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Prioritization of watershed using morphometric parameters through geospatial and PCA technique for Noyyal River Basin, Tamil Nadu, India

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ABSTRACT

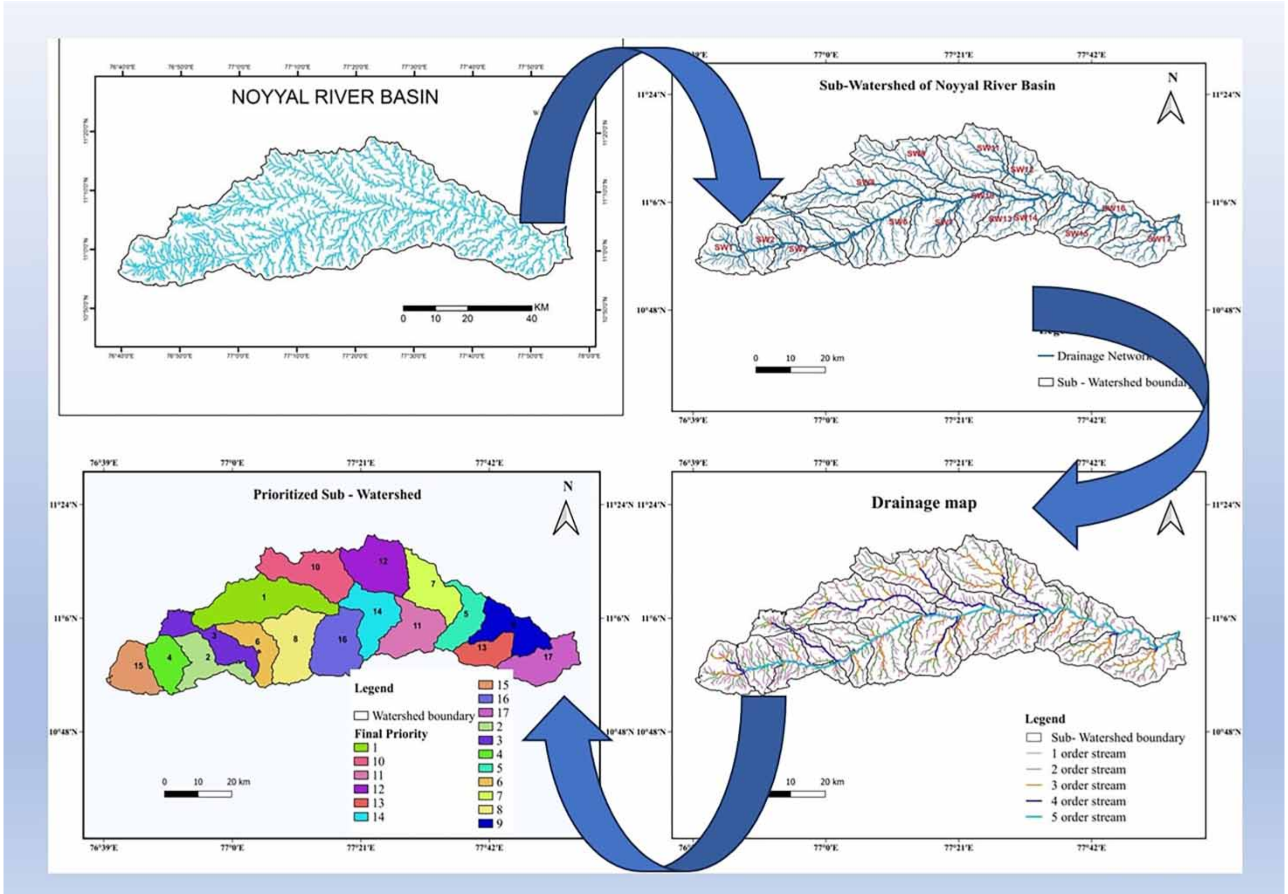
Watershed management is essential for ensuring the availability of water for sustainable development. In the current study, the geospatial technique is utilized to prioritize the sub-watershed of the Noyyal River Basin to control soil erosion and propose water conservation measures. The study describes the importance of using a digital elevation model to evaluate the drainage pattern and to extract relevant parameters. The river basin was categorized into 17 sub-watersheds, designated as SW1–SW17. The stream order of watershed ranges from first to fifth order and possesses a dendritic drainage pattern. Thirteen fundamental morphometric parameters classified as linear, areal, and relief aspects were considered for the Noyyal River Basin. Principal component analysis (PCA) was performed in the current study for categorization and the morphometric parameters were correlated. PCA analysis is a more appropriate, well-known, commonly used method for having versatility in selecting more significant parameters (correlated parameters) that are responsible for watershed prioritization. The sub-watershed with the lowest compound value is ranked first in priority. It reveals that sub-watershed SW8 has a high priority while low priority is given to sub-watershed SW17. According to the results, more water and soil-conserving measures are suggested in the respective sub-watersheds.

Key words: morphometric analysis, principal component analysis, prioritization, watershed management GIS

HIGHLIGHTS

- The study area and drainage map were prepared using geospatial technology.
- A PCA-based approach was performed to prioritize the sub-watershed in the Noyyal River Basin due to the reduction in morphometric parameters.
- Soil and water resources management can be done effectively by taking these results as a guide.

GRAPHICAL ABSTRACT



1. INTRODUCTION

A watershed is defined as a geohydrological unit where surface water from rainfall, melting snow, or ice collects at one location at a lower elevation (Biswas *et al.* 1999). This is usually where the water leaves the basin and merges with another water resource, such as a lake, river, reservoir, wetland, estuary, sea, or ocean. Watershed management has a significant impact on the sustainable growth of soil and water resources. Morphometry is the measurement of the shape and size of the landforms on the surface of the Earth (Clarke 1966; Agarwal 1998; Obi Reddy *et al.* 2002). It provides a very useful quantitative assessment of the drainage basin (Horton 1945). The geographic information system (GIS) technique and remote sensing are a simple way to conduct drainage-basin morphometric analysis since satellite images are quite useful as they offer a synoptic perspective of a wide area. Field surveys or maps have been used to provide morphometric data (Maathuis & Wang 2006). Since the development of high-resolution digital elevation models (DEMs), this has become more useful as it is a fast, accurate, modern, and economical method for flow analysis. A DEM of the area can be created to identify morphometric characteristics in a GIS framework, such as drainage basin area, density of drainage, drainage order, relief, and network diameter (Pirasteh *et al.* 2010).

The area of drainage can be effectively distinguished and recognized by employing a combination of hydrological and spatial investigation, GIS software, and data from remote-sensing satellites. According to the majority of researchers, the morphometric parameters can be obtained from the Shuttle Radar Topographic Mission (SRTM) DEM, which utilizes a C-band interferometry radar setup (Grohmann *et al.* 2007; Kaliraj *et al.* 2015; Elmahdy *et al.* 2016). The precise morphometric characteristics for each basin can be determined promptly with the use of these satellite products due to their high degree of spatial resolution and the efficient computer program. The morphometric parameters of any watershed are critical for selecting sub-watersheds. Cases of watershed prioritization are reported within the Guhiya Bowl in India (Khan *et al.*

2001) using the sediment yield index (SYI) model, and micro-watersheds to position the check dam (Nooka Ratnam *et al.* 2005) are carried out. The morphometric parameters were also computed at Kerala's Vagamon and Peermade sub-basins for assessment and critical evaluation (Manju & George 2014).

The efficacy of fuzzy analytical hierarchical processes (FAHP) was taken into consideration when elaborating on the different morphometric parameters and ranking them based on the values and weightings produced from the connections among the morphometric parameters derived from the SW classification (Abdul Rahaman *et al.* 2015). An analysis was conducted on the morphometric characteristics of the Mula River Basin and the ranking of sub-watersheds was determined based on parametric values. Furthermore, suitable conservation-plan structures were proposed for sub-watersheds that were identified as having high priority in terms of conservation efforts (Choudhari *et al.* 2018). The utilization of diverse multivariate statistical methodologies, including factor analysis (FA), principal component analysis (PCA), and cluster analysis (CA), enables the discernment of noteworthy components or factors that explain a significant number of changes within a given system (Ouyang *et al.* 2006; Shrestha & Kazama 2007). PCA was conducted to assess the relationship between geomorphic features in the Darna River Basin and to prioritize watersheds (Pathare & Pathare 2021). The prioritization of the watershed is determined by selecting strongly associated characteristics through PCA.

Noyyal River Basin is one of the sources of water for many districts in the Indian state of Tamil Nadu. The major finding from the literature review is that there is no detailed morphometric analysis and prioritization made for the study area. Detailed morphometric analysis and prioritization are done for the effective management of soil and water resources in the proposed area. The stream length, bifurcation ratio, drainage density, elongation ratio, circulatory ratio, stream frequency, and other watershed morphometric data were obtained. The objectives of the present research are (i) to use the GIS technique to extract the morphometric parameters from the DEM, including the stream length, drainage density, bifurcation ratio, stream order, elevation, and slope difference of the drainage basin and (ii) to prioritize sub-watersheds according to the morphometric analysis and PCA method.

2. STUDY AREA

The study is carried out on the Noyyal River Basin, which is a tributary of Cauvery River. It originates from the Velliangiri hills, also known as the Southern Kailayam in the Western Ghats. It flows through various districts such as Coimbatore, Tiruppur, Karur, and Erode before joining the Cauvery River at Kodumudi in Erode. It has a geographical area of 3,500 km^2. The river basin is 180 km long and 25 km wide. It is bounded by north latitudes 10°54′00″ to 11°19′03″ and east longitudes 76°39′30″ to 77°55′25″. The river Noyyal had consistently strong flows until the early 1970s. The study area of the Noyyal River Basin is shown in Figure 1. The present conditions have undergone significant transformation in recent years, resulting in the river being predominantly reliant on seasonal precipitation. This variability in rainfall within the basin can be attributed to the geographical influence exerted by the Western Ghats. The soil type in the Noyyal River Basin varies from shallow red non-calcareous soils to very deep grey calcareous ones. On average, the basin experiences an annual precipitation of approximately 700 mm. The climate has predominantly warm conditions, characterized by temperature fluctuations spanning from a peak of 47 °C during April to a minimum of 13 °C in January. The hydrological regime of the Noyyal River is characterized by a seasonal pattern, where significant water-flows occur only during the limited duration of the northeast and southwest monsoons.

The Noyyal River experiences a significant influx of water during the northeast monsoon season, which typically spans from September to November. However, during the remainder of the year, the river tends to have limited water availability, resulting in predominantly dry conditions. Furthermore, the investigation of groundwater resources has been inadequate, and the available surface water supplies are inadequate to meet the demands of the town.

Flash floods may occur when there is heavy rainfall in the watershed areas. Frequent instances of flooding are observed during the rainy season due to the presence of steep slopes in the upper section of the basin. These problems can be partially resolved by efficiently managing watersheds.

3. MATERIALS AND METHODS

The toposheets with the following bearing numbers 58A/12, 58A/16, 58B/9, 58B/B, 58E/3, 58E/4, 58E/7, 58E/8, 58E/12, 58E/16, 58F/1, 58F/5, 58F/9, 58F/13 with a scale of 1:50,000 were collected to prepare the base map of the study area. Using ArcGIS software 10.3, topographical maps were georeferenced. Toposheets and DEM were both used to delineate

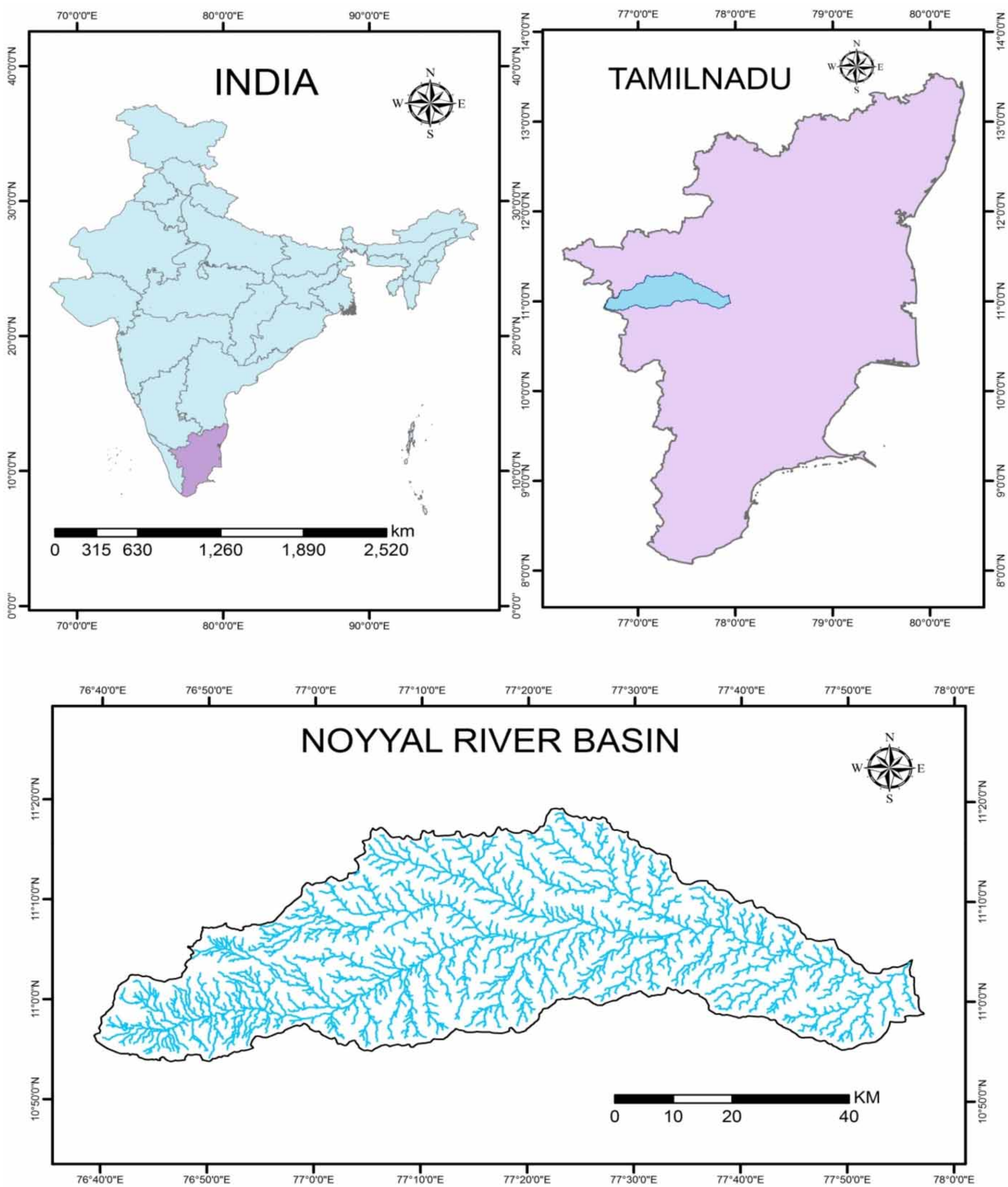


Figure 1 | Location map of the study area.

the boundary of the Noyyal River Basin. Figure 2 provides a detailed explanation of the methodology followed in the current study. The extraction and quantification of morphometric characteristics were done using the pre-processor DEM. Using ArcGIS software, the drainage network was derived from the SRTM DEM, and the sub-watershed boundaries were identified based on drainage flow direction and contour lines. The Noyyal River Basin (SW1–SW17) is divided into 17 sub-watersheds as shown in Figure 3.

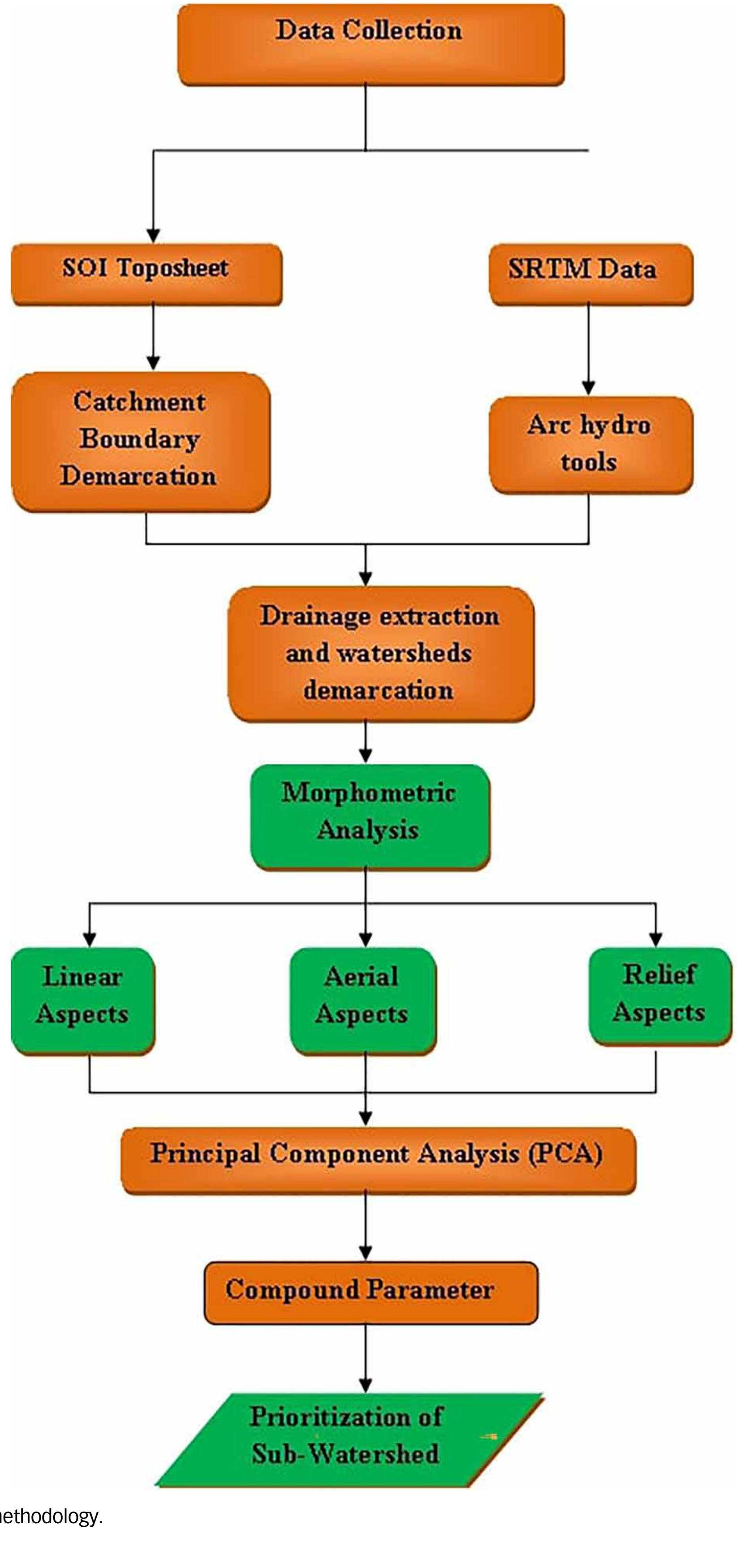


Figure 2 | Flowchart of methodology.

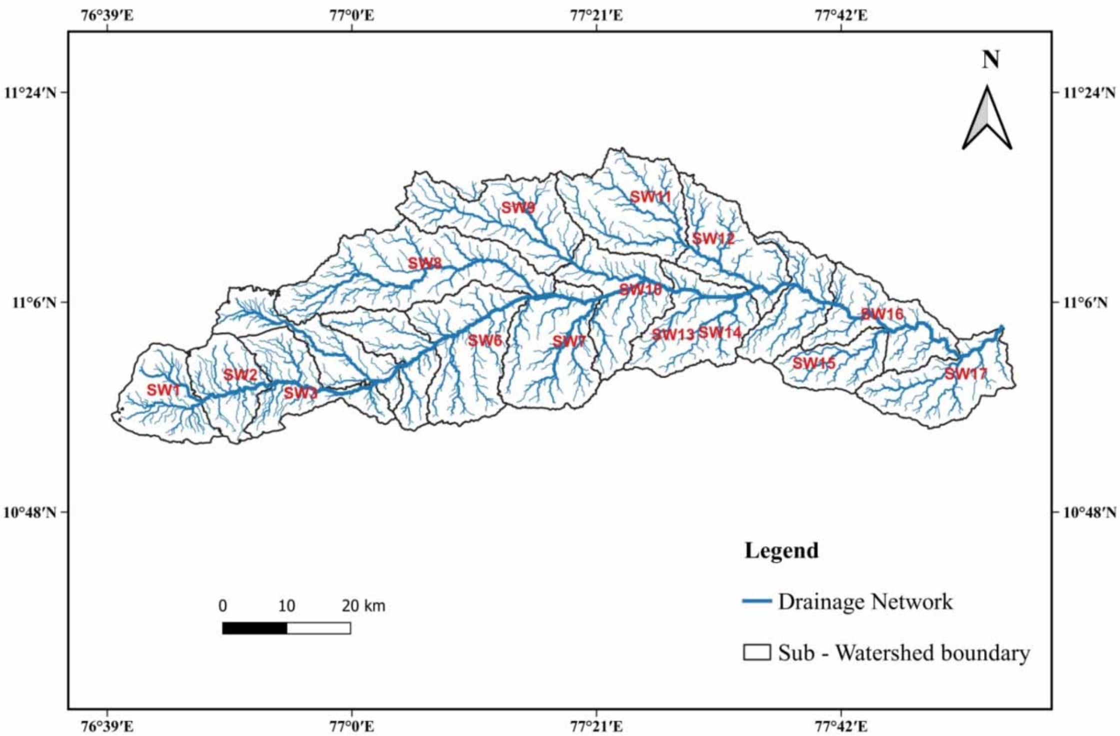


Figure 3 | Sub-watersheds in the basin of the Noyyal River.

Several morphometric parameters including stream number, perimeter, stream order, stream length, total basin length, drainage area, etc., were computed using ArcGIS software. Additionally, the morphometric parameters of drainage density, bifurcation ratio, elongation ratio, compactness constant, form factor, stream frequency, circulatory ratio, shape factor, texture ratio, length of overload flow, basin relief, and relief ratio were calculated.

Table S1 (Supplementary Material) provides the formulas required to determine the morphometric parameters. There exists a positive correlation between linear parameters and erodibility, whereby an increase in the value of the former corresponds to a higher degree of erodibility for the parameter in consideration (Nooka Ratnam *et al.* 2005; Singh *et al.* 2013). The highest value of the linear parameters was therefore evaluated as rank 1, the second highest value as rank 2, and so on, with the lowest value being placed last in rank. Erodibility is inversely related to shape factors such as elongation ratio, compactness coefficient, circulation ratio, basin shape, and form factor (Nooka Ratnam *et al.* 2005; Javed *et al.* 2009); the lower the value, the greater the erodibility. Thus, the lowest rank for the shape parameters was 1, the next lowest rank was 2, and so on, with the highest rank being the lowest. The compound value (C_p) was obtained for each of the 17 sub-watersheds by summing the ranking values of all linear and shape parameters after rating each sub-watershed based on each parameter. The final priority was established by assigning average values to these compound attributes, with the highest priority given to the least value. This approach aimed to identify areas of soil and water resources that are particularly vulnerable.

3.1. Principal component analysis

The PCA technique is used to identify the correlation matrix and the parameters that would have the greatest impact on the watershed, which in turn provides a reduction in the geomorphic parameters. For PCA calculations, SPSS 26.0 software is utilized. The first-factor loading matrix, rotated factor loading matrix, and varimax rotation method are employed. To implement soil and water conservation techniques, the pre-defined ranking system of geomorphic parameters is used.

4. RESULTS AND DISCUSSIONS

The study area has undergone elaborate morphometric analysis for each of the 17 sub-watersheds and the different parameters have been determined. For prioritization, ranking is assigned to all parameters according to susceptibility to soil erosion for effective watershed management. In general, the morphometric categories can be divided into (1) linear elements; (2) areal elements; and (3) relief elements of the basin. The following sections discuss the sub-watershed drainage characteristics while taking the three groups into account.

4.1. Linear aspects

4.1.1. Stream order (U) and mean stream length (L_{sm})

In this study, the classification of streams has been conducted using Strahler's approach (Strahler 1964). The stream network analysis is conducted and subsequently classified into five orders throughout each sub-watershed, as depicted in Figure 4. The mean stream length, which is a dimensionless parameter, provides insights into the characteristics, dimensions, and catchment areas of various components within a drainage network (Strahler 1964). The mean stream length of a succession of watersheds tends to follow a direct geometric sequence (Horton 1945). Stream ordering with the number of streams and mean stream length of each sub-watershed are presented in Table 1.

4.1.2. Stream length ratio (R_L)

The length ratio offers a comprehensive assessment of the comparative permeability of the geological strata within the basin. There is no trend in the stream length ratio among the streams in the various sub-watersheds of the study area. The variability seen in the stream length ratio value of the designated order serves as a measure of the early geomorphic development stage (Tiwari & Kushwaha 2021).

4.1.3. Bifurcation ratio (R_b)

The utilization of this method serves as a means to quantify the relief and evaluation of drainage basins, as evidenced by the works of Horton (1945), Schumm (1956), and Strahler (1957). The bifurcation ratio refers to the proportion of stream segments of a specific order in relation to the number of stream segments in the subsequent higher order (Schumm 1956). When the ratio value is smaller, the location probably exhibits plain topography, porous bedrock, and a higher possibility for groundwater. Table 1 presents the average bifurcation ratio observed across various sub-watersheds, exhibiting a range spanning from 2.86 to 7. According to Nag & Chakraborty (2003), when the R_b values are higher, it indicates a significant

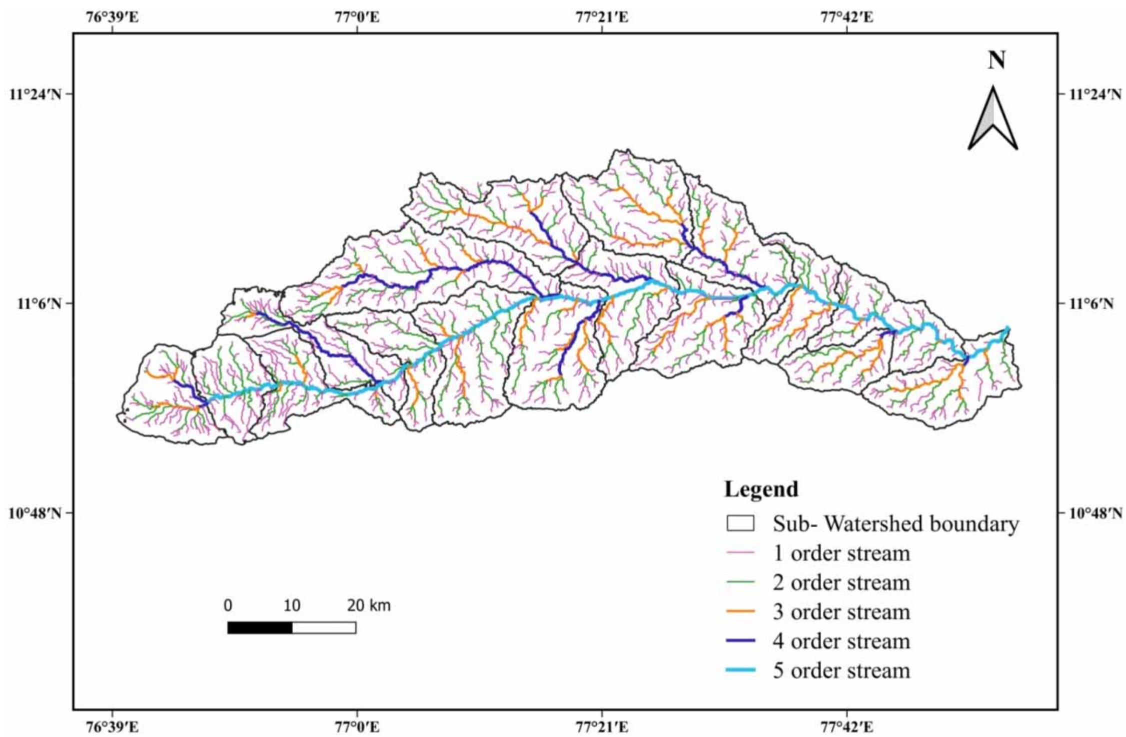


Figure 4 | Stream order map of the study area.

Table 1 | Linear parameters of each sub-watershed

Sub-watershed	Parameters	Stream order (number of streams) I	II	III	IV	V	Mean bifurcation ratio
SW1	No. of streams	55	2.86	4	2	1	2.86
	Stream length	1.45	7.00	4.31	4.59	0.00	
SW2	No. of streams	40	3.73			1	7.00
	Stream length	2.12	3.38			14.77	
SW3	No. of streams	50	5.04	3		1	3.73
	Stream length	2.12	4.95	3.27		19.42	
SW4	No. of streams	54	3.04	2	1	1	3.38
	Stream length	1.60	6.61	1.27	28.21	5.76	
SW5	No. of streams	49	4.00	1		1	5.04
	Stream length	1.06	3.20	8.07		6.57	
SW6	No. of streams	82	4.42	2		1	4.95
	Stream length	1.26	3.53	8.18		18.73	
SW7	No. of streams	72	3.31	6	2	1	3.04
	Stream length	1.24	3.73	5.64	8.63	12.61	
SW8	No. of streams	104	3.55	7	1		6.61
	Stream length	1.68	3.33	3.49	45.74		
SW9	No. of streams	63	3.29	4	1		4.00
	Stream length	1.61		7.64	12.56		
SW10	No. of streams	48		2	1	1	3.20
	Stream length	1.95	2.86	7.08	15.04	13.27	
SW11	No. of streams	75	7.00	3	1		4.42
	Stream length	1.28	3.73	12.11	6.05		
SW12	No. of streams	60	3.38	2	1	1	3.53
	Stream length	1.26	5.04	7.01	15.15	8.10	
SW13	No. of streams	68	4.95	4	1	1	3.31
	Stream length	1.50	3.04	6.87	6.23	13.13	
SW14	No. of streams	42	6.61	2		1	3.73
	Stream length	1.50	4.00	10.96		8.38	
SW15	No. of streams	36	3.20	2	1		3.55
	Stream length	1.07	4.42	11.33	3.39		
SW16	No. of streams	62	3.53	3	1	1	3.33
	Stream length	1.31	3.31	1.43	0.01	28.81	
SW17	No. of streams	62	3.73	3	1	1	3.29
	Stream length	1.11	3.55	8.38	1.67	9.41	

influence of structural factors on the drainage pattern. Conversely, lower R_b values indicate a decrease in structural disturbances and the presence of a stable drainage pattern.

4.2. Areal aspects

4.2.1. Drainage density (D_d)

Drainage density is a geomorphological parameter that quantifies the amount of stream channel length within a defined area (usually a watershed or drainage basin). It is a crucial parameter used in hydrology and geomorphology to characterize the drainage network and understand the efficiency of water flow within a particular region. It is an expression indicating how closely spaced the channels are. In the different sub-watersheds, drainage density value varies from 0.723 to 1.02 km/km^2. The drainage density map is shown in Figure 5. Hard or impermeable underlying materials, sparse vegetation, and hilly terrain all contribute to high drainage density. An area of high resistance permeable subsurface material presumably exists under dense vegetation and low relief due to low drainage density.

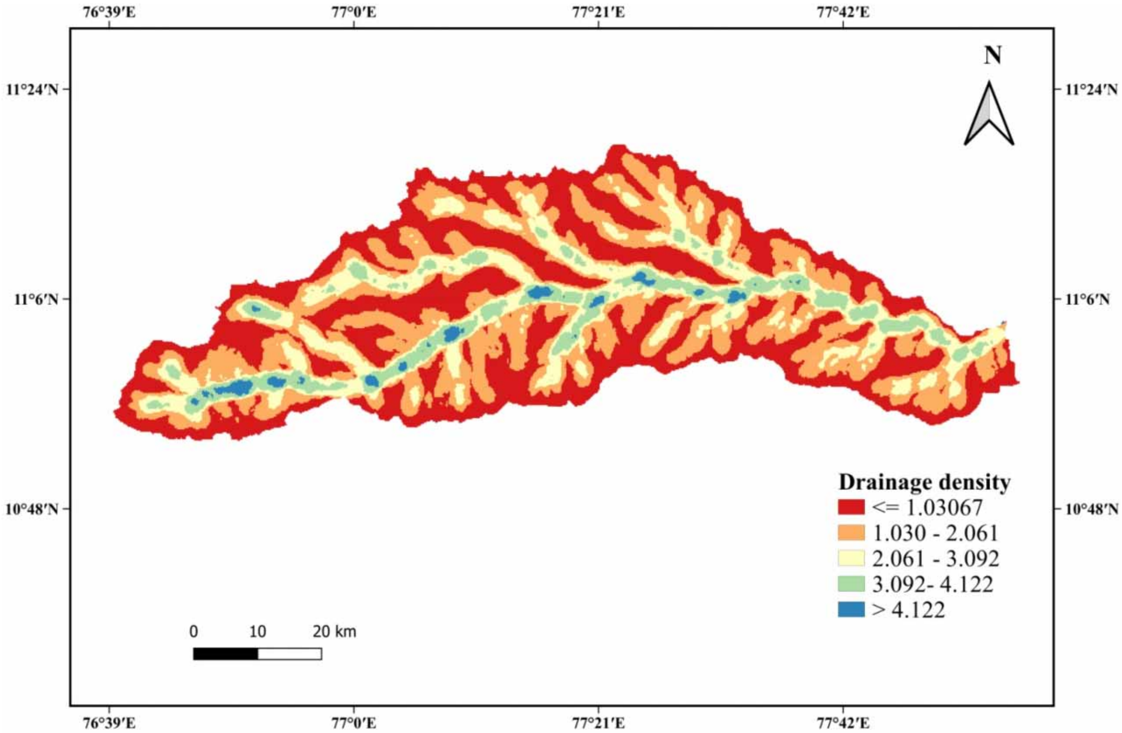


Figure 5 | Drainage density map of the study area.

4.2.2. Texture ratio (*T*)

The texture ratio is an important parameter that is influenced by the subsurface lithology, the areal feature of the terrain, and infiltration capacity. It shows how close together the drainage lines are spaced in a watershed. In the Noyyal River Basin, texture ratio value varies from 0.58 to 1.18 km^{-1}.

4.2.3. Length of overland flow (L_o)

The length of overland flow is the distance that water flows across land before it condenses into stream channels. It equals nearly half of the reciprocal of drainage density (Horton 1945). It influences the physiographical and hydrological processes of the drainage basin (Horton 1945). The values of the length of overland flow are given in Table S2 (Supplementary Material).

4.2.4. Stream frequency (F_s)

Stream frequency is the sum of all segments in a stream of all orders per unit area (Tiwari & Kushwaha 2021). High surface runoff and steeper terrain are indicated by high stream frequency (Horton 1932; Rao 2009; Yadav *et al.* 2014). Low stream frequency values imply a permeable underlying layer and low relief. This value exhibits how the drainage network is structured and it depends on the lithology of the basin. The value of stream frequency varies from 0.30 to 0.46 km^{-2}.

4.2.5. Circulatory ratio (R_c)

The circulatory ratio refers to the relationship between the overall area of a basin and the surface area of a circle that has the same circumference as the perimeter of the watershed of the basin (Miller 1953). The circularity ratio is influenced by various factors, including the duration and regularity of the watercourses, geological characteristics, climatic conditions, topographical attributes, land utilization patterns, land cover composition, and the slope of the basin. R_c values of low, medium, and high indicate the young, mature, and old stages of the life cycle of the tributary watershed. The circularity ratio (R_c) ranges between 0.15 and 0.49, indicating that the majority of the sub-watershed tributaries are in their early to mid-stages of development.

4.2.6. Elongation ratio (R_e)

The elongation ratio is the ratio of the diameter of a circle of the same area as that of a basin to the maximum length of the basin (Schumm 1956). Based on the geological type and climate, it evaluates the shape of a basin. In terms of runoff discharge, a circular basin is more effective than an elongated basin (Horton 1932). Higher elongation ratio values imply low runoff and greater infiltration capacity, whereas lower values reflect higher vulnerability to erosion and sediment loading (Reddy *et al.* 2004; Yadav *et al.* 2014). The value of the elongation ratio varies from 0.37 to 0.99 and the average value of the Noyyal River Basin is 0.568, showing a high relief and steep slope.

4.2.7. Form factor (R_f)

The form factor describes the flow rate of a basin for a particular area. In contrast to high form-factors, which possess larger peak flows through shorter durations, low form-factors possess smaller peak flows with a longer duration. If the value of the form factor is lower, then the basin will have an elongated shape. The value of the form factor in the given study area varies from 0.11 to 0.78, showing the elongated shape of the basin.

4.2.8. Shape factor (B_s)

The shape factor is the ratio of the square length of the basin to the basin area (Tiwari & Kushwaha 2021). A basin shape factor aids in assessing the drainage basin's irregular shape (Yadav *et al.* 2014). The Noyyal River Basin has an average shape factor of 4.739 with a range of values between 1.27 and 9.05.

4.2.9. Compactness constant (C_c)

A circular basin has the shortest duration until it reaches its maximum flow rate, making it most vulnerable from a drainage perspective. C_c helps to show how a circular basin and a hydrologic basin are related, resulting in a circular basin occupying the same area as the hydrologic basin (Tiwari & Kushwaha 2021). Less susceptibility to risk factors is indicated by lower C_c values, whereas greater values imply greater vulnerability to the execution of conservation measures. The C_c value ranges within the study area show a significant difference among sub-watersheds.

4.3. Relief aspects

4.3.1. Basin relief (R)

This is one of the morphometric factors that aid in understanding the denudational features of the basin. Additionally, it influences surface runoff, silt, and stream gradient regulation. The Noyyal River Basin has an elevation of 1,833 m above mean sea level.

4.3.2. Relief ratio (R_r)

The relief ratio refers to the ratio of a basin's total relief to its longest dimension, which is parallel to its major drainage line (Choudhari *et al.* 2018). The value of the relief ratio in the area of study ranges from 0.003 to 0.105, as given in Table S3 (Supplementary Material). It has been observed that areas characterized by significant elevation differences and steep inclines demonstrate elevated relief ratios, whereas areas with less noticeable elevation differences and milder slopes exhibit lower relief ratios.

4.3.3. Ruggedness number (R_n)

This is expressed as the product of the drainage density and the relief of the basin (Melton 1957; Strahler 1957). The ruggedness number in the current study varies from 0.08 to 1.32. The maximum value of the ruggedness number was found in the sub-watersheds of SW1 and SW2. In comparison with the other locations, these two regions are extremely vulnerable to erosion of soil.

4.4. Intercorrelation among geomorphic parameters

The correlation matrix is generated using SPSS 26.0 software (Table 2) for 13 selected geomorphic parameters to understand the intercorrelation. According to the correlation matrix, there is a strong correlation (correlation coefficient >0.9) between R_h and R_r; R_r to R_h and R_n; D_d and L_o; R_c and C_c; R_f and R_e. In addition, a good correlation (correlation coefficient >0.75) exists between R_h and R_n; R_n to R_h and L_o; B_s to R_f and R_e; T to R_c and C_c. A moderate correlation is found between R_r to D_d and L_o; R_n and D_d; B_s and R_c. Certain parameters do not correlate with other parameters. As a result, the correlation matrix was subjected to PCA, a useful screening method, to group the components (Meshram & Sharma 2015).

Table 2 | Intercorrelation matrix among geomorphic parameters of the study area

	R_h	R_r	R_n	R_b	D_d	F_s	B_s	R_c	R_f	R_e	T	L_o	C_c
R_h	1.000	0.975	0.871	0.078	0.573	0.420	−0.328	0.322	0.579	0.541	0.208	−0.593	−0.151
R_r	0.975	1.000	0.936	0.234	0.674	0.314	−0.201	0.279	0.456	0.417	0.130	−0.685	−0.113
R_n	0.871	0.936	1.000	0.304	0.747	0.173	0.061	−0.002	0.245	0.190	−0.054	−0.756	0.177
R_b	0.078	0.234	0.304	1.000	0.279	−0.435	0.173	−0.015	−0.042	−0.053	−0.111	−0.261	−0.024
D_d	0.573	0.674	0.747	0.279	1.000	0.084	0.048	−0.087	0.128	0.106	−0.255	−0.994	0.197
F_s	0.420	0.314	0.173	−0.435	0.084	1.000	−0.248	0.285	0.393	0.360	0.394	−0.094	−0.183
B_s	−0.328	−0.201	0.061	0.173	0.048	−0.248	1.000	−0.616	−0.820	−0.887	−0.489	−0.021	0.588
R_c	0.322	0.279	−0.002	−0.015	−0.087	0.285	−0.616	1.000	0.526	0.565	0.759	0.094	−0.966
R_f	0.579	0.456	0.245	−0.042	0.128	0.393	−0.820	0.526	1.000	0.991	0.559	−0.164	−0.477
R_e	0.541	0.417	0.190	−0.053	0.106	0.360	−0.887	0.565	0.991	1.000	0.563	−0.140	−0.520
T	0.208	0.130	−0.054	−0.111	−0.255	0.394	−0.489	0.759	0.559	0.563	1.000	0.247	−0.756
L_o	−0.593	−0.685	−0.756	−0.261	−0.994	−0.094	−0.021	0.094	−0.164	−0.140	0.247	1.000	−0.207
C_c	−0.151	−0.113	0.177	−0.024	0.197	−0.183	0.588	−0.966	−0.477	−0.520	−0.756	−0.207	1.000

4.5. Principal component analysis

The components have been grouped using PCA, a statistical technique commonly employed to identify the most significant components for prioritizing watersheds. Additionally, the first-factor loading matrix was obtained and then subjected to an orthogonal transformation for rotation. The findings of the PCA are discussed in the sections that follow.

4.5.1. First-factor loading matrix

The first three components of the first-factor loading matrix as shown in Table S6 (Supplementary Material), which all have eigen values greater than 1, account for 81.407% of the total variance. Table S5 (Supplementary Material) shows that the first component has strong correlations (>0.9) with R_h; good correlations (>0.75) with R_r, R_f, and R_e; and moderate correlations (>0.6) with B_s and R_c. The second component is correlated well with R_n, D_d, and L_o; it has a moderate correlation with C_c. The third component is correlated well with R_b and correlated moderately with F_s. The matrix demonstrates that T does not have any correlation with any other component. Finding the important factors for correlation at this time is impossible. To obtain a better correlation, the first-factor loading matrix has to be rotated.

4.5.2. Rotation of the first-factor loading matrix

The transformation matrix is post-multiplied with the chosen components to produce the rotated factor loading matrix from the first-factor loading matrix. According to the rotational factor loading matrix as given in Table S6 (Supplementary Material), the first component is strongly correlated with R_c, and moderately correlated with B_s, R_e, T, R_f, and C_c. The second component shows that R_r and R_n are strongly correlated, and are correlated well with R_h, D_d, and L_o. The third component is correlated well with R_b and F_s. As a result, R_c, $R_{n,}$ and R_b were considered to be the most important factors for watershed prioritization.

4.6. Comparison of two approaches to prioritization

Table S7 (Supplementary Material) shows the compound parameters (C_p) created by summing the ranks of the 13 geomorphic parameters acquired from the linear, areal, and relief aspects. The highest priority is assigned to sub-watershed SW8, which has a compound parameter value of 7.85, and the sub-watershed SW10 having a compound value of 10.92 receives the lowest priority for watershed prioritization.

According to the results of the PCA-based method, the parameters R_b, R_c, and R_n have a strong correlation. These parameters can be utilized for prioritization of the sub-watershed after determining the compound parameter value (C_p) and final priority rank (R_p) values (Table 3). The highest rank is given to the compound value with the lowest value, and vice versa. Hence, sub-watershed SW8 was given a priority rank of 1, while sub-watershed SW17 was given a priority rank of 17.

Table 3 | Sub-watershed priorities and ranking utilizing PCA-correlated parameters

Sub-watershed	R_b	R_c	R_n	C_p	Final priority
SW1	17	17	1	11.67	13
SW2	1	15	2	6.00	4
SW3	8	2	4	4.67	2
SW4	11	1	3	5.00	3
SW5	3	3	17	7.67	6
SW6	4	10	13	9.00	8
SW7	16	14	8	12.67	16
SW8	2	4	5	3.67	1
SW9	6	7	16	9.67	10
SW10	15	8	12	11.67	13
SW11	5	13	15	11.00	12
SW12	10	9	6	8.33	7
SW13	13	12	7	10.67	11
SW14	7	6	9	7.33	5
SW15	9	16	10	11.67	13
SW16	12	5	11	9.33	9
SW17	14	11	14	13.00	17

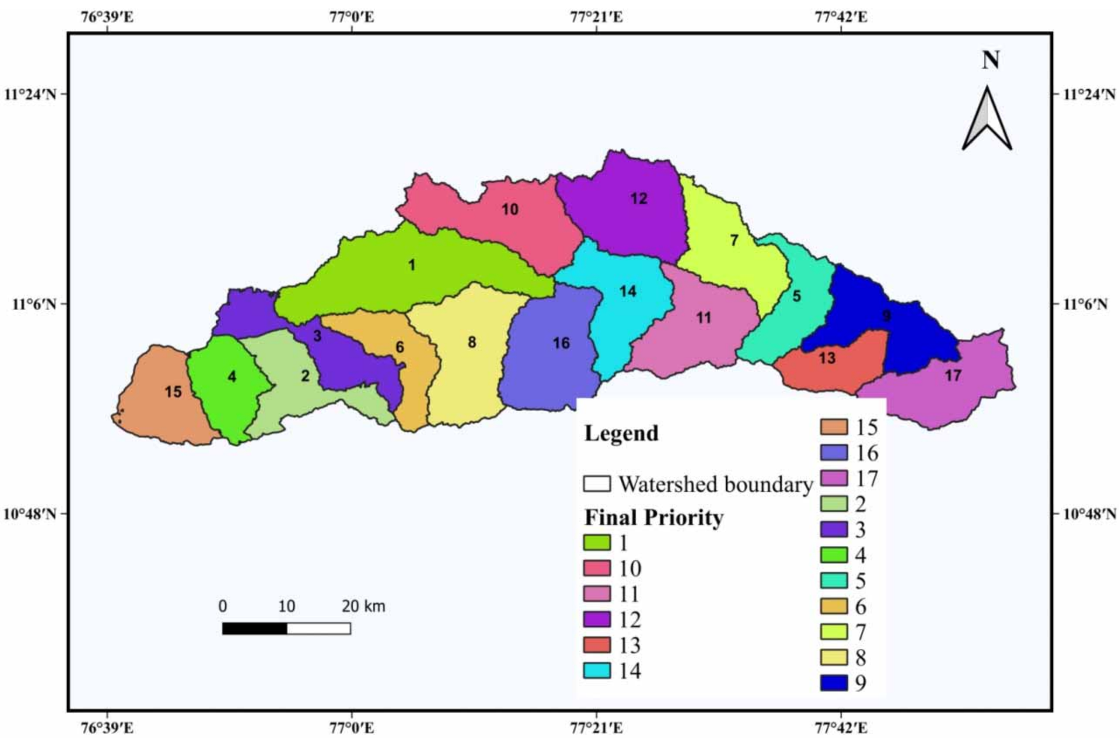


Figure 6 | Prioritized sub-watershed.

Figure 6 shows the final prioritized map of the study region. The morphometric analysis for prioritization involved the utilization of 13 parameters, whereas the PCA-based system employed just three parameters. This approach not only results in time-savings but also facilitates the process of parameter selection for fluvial geomorphologists and hydrologists.

5. CONCLUSION

The study area of the Noyyal River was delineated into 17 sub-watersheds using a geospatial technique. A morphometric study was conducted to prioritize the sub-watershed based on factors such as linear aspects, areal aspects, and relief aspects. To enhance the prioritization process using morphometric analysis, it was determined vital to include more parameters. To decrease the quantity of morphometric parameters, a method based on PCA was employed. This methodology facilitated the identification of optimal parameters for ranking the sub-watersheds more efficiently. Based on the PCA findings, it is observed that three out of the 13 parameters, namely R_c, R_n, and R_b, exhibit a significant association with each other. Consequently, the aforementioned parameters were employed in the ultimate prioritization of sub-watersheds. According to the PCA approach, the sub-watershed SW8 is granted the highest priority due to its compound parameter value of 3.67. Conversely, the sub-watershed SW17, with a compound value of 13, obtains the lowest priority in the prioritization of watersheds. To mitigate the occurrence of soil erosion within these watersheds, it is imperative to implement appropriate preventative measures. The present study highlights the significance of geographic information system (GIS) and PCA methodologies in the prioritization of sub-watersheds through morphometric analysis. The findings of this study can serve as a valuable resource for hydrogeologists in effectively managing soil and water resources and providing enhanced insights for informed decision-making.

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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