Morphologic and Engineering Characteristics of Watersheds (A Case Study: East Wasit Watersheds that Feed the Al-Shewicha Trough - Iraq)

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Abstract. The Al-Shewicha Trough represents a real flood hazard to Kut City (capital of Wasit Province, Iraq) as well as to the other cities along the Tigris River downstream Kut Barrage, especially heavy monsoon years. Under the acute lack of water resources around the world, many modern techniques in unconventional innovative water resources management were developed. In this study, ArcGIS was used in the morphologic analysis of six river basins which represent the main sources of feed for the Al-Shewicha Trough. The results show that the high value of the greatest length of a basin 1, 5 and 6 indicate that these watersheds have high value of concentration time (t_c) which delays the peak flow. All basins consisted of very coarse and permeable subsurface strata, and were of coarse texture. Circularity ratio Form factor and elongation ratio shows an elongated shape of all basins with lower peak flow and long duration. Analyses of soil data demonstrate that the soil type that covers a large area is loam soil within the hydrologic soil group type B, which indicates that all basins have low permeability and high runoff. The most predominant land use was bare soil and all basins have a covering of poor vegetation which highlights the basins that are most susceptible to erosion, thus resulting in the generation of higher sedimentation.

Keywords: Watersheds Morphology, Al-Shewicha Trough, Iraq

1. Introduction
The Al-Shewicha Trough is the terminal marshland for several seasonal creeks which transports the excess runoff from watersheds in the mountains that extend to the Islamic Republic of Iran. It is located east of Kut City which is the capital of Wasit Province in Iraq. In rainy years, the quantity of runoff collected in Al-Shewicha Trough poses a real flood hazard to Kut City. The volume of water that collects in this trough sometimes reach very high values, as happened in 2019, where an estimated volume of water (1.8 × 10⁹ cubic meters) with very high sedimentation was deposited (see Figure 1). The Al-Shewicha Trough falls into the Tigris River at the station 35.0 km D/S of Kut barrage, and the result of the high-tide floods carried by the Al-Shewicha Trough posed a real flood threat to the cities that are located along the Tigris River south of Kut City, viz., Sheikh Saad City, Ali Algarbi City and Amara City. The quality of the flood water is very poor, and is not suitable for agricultural uses because it contains high levels of sulfates and dissolved salts, which affects the water quality of the Tigris River in the cities situated south of Kut City, where the Tigris River is the only source of water for them.
Owing to the hydrological importance of the basins and its obvious impact on the safety of Kut City and the water environment in the region, in addition to the absence of research studies on those basins, this requires study and knowledge of the characteristics of morphometric and engineering for basins and their ability to produce the floods and sedimentations. Hydrological processes have a direct relation to weather, topography, soil characteristics and land use of the watershed. The hydrological and physical characteristic description of a watershed constitutes an essential task for hydrology. Delineation of hydrologic basins and determination of their morphometric parameters have been considered as regular geomorphologic tasks [1]. In hydrology, just same as fluid discharging similarity in systems of different sizes is significant, the geomorphology of the basin, or quantitative study of the basin surface form is used to access at measures of geometric similarity among basins, especially among their stream networks [2]. In recent years, the orientation to hydrological study using the geographic information system (GIS) application was increased. The GIS is used as effective assistance which is a means to delineate a watershed from a digital elevation model (DEM), and to deal with available data of soil types and land uses.

Many researchers have studied the physical characteristic of watersheds around the world. These are the core elements for the analysis of any hydrologic process [1, 3-8]. The physical characteristics of watersheds data were used for different purposes. There were some studies which give the relationship between the physical characteristics of watersheds and surface water quality [9,10]. Other studies were introduced to predict sediment quantity and its sources depending on the physical characteristic of watersheds [11].

Splinter et al. 2010 [7], showed that four of five prevalent morphometric variables (relief, drainage density, relief ratio, and ruggedness number) used to depict watershed morphology that differed through ecoregions, while circularity ratio only varied with stream order. All five parameters differed by stream order. Bilewu et al. 2015 [9], reduced the number of morphometric parameters required to run a runoff model without losing any major information to three which are (Fitness Ratio, Ruggedness Number and Watershed Eccentricity). Ding et al. 2015 [12], were the ones who investigated the spatial and seasonal variability of land use impacts on water quality. GIS has been proved to be an effective tool in the delineation of watersheds and stream networks to arrive at morphometric, flood and sediment estimation as well as water quality [6, 5, 8, 13-17].

The aims of this study are to devise some physical characteristics, and then analyzing them in order to reflect the characteristics of the river network area of the basins. In addition, the study aims to devise the soil classification and land use of the basin case study to be the base of hydrodynamic and sediment models in addition to flood mapping.

2. Study Area
The watersheds feeding the Al-Shewicha trough extend from 509374 E to 659374 E, and from 3603825 N to 3803825 N. The watersheds are characterized as plain land, mountains, and hilly regions. The Al-Shewicha trough is a flat area with minimum elevation of +10.0 m from m.s.l. Topographic relief
changes significantly through the drainage basins. The mean descent of all watersheds ranges from an altitude of 1837 m to 10 m in the Al-Shewecha marsh. The area of the catchments is equal 13290 km$^2$, and most of these areas lie inside the boundary of the Islamic Republic of Iran, which is considered as rainy during the winter season (Figure 2).

![Image](image.png)

Figure 2. Location map of study area with stream networks

3. Catchment Area Characteristics.
The whole area of a stream basin whose surface runoff (e.g., due to a storm) drains into the stream in the basin is deemed as a hydrologic unit, and is called the catchment area of the river flowing through it. The characteristics of the drainage net and shape of a drainage basin can be presented as shown in Table 1 [18].

4. Data and Methodology
Shuttle Radar Topographic Mission (SRTM) digital elevation model (DEM) of the study area is a raster depiction of surface terrain elevation in xyz directions. The SRTM DEMs used was with horizontal spatial resolution of 30 m. The study area was projected to regional projection (WGS 1984 UTM Zone 38). The global FAO/UNISCO soil map of the world was utilized as the base data to classify the soil of the study area. The national land cover database NLCD 2011 which was created by multiresolution land characteristics was employed to identify the land cover of watersheds.

The steps for producing the maps which demonstrated the morphometric, soil classification, and land use were prepared using the Arc GIS 9.3 program. To determine the physical characteristics of watersheds which are feeding the Al-Shewecha marsh, the Hydrology tools in spatial analyst of ArcGIS 9.3 should be performed in sequential order to identify the drainage system and classify the land use and soil characteristics of the study area. The Fill function modifies the elevation value to.
Table 1. Streams and Basin Parameters

| Parameter                      | Expression                                      | Reference |
|--------------------------------|--------------------------------------------------|-----------|
| characteristics of streams     |                                                  |           |
| Stream order (U)               | Hierarchical rank                                | [19]      |
| Stream length ($L_u$)          | Length of the stream                             | [20]      |
| Mean stream length ($L_{sm}$)  | $L_{sm} = L_u/N_u$                                | [19]      |
| Stream length ratio ($R_L$)    | $R_L = L_u/L_{u-1}$                              | [20]      |
| Bifurcation ratio ($R_b$)      | $R_b = N_u/N_{u-1}$                              | [21]      |
| Mean bifurcation ratio ($R_{bm}$) | $R_{bm} = \text{average of bifurcation ratios of all order}$ | [22]      |
| Stream frequency (Fs)          | $F_s = N_u/A$                                    | [20]      |
| Drainage density               | $D_d = L_u/A$                                    | [20]      |
| Drainage texture (Dt)          | $D_t = N_u/P$                                    | [23]      |
| Average stream slope           | $\text{Average stream sl} = \text{total fall of the longest water course} / \text{length of the longest water course}$ | [18]      |
| characteristics of basins      |                                                  |           |
| form factor                    | $F_f = W_b / L_p$                                 | [20]      |
| Compactness coefficient        | $C_c = \frac{P_b}{2\sqrt{\pi A}}$                |           |
| elongation ratio ($R_e$)       | $R_e = \frac{2R}{L_b} = 1.128 \sqrt{\frac{A}{L}}$ | [21]      |
| circularity ratio ($R_c$)      | $R_c = \frac{A}{\pi R^2}$                        | [19]      |
| Length of overland flow ($L_g$) | $L_g = \frac{1}{D - 2}$                          | [20]      |
| Relief (R)                     | $R = H - h$                                      | [18]      |
| Relief ratio ($R_r$)           | $R_r = R - L$                                    | [18]      |

eliminate cells with a higher elevation that surround a cell which trapped the water in that cell, and cannot allow it to flow.

Then, the flow direction for a given grid was derived to demonstrate the direction of drainage between the central cell and one of its other neighbors. Flow direction is a necessary component of watershed calculations. Flow accumulation is the number of upslope cells that flow into each cell. By applying threshold value to the result of flow accumulation function, a stream network can be delineated. The stream network of the study area is extracted from a series of Hydrology tools in a spatial analyst. Once created, the stream order can be further analyzed using stream order and stream-to-feature functions. Stream ordering is a method of assigning a numeric order to links in a stream network. This order is a method for identifying and classifying types of streams based on their number of tributaries. There are two methods proposed by Strahler 1957[22] and Shreve 1966[24] for this. In both methods, the most upstream stream segments, or exterior links, are always assigned an order of one. In the Strahler method, stream order increases when streams of the same order intersect. The intersection of two links of different orders will not result in an increase in order but will retain the order of the highest ordered link. The Strahler method is the most common stream ordering method. However, because this method only
increases in order at intersections of the same order, it does not account for all links and can be sensitive to the addition or removal of links.

The Shreve method accounts for all links in the network. As with the Strahler method, all exterior links are assigned an order of one. For all interior links in the Shreve method, however, the orders are additive. Because the orders are additive, the numbers from the Shreve method are sometimes referred to as magnitudes instead of orders. The output of stream extraction technique will create a stream network grid with stream classification based on Strahler (1964) [19]. The Stream Link function allows assigning unique values to each of the links in a raster linear network. This is most useful as it is an input to the Watershed function to quickly create watersheds based on stream junctions. It can also be useful for attaching related attribute information to individual segments of a stream. A raster linear network can be accurately converted to features representing the linear network using the Stream-to-Feature function. The vectorization algorithm is designed primarily for vectorization of raster stream networks or any other raster representing a raster linear network for which directionality is known (Figure 3).

**Figure 3.** Extraction of Stream Networks and Basins for Study Area.
The watershed function uses a raster of flow direction to determine the contributing area. Flow across a surface will always be in the steepest down slope direction. Once the direction of flow out of each cell is known, it is possible to determine which and how many cells flow into any given cell. This information can be used to define watershed boundaries and stream networks. Watersheds delineation needs to identify the pour point. Usually, these locations are mouths of streams or other hydrologic points of interest, such as a gauging station. This will create watersheds for each stream (Figure 4).

Figure 4. Digital Elevation Model and Streams for the Six Watersheds Feeding Shewicha Trough.
Land use and soil characteristics affect both the volume and timing of runoff. During a rainstorm, flow from an impervious, steeply sloped, and smooth surface, makes a little retardation and no loss to the flow. In comparison, flow along a pervious grassy hill of the same size will produce retardation and significant loss to the flow due to infiltration. Land use classes and soil group type are in different categories which may be left unchanged, or we can reclassify the grid to reduce the number of land use classes to make the task easier. By opening the attribute table of the study of land use, many classes can be noticed. Adequate reclassification of the study area land use and the soil type need to be applied. The soil classification for the six watersheds feeding Al-Shewicha Trough, according to the global FAO/UNESCO soil map of the world is presented in Figure 5.

![Soil Classification Map](image)

**Figure 5.** Soil Classification Map for the Six Watersheds Feeding Shewicha Trough.

Soils are classified by the Natural Resource Conservation Service into four Hydrologic Soil Groups (HSG) based on the soil's runoff potential. The four HSGs are A, B, C and D (see Table 2). Soil
information of the study area obtained is used for making appropriate hydrological soil classifications A, B, C and D.

| Type of Group | Description of Soil                                                                 |
|---------------|--------------------------------------------------------------------------------------|
| Group A       | Soils in this group have low runoff potential and high infiltration rate when thoroughly wet. Water is transmitted freely through the soil. |
| Group B       | Soils in this group have moderately low runoff potential and moderate infiltration rate when thoroughly wet. Water transmission through the soil is moderate. |
| Group C       | Soils in this group have moderately high runoff potential and low infiltration rate, when thoroughly wet. Water transmission is somewhat restricted through the soil. |
| Group D       | Soils in this group have high runoff potential and low very low infiltration rate, when thoroughly wet. Water transmission is restricted through the soil. |

Land use represents the surface conditions in a drainage basin and is related to the degree of cover. Land use is an important characteristic of the runoff process which affects erosion and infiltration. In the present study, the Land use/Land cover map of the study area was using the satellite imageries (GlobGover-2009) in GIS which was used to classify the type of land use for these basins. Land use / Land cover map of the study area is shown in Figure 6.

**Figure 6.** Land Cover Map for the Six Watersheds Feeding Shewicha Trough.
5. Results and Discussion

Stream Characteristics

The area of the watershed is the most important watershed characteristic for hydrologic analysis. It reflects the volume of water that can be generated from a rainfall. Thus, the drainage area is required as input to models ranging from simple linear prediction equations to complex computer models. Once the watershed has been delineated, its area can be determined with the help of GIS. According to the spatial analyst, there are six basins feeding Shewicha Trough with a total area of 13290 km2 (see Table 1). Figure 7 shows the percentage of each basin area. It is obvious that basin 1 represents 27.26%, basin 6 represents 23.37%, and basin 2 represents 21.95% of the total area of all basins.

![Percentage area for the Six Watersheds Feeding Shewicha Trough](image)

The length of the watershed is the distance traveled across the surface. This length is usually used in computing a time parameter which is a measure of the travel time of water through a watershed. The watershed length is therefore measured along the principal flow path from the watershed outlet to the basin boundary. Since the channel does not extend up to the basin boundary, it is necessary to extend a line from the end of the channel to the basin boundary.

The streams of the six basins were identified according to the Strahler 1964 system of stream ordering. The numbers of streams gradually decrease as the streams order increase. The total numbers of streams in each order for all basins are shown in Table 3. Depending on Strahler, 1964, basins 1, 2, 5 and 6 have been designated as fifth order basins, while basins 3 and 4 have been designated as fourth order basins. The first order streams for basins 1, 2 and 6 having high number of streams refer to terrain complexity, compact nature of the bed and undergoing erosion. Basins 3, 4 and 5, having less numbers of streams which reflect the topography of these basins. As demonstrated in Table 2, the number of streams varied inversely with the stream order. Figure 8 gives the percentage of stream segment in each order for all six basins. These are 77.78%, 75.33%, 77.14%, 75.24%, 74.21% and 76.38% of stream segment in the 1st order for basins 1, 2, 3, 4, 5 and 6, respectively. The high percentage value of 1st order streams refer to possibility of sudden flash floods due to rainfall storm in the Shewicha Trough that may occur.
Horton, 1945 [20], states that the geometrical similarity is maintained in basins of increasing order. As presented in Table 3, the maximum total length of stream segments was in 1st order streams, and decreases with increases in the stream order.

Mean stream length is total stream length of order \( u \) divided by the number of stream segment in order (see Table 1). The Mean stream length is presented in Table 3. The mean value of length of the streams for six basins is given in Figure 9. It is related to the size of the drainage network along with its associated surface.

The stream ratio represents the ratio between the length of streams in given order to the total length of streams in next order [25]. For the six basins east of Wasit Province, Iraq, the stream ratios range between 0.753 and 10.227 (see Table 3).

The bifurcation ratios for all watersheds are shown in Table 3. It is apparent from this table that the bifurcation ratio varies from 3.0 to 5.5 for all basins with means of 4.18, 3.88, 3.83, 4.32, 3.68 and 4.03 for basins 1, 2, 3, 4, 5 and 6, respectively. In accordance with the present results, a previous study demonstrates that the geological structure has a negligible influence on drainage network for all basins.
It is interesting to note that in all six basins in this study, the height values of bifurcation ratio indicate height structural complexity and low permeability of the terrain [19].

| Watershed no. | Parameter                        | Stream Order |
|---------------|----------------------------------|--------------|
|               | No. of Streams                   | I  | II | III | IV | V  |
| 1             | Stream Length, $L_u$ (m)         | 840763 | 386250 | 271713 | 54524 | 116067 |
|               | Mean Stream Length, $L_{sm}$ (m) | 2793.2 | 5852.3 | 18114.2 | 13631.0 | 116067.0 |
|               | Stream Ratio, $R_s$              | -  | 2.095 | 3.095 | 0.753 | 8.515 |
|               | Bifurcation Ratio, $R_b$         | -  | 4.56  | 4.40  | 3.75  | 4.00  |
|               | Mean Bifurcation Ratio, $R_{bm}$ | -  | 4.18  |       |       |       |
| 2             | No. of Streams                   | 226 | 54  | 15  | 4   | 1   |
|               | Stream Length, $L_u$ (m)         | 650848 | 300439 | 195672 | 45741 | 116944 |
|               | Mean Stream Length, $L_{sm}$ (m) | 2879.9 | 5563.7 | 13044.8 | 11435.3 | 116944.0 |
|               | Stream Ratio, $R_s$              | -  | 1.932 | 2.345 | 0.877 | 10.227 |
|               | Bifurcation Ratio, $R_b$         | -  | 4.19  | 3.60  | 3.75  | 4.00  |
|               | Mean Bifurcation Ratio, $R_{bm}$ | -  | 3.88  |       |       |       |
| 3             | No. of Streams                   | 54  | 12  | 3   | 1   | -   |
|               | Stream Length, $L_u$ (m)         | 195570 | 111829 | 42460 | 49338 | -   |
|               | Mean Stream Length, $L_{sm}$ (m) | 3621.7 | 9319.1 | 14153.3 | 49338.0 | -   |
|               | Stream Ratio, $R_s$              | -  | 2.573 | 1.519 | 3.486 | -   |
|               | Bifurcation Ratio, $R_b$         | -  | 4.50  | 4.00  | 3.00  | -   |
|               | Mean Bifurcation Ratio, $R_{bm}$ | -  | 3.83  |       |       |       |
| 4             | No. of Streams                   | 79  | 20  | 5   | 1   | -   |
|               | Stream Length, $L_u$ (m)         | 261224 | 104345 | 127835 | 63184 | -   |
|               | Mean Stream Length, $L_{sm}$ (m) | 3306.6 | 5217.3 | 25567.0 | 63184.0 | -   |
|               | Stream Ratio, $R_s$              | -  | 1.578 | 4.900 | 2.471 | -   |
|               | Bifurcation Ratio, $R_b$         | -  | 3.95  | 4.00  | 5.00  | -   |
|               | Mean Bifurcation Ratio, $R_{bm}$ | -  | 4.32  |       |       |       |
| 5             | No. of Streams                   | 141 | 35  | 11  | 2   | 1   |
|               | Stream Length, $L_u$ (m)         | 374267 | 143484 | 65782 | 128154 | 63617 |
|               | Mean Stream Length, $L_{sm}$ (m) | 2654.4 | 4099.5 | 5980.2 | 64077.0 | 63617.0 |
|               | Stream Ratio, $R_s$              | -  | 1.544 | 1.459 | 10.715 | 0.993 |
|               | Bifurcation Ratio, $R_b$         | -  | 4.03  | 3.18  | 5.50  | 2.00  |
|               | Mean Bifurcation Ratio, $R_{bm}$ | -  | 3.68  |       |       |       |
Table 3. Continue

| Watershed no. | Parameter                          | Stream Order |
|---------------|-----------------------------------|--------------|
|               | No. of Streams                     | I   | II  | III | IV  | V   |
| 6             | 249                               | 59  | 14  | 3   | 1   |
|               | Stream Length, \(L_u\) (m)        | 789192 | 416708 | 180582 | 51316 | 106834 |
|               | Mean Stream Length, \(L_{\text{m}}\) (m) | 3169.4 | 7062.8 | 12898.7 | 17105.3 | 106834.0 |
|               | Stream Ratio, \(R_s\)             | -   | 2.228 | 1.826 | 1.326 | 6.246 |
|               | Bifurcation Ratio, \(R_b\)        | -   | 4.22 | 4.21 | 4.67 | 3.00 |
|               | Mean Bifurcation Ratio, \(R_{b\text{m}}\) | -   | -   | -   | -   | 4.03 |

**Basin Characteristics**

The shape of the basin affects the stream flow and peak flow hydrographs. There are important parameters that can be used to describe the shape of a basin, such as geometry characteristics, relief ratio, elongation ratio, drainage density, stream frequency, circulatory ratio, drainage texture, and form factor. The basin characteristics were calculated and are presented in Table 4.

The length of the basin, which represents the greatest length from the dividing line to the basin outlet [27], was determined for each basin. The longest (Thalweg) basins 1, 2, 3, 4, 5 and 6 are 113.317, 104.554, 84.437, 92.337, 111.347 and 110.742 km, respectively. The high value of longest length of basins 1, 5 and 6 indicators are that these watersheds have high value of concentration time \(t_c\) and delay of peak flow.

Relief, which represent the difference between the highest and lowest points of a basin [28]. Relief ratio, which is defined as the ratio of relief to the longest horizontal distance parallel to the main drainage line. Interestingly, the high value of relief for basin 1 indicates the high runoff condition which causes the flash flood hazard for the areas lying downstream these watersheds, represented by the Shewicha Trough. Also, the high values of relief ratio that show quick depletion of water and cause large peaked and steep recession hydrographs, the analysis showed that basins 1, 2 and 5 have high value of relief ratio which reflects the high gradient of these basins as shown in Table 4. The basins 2, 3, 4, 5 and 6 were moderate to relief. The next second theme deals with the basins’ characteristics-related streams with basins’ dimensions, such as drainage density, stream frequency and stream texture.

The ratio of total stream length to total area of stream is called (drainage density). The drainage density is the measure of the closeness of channels spacing of a drainage network, and therefore, gives a quantitative scale of the average length of stream channel for the entire basin [19,20]. High drainage density is due to impermeable subsoil material, sparse vegetation and high relief. Low drainage density leads to highly resistant, dense vegetated cover, low relief, and coarse drainage texture.

The drainage density was calculated for all basins in the study area, as shown in Table 4. The drainage density for all basins was less than 2, according to (Smith 1950) [23], indicating low drainage density which means very coarse and permeable subsurface strata.

Three broad themes emerged from the analysis of basin characteristics. First, the characteristics related to basins dimensions; second, the characteristics related between streams and basin dimensions; and third, the characteristics related to basins shapes.

The Stream frequency (Drainage Frequency) is defined as the total number of stream segments within the area of a basin [20]. For basins in the study area, they are ranged from 0.05 to 0.105. The stream frequency indicates that the soil in the study area is permeable. According to Smith, 1950 [20], all basins in the study area can be classified as of coarse texture. With low value of stream frequency...
and drainage density, the surface runoff is slowly removed from the basins, making it highly susceptible to flooding, gully erosion and landslides. The final theme is concerned with basins shapes. So, form factor, circulatory ratio, and elongation ratio will be discussed here.

Form factor is the dimensionless ratio of basin area to the square of basin length [25]. According to Horton (1932) [25] all basins feeding Shewicha Trough can be classified as elongated basins with lower peak flows of longer duration than the average because of the form factor of these basins which range from 0.13 to 0.29, which are less than 0.78 (see Table 4 and Figure 3).

Circulatory ratio is defined as the ratio of the area of the basin to the area of the circle having the same circumference as the basin perimeter [29]. The circulatory ratio for all basins feeding Shewicha Trough is less than 0.5, thereby indicating an elongated shape.

Elongation ratio is defined as the ratio of a circle’s diameter of the same area as the basin to the maximum basin length [21]. The current study found that the elongation ratio for basin 1 was 0.6 while it ranges from 0.36 to 0.58 for the rest of the basins. According to Schumm, 1956 [21], basins 1, 2 and 6 were elongated, and 3, 4 and 5 were more elongated, which indicate a lower peak flow and longer duration. Elongation ratio for basin 3 is the lowest value, which indicates a high relief and strong slope.

Drainage Texture is the total number of stream segments of all orders per perimeter of that basin [20]. In the present study, the drainage texture ranges from 0.314 to 1.05.

According to the classification of drainage texture, drainage texture for all basins less than 2 come under the category of very coarse drainage texture [23].

Table 4. Basin Characteristics for the Six Watersheds Feeding Shewicha Trough

| Parameters                  | Watershed No.       |
|-----------------------------|---------------------|
|                             | 1  | 2  | 3  | 4  | 5  | 6  |
| Basin Area (Km²)            | 3671 | 2917 | 716 | 1070 | 1810 | 3106 |
| Basin Perimeter (Km)        | 367 | 330 | 223 | 258 | 405 | 349 |
| Basin Length (Km)           | 113.317 | 104.554 | 84.437 | 92.337 | 111.347 | 110.742 |
| Basin Width (Km)            | 32395.85 | 27899.46 | 8479.69 | 11587.99 | 16255.49 | 28047.17 |
| Total relief (R), (m)       | 1827 | 1689 | 996 | 1034 | 1689 | 906 |
| Relief ratio (Rh)           | 0.0161 | 0.0162 | 0.0118 | 0.0112 | 0.0152 | 0.0082 |
| Elongation ratio (Re)       | 0.60 | 0.58 | 0.36 | 0.40 | 0.43 | 0.57 |
| Drainage density (Dd)       | 0.45 | 0.45 | 0.56 | 0.52 | 0.43 | 0.50 |
| Stream frequency (Fs)       | 0.105 | 0.103 | 0.098 | 0.098 | 0.050 | 0.105 |
| Drainage Texture (Dt)       | 1.05 | 0.909 | 0.314 | 0.407 | 0.47 | 0.934 |
| Circularity ratio (Rc)      | 0.34 | 0.34 | 0.18 | 0.20 | 0.14 | 0.32 |
| Form factor (Ff)            | 0.29 | 0.27 | 0.10 | 0.13 | 0.15 | 0.25 |
Hydrological Soil Group (HSG)

FAO-UNESCO Soil Map, at the scale of 1:500,000, was used to determine the soil type and soil hydrological group. This soil map was scanned and georeferenced with respect to study area with the help of ArcGIS software. The vector data layer of the soil map was thus created. The type of soil has a significant impact on the characteristics of the basin in terms of floods and sediments. The runoff was significantly related to soil texture. The rate of water entering the soil is higher than that of fine textured soils, and so, generation of runoff is lower [30]. Analysis of data were carried out showing that the soil is of fine texture such as loam, clay loam, and clay for all areas of the six basins. The type of loam soil was covering the larger part of the basins as shown in Table 5. Soil texture of the basins fall within groups B and D. Khalighi Sigaroodi, 2004 [31] calculated the infiltration rate for different groups of soils. The infiltration of groups B and D ranged from 0 to 1.25 mm/hr, and 3.81 to 7.62 mm/hr, respectively, which indicates that all basins were divided into groups: first, we have moderately low runoff potential and moderate infiltration; and secondly, we have high runoff potential and very low infiltration rate. Table 5 presents the type of soil for basins according to symbols of the soil map as shown in Figure 4.

Table 5. Soil Symbols Description for the Six Watersheds Feeding Al- Shewicha Trough

| Item | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|------|---|---|---|---|---|---|---|---|
| Symbols | I-Re-Xk-c | I-Re-Yk-2c | Je40-2/3a | Re33-3bc | Yk34-b | Zo22-2/3a | Zo7-2/3a | WAT |
| Soil Type | Loam | Loam | Loam | Loam | Loam | Clay-Loam | Clay-Loam | Water |

Land use / land cover

ArcGIS was used to determine the type of land cover, multitype of land cover covering these watersheds. Different land use and land cover categories were interpreted from satellite image (GlobGover-2009). Land use and land cover studies are important in management and development of water resources, and this directly affects the hydrological processes of river watersheds [32, 33]. Generally, four types of land use covered those basins which had two items of high percentages, i.e., bare soil and open space, which includes lawns and grass cover under poor condition.

The most predominant land use was bare soil covering 64.70%, 65.74%, 90.4%, 77.5%, 31.0% and 67.9% of total area for basins 1, 2, 3, 4, 5 and 6, respectively, as shown in Table 6. These indicate that all basins have cover of poor vegetation. Most of the erosion comes from the bare land, then these basins has been most susceptible to erosion, and so, leads to generation of higher sedimentation [34], as shown in the Figure 1 of the floods of 2019.

6. Conclusions.

The present study was designed to determine the effectiveness of a spatial analyst tool for calculation and analysis of many morphometric and engineering parameters.

The morphometric analysis showed that there were six basins feeding the Shewicha Trough with a total area of 13290 km², and that basin 1 was the largest of the basins with a percentage of 27.26% of the total area of all the basins. The basins feeding Shewicha Trough are well drained with stream order ranging from 1 to 5 for basins 1, 2, 5 and 6, and from 1 to 4 for basins 3 and 4. The first order streams for basin 1, 2 and 6 were of complex terrain, compact nature of the bed, and undergoing erosion due to having a high number of first order stream.

The total length of the stream segments are maximum in the first order streams for all basins. Basin 1 has a high percentage value of 1st order stream which refers to the possibility of a sudden flash flood.
The stream ratio ranges from 0.753 to 10.227, and the mean bifurcation ratio varies from 3.68 to 4.32. The drainage networks of all basins exhibit the dendritic to subdendritic drainage pattern, and the contrast in ratio of stream length may be because of the changes in surface slope.

The high value of the greatest length of basins 1, 5 and 6 indicate that these watersheds have high value of $t_c$ and delay of peak flow. The high value of relief ratio for basins 1, 2 and 5 reflect the high gradient of these basins. From the drainage density, all basins were very coarse and had permeable subsurface strata. The stream frequency for all basins in the study area are ranged from 0.05 to 0.105, and that can be classified as coarse texture. Circularity ratio, form factor, and elongation ratio show an elongated shape of all basins with lower peak flow and long duration. Basin 1 is an elongated basin with a high elongation ratio (0.6). The elongation ratio for basin 3 is of the lowest value which indicates high relief and strong slope. Drainage textures for all basins were under the category of very coarse drainage texture.

The engineering parameters include all parameters related to the runoff and sediment production of basins. Analysis of soil data that were carried out showed that the soil was of fine texture, such as loam and clay loam, for all areas of six basins, and the soil type that gave coverage to a large area are loam soil within hydrologic soil group, type B, that indicates all basins have low permeability and high runoff.

The most predominant land use was bare soil, and all basins had a coverage of poor vegetation that shows the basins most susceptible to erosion, and so, generation of higher sedimentation.

From this study, it can be concluded that the effectiveness of the spatial analyst tool to delineate a watershed from a digital elevation model DEM, FAO-UNESCO Soil Map, and land use from satellite imagery (GlobGover-2009), prove to be competent tools in morphometric analysis and classification of soil type and land cover.

| Table 6. Land Use Description for the Six Watersheds Feeding Shewicha Trough |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Type of Land Use         | Symbols                  | % Area of land use        |
|                         |                          | Basin 1 | Basin 2 | Basin 3 | Basin 4 | Basin 5 | Basin 6 |
| Cultivated land         | 1                        | 0.20    | 0.16    | ---     | ---     | 1.1     | 0.16    |
| Wood and forest land    | 2                        | 7.03    | 7.73    | 0.55    | 1.95    | 29.7    | 1.8     |
| Herbaceous -grass -weeds| 5                        | 0.02    | 0.004   | ---     | ---     | ---     | ---     |
| Pasture ,grassland      | 6                        | 2.08    | 2.04    | 1.25    | 2.85    | 4.2     | 8.64    |
| Bare soil               | 8                        | 64.70   | 65.74   | 90.4    | 77.5    | 31.0    | 67.9    |
| Open space              | 11                       | 25.97   | 24.33   | 7.8     | 17.7    | 34.0    | 21.5    |
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