Global Research Journal of Geography: ISSN-2360-8005
Abbreviated Key Title: Glob. Res. J. Geog
ISSN-2360-8005, (Print) & Open Access
Vol. 12(11): Pp 1-15, November, 2024

Volume-12 | Issue-11 November, 2024 | ***Full length Research Paper***

Morphometric analysis of Gojeb river sub basin around South Western part of Ethiopia by using GIS and remote sensing

***Deginet Tesfaye Youkamo**

*Department of Geology, College of Natural and Computational Sciences, Bonga University, Bonga, Ethiopia, P.O. Box 334
Corresponding author: Email: *detesfaye1311@gmail.com*
Orcid: 0000-0001-6620-4098

***Corresponding author: Youkamo D.T** **Accepted:** 1/11/.2024 | **Published:** 16//11/2024

Abstract: Morphometry is the science of measuring and analyzing the patterns and dimensions of landforms on the Earth's surface. By conducting a morphometric analysis of a river basin, one can obtain a quantitative description of its drainage system, which is crucial for understanding and characterizing the basin. This study employed ARCGIS and image processing techniques to identify and analyse the morphological features and basin characteristics of the Gojeb watershed. By using GIS hydrology tools, watersheds were delineated and analysed based on DEM data. The analysis revealed several important drainage parameters: The largest stream order is five, with a bifurcation ratio of 4.62. The total stream length is 191.9 km, and the drainage pattern is dendritic. The basin covers an area of 4405.5 km2, with a form factor of 0.74, indicating an elongated shape. The circularity ratio is 0.25, and the drainage density is 0.04, suggesting porous lithology with high infiltration capacity. Additionally, the stream frequency is 0.12, indicating high humidity, and the overland flow value is 11.5, indicating a very coarse drainage texture. Consequently, the basin is susceptible to groundwater pollution through infiltration and percolation. The morphometric parameters suggest low runoff rates and very high infiltration rates, which indicate the presence of geological structures such as faults, fractures, and porosity that facilitate infiltration and percolation.

Keyword: GIS, Gojeb River, morphometric parameter, remote sensing

1. INTRODUCTION

Morphometry refers to the measurement and numerical analysis of the Earth's surface pattern and the shape and dimensions of its features (Kumar & Kshitij, 2017). A morphometric analysis of a river basin is essential for understanding its drainage system and characterising the basin. This analysis plays a crucial role in various hydrological investigations, such as assessing groundwater potential, managing groundwater resources, basin management, and environmental assessment. By examining the physiographic characteristics of a drainage basin, including its size, shape, slope, drainage density, and the size and length of its tributaries, hydrological phenomena can be correlated (Rastogi & Sharma, 1976; Magesh et al., 2012). Morphometric analysis typically involves measuring linear, areal, and relief gradients.

Horton (1945), a primary pioneer in this field, laid the foundation for quantitative morphological investigation. Geomorphologists such as Strahler (1950, 1952, 1957, 1964, 1968), Schumm (1954, 1956), Morisawa (1958), Scheidegger (1965), Shreve (1967), and Gregory & Walling (1973) subsequently made several advancements. Many researchers have utilized the principles developed by these pioneers to quantitatively analyze river morphometry using remote sensing and geographic information systems (GIS). For example, Shankar Karipunana (2020) analyzed and interpreted the morphometric characteristics of the Wonji Basin in East Africa. Similarly, studies conducted by Gebreegziabher et al. (2015), Fenta et al. (2017), and Fayera et al. (2018) used remote sensing and GIS tools for drainage analysis in Ethiopia. Resmi et al. (2019) conducted a quantitative analysis of drainage and morphometric characteristics using the bAd calculator (bearing azimuth and drainage) and GIS. They built their methodology upon the methodologies developed by Raj et al. (1999), Awasthi & Prakash (2001), and Sinha Roy (2002).

The research on the Gojeb River Basin aims to understand its drainage characteristics through the use of advanced geospatial tools such as GIS and remote sensing. By utilizing Geographic Information Systems (GIS) and data from the Shuttle Radar Topography Mission (SRTM) and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), this study seeks to effectively determine and interpret spatial knowledge relevant to drainage basins. Both ASTER and SRTM provide valuable alternatives to traditional hypsographic data, offering high-resolution insights into basin morphology (Albaroot et al. 2018; Oyedotun 2020).

The expectation is that this study will enhance our understanding of various morphometric parameters, including stream orders, bifurcation ratio, total stream length, drainage pattern, form factor, circularity ratio, drainage density, lithologic characteristics, stream frequency, overland flow, and drainage texture. While previous analyses of the Gojeb River Basin by Eyasu Tafese Mekuria (2023) identified several morphometric parameters, this study did not include critical ones like form factor, circularity ratio, bifurcation ratio, and overland flow. These parameters play a crucial role in connecting the morphometric features of the basin to its geologic and hydrogeologic features. Furthermore, previous studies did not accurately represent the decrement of the number of stream segments as the order of the river increased. According to Horton (1945), the number of streams decreases as the stream order becomes higher, a pattern also supported by Joy, Md. Ashikur Rahman, et al. (2023). However, earlier research reversed this pattern, reporting higher numbers of third-order streams than first and second-order streams and more sixth-order streams than fifth and fourth-order streams. The current study corrects this by identifying that the basin has only one fifth-order stream (Gojeb River) and demonstrating the expected decrease in the number of streams as the order increases. The Gojeb River Basin experiences low rates of runoff and very high rates of infiltration, suggesting the presence of geologic structures such as faults and fractures that facilitate water infiltration and percolation into groundwater.

1.1 Objectives of study

The purpose of this study is to create a drainage map for the Gojeb river basin. The study aims to scrutinize crucial morphometric features like the basin's form, the relief basin, and the drainage system.

In addition to this primary objective, the study also has specific goals. The study aims to analyze the prepared drainage basin map using quantitative methodologies, including conventional methods. It will also make use of advanced technologies such as remote sensing (RS) and geographic information systems (GIS). Furthermore, the study aims to apply drainage basin analysis to geological studies, including groundwater, structure, and lithology.

1.2 description of the study area

In order to delineate the study area from the entire country, for further clarification, some unique positional, geologic, and climatic characteristics of the area are discussed below.

1.3 Location of study area

The study took place at the Gojeb River watershed, which is a part of the Omo-Gibe basin in Ethiopia. Figure 1 below illustrates the location of this area in the southern part of the country. It covers an area of 6932.3 km2 and is located between 81321 ′N and 862321 ′N latitude and between 162421E to 280000E longitude. The main anthropogenic activity in this area is agriculture.

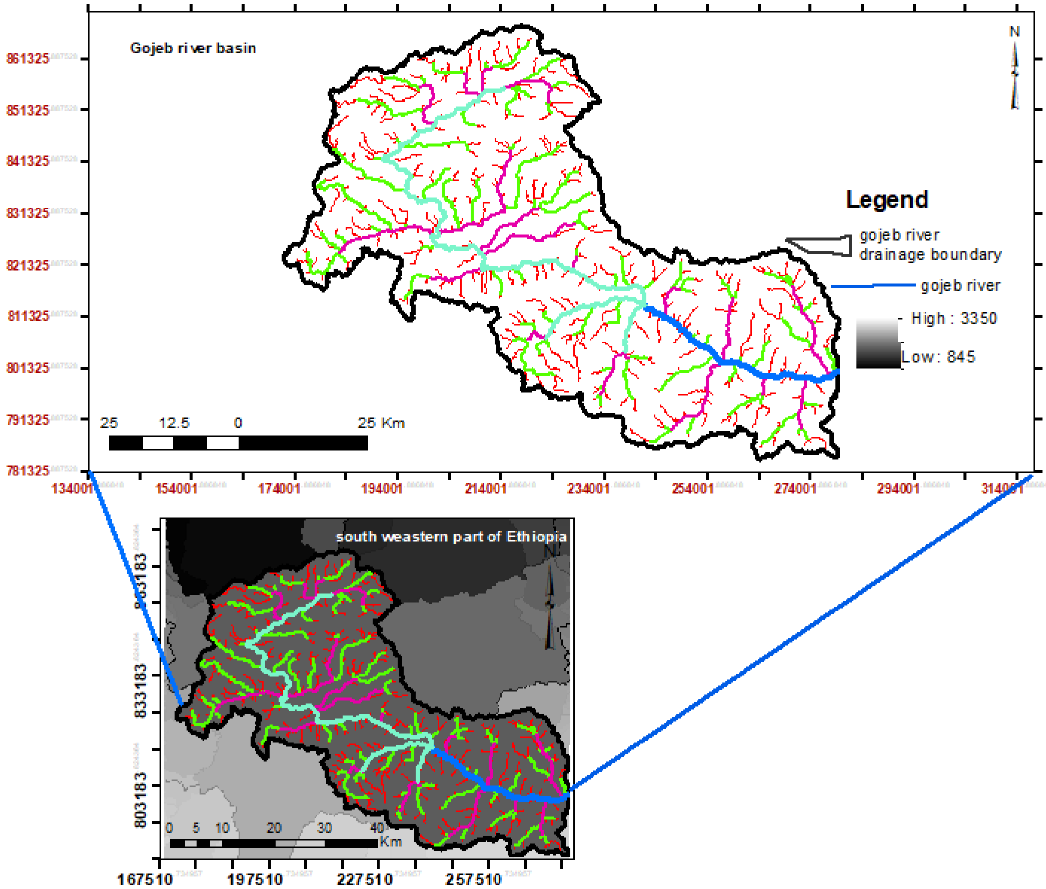

Figure 1 location map

Regional Geology of study area

On the geological map of Ethiopia (Mengesha, 1996), the area under study belongs to the Jimma volcanic area (upper part), which consisted of highly weathered trachite, ignimbrite, rhyolite, and tuff with minor basalt. This upper part is responsible for the potential groundwater of the area with a higher iron content. The lower part, known as the Jimma volcanic region, is composed of flood basalt and features minor salic flows from the late Eocene to late Oligocene age. While a new engineering geological map of the area at a scale of 1:50,000 was made because of the current landslide problem, it shows basic lava flow and pyroclastic materials that were formed by tertiary volcanism.

Climate and Rainfall Features

Climate of the Gojeb River Basin is tropical and humid in the highlands, which includes areas surrounding Jimma and the headwaters of the Gojeb River. The annual rainfall in the basin varies significantly, ranging from 400 mm in the extreme southern lowlands to 1900 mm in the highland areas, with an average of 1140 mm. The mean annual temperature also varies widely, ranging from less than 17°C in the western highlands to over 29°C in the southern lowlands (OMGRBIDMP, 1996). Figures 2 and 3 display the mean monthly temperatures and rainfall recorded at various meteorological stations within the basin, such as Jimma, Wolayita, Sekoru, Gojeb, Jinka, and Agaro. These stations represent the upper, middle, and lower parts of the basin.

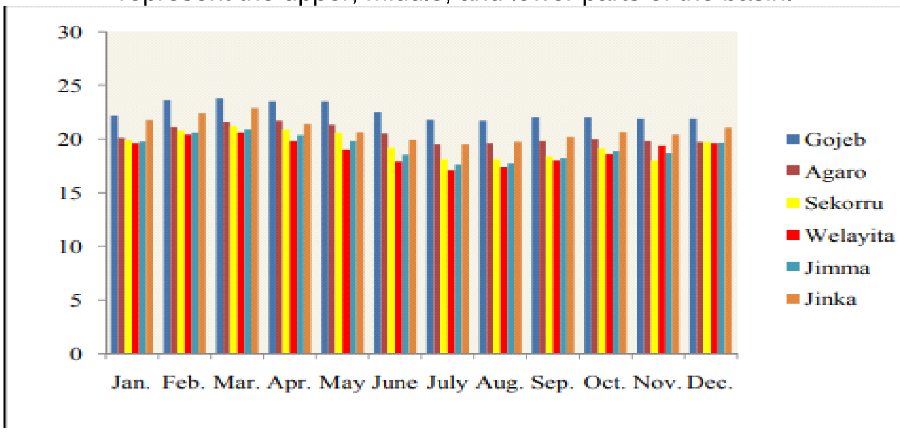

Figure 2: Mean monthly temperature in the basin

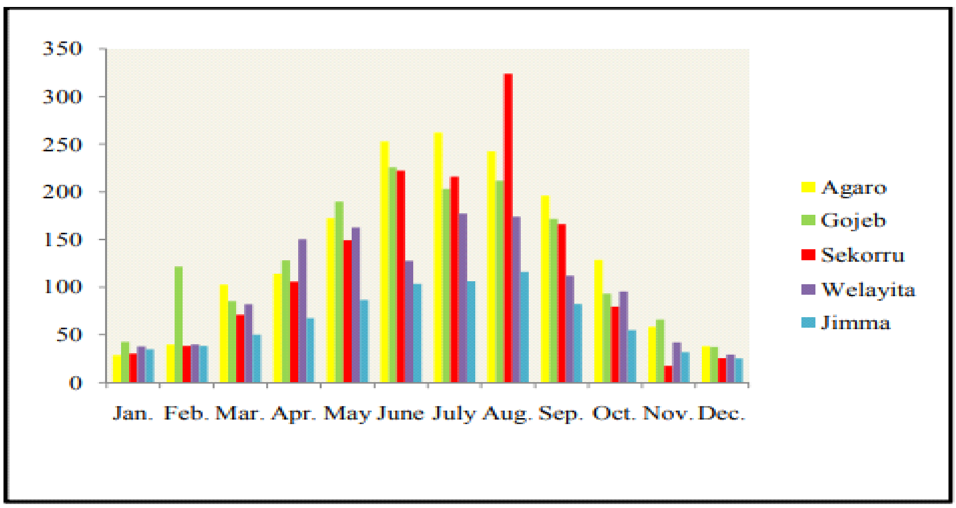

Figure 3: Mean monthly rainfall in the basin (source Daniel asefa Water Use and Operation Analysis of Water Resource Systems in Omo Gibe River Basin Addis Ababa May 2011).

Slope of study area

The topography of the basin and its surrounding consisting of flat to undulating, deep gorges and river dissections. Steeper slope feature at north eastern part basin is the result of its relative closer location to the rift margin (escarpment) as in (Figure 4). The larger part of the basin characterized by the hilly portion and measures an average slope of greater than 10 percent.

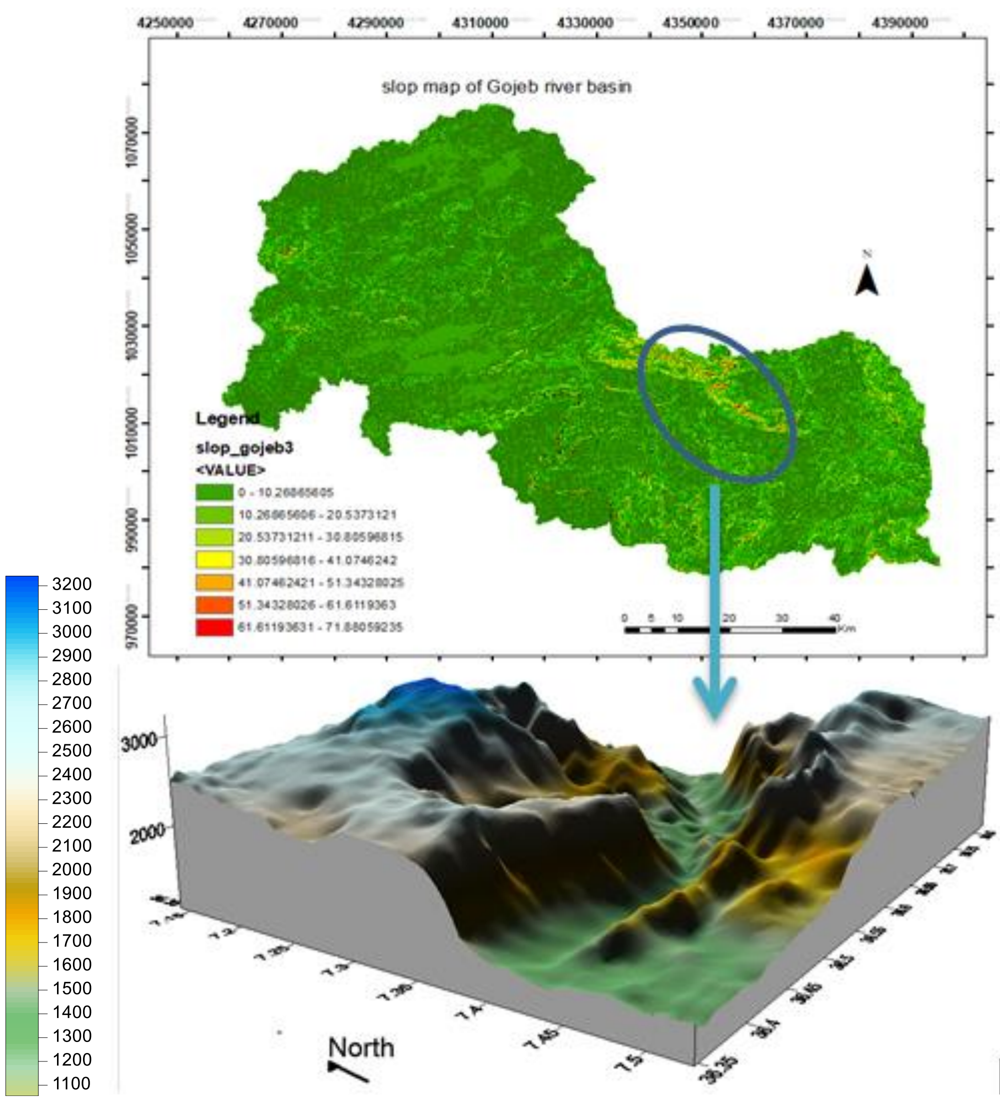

Figure 4: Slop map of study area

MATERIAL AND METHODOLOGY

The process of evaluating the morphometric parameters of a drainage basin involves several steps that utilize GIS software. These parameters include all linear, relief and aerial characteristics. Below is a detailed outline and conceptual framework for this process.

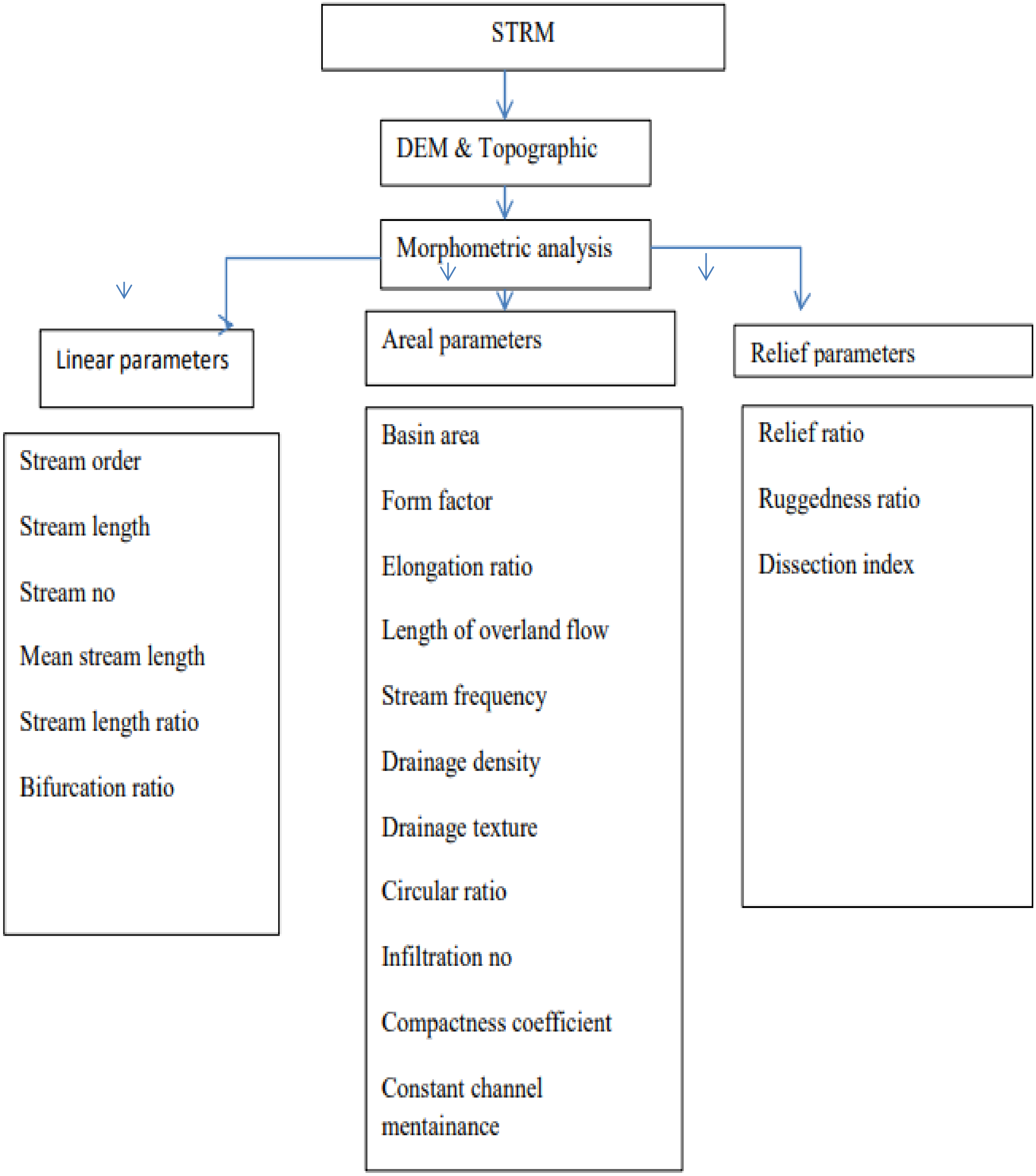
STRM
DEM & Topographic
Morphometric analysis
Linear parameters
Areal parameters
Relief parameters
Stream order
Stream length
Stream no
Mean stream length
Stream length ratio
Bifurcation ratio
Basin area
Form factor
Elongation ratio
Length of overland flow
Stream frequency
Drainage density
Drainage texture
Circular ratio
Infiltration no
Compactness coefficient
Constant channel mentainance
Relief ratio
Ruggedness ratio
Dissection index

Table 1: Methods of calculating morphometric

Morphometric parameters	Formulas		References
Area (A)	Area of the watershed		-
Perimeter (P)	The perimeter is the total length of the watershed Boundary		-
Length (Lb)	Maximum length of the basin		-
Stream Order (Nu)	Hierarchical rank		Strahler 1957
Stream Length(Lu)	Length of the stream		Horton 1945
Maximum and Minimum Heights (H, h)	Maximum and Minimum elevation		-
Slope (Sb)	Derived from SRTM 90 m DEM		
Bifurcation ratio (Rb)	$Rb = Nu / N u + 1$		Schumm 1956
Stream length ratio (Rl)	$Rl = Lu / Lu-1$		Sreedevi et al.2004
RHO coefficient (RHO)	$RHO = RI / RB$		Horton 1945
Stream frequency (Fs)	$Fs = \sum Nu/A$	Nu=No of stream in u order	Horton. 1945
Drainage density (Dd)	$Dd = \sum Lu/A$	Lu= length of order in u order	Horton. 1945
Drainage texture (T)	$T =\sum Nu/P$		Strahler 1957
Constant of Channel maintenance (C)	$C = 1/ Dd$		Schumm 1956
Basin relief (R)	$R = H – h$	H = Maximum height; h = Minimum Height	Hadley and Schumm 1961
Relief ratio (Rr)	$Rr = R / L$	L=longest horizontal line of the watershed	Schumm (1963)
Elongation ratio (Re)	$Re = 1.128 \sqrt{A} / L$		Schumm (1956)
Circularity index (Rc)	$Rc = 4\pi A / P^2$		Miller (1953),Strahler (1964)
Form factor (Ff)	$Ff = A / Lb2$		Horton (1945)
Compactness coefficient (m)	$0.282 P/ \sqrt{A}^{0.5}$		Gravelius (1914)

2 RESULTS AND DISCUSION

The current study examines the assessment of morphometric parameters of the Gojeb river subbasins. The analysis is divided into three categories: linear aspects, areal aspects, and relief aspects. The methods and equations described earlier were used to evaluate the values of 21 morphometric parameters of the sub-basins. Each parameter has received a detailed discussion.

2.1 Linear aspect

Linear aspects include the measurements of linear features of drainage such as stream order, bifurcation ratio, stream length, stream length ratio, length of overland flow, etc. (Ven Tee Chow, 1964). To gain a deeper understanding of hydrological behavior, geomorphological processes, and the development of a basin's drainage network, it is important to consider its linear aspects. Two key factors that play a significant role in analyzing the branching pattern and integrating the drainage network are stream order and bifurcation ratio. Additionally, stream length and stream length ratio are useful in assessing the hydrological efficiency and gradient of streams. The length of overland flow also impacts the initial movement of water in the basin, which in turn influences erosion processes and sediment transport. The following section will discuss these linear characteristics of the drainage basin in further detail.

Stream orders

Stream ordering is an essential first step in analyzing the morphology of drainage basins, and there are various approaches to accomplishing it. The Strahler modified Horton method is the most commonly used system due to its simplicity. This method classifies the smallest unbranched streams as 1st order. When two 1st order streams merge, they form a 2nd order stream. Similarly, the confluence of two 2nd order streams results in a 3rd order stream, and so on.

Understanding the relationship between stream characteristics and agricultural productivity is crucial, and stream order plays a key role in this. Several studies have demonstrated that stream order is a valuable indicator for evaluating sediment geochemical anomalies (Emmanuel John M., 2010) and analyzing the distribution of nitrate concentrations and loads in agricultural watersheds. Additionally, integrating stream order data is essential for modeling the spatial distribution of hydromorphic soils and the buffering efficiency of wetlands in agricultural catchments (Mérôt, P., et al., 2009). In summary, stream order is a valuable tool for assessing and predicting the impact of agricultural activities on stream ecosystems and productivity.

The current study employs Strahler's system, identifying the Gojeb River as having the highest stream order of 5. The following Table 2 summarizes the order and total number of streams.

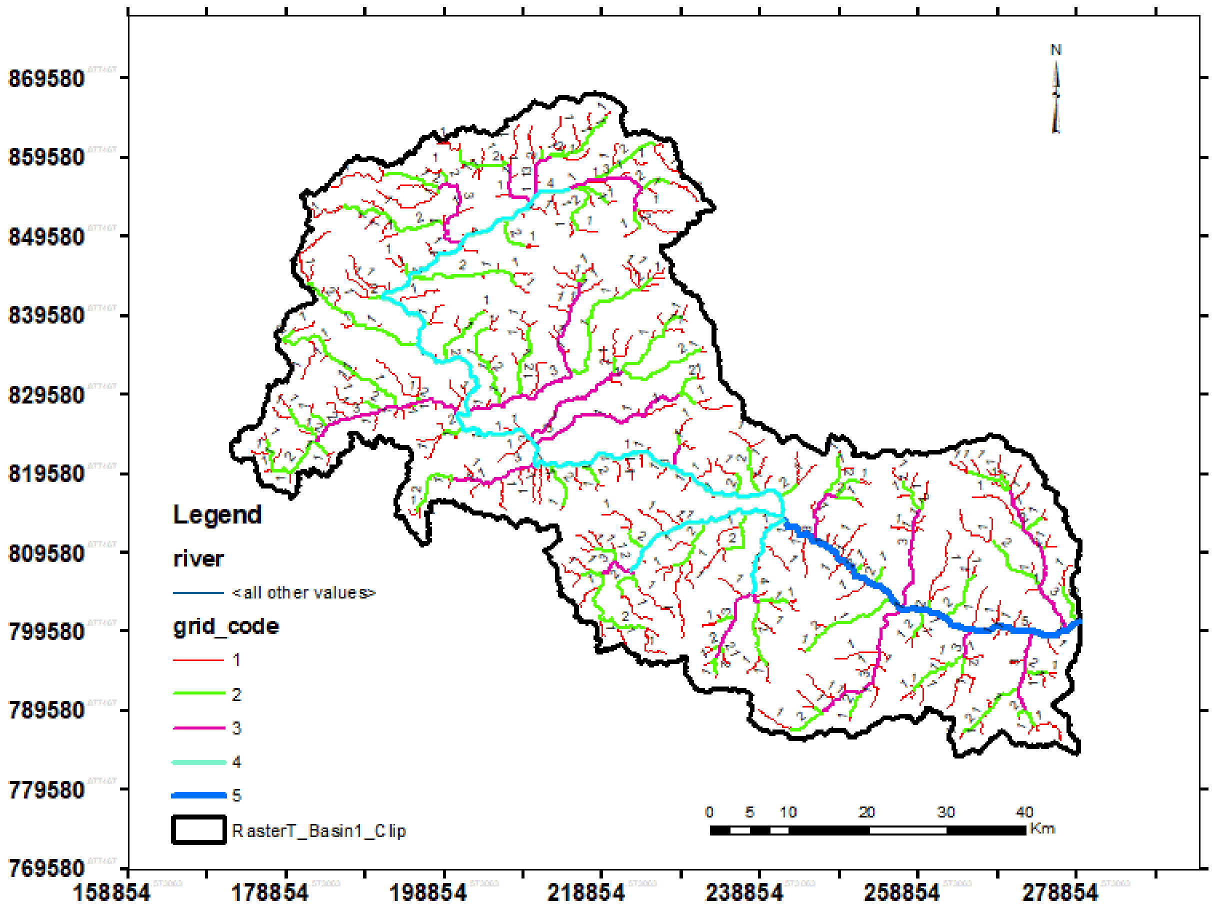

Figure 5: drainage map

Table 2: stream order and number

Number of stream order 1	429
Number of stream order 2	95
Number of stream order 3	21
Number of stream order 4	3
Number of stream order 5	1
Total Number of stream	549

There are many small streams in the area because the landscape is young and the catchment can handle surface drainage well. The number of streams decreases significantly from first to second order, as shown in Figure 6, indicating a significant change in morphology. The large number of small streams increases the amount of water flowing into the lower parts of the basin, leading to a significant water flow.

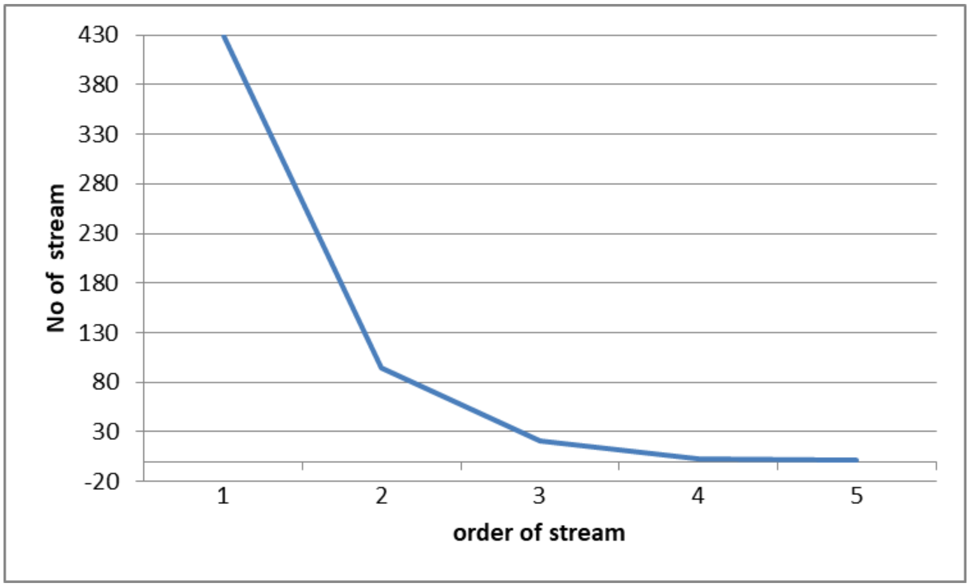

Figure 6: Number of stream versus stream order

Bifurcation Ratio

The bifurcation ratio (Rb) is an important measurement in the fields of geomorphology and hydrology because it offers insights into drainage patterns and basin characteristics. In the case of the Gojeb River sub-basins, the weighted mean bifurcation ratio of 4.7 indicates a relatively high Rb value. The high bifurcation ratio indicates lower sensitivity to runoff and soil rosion. As previously mentioned, a higher bifurcation ratio indicates that the basin is less susceptible to runoff and soil erosion. This is because the high ratio typically .
indicates that the drainage network has a more developed hierarchy with fewer but larger stream segments at higher orders. A higher Rb also means that flow energy is lower, allowing more time for water to infiltrate into the soil and recharge groundwater. This can be beneficial for sustaining groundwater levels and reducing surface runoff. The bifurcation ratio reflects the complexity and development of the stream network. A high Rb value often corresponds to well-developed, stable stream networks that have a more balanced and efficient drainage system. For the Gojeb river subbasin, the bifurcation values are summarised as shown in table 3 below

Table 3: bifurcation ratio

Rb for 1:2	4.5	Average Rb
Rb for 2:3	4.52	4.7
Rb for 3:4	7	
Rb for 4:5	3	

The lower mean Rb value (0.47–3.09) indicates that there is water stress in the drainage basin (Mahala 2020). Otherwise when Rb value gets higher there is no stress because large volume of water absorbed and infiltrate into subsurface.

Stream Lengths

Mean Stream Length (l) is a property that measures the average length of streams within a specific order. It provides insight into the typical size of components in both the drainage network and its contributing basin surfaces. Channel length is determined using ArcGIS software, directly from the stream order map. Generally, as the stream order increases, the mean stream length also increases, indicating that higher-order streams tend to be longer. In basins with steep slopes, streams are typically shorter due to their faster flow and limited time for extension over the landscape. Conversely, basins with smoother, more gradual slopes tend to have longer streams as the flow is less direct and allows for more meandering. Given the medium slope and coarse texture of the basin, it can be inferred that the stream lengths are moderately sized.

For Gojeb river basin length each of stream are expressed in table 4

Table 4: total and mean stream length

Order	Total length	Total no	Average length
1	102.3304	429	0.23
2	31.5514	95	0.33
3	46.1295	21	2.19
4	10.9377	3	3.64
5	0.9895	1	0.9895

2.2 Areal aspects

This metric encompasses the entire area that contributes overland flow to a specific channel segment, including all tributaries of lower order. It takes into account various parameters such as drainage density, drainage texture, stream frequency, form factor, circularity ratio, elongation ratio, and length of overland flow.

Drainage pattern

The most well-known drainage patterns in the world are Dendritic, Parallel, Trellis, Rectangular, and Radial. Dendritic drainage patterns appear similar to the branching of tree roots or veins and occur in areas where the underlying rock has a uniform resistance to erosion. This pattern forms as the stream channels naturally follow the path of least resistance, creating a network that resembles a tree. According to the FIG.5 the drainage pattern in Gojeb river basin is dendritic

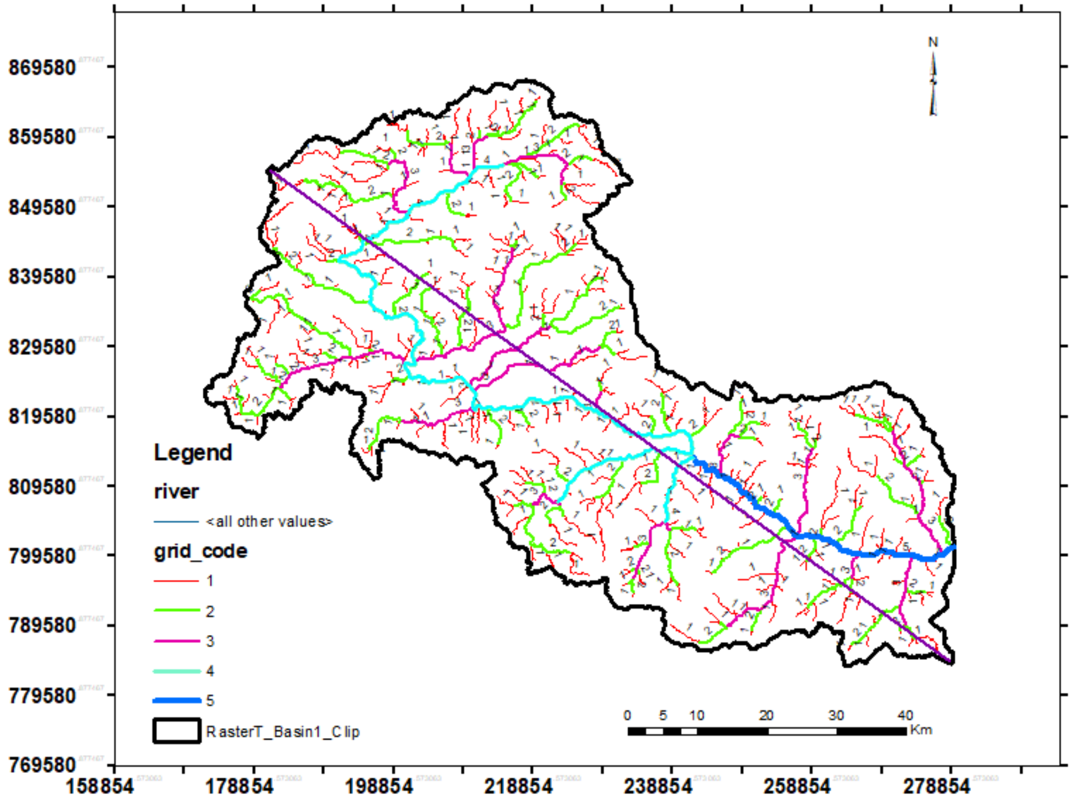

Figure .5: drainage pattern map

Basin area (A)

The basin area is crucial in morphometric analysis because it directly influences the amount of water that a river or stream can potentially generate. Larger basins typically have a higher capacity to collect and store precipitation, which can lead to greater streamflow and river discharge. Additionally, the basin area helps determine other morphometric parameters, such as drainage density, stream order, and basin shape, all of which impact hydrological and erosion processes in the area.Gojeb river basins cover an area of 4405.5Km2

Form factor(Rf)

The form factor (Rf) is a dimensionless ratio that shows the relationship between the basin area (A) and the square of the length of the watershed (L). In general, a form factor value lower than 0.7854 indicates a perfectly circular watershed (Hurton, 1945). Watersheds with higher form factor values are typically circular in shape and experience higher peak flows in shorter periods. Conversely, elongated watersheds with lower form factor values have lower peak flows.For the present study the value of form factor = 0.74 and this indicate that, the basin elongated basin.

Circularity ratio

The circularity ratio is a ratio that compares the area of a watershed to the area of a circle with the same circumference as the watershed's perimeter (Miller, 1953). This ratio falls between 0.2 and 0.8. Lower values indicate a more elongated or irregular watershed shape, while higher values indicate a more circular shape. These variations in circularity ratio can be used to determine the youth, mature, and old stage of the tributary watershed, with low, medium, and high values respectively. Typically, areas with higher ratios are still experiencing significant erosion and sediment transport. For the this research circularity ratio =0.24

Elongation ratio

The elongation ratio is the ratio between the diameter of a circle with the same area as the basin and the maximum length of the basin (Schumn, 1956). A smaller form factor indicates a greater elongation of the basin. A higher form factor means a higher peak flow, but for a shorter duration. Conversely, an elongated basin with a low form factor will have a more gradual peak flow that lasts longer. The elongation ratio can range from 0.4 to 1, with lower values indicating a greater degree of elongation in the watershed. In this study, the elongation ratio is 0.54, indicating that the study area is elongated.

Drainage density

Drainage density is a key component of drainage analysis that offers a more precise way to study and understand landforms. While influenced by factors such as climate, lithology, structures, and relief history of the region, it can indirectly indicate these variables and shed light on landform development. The inverse relationship between drainage density and overland flow length also provides insight into the efficiency of the basin's drainage system.

Based on measurements of drainage density in different geological and climatic conditions, it has been observed that regions with weak and permeable subsoil material, dense vegetative cover, and low relief are more likely to have low drainage density. Conversely, areas with resistant or impermeable subsurface material, sparse vegetation, and mountainous relief tend to have high drainage density. This difference in drainage density leads to a coarse texture for low drainage density and a fine texture for high drainage density (Strahaler, 1964).

In the present study, the drainage density of the basin is calculated to be 0.043, which means that there are 0.043 km of river valleys for every km2 of the basin area. According to Strahler (1957), drainage density values can be classified as coarse (less than 5), moderate (5.0-13.7), fine (13.7-15.3), or very fine (15.3+). Therefore, based on this classification, the low drainage density value in this basin indicates that it is coarse. A drainage basin with a high drainage density is typically characterized by impermeable subsoil material, sparse vegetation cover, high relief, high runoff, and low infiltration capacity. On the other hand, a drainage basin with a low drainage density is characterized by permeable subsoil material, dense vegetation cover, low relief, low runoff, and high infiltration capacity. The Gojeb Drainage basin exhibits all of these characteristics, including highly permeable geological formations, dense vegetation cover, and a medium slope percentage.

Stream frequency

Stream frequency refers to the number of stream segments in a watershed divided by the area of the watershed. The concept of stream frequency was introduced by Horton, who defined it as the number of stream segments per unit area (Horton, 1932). In this study, the stream frequency for the basin is calculated to be 0.12 (number/km2). A higher stream frequency value indicates a greater number of streams in the area. Additionally, watersheds with higher stream frequency tend to have high runoff. A stream frequency value close to 1.0 suggests that the rocks in the area are fresh and/or there is high humidity. Conversely, a value approaching 0.0 indicates weathered rocks and/or drought conditions.

Length of overland flow

Horton defined the length of overland flow (Lo) as the horizontal projection of the flow path, without channel flow, from a point on the drainage divide to a point on the adjacent stream channel. He emphasized that the length of overland flow is a crucial independent variable that impacts both the hydrologic and physiographic development of drainage basins. As the drainage system evolves, L0 is adjusted to a magnitude that corresponds to the scale of the initial drainage basins, and it is approximately equal to half the reciprocal of the drainage density. The shorter the length of overland flow, the faster the surface runoff from the streams. In current study, the average Length of Overland flow is 11.5, indicating a relatively rapid flow.

Drainage Texture

The drainage texture ratio (T) is defined as the total number of stream segments of all orders per perimeter of a given area (Horton, 1945). It is influenced by various natural factors, including climate, rainfall, vegetation, rock and soil type, infiltration capacity, relief, and stage of development. Smith (1939) classified drainage texture into five categories: very coarse (<2), coarse (2-4), moderate (4-6), fine (6-8), and very fine (>8). In this study, the texture ratio of the basin is 1.16, indicating a classification of very coarse.

Constant channel maintenance (C)

Schum (1956) introduced the concept of the constant of stream maintenance, denoted as C, which is calculated by taking the inverse of drainage density. This constant, measured in km per km2, represents the length dimension and increases as the size of the land-form unit increases. In simple terms, C provides information on the amount of watershed surface area needed to sustain one linear km of stream. A higher value of C indicates a lower potential for flooding and suggests that the land-form is undergoing less geomorphological adjustment (Mahala 2020). For the basin in question, the value of C is 22.9 km/km2, meaning that on average, 22.9 km2 of surface area is required in the basin to form one linear km of the stream channel.

2.3. Relief aspects

Relief aspects are important factors in understanding the extent of denotational processes within the catchment. They also serve as indicators of the flow direction of ground and surface water.

Basin relief

Basin relief refers to the variation in height between the farthest point along the water divide line and the outlet of the basin. It can be calculated by subtracting the difference in elevation between the highest point in the basin and the elevation at the basin outlet. To obtain this difference in elevation, one can refer to the contour map. In this case, Basin relief is 2505 Km.

Relief ratio

Schumm (1956) defined the relief ratio as the total watershed relief (2505 km) divided by the maximum length of the watershed. This ratio is used to measure the sharpness of the drainage basin and serves as an indicator of the intensity of processes shaping the watershed. In the case of the Gojeb river basin, the relief ratio is 1.3.

Relative relief

Relative relief refers to the ratio of the maximum relief within a watershed to the perimeterof the same watershed. In the present study, the value of relative relief is 7.08.

Ruggedness number

The concept of the Ruggedness number was introduced by Strahler. This number is obtained by multiplying the basin relief by the drainage density, as mentioned in Strahler's 1965 publication. In essence, the Ruggedness number combines the steepness and length of slopes within the basin. As both relief and drainage density increase, the Ruggedness number in a given basin area tends to be higher. This number is often used to evaluate the structural complexity and erosion potential of landforms. For example, in the Gojeb river basin, the Ruggedness number has been calculated to be 109.

3. CONCLUSIONS

The present study conducted various morphometric analyses of the Gojeb sub-basin in the south western part of Ethiopia using remote sensing and GIS. The purpose of this study is to create a drainage map for the Gojeb river basin. Specifically, to analyze key morphometric characteristics such as basin shape, relief, and drainage network.

The analysis evaluated major parameters in three aspects: linear, areal, and relief. Morphometric analysis plays a crucial role in the area's agricultural activity as it helps control runoff, erosion, and the quality of groundwater by accurately representing basin features. The arrangement of streams in a drainage system, known as the drainage pattern, reflects the hydrogeological characteristics of the underlying rock or soil. By observing the drainage map (fig.5), it was determined that the entire basin has a dendritic drainage pattern. However, a single trellis nature of pattern was observed on third order at the north eastern part of the basin, indicating the presence of a geological structure responsible for this pattern. The basin is characterized by undulating, highly dissected, moderately sloped regions with mostly homogeneous geological materials, as validated by the slope map. The high mean bifurcation ratio of 4.7 indicates hilly, moderately sloped terrain, with less water pressure and a homogeneous geological nature. The drainage density, stream frequency, and drainage texture of the basin are 0.043, 0.1246 (number/km2), and 1.16, respectively. This suggests that the basin has low runoff, a high rate of infiltration, and dense vegetation. The high value of the constant channel maintenance (C) 22.9 km2/km implies that the basin has very low flood potential with young geomorphological adjustment. The shorter length of overland flow, indicated by the value of 11.5, means that the flow is quicker. The basin's form factor, circularity ratio, and elongation ratio have values of 0.74, 0.24, and 0.54, respectively. This indicates that the basin is elongated with low peak flows lasting for a longer duration. Relief aspects are important for understanding the extent of denotational processes within the catchment and serve as indicators of the flow direction of ground and surface water. The values of basin relief, relief ratio, and relative relief are 2505, 1.3, and 7.08, respectively. Overall, the morphometric analysis shows that the basin experiences low rates of runoff and very high rates of infiltration. This hydrogeological situation suggests the presence of geological structures (faults, fractures, porosity) that enable the percolation of water to the groundwater table. Therefore, the use of natural and organic fertilizers is highly recommended to minimize groundwater pollution. Additionally, it is suggested that high-resolution satellite data be utilized to enhance the understanding of basins for efficient planning and management. Based on this study, it can be concluded that GIS is primarily a data-handling technology, while remote sensing is primarily a data-collection technology.

Acknowledgments

The author acknowledges Bonga university, Department of Geology, College of Natural and Computational Sciences and Mr. Mahitot Alemu offering the opportunity.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or non-profit sectors.

Availability of data and materials

The datasets supporting the findings of this thesis process are all presented in the main manuscript**.**

Consent for publication

Not applicable

Competing interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

References

1. Raj R, Maurya DM, Chamyal LS (1999) Tectonic geomorphology of the Mahi river basin, Western India. J GeolSoc India 54:387–398
2. Magesh, Nochyil S., Nainarpandian Chandrasekar, and John Prince Soundranayagam. "Delineation of groundwater potential zones in Theni district, Tamil Nadu, using remote sensing, GIS and MIF techniques." Geoscience frontiers 3.2 (2012): 189-196.
3. Horton, Robert E. "Erosional development of streams and their drainage basins; hydrophysical approach to quantitative morphology." Geological society of America bulletin 56.3 (1945): 275-370.
4. Strahler, Arthur N. "Quantitative/dynamic geomorphology at Columbia 1945-60: a retrospective." Progress in Physical Geography 16.1 (1992): 65-84.
5. Schumm, Stanley Alfred. The disparity between present rates of denudation and orogeny. No. 454-H. US Govt. Print. Off.,, 1963.
6. Morisawa, Marie. "Measurement of drainage-basin outline form." The Journal of Geology 66.5 (1958): 587-591.
7. Scheidegger, ADRIAN E. "The algebra of stream-order numbers." United States Geological Survey Professional Paper 525 (1965): 187-189.
8. Shreve, Ronald L. "Infinite topologically random channel networks." The Journal of Geology 75.2 (1967): 178-186.
9. Gardiner, V., and C. C. Park. "Drainage basin morphometry: review and assessment." Progress in Physical Geography 2.1 (1978): 1-35.
10. Shreedhara, V., K. Shankar, and Muhammed Haji. "A morphometric analysis of wonji drainage basins around central Rift Valley, Ethiopia, using geospatial tools." Int. J. Sci. Res.(IJSR) 9.8 (2020): 787-794.
11. Fenta, Ayele Almaw, et al. "The dynamics of urban expansion and land use/land cover changes using remote sensing and spatial metrics: the case of Mekelle City of northern Ethiopia." International journal of remote sensing 38.14 (2017): 4107-4129.
12. Mekuria, Eyasu Tafese. "Assessment of Morphometric Characteristics of Gojeb watershed, Omo-Gibe Basin, Ethiopia." (2023).
13. Carranza, Emmanuel John M. "Mapping of anomalies in continuous and discrete fields of stream sediment geochemical landscapes." Geochemistry 10.2 (2010): 171.
14. Merot, P., et al. "Using the stream order to model the internal structure and function of the wetlands within a catchment from the headwater to the sea." EGU General Assembly Conference Abstracts. 2009.
15. Delleur, Jacques W. "Ven Te Chow and deterministic hydrology." World Environmental and Water Resources Congress 2014. 2014.
16. Olson, Everett C., and Robert L. Miller. Morphological integration. University of Chicago Press, 1999.
17. Chorley, R. J. "The elevation of the Lower Greensand ridge, south-east England." Geological Magazine 106.3 (1969): 231-248.
18. Asefa, Daniel, and Addis Ababa. "Water use and operation analysis of water resource systems in Omo Gibe river basin." Addis Ababa University (2011).
19. Kelelew, Haftu, Jema Haji, and Abbadi Girmay. "Determinants of smallholder farmers' adaptation strategies against climate change stresses in Raya Azebo District, North-ern Ethiopia: Multivariate analysis."
20. Albaroot, M., et al. "Quantification of morphometric analysis using remote sensing and GIS

techniques in the Qa'Jahran Basin, Thamar Province, Yemen." Int J New Technol Res (IJNTR) 4.8 (2018): 12-22.

21. Joy, Md Ashikur Rahman, et al. "Application of GIS and remote sensing in morphometric analysis of river basin at the south-western part of great Ganges delta, Bangladesh." Hydrology Research 54.6 (2023): 739-755

22. Mahala, A. 2020 The significance of morphometric analysis to understand the hydrological and morphological characteristics in two different morpho-climatic settings. Applied Water Science 10 (1), 1–16. https://doi.org/10.1007/s13201-019-1118-