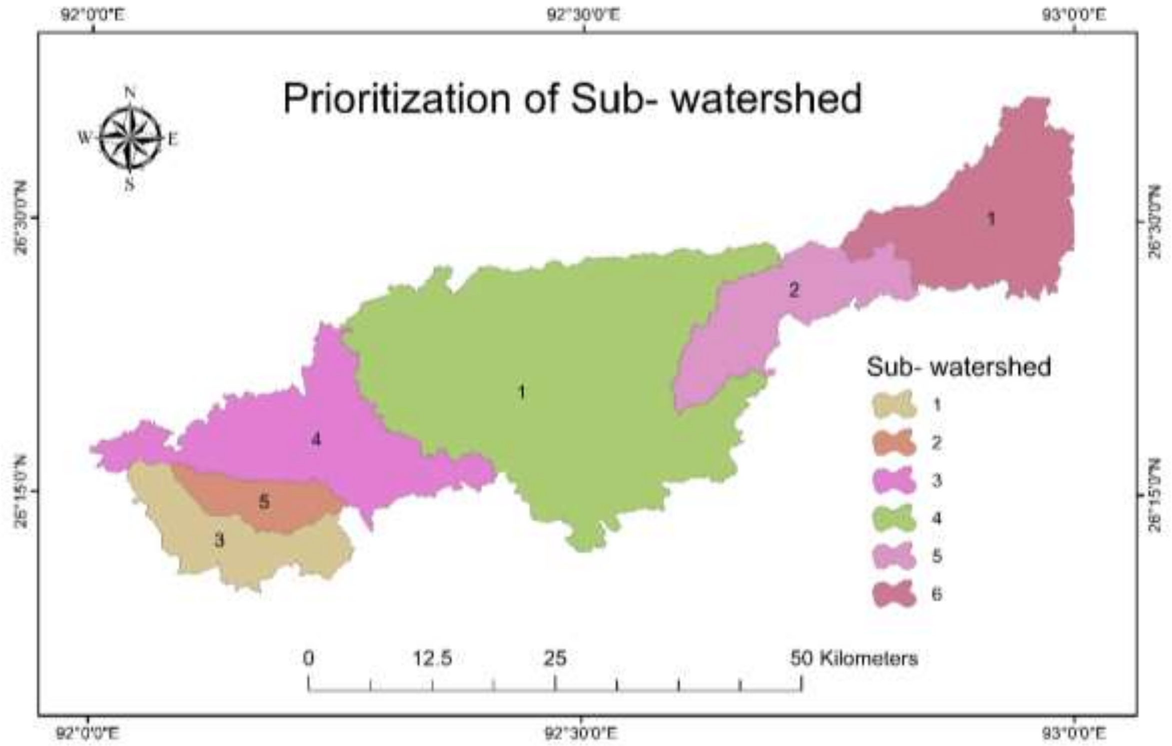

Fig. 6. Map showing sub-watersheds and their priority ranks.

characteristics in the current study. Identifying priority zones makes it easier to put into practice the efficient watershed management plans for managing groundwater supplies. The morphometric parameters for each sub watershed were determined, to generate the priority ranking, as presented in Table 7. The final prioritization map in Figure 6, highlights the sub watersheds and their corresponding ranks.

Table 7. Estimated compound parameter with priority ranking

Morphometric parameters Priority Ranking

Sub-watershed	Linear Parameters					Areal Parameters					Compound Factor	Priority Ranks
	(Rb)	(Dd)	(Fμ)	(Lo)	(T)	(Rc)	(Ff)	(Bs)	(Re)	(Cc)		
1	2.0	2	6	2	5	3	5	5	5	3	3.80	3
2	5.5	6	5	6	6	1	6	6	6	1	4.85	5
3	1.0	5	3	5	4	6	4	4	4	6	4.20	4
4	3.0	3	1	3	1	4	1	1	1	4	2.20	1
5	5.5	4	2	4	3	5	3	3	3	5	3.75	2
6	4.0	1	4	1	2	2	2	2	2	2	2.20	1

Note: The first priority shows most deficit area in ground water and last priority indicates surplus zone of groundwater.

6. Site Suitability Assessment for Potential Groundwater zones for Conservational Measures

The Remote Sensing and GIS based techniques are proven as highly effective for prioritization of the sub watersheds and in the delineation f the suitable zones for implementing conservation measures, particularly within high-priority sub watersheds. A Weighted Overlay Analysis was used in this study to identify possible areas for erosion control and groundwater recharge. This approach incorporates several thematic layers, each representing important hydrological and geomorphological elements considered for the site suitability analysis of the present study.

LULC, slope, Dissection Index, and other linear and areal morphometric parameters were among the theme layers that were employed in the investigation. Based on how each layer contributed to groundwater potential and erosion sensitivity, each layer was categorized and given a standardized score. Each layer was then given the proper weights based on its relative significance in the overall appropriateness study. A composite suitability map was then created by superimposing the weighted layers in GIS using the Weighted Sum Method (WSM).

The degree of vertical erosion or incision within each sub watershed was evaluated using the Dissection Index (DI), a crucial geomorphological measure. It was computed as ratio of the watershed perimeter to the greatest relief of the basin. High DI values indicate high steepness, and highly dissected terrain with higher erosion risk and limited groundwater recharge potential. Conversely, lower DI values represent a stable, and a less eroded landscapes conducive to infiltration and suitable for the implementation of conservation measures.

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Based on the results of the weighted sum analysis presented in Fig. 7, Sub watersheds 1, 2, and 3 were identified as having high potential for groundwater recharge due to their favourable combination of morphometric characteristics, gentler slope, lower dissection index, and land use patterns conducive to infiltration capacity. Sub watershed 5 demonstrated moderate potential, while Sub watersheds 4 and 6 showed lower potential for groundwater recharge. These variances show how various factors such as surface cover, drainage features, and terrain affect groundwater prospects in the basin area. To improve groundwater recharge and sustainable water resource management in the basin area, it is important to identify various priority zone as well as recharge zones to direct future groundwater management initiatives and put site-specific conservation measures into place.

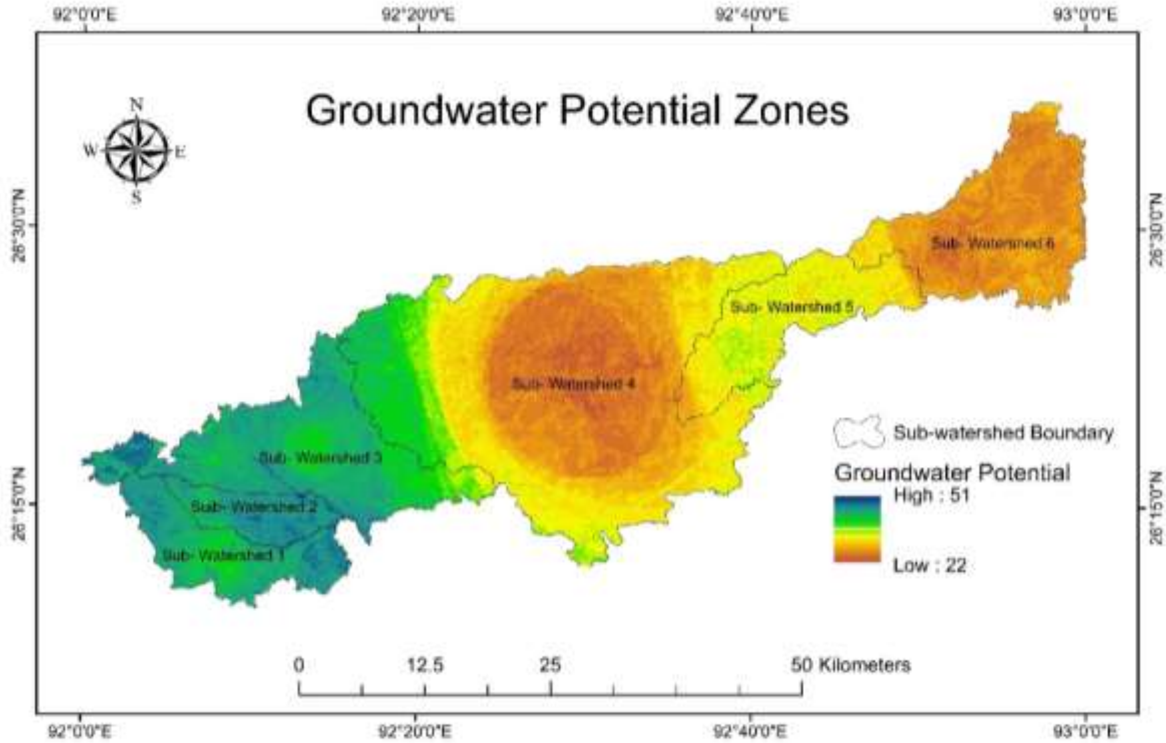

Fig. 7. Groundwater potential zones within the sub-watersheds.

Conclusion

The morphometric analysis conducted in the Pokoria River Basin provides important insights about the topographical features, groundwater recharge potential, and hydrological behaviour of the basin. The study effectively identified six sub watersheds and assessed their drainage characteristics by calculating the linear, areal and relief aspects using DEM derived data and various thematic layers in the GIS environment. The findings reveal a dendritic drainage pattern indicating a uniform geological structure with fewer structural disruptions. The topographic and geomorphic characteristics of the basin is reflected in the variations in the bifurcation ratios and length and order of the stream. With the longest overall stream length, sub watershed 4 has a higher priority for conservation measures due to its high runoff potential. Sub watershed 2 on the other hand, with its shorter stream length and lower drainage density, indicates low potential of surface runoff and better infiltration capacity which indicates a greater potential for groundwater availability in the basin.

In this study areas that need sustainable groundwater management have been successfully identified using important morphometric indicators in an integrated approach. These results are crucial for setting sub watershed priority for soil and water conservation, especially in regions having undulating terrain like Assam that are prone to flooding and have limited data. The analysis highlights the significance of remote sensing and GIS techniques in integrated planning of water resource and shows the importance of morphometric analysis backed by geospatial techniques that serves as an time and cost-efficient tool for effective watershed management.

Conflict of Interest Statement

The authors declare that there are no conflicts of interest relevant to this study. No financial or personal relationships have influenced the preparation or outcomes of this manuscript.

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Author Statement

Dr. Subhajit Sarkar (Corresponding Author): Conceptualization, Methodology, Data Collection, Supervision, and Writing – Original Draft. Prajatna Rabha: Software Analysis, Data Processing, and Writing – Review & Editing. Both authors approved the final manuscript.

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