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Morphometric Analysis of Olanthichira Watershed using Geographic Information System in Malappuram District, Kerala, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Morphometric analysis of watershed is important for understanding its geo-hydrological behaviour. The objective of this study is to determine morphometric parameters of Olanthichira watershed, Kuttipuram block, Malappuram district of state Kerala, India. The stream channels of the watershed were extracted from SRTM DEM and SOI topographical maps on 1:50,000 scale using Hydrology tools in Arc GIS software showing dendritic drainage pattern. Then morphometric analysis is carried

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out by determining parameters of linear, areal and relief aspects. Drainage density of 1.836 km/km^2 is moderate suggests semi-permeable rocks, moderate relief, and a balanced hydrological response. The drainage texture of watershed is 4.359/km indicates a moderate to fine drainage texture means the watershed has a fairly advanced drainage system, with a moderate number of stream channels with highest channel maintenance constant of 0.544 experiencing low runoff and fewer structural disruptions. The moderate bifurcation ratio of 3.68 in a drainage network suggests that the network's development is influenced by some degree of structural control. The areal aspects of the watershed point out elongated shape which possess lower erosion and sediment transport capacities and less prone to sudden floods but might require interventions to prevent sediment deposition in channels. The results of morphometric analysis along with slope map, aspect map and vegetation (NDVI) map are helpful for decision makers to implement soil and water conservation measures for sustainable management of the resources in watershed.

Keywords: ArcGIS; Malappuram; morphometric analysis; remote sensing; SRTM DEM; watershed characterization.

1. INTRODUCTION

“Morphometry is the measurement and mathematical analysis of the configuration of the earth's surface, shape, dimension of its landforms” (Clarke, 1966). “Morphometric analysis involves the characterization of a river basin or watershed through the quantitative measurement of various parameters including linear aspects, areal aspects, and relief aspects. Morphometric characteristics at the watershed scale can provide significant insights into its formation and development, as all hydrologic and geomorphic processes take place within the watershed” (Pareta & Pareta, 2011). “Morphometric analysis plays a critical role in watershed management by providing a scientific basis for understanding the physical characteristics of a watershed. These characteristics directly influence hydrological processes like surface runoff, infiltration, groundwater recharge, erosion, and sediment transport, which are key factors in managing watersheds effectively. It helps in planning water conservation, erosion control, flood mitigation, and sustainable resource utilization strategies. Assessing the physical characteristics of a watershed helps identify areas vulnerable to soil erosion that require urgent mitigation. Therefore, effective measures like contouring, terracing, filter strips, and other structural or non-structural approaches should be applied in regions contributing significantly to soil erosion” (Duressa et al.,2024).

Earlier, morphometric analysis was conducted manually using topographic maps to delineate watersheds and drainage networks. Measurements, such as stream lengths, drainage density, and basin areas, were calculated using tools like planimeters and curvimeters, while contour maps were analysed to estimate relief and slope. This process was labour intensive, time consuming and prone to human error, with limited accuracy due to the coarse resolution of maps and restricted data availability. These limitations have been overcome by the evolution of Geographic Information System (GIS) and Digital Elevation Model (DEM). GIS software enables efficient delineation of drainage networks, stream ordering, and watershed boundaries, while DEMs provide high-resolution elevation data for precise terrain analysis. Integrating morphometric insights with modern tools like GIS ensures precision and efficiency in addressing watershed challenges. Recent advancements in GIS and remote sensing technology have made it easier, faster, and more affordable to analyze drainage basins. This is largely due to freely available DEM (Digital Elevation Model) data, which is highly effective for morphometric analysis. Two commonly used DEMs are the Shuttle Radar Topographic Mission (SRTM) and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). However, SRTM-DEM is preferred for basin-scale analysis due to its higher spatial accuracy compared to ASTER-GDEM (Chowdhury, 2024).

Krishnan (2024) analyzed the morphometric characteristics of Kali Subbasin in Karnataka using remote sensing and GIS tools. It found that the basin had reached a mature geomorphic stage, shown by an increasing stream length ratio from lower to higher orders. The study emphasized the need for strategies like floodplain zoning, afforestation, and terracing to manage flooding and soil erosion. These findings are crucial for improving water resource management and preparing the basin for future hydrological challenges.

Sreedevi et al. (2009) analyzed "the Wailapalli watershed in South India using SRTM data and GIS, revealing that its elongated shape is influenced by thrusting and faulting, with lower-order streams dominating the drainage. The study highlights a drainage pattern with high discharge capability but low groundwater potential, offering insights for rainwater harvesting and watershed management strategies". Mani et al. (2022) analyzed" the Suswa River basin using SRTM-DEM data and ArcGIS, revealing a sub-dendritic to dendritic drainage pattern with a drainage density of 2.84 km/km². The basin's elongated shape and moderate relief highlight its geo-hydrological characteristics, providing valuable insights for sustainable development planning". Pasham et al. (2024) analyzed "the Mahi River basin, focusing on morphometric parameters and structurally controlled terrains in relation to the topsoil grain size index (TGSI). They used satellite data, including Landsat 8 OLI/TIRS and SRTM-DEM, processed with ArcGIS software. Their findings showed that combining remote sensing data (SRTM-DEM) with GIS methods was an effective approach for morphometric analysis".

Shekar & Mathew (2022) highlight "the importance of studying watersheds to prevent soil erosion, conserve water, and promote sustainable development. They emphasize the effectiveness of GIS and remote sensing techniques in analyzing the hydraulic processes of river basins. Additionally, they note that extracting drainage features from SRTM DEM has become a popular, fast, accurate, and cost-effective method for conducting catchment studies".

2. MATERIALS AND METHODS

2.1 Study Area

Olanthichira watershed is a micro-watershed of Bharathapuzha river basin, which spreads over an area of 814 ha in Edayoor and Melmuri villages of Marakkara and Edayoor panchayats in Kuttippuram block of Malappuram District, Kerala. The watershed lies between 76° 02' 45" to 76° 04'30" E longitude and 10˚ 55' 15" to 10° 58' 30" N latitude. The location map of study area map is shown in Fig. 1. Physio-graphically, it falls midland region with elevation ranges from 15 m to 150 m above MSL. The general slope is towards South-West direction with average slope of 25 %. The watershed has a humid tropical climate with an average annual rainfall of 2800 mm. The main drain of the watershed is Kannamkadavu Olanthi thodu which orginate from Parappur chola and other drainwise, Devar chola, Thengat chola, Nechikkatu chola, Ayanikkundu thodu, Parakkandam thodu and Moolam chola, joins to main drain at several points. The outlet is at Olanthichira. The main drain joins to Kunthippuzha then to Bharathapuzha.

2.2 Data and Software Used

Survey of India (SOI) topographic map of 1:50,000 scale (C43K1) and Shuttle Radar Topography Mission (SRTM) DEM of 30m spatial resolution downloaded from USGS Earth explorer were used for delineation of Olanthichira watershed and morphometric analysis. SRTM was used in this study since it generally offers higher accuracy than ASTER DEM also observed that SRTM outperformed ASTER DEM in deriving drainage networks and morphometric parameters (Thomas & Prasannakumar, 2015). Landsat 9 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) with spatial resolution of 30m and spectral resolution of 11bands was downloaded from USGS Earth Explorer for Land Use/Land Cover (LULC) mapping and NDVI mapping. Arc GIS software (10.7.1) was used to prepare different maps and conduct the morphometric analysis.

2.3 Methodology

The watershed was delineated using hydrology tools in ArcGIS. The process began with filling the SRTM DEM, followed by calculating flow direction and flow accumulation. Streams were then generated by applying threshold values to the flow accumulation data. The stream generated were verified using georeferenced topographic map. Finally, Olanthichira watershed was delineated by defining outlet point. The complete process was shown as flow chart in Fig. 2. Morphometric parameters represent the physical characteristics of a watershed and are primarily classified into three categories: linear, areal, and relief aspects. These parameters were determined using formulae mentioned in Table 1.

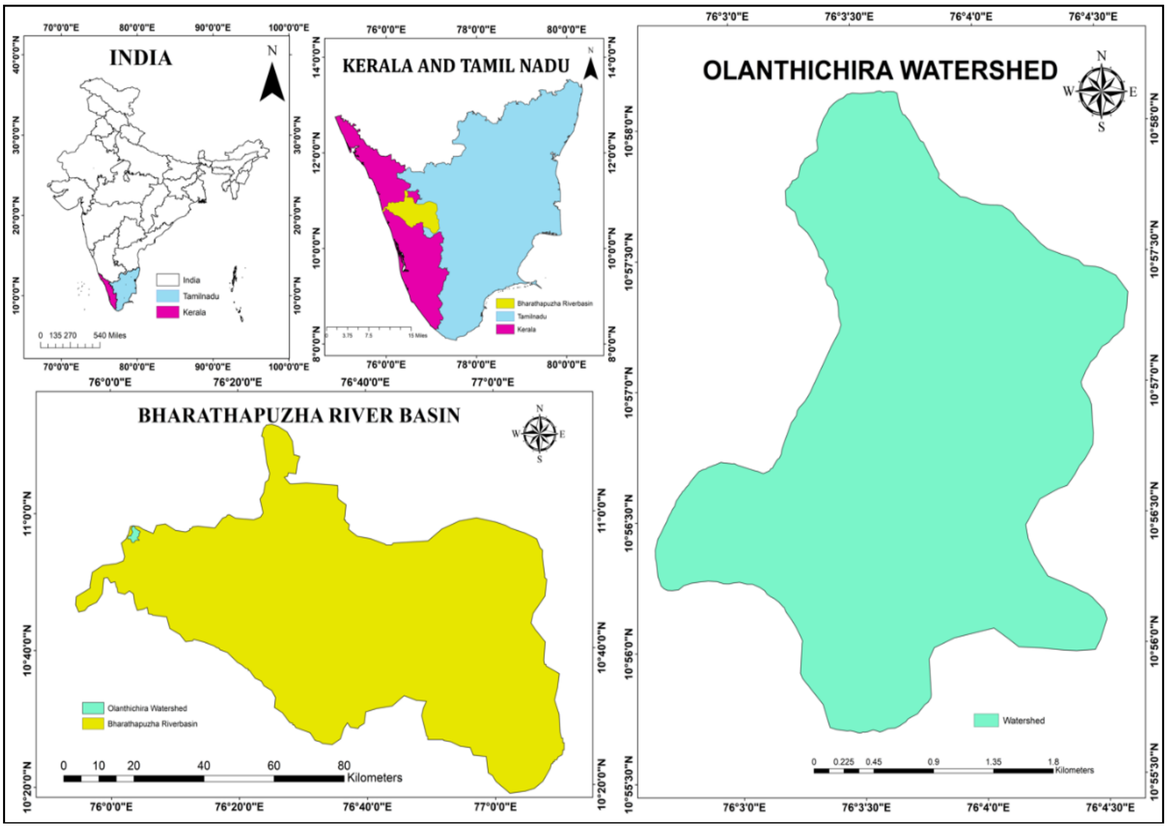

Fig. 1. Location map of Olanthichira watershed, Malappuram

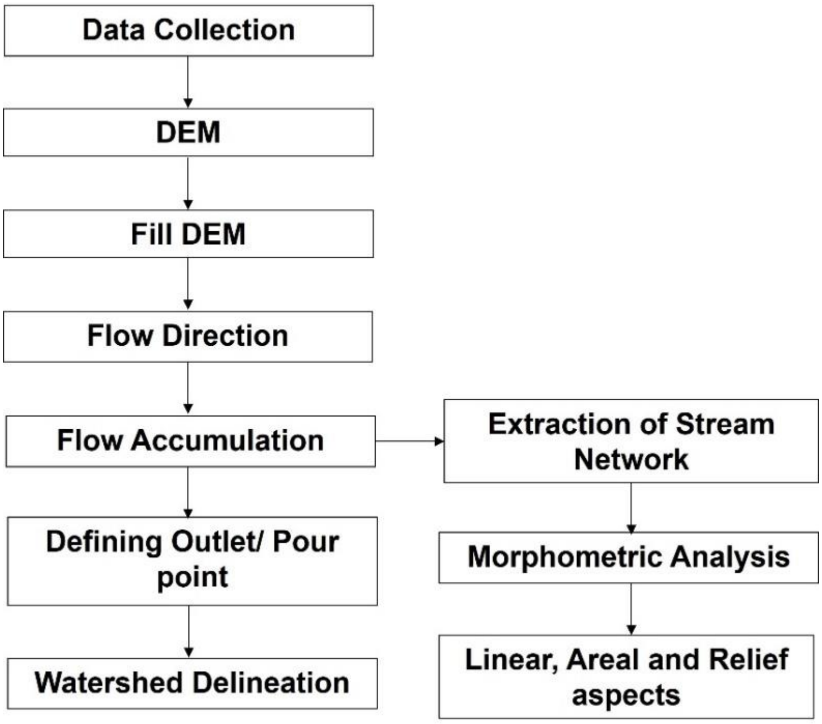

Fig. 2. Watershed delineation process

Table 1. Mathematic equations for determining morphometric parameters

Sl.No.	Morphometric Parameters	Formula/ Definition	References
A	**Basin Parameters**		
1	Area (A)	GIS Analysis	
2	Perimeter (P)	GIS Analysis	
3	Basin length (L_b)	$L_b = 1.312\ A^{0.568}$	Schum (1956)
4	Mean basin width (W_b)	$W_b = A/\ L_b$	Horton (1945)
5	Stream order (u)	Ranking hierarchically	Strahler (1952)
6	Stream number (N_u)	$N_u = N_1 + N_2 +\ldots N_n$	Horton (1945)
B	**Linear Parameters**		
1	Stream length (L_u)	$L_u = L_1 + L_2 +\ldots L_n$	Strahler (1964)
2	Mean stream length (L_{sm})	$L_{sm} = L_u / N_u$	Strahler (1952)
3	Stream length ratio (L_{ur})	$L_{ur} = L_{smu} / L_{smu-1}$	Strahler (1964)
4	Mean stream length ratio (R_{slm})	$R_{slm} = \sum L_{ur}/n$	Schumm (1956)
5	Bifurcation ratio (R_b)	$R_b = N_u / N_{u+1}$	Strahler (1964)
6	Mean bifurcation ratio (R_{bm})	$R_{bm} = \sum R_b/n$	Strahler (1964)
7	Rho coefficient (ρ)	$\rho = R_{slm}/\ R_{bm}$	Horton (1945)
8	Drainage density (D_d)	$D_d = L_u/A$	Horton (1932)
9	Stream frequency (F_s)	$F_s = N_u/A$	Horton (1932)
10	Drainage texture (D_t)	$D_t = N_u/P$	Horton (1945)
11	Infiltration number (I_f)	$I_f = F_s * D_d$	Faniran (1968)
12	Length of overland flow (L_o)	$L_o = 1/2D_d$	Horton (1945)
13	Drainage intensity (D_i)	$D_i = F_s / D_d$	Faniran (1968)
C	**Areal Parameters**		
1	Circularity ratio (R_c)	$R_c = 4\pi A/P^2$	Miller (1953)
2	Elongation ratio (R_e)	$R_e = D/L_b = 1.128\sqrt{A}/L_b$	Schumm (1956)
3	Form factor ratio (F_f)	$F_f = A/L_b^2$	Horton (1932)
4	Compactness constant (C_c)	$C_c = 0.282\ A/\ P^{0.5}$	Horton (1945)
5	Lemniscate's ratio (k)	$k = L_b^2 / 4A$	Chorley et al. (1957)
6	Shape factor (B_S)	$B_S = L_b^2 /A$	Horton (1932)
7	Constant of channel maintenance (C)	$C = 1/D_d$	Schumm (1956)
C	**Relief Parameters**		
1	Elevation of basin outlet (h)	GIS analysis	
2	Maximum elevation of the basin (H)	GIS analysis	
3	Basin relief (R)	$R = H – h$	Strahler (1952)
4	Relief ratio (R_h)	$R_h = R/L_b$	Schumm (1956)
5	Relative relief (R_r)	$R_r = R/P$	Schumm (1956)
6	Ruggedness number	$H_d = D_d * R$	Strahler (1957)

Using Landsat 9 image, Normalised difference vegetation index (NDVI) map was prepared for 2023 to know the vegetation status of watershed using raster calculator in ArcGIS software. NDVI is a measure of the vegetation status of the study area and can be measured by calculating the difference of the Band 5 (NIR) and Band 4 (red) images of the TIRS Landsat imagery given in Equation 1 & 2 (Aravind, P et al. 2022).

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)} = \frac{(Band\ 5 - Band\ 4)}{(Band\ 5 + Band\ 4)}$$

Then slope map and aspect map of Olanthichira watershed were prepared in ArcGIS software.

3. RESULTS AND DISCUSSION

This study provided the morphometric analysis of Olanthichira watershed in three different aspects (Linear, Areal and Relief aspects). The slope, aspect, drainage density, vegetation (NDVI map), and soil characteristics of the watershed were analysed, providing a critical basis for understanding and managing the watershed. These aspects were determined based on various parameters outlined below.

3.1 Basin Parameters

Drainage area (A) is a key watershed characteristic of hydrological analysis and design. Larger area and higher difference in elevation results in greater discharge (Sujatha et al., 2015). The elevation of Olanthichira watershed ranges from 18 to 146 m shown in Fig. 3. The total area of Olanthichira watershed is 814 ha (8.14 km^2) and the perimeter is 15.138 km. The basin length of watershed represents maximum length running parallel to the main drainage line which is 4.137 km. The basin width is 1.885 km which is the distance of line drawn perpendicular to basin length.

3.2 Linear Parameters

3.2.1 Stream order and stream number

Stream ordering is the first step in morphometric analysis. Strahler's method of stream ordering has been adopted and found that the Olanthichira watershed is of fourth order drainage basin with dendritic drainage pattern which is shown in Fig. 4. Stream numbers representing the number of streams in each order and the total number of streams in watershed is 66 given in Table 2, which showed that the total number of streams decreases as the stream order increases.

3.2.2 Stream length, mean stream length and stream length ratio

The total stream length of watershed is 14.95 km and the individual stream length of each order is given in Table 2. The mean stream length ratio of this watershed is 0.683 and the stream length ratio of each order is given in Table 2, an increasing stream length ratio from lower order to higher order indicates their mature geomorphic stage.

3.2.3 Bifurcation ratio and mean bifurcation ratio

In this Olanthichira watershed, the range of bifurcation is between 3 to 4.16 shown in Table 2 and other parameters are shown in Table 3. The mean bifurcation ratio of 3.68 is within the normal range (3–5) for natural drainage systems (Strahler, 1964). This ratio reflects a relatively moderate influence of geological structures on the drainage network. The rho coefficient of 0.183 indicates moderate branching but relatively shorter stream lengths for higher-order streams reflect a balanced system with neither rapid drainage nor excessive storage, favouring sustainable hydrological management.

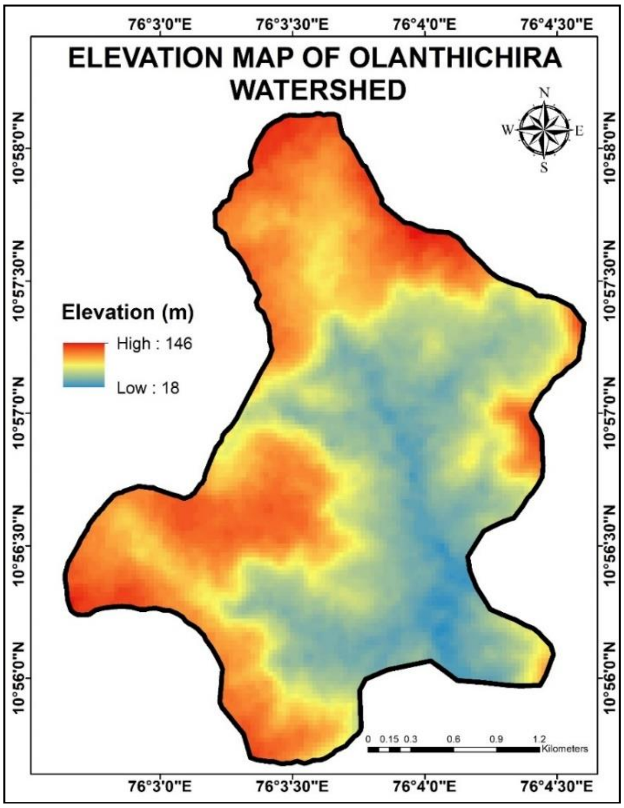

Fig. 3. Elevation map of Olanthichira watershed

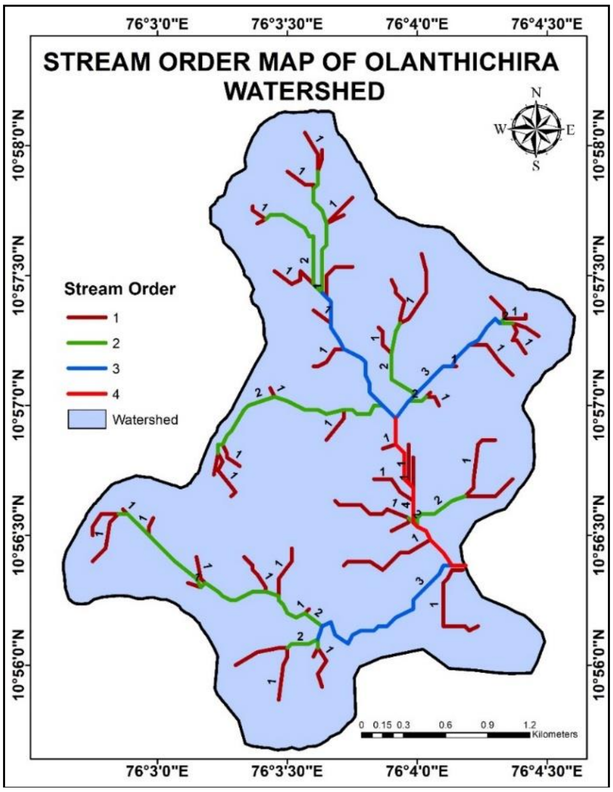

Fig. 4. Stream Order map of Olanthichira watershed

Table 2. Stream length, Stream length ratio and Bifurcation ratio of Olanthichira watershed

Stream order (u)	Stream Number (N_u)	Stream Length (L_u)	Mean Stream Length (L_{um})	Stream Length Ratio (R_l)	Bifurcation ratio (R_b)
1	50	12.470	0.249	-	4.16
2	12	1.989	0.165	0.665	4
3	3	0.412	0.137	0.830	3
4	1	0.076	0.07	0.556	-

Table 3. Linear aspects of Olanthichira watershed

Parameters	Values
Total stream length (L_u)	14.949 km
Mean stream length ratio (R_{slm})	0.683
Mean bifurcation ratio (R_{bm})	3.722
Rho coefficient (r)	0.183
Drainage density (D_d)	1.836 km/km^2
Stream frequency (F_s)	8.108 streams/ km^2
Drainage texture (D_t)	4.359 streams/ km
Infiltration number (I_f)	14.890
Length of overland flow (L_o)	0.91 km
Drainage intensity (D_i)	4.414 / km

3.2.4 Drainage density and drainage texture

The drainage density of this watershed is 1.836 km/km^2 falls in medium category which indicates moderately developed drainage network with gentle to steep slope terrain, medium dense vegetation, and less permeable for medium precipitation (Soni, 2017). A drainage texture value of 4.359/km indicates a moderate to fine drainage texture. This means the watershed has a relatively well-developed drainage network with a moderate number of stream channel (Soni, 2017). An infiltration number of this watershed is 14.89 suggesting that the soil has a high capacity to absorb water. This means water can enter the soil quickly, reducing surface runoff and potential erosion whereas 4.414 of high drainage intensity value typically points to higher potential for erosion.

3.2.5 Stream frequency

A stream frequency of 8.108/ km2 indicates a very high density of stream channels per unit area in the watershed, the watershed is likely to have a higher capacity for watershed drainage and runoff management (Shekar and Mathew, 2023).

3.2.6 Length of overland flow

The length of overland flow of this watershed is 0.91km implying gentle slopes and longer flow paths, high infiltration, and reduced runoff (Sukristiyanti et al., 2018).

3.3 Areal Parameters

Areal parameters such as circularity ratio, elongation ratio, form factor, compactness constant, lemniscate ratio, shape factor and compactness of channel maintenance were determined and given in Table 4. These parameters focus on size and shape of watershed.

3.3.1 Circularity ratio

Circularity ratio (R_c) value close to 1 indicates that the basin shapes are circular, allowing for consistent water infiltration providing more time for excess water to drain out of the basin (Soni, 2017). The R_c values of this watershed is 0.44 indicating of the lack of circularity characterized by medium to low relief. Such drainage systems are partially controlled by the structural disturbances (Kuntamalla et al., 2018).

3.3.2 Elongation ratio

According to Pareta & Pareta (2011), the shape of a watershed is highly elongated (R_e < 0.5), elongated (Re = 0.5–0.7), less elongated (Re = 0.7–0.8), oval (Re = 0.8–0.9) and circular (Re = 0.9–0.10). Since Olanthichira watershed has Re value of 0.745, its elongated in shape.

3.3.3 Form factor

If form factor is below 0.78, its elongated. If above 0.78, its circular (Singh et al., 2023). This watershed has a form factor of 0.436 signifying an elongated watershed which has low peak flows for longer duration.

3.3.4 Compactness constant

A C_c value of 1.0 represents a perfectly circular catchment, whereas a C_c value greater than 1.0 indicates a significant deviation from a circular basin shape (Singh et al., 2023). The compactness constant of 1.5 suggests that this watershed is less compact and more elongated which typically have longer flow paths and may exhibit slower and more prolonged runoff response.

3.3.5 Shape factor

Shape factor or shape index is the reciprocal of form factor (Vincy et al., 2012). This watershed has higher shape index of 2.289 indicating elongated shape tends to have longer flow paths and more prolonged runoff response compared to more compact watershed. Lemniscate ratio describes the shape of a watershed and a higher value (37.9) of this watershed suggests that the watershed is more elongated and less circular.

3.3.6 Constant of channel maintenance

The constant of channel maintenance of this watershed is 0.544/km which comes under the low erodible category. These channels can accommodate sediment within the range of 0.4 to 0.5/km, indicating their ability to handle a moderate amount of sediment transport (Shekar and Mathew, 2023).

3.4 Relief Parameters

The relief aspects focus on topography and elevation surface of watershed and the results are shown in Table 5.

3.4.1 Relief

Basin relief represents the maximum vertical distance between the lowest and the highest point of a basin. It triggers stream gradient affecting flood pattern and amount of sediment that can be transported (Hadely & Schumm 1961). The basin relief of 125m of this watershed represents areas with moderate topographical variation, balanced runoff and erosion potential and a relief ratio of 0.0302 suggests that the watershed has a relatively gentle slope indicating area is in a region with low to moderate topographic variation.

3.4.2 Relative relief

Relative relief of this watershed is 8.257 m/km. This low value suggests that the area has gentle slope means runoff will be slower and more controlled leading to lower runoff potential.

3.4.3 Ruggedness number

The ruggedness number of this watershed is 0.229 which hints watershed is less prone to erosion and have low to moderate complex structure related to relief and drainage density (Soni, 2017).

3.5 Aspect Map

Aspect shows the direction of the slope. As of now, the direction of slope at 0° is north, at 90° it is east and so on. It strongly influences water flow across the watershed shown in Fig. 5. In this watershed, North-facing slopes may receive less direct sunlight, leading to lower evaporation and potentially greater soil moisture retention. Conversely, south-facing slopes may experience faster runoff due to higher solar exposure and reduced moisture.

Table 4. Areal aspects of Olanthichira watershed

Parameters	Values
Circularity ratio (R_c)	0.446
Elongation ratio (R_e)	0.745
Form factor ratio (F_f)	0.436
Compactness constant (C_c)	1.500
Lemniscate's ratio (k)	0.570
Shape factor (B_S)	2.289
Constant of channel maintenance (C)	0.544 km^2/km

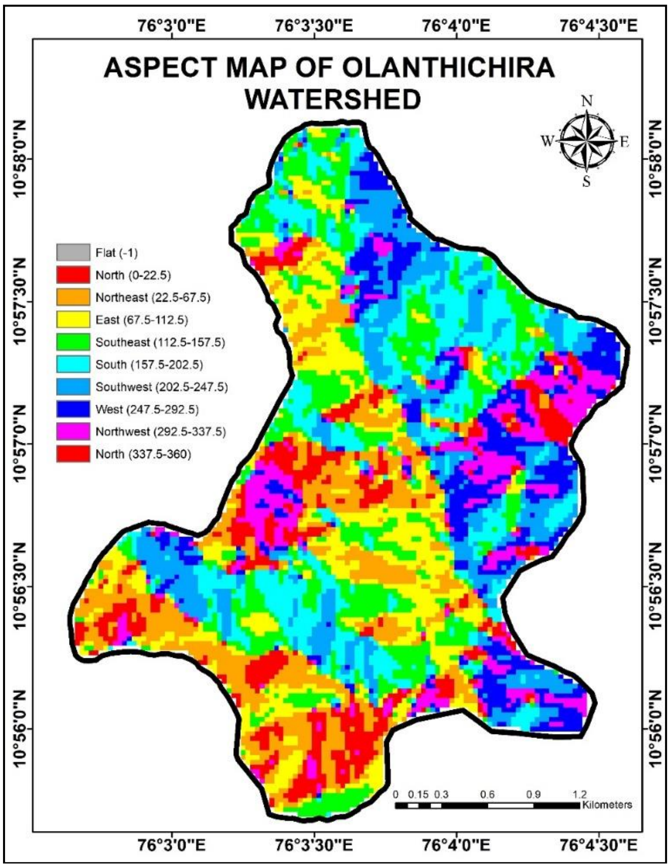

Fig. 5. Aspect map of Olanthichira watershed

Table 5. Relief aspects of Olanthichira watershed

Parameters	Values
Elevation of basin outlet (h)	21 m
Maximum elevation of the basin (H)	146 m
Basin relief (R)	125 m
Relief ratio (R_h)	0.0302
Relative relief (R_r)	8.257 m/ km
Ruggedness number	0.229

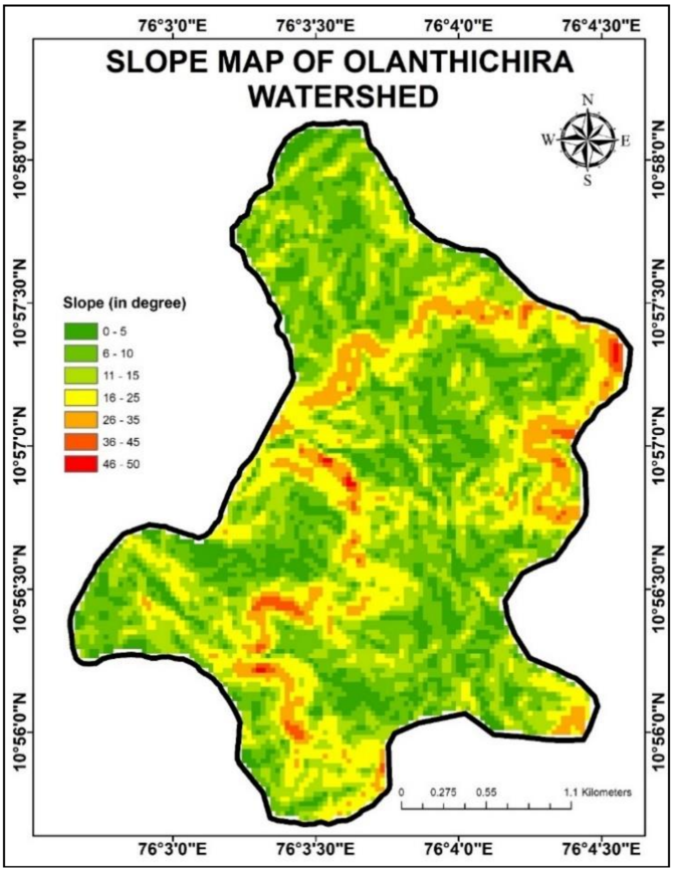

Fig. 6. Slope map of Olanthichira watershed

3.6 Slope Map

Slope of a watershed is important morphometric factor of hydrological as it influences the velocity of run-off and concentration time (Sujatha et al., 2015). The slope map of this watershed was prepared using DEM, it varies from 0° to 53°. The slope is classified into seven classes and shown in Fig. 6. The maximum area of watershed has slope of 15°–25°.

3.7 NDVI Map

NDVI map of watershed was prepared using Landsat-9 image in ArcGIS shown in Fig. 7. The range of NDVI values 0.078–0.597 indicates a landscape with varied vegetation health and density, from degraded or bare areas to regions of dense, healthy vegetation. Higher NDVI zones (light green to green) are crucial for ecological and agricultural productivity, indicating areas with high biomass and strong vegetation health. Lower NDVI zones (red to orange) might represent regions requiring intervention, such as reforestation, irrigation, or land improvement, to enhance vegetation cover and productivity. This map can be used to identify priority areas for conservation or rehabilitation.

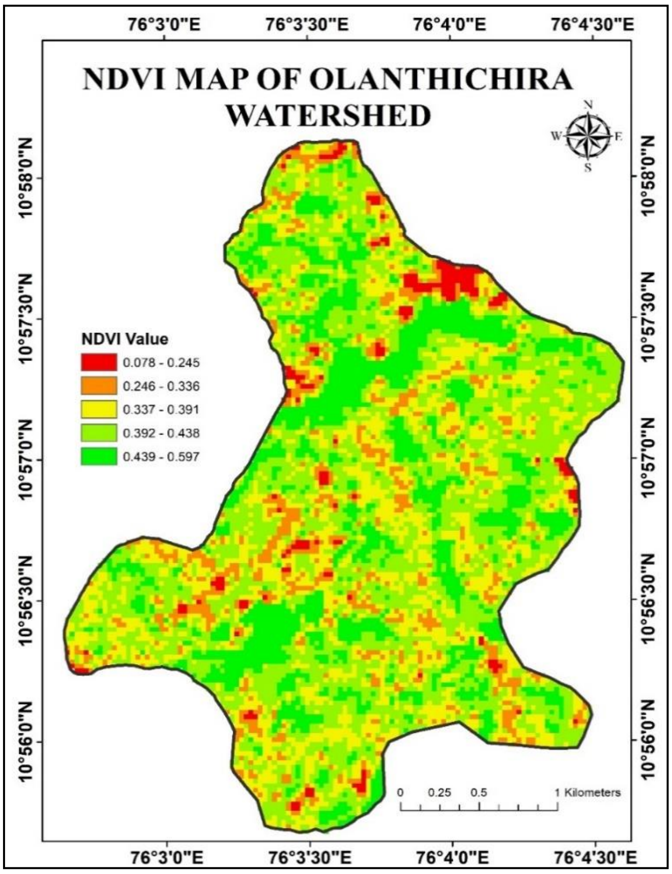

Fig. 7. NDVI map of Olanthichira watershed

4. CONCLUSION

Morphometric analysis gives a quantitative description of drainage basin which is very much useful in studies such as hydrologic modelling, watershed prioritization, natural resources conservation and management, and rehabilitation. GIS and remote sensing techniques found to be most effective for morphometric analysis compared to traditional approaches. Hence in this study, a quantitative morphometric analysis was done using geospatial technology. First using SRTM DEM and topographic map, Olanthichira watershed was delineated. Then by extracting drainage networks, morphometric parameters were calculated using mathematical equations. This micro watershed is classified as fourth-order watershed with dendritic drainage pattern. The bifurcation ratio of watershed suggests that drainage pattern is moderate influenced by geology and structural controls. Then the low drainage density, high infiltration number and length of overland flow indicates that watershed has low erosion potential. Form factor, elongation ratio, circularity ratio and compactness constant describe watershed is elongated in shape with smaller flood peaks and longer flood flows. These parameters describe geology, runoff characteristics, permeability of region in watershed whereas slope, aspect, NDVI and soil map provide effective information. The integration of these parameters with slope, aspect and NDVI map provides a comprehensive approach for assessing a watershed behaviour and identifying optimal sites for soil and water conservation measures. Morphometric analysis helps identify areas vulnerable to soil erosion by evaluating slope, drainage patterns, and relief ratios. It supports the promotion of soil conservation practices like afforestation, contour farming, and terracing in erosion-prone regions. By analyzing infiltration capacity and slope characteristics, it also identifies areas suitable for groundwater recharge. This information aids in developing policies for constructing recharge structures such as check dams, percolation tanks, and artificial recharge wells. Additionally, it facilitates the formulation of water conservation policies, ensures equitable distribution of water resources, and guides the effective allocation of resources and funds for rural development projects.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that generative AI technology (ChatGPT) have been used during the writing or editing of manuscripts. The AI was used exclusively for summarizing content, and all interpretations, conclusions, and opinions are those of the author(s).

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Aravind, P., Selvakumar, S., Thiyagarajan, G., Kannan, B., & Boomiraj, K. (2022). Estimation of land surface temperature for Coimbatore District using Landsat imagery. *Journal of Applied and Natural Science*, *14*(SI), 8-15.

Chorley, R. J., Malm, D. E. G., & Pogorzelski, H. A. (1957). A new standard for estimating drainage basin shape. *American Journal of Science*, *255*(2), 138–141.

Chowdhury, M. S. (2024). Morphometric analysis of Halda River basin, Bangladesh, using GIS and remote sensing techniques. *Heliyon*, *10*(7).

Clarke, J. J. (1966), Morphometry from map, Essays in geomorphology. Elsevier Publishing Company, New York, 235-274.

Duressa, A. A., Feyissa, T. A., Tukura, N. G., Gudeta, B. G., Gechelu, G. F., & Bibi, T. S. (2024). Identification of soil erosion-prone areas for effective mitigation measures using a combined approach of morphometric analysis and geographical information system. *Results in Engineering*, *21*, 101712.

Faniran, A (1968), The Index of Drainage Intensity - A Provisional New Drainage Factor, Australian Journal of Science, 31, 328-330.

Hadley, R. F., & Schumm, S. A. (1961). Sediment sources and drainage basin characteristics in upper Cheyenne River basin. US geological survey water-supply paper, 1531, 198.

Horton, R. E. (1932). Drainage-basin characteristics. Transactions, American geophysical union, 13(1), 350-361.

Horton, R. E. (1945). Erosional development of streams and their drainage basins; hydro physical approach to quantitative morphology. Geological society of America bulletin, 56(3), 275-370.

Krishnan, A. (2024). Morphometric analysis in the sub basins of the Kali River using Geographic Information System, Karnataka, India. *Geomatica*, *76*(2), 100013.

Kuntamalla, S., Nalla, M., & Saxena, P. R. (2018). Morphometric Analysis of Drainage Basin through GIS: A Case Study from South Western part of Rangareddy District, Telangana State, India. In *11th International Conference on Researches in Science, Technology and Managment* (p. 11).

Mani, A., Kumari, M., & Badola, R. (2022). Morphometric analysis of Suswa River Basin using geospatial techniques. *Engineering Proceedings*, *27*(1), 65.

Miller, V. C. (1953). Quantitative geomorphic study of drainage basin characteristics in the Clinch Mountain area, Virginia and Tennessee. Technical report (Columbia University. Department of Geology); no. 3.

Pareta, K., & Pareta, U. (2011). Quantitative morphometric analysis of a watershed of Yamuna basin, India using ASTER (DEM) data and GIS. *International journal of Geomatics and Geosciences*, 2(1), 248-269.

Pasham, H., Gugulothu, S., Badapalli, P. K., Dhakate, R., & Kottala, R. B. (2024). Geospatial approaches of TGSI and morphometric analysis in the Mahi River basin using Landsat 8 OLI/TIRS and SRTM-DEM. *Environmental Science and Pollution Research*, *31*(41), 54129-54146.

Schumm, S. A. (1956). Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey. Geological society of America bulletin, 67(5), 597-646.

Shekar, P. R., & Mathew, A. (2022). Morphometric analysis for prioritizing sub-watersheds of Murredu River basin, Telangana State, India, using a geographical information system. Journal of Engineering and Applied Science, 69(1), 44.

Shekar, P. R., & Mathew, A. (2023). Morphometric analysis of watersheds: a comprehensive review of data sources, quality, and geospatial techniques. *Watershed Ecology and the Environment*.

Singh, M. C., Satpute, S., & Prasad, V. (2023). Remote sensing and GIS-based watershed prioritization for land and water conservation planning and management. Water Science & Technology, 88(1), 233-265.

Soni, S. (2017). Assessment of morphometric characteristics of Chakrar watershed in Madhya Pradesh India using geospatial technique. Applied Water Science, 7, 2089-2102.

Sreedevi, P.D., Owais, S., Khan, H.H., & Ahmed, S. (2009). Morphometric analysis of a watershed of South India using SRTM data and GIS. *Journal of the Geological Society of India, 73 (4), 543–552.*

Strahler, A. N. (1952). Hypsometric (area-altitude) analysis of erosional topography. Geological society of America bulletin, 63(11), 1117-1142.

Strahler, A. N. (1957). Quantitative analysis of watershed geomorphology. Eos, Transactions American Geophysical Union, 38(6), 913-920.

Strahler, A. N. (1964). Quantitative geomorphology of drainage basin and channel networks. Handbook of applied hydrology.

Sukristiyanti, S., Maria, R., & Lestiana, H. (2018, February). Watershed-based morphometric analysis: a review. In *IOP conference series: earth and environmental science* (Vol. 118, No. 1, p. 012028). IOP Publishing.

Thomas, J., & Prasannakumar, V. (2015). Comparison of basin morphometry derived from topographic maps, ASTER and SRTM DEMs: an example from Kerala, India. *Geocarto International*, *30*(3), 346-364.

Vincy, M. V., Rajan, B., & Pradeepkumar, A. P. (2012). Geographic information system–based morphometric characterization of sub-watersheds of Meenachil river basin, Kottayam district, Kerala, India. *Geocarto International*, *27*(8), 661-684.

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