Morphometric Analysis of Al-Chabab River Basin East of Iraq Using Remote Sensing and GIS Techniques

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Abstract: ***The aim of this study is to reveal the capability of remote sensing techniques and geographic information system (GIS) in analyzing the morphometric properties. The digital elevation model (DEM) was used to draw the drainage pattern of the studied area. The drainage pattern was dendritic of five orders and the relation between orders of streams and the numbers of streams was inversely. The morphometric property shows the faraway from circular shape and the closeness from rectangular shape of Al chabab River Basin which means the danger of floods is small. The basin texture of Al chabab River Basin is (4.04 valley / Km) and that regarded as intermediate basin texture.***

Keywords: Al Chabab River Basin, Morphometric Analysis, Remote sensing, GIS, DEM

1. Introduction

Remote sensing techniques and geographic information system (GIS) techniques regarded as a one of the strongest modern techniques in extracting the morphometric properties throughout the capability in determining the shapes, dimensions, and gradients of the earth surface [1]. The studies of morphometric properties represent one of the modern directions to study the basins. The morphometric properties are directly related to the natural factors such as water resources for the basins [2]. The morphometric studies help in determining the shape of basins and the earth appearances that developed according to the shape of the basin so that the river drainage basin is the essential unit to make the quantified researches [3]. The geographic and geomorphic characteristics of a drainage basin are important for hydrological investigations involving the assessment of groundwater potential, watershed management and environmental assessment [4]. The morphodynamic evaluation of drainage data provides a quantitative explanation of basin geometry used to reveal the geological and geomorphic history of each drainage basin. This necessitates the analysis of various drainage parameters such as ordering of various streams, measurement of drainage area and perimeter, length of drainage channels, drainage density (Dd), stream frequency (Fs), bifurcation ratio (Rb), texture ratio (T_R), Lemniscate Factor (K) and Channel Maintenance Constant (C) to predict the approximate behavior of the watersheds during periods of heavy rainfall [5].

The present study area is drained for a variety of agricultural fields, industrial purposes and also major source for the water supply to Marshes and groundwater.

2. Describing Studied Area

The studied area is a basin contains a river named Al chabab River Basin. The basin rises from the Iranian lands and flow in the direction of Iraqi lands and pours in Tigris River. The basin located between latitudes (32°30', 32°35') and longitudes (46°55', 46°10') as shown in figure (1).

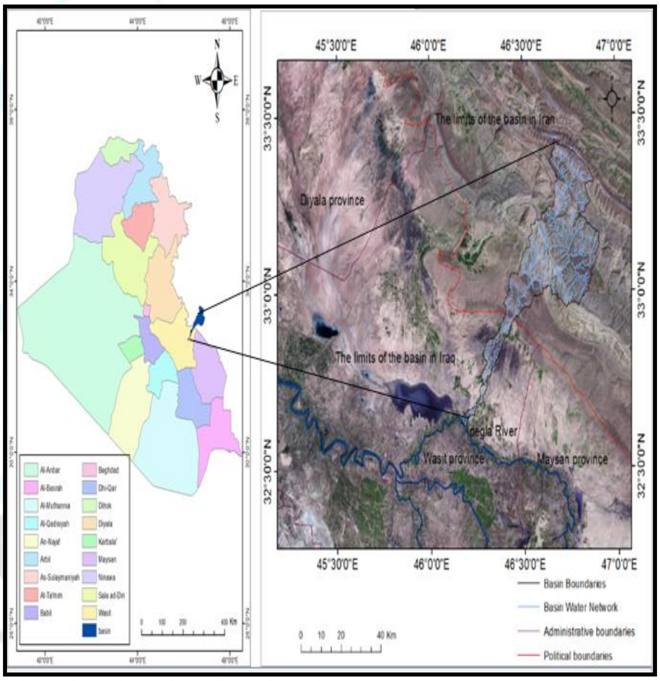

Figure 1: Location of studies area

3. Geology of Basin

The geology of the study area indicates various litho units dating from Oligocene to Recent. The studied area is mostly dominated by dolomite, limestone, sandstone, silt, red and gray marls, gypsum, anhydrite and recent alluvial.

The formations cropping out in the study area are, Euphrates formation, Fatha formation, Injana formation, and Mukdadiya formation [6].

4. Data & Software Used

1- Digital Elevation Model (DEM) of (30 m) resolution.
2- Satellite Image for the Region.
3- ArcGIS software (10.2.2).

5. Extraction of Basin Boundaries

It is needed to extract a DEM cover the basin to use it in drawing the drainage pattern. Firstly, a DEM were prepared and a polygon cover the basin were sketched to use it as a mask as shown in figure (2).

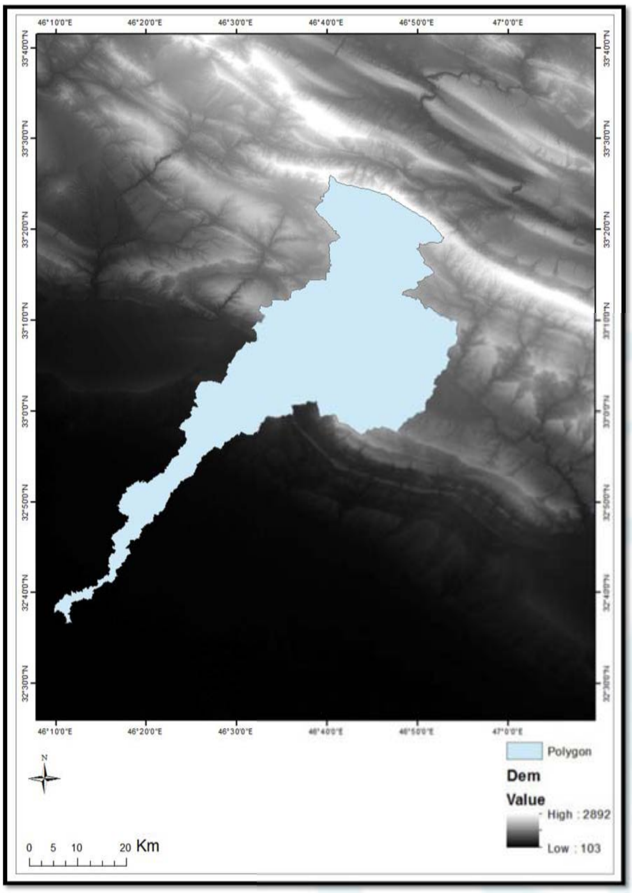

Figure 2: DEM & a polygon represent the basin.

The polygon and the DEM were used as an input for the tool Extract by Mask in ArcGIS software. The result of extraction is illustrated in figure (3).

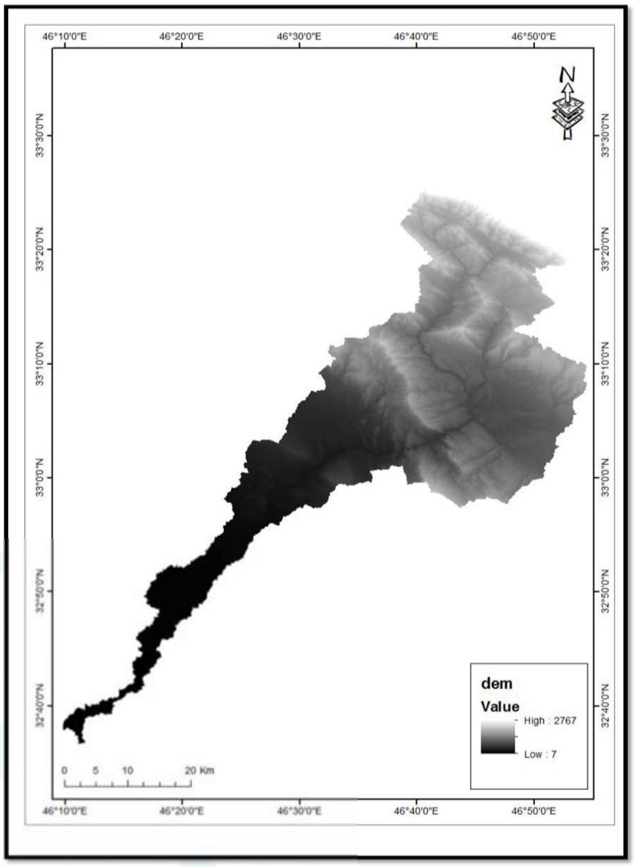

Figure 3: DEM for studied basin.

6. Morphometric properties of the basin

Morphometric properties defined as the geometrical properties of the basin which include the area and the distances related to the basin and its tributaries. These measurements regarded as essential variables for the morphometric relations.

7.1 Dimensions of studied basin

Basin perimeter denoted by (P), it is measured in (Km). It is regarded as one of the essential morphometric variables because it is related to many morphometric properties [7]. The perimeter of the basin can be found by using Spatial Analysis tool in ArcGIS software and depending on DEM, so it is found that the perimeter of the basin is 302.67 Km.

The area of the basin is measured in square kilometers and it is denoted by (A). The area of the basin is 1467.41 Km^2.

Also the width can be measured by determining the maximum width of the basin and compared it with maximum length of drainages basins. It is also can be measured using equation (1) [8].

$$\mathbf{Bw} = \frac{A(Km^2)}{L(Km)} \quad (1)$$

Where:
Bw: width of the basin.
A: area of the basin.
L: length of the basin.

By applying equation (1) it is found that the width of studied basin is 14.25 Km.

The length of the basin denoted by (L) and it is measured in (Km). It can be calculated by using the morphometric relation (equation (2)) [9].

$$L = \frac{A(Km^2)}{Bw(Km)} \quad (2)$$

Where:
L: length of the basin.
A: area of the basin.
Bw: width of the basin.
By applying equation (2) it is found that the length of the basin is 103 Km. Table 1 shows all previous parameters.

Table 1: All dimensions of studied basin.

Basin	Perimeter (Km)	Area (Km^2)	Length (Km)	Width (Km)
Al chabab	302.67	1467.41	103	14.25

6.2 Form factor Ratio

Quantitative expression of drainage basin outline form was made by [10] through a form factor ratio (F) and it's measured by dividing the area of the basin by square of basin length as in equation (3) [10].

$$F = \frac{A(Km^2)}{L^2(Km)} \quad (3)$$

Where:
F: form factor (dimensionless).
A: area of the basin.
L: length of the basin.

It is clear that the form factor is related to the length and area of the basin and that imply the format range between basin parts and regularity of its shape. The high value of the form factor reflect the closeness of basin shape from square or nearly spherical shape which mean quickly of transforming rainfall to floods, while low value of form factor closeness of basin shape from triangle shape. The form factor of Al chabab river basin is (0.14) which imply the expansion of the basin in source and tight in estuary which poses increasing the danger of floods.

6.3 Basin circularity (Circularity ratio)

Defined a dimensionless circularity ratio (Rc) and it's measured by dividing the area of the basin by area of circle has the same circumference of the basin as in equation (4) [11].

$$Rc = \frac{4\pi A}{P^2} \quad (4)$$

Where:
Rc: the Circularity ratio.
A: the area of the basin.
P: the circumference of the basin.

The closeness of the circularity ratio from (1) mean the shape of the basin nearly circular and vice versa [12]. The circularity ratio of the basin is (0.201) which is small ratio and that reflect the estrangement of the basin form the circular shape.

6.4 Elongation ratio

Used an elongation ratio (E) and it's measured by dividing a diameter of circle its area equal to area of the basin by maximum basin length. If the ratio is less than 1 the basin shape is close to the rectangular shape, while larger than 1 ratio indicate to estrangement from rectangular shape and closeness from circular shape. The elongation ratio represented by equation (5) [13].

$$E = 2\frac{\sqrt{\frac{A}{\pi}}}{L} \quad (5)$$

Where:
E: Elongation ratio.
A: area of the basin.
L: Maximum basin length.

The elongation ratio of the basin is (0.42) which indicate the elongation of the basin and that compatible with form and circular factors.

6.5 Lemniscate Factor

Lemniscate Factor is denoted by (K) and it is measured by dividing the square of basin length by 4 times the area of the basin as in equation (6) [14].

$$K = \frac{L^2}{4A} \quad (6)$$

Where:
K: lemniscate factor.
L: Maximum basin length.
A: Area of the basin.

Lemniscate factor indicate to the similarity between the shape of the basin and pear shape, because most of the basins tend to have pear-shaped rather than the completely circular shape [6]. The high values of this factor indicate the increasing in the elongation of the basin, while the low values indicate to the flattening of the basin which cause increasing in length and numbers of low order streams. Lemniscate factor of the basin was (1.8) and that mean the basin is closest to the elongation.

$$C = \frac{P}{2\sqrt{M\pi}}$$

6.6 Compactness factor

It is another factor to emphasizing the estrangement of the basin from circular shape. As this factor estrangement from 1 the basin will be of more elongation [15]. The compactness factor is denoted by (C) and can be measured by equation (7).

$$C = \frac{P}{2\sqrt{M\pi}} \quad (7)$$

Where:
C: compactness factor.
P: perimeter of the basin.
M: circumference of a circle has the same area of the basin.
The compactness factor of the basin is (2.23) and this value indicates to closeness of the basin shape from the elongation. All previous factors of the basin are summarized in table 2.

Table 2: Morphometric factors of studied basin

Form factor	Circular factor	Elongation ratio	Lemniscate Factor	Compactness factor
0.14	0.201	0.42	1.8	2.23

8. Morphometric properties of water net

It is the properties of a set of tributaries and valleys that comprise drainage basin.

7.1 Drawing the drainage pattern

Drainage pattern can be drawn from digital elevation model (DEM) and by using ArcMap software as in figure (4) which illustrates the main steps for drawing drainage pattern [16].

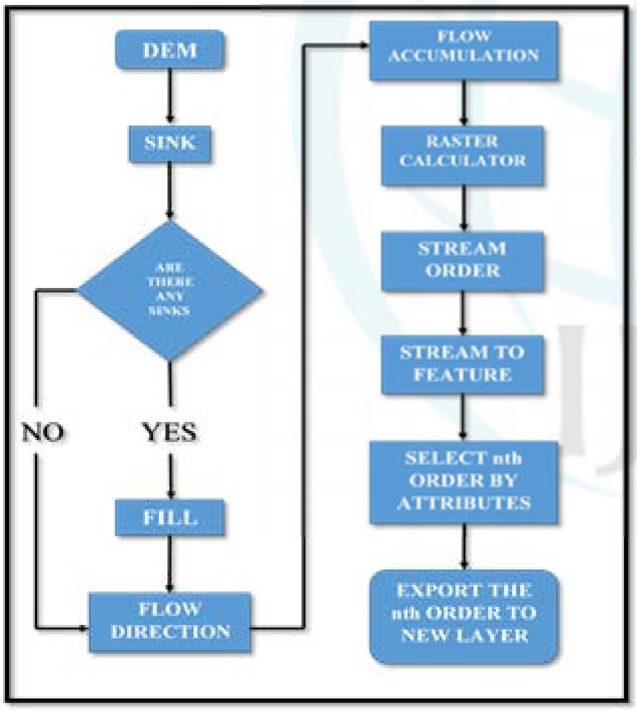

Figure 4: The main steps for drawing drainage pattern

In ArcMap software the hydrology tools were used to model the flow of water across a surface. When modeling the flow of water, we may want to know where the water came from and where it is going. After drawing the drainage pattern of the studied basin depending on Strahler method, it is observed that the basin has a dendritic drainage pattern of five orders as shown in figure (5).

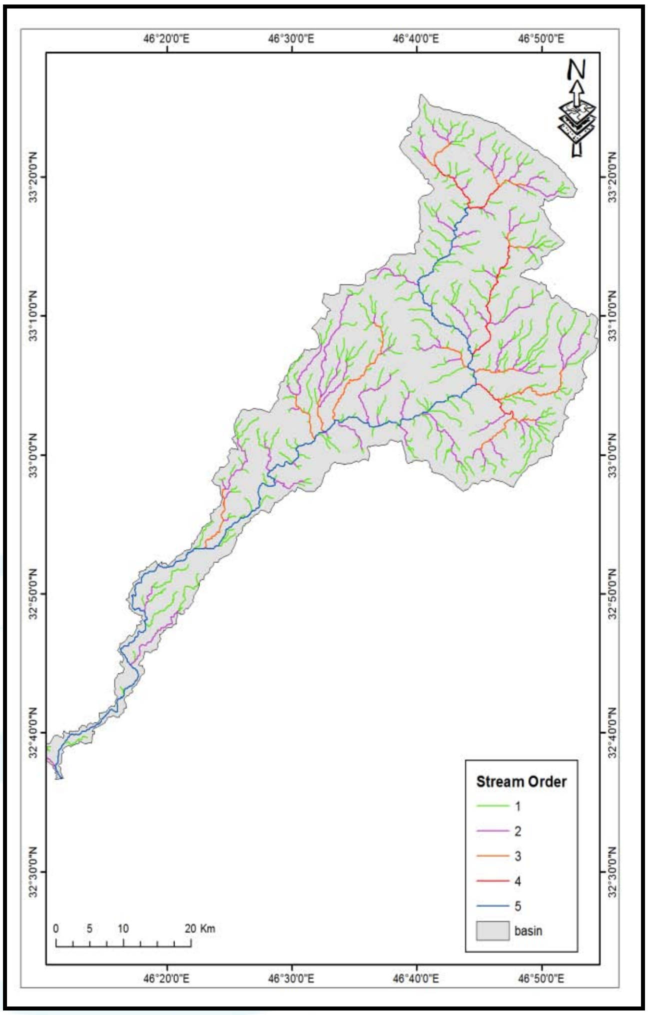

Figure 5: Orders of streams

The numbers and lengths of streams for each order are listed in table 3.

Table 3: Numbers of streams

Order	1st	2nd	3rd	4th	5th	Aggregate
Number	324	75	15	4	1	419
Percentage %	77.33	17.9	3.6	0.96	0.24	100
Length (km)	657	210	79	15	115	1076
Percentage %	61.06	19.51	7.34	1.4	10.69	100

7.2 Bifurcation Ratio

The term bifurcation ratio is denoted by (R_b), and it is given by equation (8) [10].

$$R_b = \frac{Nu}{Nu+1} \quad (8)$$

Where:
Rb: Bifurcation Ratio.
Nu: number of streams for a certain order.
Nu +1: the number of steams for order post Nu.

It is defined as the ratio between the numbers of streams for a certain order to the number of streams for an order follow the previous order [15]. The increasing of bifurcation ratio lead to increasing the dangerous of floods during high rainfall [17]. Table 4 summarizes the bifurcation ratios for each order.

Table 4: Bifurcation Ratio for each order

Order	1st	2nd	3rd	4th	5th	Aggregate	Average
Rb	---	4.32	5	3.75	4	17.07	4.267

7.3 Streams Frequency

Stream frequency or channel frequency is denoted by (Fs). It is measured by dividing the sum of streams number by the area of the basin as in equation (9) [18].

$$F_S = \frac{\sum N_U}{A_U\ (Km^2)} \quad (9)$$

Where:
Fs: stream frequency.
Nu: Number of steams.
Au: Area of the basin.

The high values of streams frequency indicate the existence of a large number of tributaries which increase the capability of grouping the water as surface runoff, while the low value of steams frequency indicate a small number of tributaries which decrease the chance of surface runoff and increase the infiltration of water to the underground water [19]. The streams frequency of studied area was (0.2855) which regarded as relatively low value and that means decreasing of surface runoff.

7.4 Drainage Density

The study of land topography for the draining water regarded as one of the studies which illustrate the operation of diversity and changing from one region to another according to climate, weather, rock nature, and rock structure. the drainage density It is denoted by (Dd) and it's measured by using equation (10) [20].

$$\mathbf{Dd} = \frac{\sum \mathbf{L_U}}{\mathbf{A_U}} \quad (10)$$

Where:
Dd: drainage density.
Lu: sum of streams lengths.
Au: area of basin.
The drainage density indicates the breaks in region. The drainage density of the basin (0.727).

7.5 Channel Maintenance Constant

Channel Maintenance Constant is denoted by (C) and it's measured by equation (11) [21].

$$\mathbf{C} = \frac{\mathbf{1}}{\mathbf{Dd}} = \frac{\mathbf{A_U}}{\sum \mathbf{L_U}} \quad (11)$$

The channel maintenance constant of the basin is (1.375 Km), and that indicates there is no area of basin hasn't water net in the future.

7.6 Texture Ratio

Texture ratio (T_R) is an important factor in the drainage morphometric analysis which is depending on the underlying lithology, infiltration capacity and relief aspect of the terrain. It is given by equation (12) [20].

$$T_R = \frac{\mathbf{Nu}}{\mathbf{P}} \quad (12)$$

Where:
Nu : Total number of order streams.
P : Perimeter of watershed

In the present study the texture ratio of the basin is (4.04 valley / Km) and categorized as bad land topography in nature [19].

9. Results and Discussion

The mathematical morphometric equations had been applied in this study to obtain the values of morphometric variables as in (schematic features, net features and features of Al Chabbab Basin topography). Basin of Al chabab river ending in fifth class according to Strahler classification, the basin is one of the biggest basins, basin space about (1467.41km^2) and in surroundings at (302.67 km), crosswise of the basin are (14.25 km) and lengthwise at (103 km). Basin consist of (419) sub-grades, starting from first grade and ending of fifth grade, where we found that the number of first grade riverbed is (324) grade, the number of second grade riverbed is (75) grade, the number of third grade riverbed is (15) grade, the number of fourth grade riverbed is (4) grade, finally fifth grade riverbed is one grade, so the totaling of all grades of the long riverbeds (1076 km) for all grades, mainly drainage patterns classified of arboreal to semi arboreal. Basin Properties contain of contrast or divergence of formalism, cadastral and morphologies properties and Drainage network properties, and network of drainage, the Morphometric properties of basin at Al chabbab River Basin according to natural factors of basinThe shapes of the drainage generally were dendritic to semi-dendritic.

It is clear from the studying of the morphometric Analysis properties that the basin tend to the elongation more than the circular shape and that is proven from the circularity ratio (0.201) which indicates the estrangement from the circular shape. While the elongation ratio (0.42) indicates the elongation in basin, and that is proven from the other morphometric factors such as (compactness factor, leminiscate factor, and from factor).

The Drainage Density of Al chabab river basin reaches to (0.727 km/km2) and that mean for all (0.722 km) from the longest riverbeds of Drainage network of Al chabbab River Basin taken a space about (1 km2).

The texture of the basin was (4.04 v/km) and for that it is considered as medium because it has four valleys per kilometre.

After drawing the drainage pattern of studied basin it is clear from morphometric factors of water network that the basin has a lot of breaks which increase the number of tributaries and distribute of these tributaries randomly throughout the basin.

From the studying of morphometric properties of the basin and water network it is clear that the basin in the dangerous of floods.

10. Conclusions and Recommendations

Generally, this study aims to show the possibility of Remote Sensing and Geographic Information Systems Technics in analysing the Morphometric Changes of Al chabbab River Basin. An advantage took from the different applications system to obtain the morphometric treatments to Al Chabbab Basin. This study neglect the ratio of generalization that affect the morphometric measurements in classical methods by using accurate data of a high local clarity degree represented by Digital Elevation Model instead of paper topographic maps. The Digital Elevation Model helped us in drawing the water drainage net accurately and clearly, that led to get results which was distinctive of accuracy than the results of morphometric analysis, and saved time and effort, The study concluded the following results:

1) The maximum high level in Al chabab Basin River reached at (2767 m) above sea level, while the minimum high level of basin reaches at (7 m).

2) the formalism properties of Al chabbab River Basin (Form factor, Circular factor, Elongation ratio, Lemniscate Factor and Compactness factor) are refer to the basin living outside of circular form and closing to rectangular form , so that mean the risks of floods happened are in a small percentage happen , and the line of water network of basin are irregular extension , but in zigzag form and clearly.

3) This study will help the locals to use water resources for a constant growth in the area of drainage basin, and to know the amounts of water drainage and deposits that held by side streams of the basin and deposit as economical deposits like soil (for agriculture) and quarries of sand and gravels (for building).

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