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Geomorphology of Adirish basin in Amadiyah, Northern Iraq, Using Remote Sensing Techniques and Geographical Information System (GIS)

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Abstract: ***River basins represent important geomorphological features. They are supplied with runoff and ground water flow. The geometric, morphological, surface and stream density characteristics of the aqueduct are main objectives of the study of river basins because of their importance in explaining the geomorphological appearance of river.The Adirish Basin was studied by using quantitative analysis remote sensing and GIS techniques using Erdas Imagine V.9.2 and GIS software V.10.1.From an analysis of river features of adirish basin through coefficient of elongation ratio, circularity ratio and basin shape parameters, it turns out that the basin far from the rectangular shape and rotation, because their values are 0.2,0, respectively. It is approach the triangle shape because lese for the basin shape coefficients which reached 0.5217.The stream order of the study area reached five order, and the rate of bifurcation ratio was within the normal range. The stream frequency in the basin has reached an advanced stage of activity, and the drainage texture indicates that the basin is within the soft textile, it represent the prevailing drainage pattern is the type of dendritic.***

Keywords: Steam density, Circularity ratio, Morphometric, Steam order

1. Introduction

The area of study GeliAdirish lies few kilometers south of Amadiya Town. It runs along the northern flank of Gara anticline. The area is part of the High-Folded Zone with axes of structures running E-W that is Taurus trend. Between latitude 37 ˚ 1` 37 ˚ 2` N, longitude 43 ˚36`50" 43 ˚38` E, as shown in **Figure 1**

1.1 Natural characteristics of the basin

The Gara anticline is an asymmetrical double plunging anticline with a steeper northern flank. 19 lithostratigraphic units are exposed along the section starting with the Upper Triassic Baluti Formation and terminate with the Pliocene Mukdadiya Formation as shown in **Table 1**. These units represent parts of six Tectonostratigraphic Mega sequences (AP6-AP 11) proposed by **Sharland and et. al.[1]**.The following are some notes on the exposed Mesozoic formations only, **[1, 2]**.

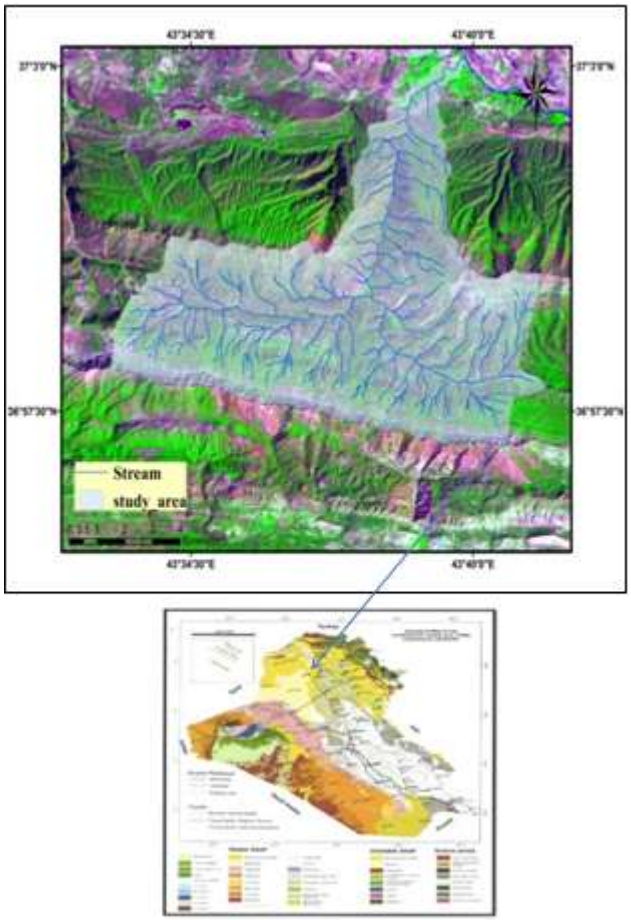

Figure 1: Location of study area

Table 1: Mega sequences and related formations with the ages and tectonic settings

Tectonostratigraphic Megasequence	Formation	Age and Tectonic Setting
AP11	Bi-Hasan	Mid-Miocene to Late-Pliocene : Western Extension (Gulf of Aden/Red Sea Spreading) and eastern compression (collision with Eurasia and Zagros Inversion)
	Mukdadiya	
	Injana	
	Fatha	

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AP10	PilaSpi	Early Palaeogene to Latest Eocene: Mild compression and closure of Neo-Tethys
	Gercus	
	Sinjar/Khurmala	
	Kolosh	
AP9	Aqra	Late Cretaceous to Early Palaeogene: Compression and ophioliteobduction.
	Bekhme	
AP8	Qamchuqa	Late Cretaceous to Early Palaeogene: Compression and ophioliteobduction. Late Jurassic to Late Cretaceous: Opening of the Indian Ocean, southern extension and passive margin post-rift thermal subsidence.
	Sarmord	
	Garagu	
AP7	Barsarin	Early Jurassic to Late Jurassic: Opening of the Mediterranean Basin, northern extension and passive margin post-rift thermal subsidence.
	Naokelekan	
	Sargelu	

1.2 Geological Tectonic Settings

Geological formations that exposed in the study area are**[2]**:

1) **Kurra Chine Formation: (Late Triassic)**
   The kurra Chine formation is the most widespread formation of the late Triassic Sequence. from the northern thrust zone of north Iraq where it up to 850 m thick and comprises dark brown and black limestone's, thin and thick bedded, with occasional beds of thick bedded dolomite with slump structure, and papery shales, recrystallization breccias also occur occasionally.
2) **Baluti Formation: (Late Triassic)**
   Baluti formation of supposed Rhaetic age. The formation was first named and described from an incomplete outcrop.
   In the study area: the formation consists of interbedding of (1-4)m dark gray marlstone with (0.5-1)m pale gray calcareous siltstone and thin beds of dark dolomites. In some locations thin beds of siltstone and dolomite become medium bedded, with thin laminas of gypsum with oxidization surfaces. Thickness of the formation is about 50-60 meters, **[3]**.
3) **Sarki Formation: (Early Liassic)**
   - Upper division of 181 meters - Soft, grey dolomites, highly cavernous, and weathering into massive beds of "cargneule-or cornieule" type, alternating with soft, featureless, friable, cherty dolomites and yellowish shales and blocky marls with melikaria.
   - Lower division of 122 meters- thin-bedded, cherty and dolomitic limestones, fine-grained to porcellanous, pale grey, weathering whitish, altemating with frable, cherty shales, and occasional dark, sugary dolomites.
4) **Sehkaniyan Formation: (Jurassic, Upper Liassic)**
   The Sehkaniyan Formation from the Surdash anticline of the high folded zone of north east Iraq as a 180 m thick carbonate unit devided into three units. Age of formation: Liassic, probably Upper Liassic, by regional correlation.

5) **Sargelu Formation: (Middle Jurassic)**
   Location: Surdash anticline, Sulaimaniya District, northeastern Iraq. The type section is in the course of the stream which flows northwards through Sargelu village; the base lies about 280 metres north of the stream confluence at Sargelu.

   In the study area: the Formation is of the same succession of the type locality with high content of bitumen and foetid carbonates and papery shales. Contoured bedding structures are observed in the lower part of this formation, **[3].**

6) **Naokelekan Formation: (Late Jurassic)**
   The Naokelekan Formation was defined from the Balambo- Tanjero Zone near Rawanduz N-E Iraq. abetter supplementary type section from the Chia Gara fold of the high folded zone

7) **Barsarin Formation: (Late Jurassic)**
   The barsarin Formation was defined from type area in Balambo- tanjero Zone near Rawanduz in the NE Iraq.

8) **GaraguFormation: (Cretaceous, Valanginian-Hauterivian)**
   Garagu Formation, in core of the Chia Gara anticline, Amadia District, N Iraq. The section runs along the Gel-i-Garagu, the top being situated at the foot of the massive cliff. The base lies at approximately tat. 37°00'50" N; long.43°23'38" E, about 600 metres north of Garagu village, from which the formation takes its name.Thicknessis 92 metres.

9) **Sarmord Formation: (valanginian- Aptian)**
   Surdash anticline, Sulaimaniya District, northeastern Iraq. The type section is made up in two different areas.

10) **Qamchuqa Formation:(Hauterivian -Albian)**
   The type section of Qamchuqa Formation lies in Sulaimaniya governorate, NE Iraq. The section runs along the gorge to Sarmord, with top at lat. 35°54'03" N, long. 45°03'05" E, and base at lat. 35°54'12" N, long.45°03'21" E, with thickness about 799 m formation consistes of five units of well bedded dolomites and limestone.
11) **Baklhma Formation: (Upper Senonian)**
   Bekhme Gorge, Greater Zab River, North East Iraq. The section lies on the eastern bank, at the northern end of the gorge along the mule parth to Dar-e-Tesu. The base of the section is at lat. 36°41'45" N; long. 44'16'30" E, and the top at lat. 36°41'57" N; long. 44°16'37" E. Thickness is 315 meters.
12) **Agra Formation: (Maastrichtian)**
   The type locality of Aqra Formation lies in Agra district in northeastern Iraq. Section runs along the Geli Sheikh Abdul Aziz, with base in the lowest exposed beds, about 1 kilometre northwest of Aqra, at lat.
13) **Kolish Formation: (Paleocene-Early Eocene)**
   The Kolosh Formation lies in N of Koi sanjak, in the high folded zone. The type section of the Formation includes part of Sinjar limestone.
14) **Sinjar Formation: (Early Eocene)**

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The sinjar Formation was first described from the JabalSinjar area (near Mantissa village). It compreises 176m of limestone of algal reef, lagoonalmiliolid, and shoal nummuliticfacies.

15) **Gercus Formation: (Late-Early Eocene to Mid Eocene)**
The Gercus Formation consists of molasse deposited following Mid Eocen uplift.

16) **PilaSpi Formation: (Late Eocene)**
The resistance pilaSpi Formation forms a conspicuous ridge between the recessive weathering Gercus and Fatha Formation throut the high folded zone. The PilaSpi Formation is 100-200 m thick.

17) **Fatha Formation:**
The fatha Formation is one of the most aerially widespread and economically important formations of Iraq.

18) **Injana Formation: (Late Miocene-Ploiocene)**
The Injana Formation comprises fine grained pre-molasse sediments deposited initially in coastal areas, and later in a fluviolacustriansustem. A subsidiary type section was measured near injana.

19) **Muqdadiya Formation:**
The Muqdadiya Formation comprises of 2000 m of fining upwards cycles of gravely sandstone and red mudstone. The sandstone are often strongly cross-bedded and associated with channel lags and clay balls.

20) **Bi-Hassan Formation:**
The Bi-Hassan Formation comprises of marl, sandstone and conglomerates and thickness about 300-400 meters. The age of formation is Pliocene.

1.3 Climate

The study area has semi arid climate, the major portion of rainfall is received during months of October to April. That mean rain falls in the winter and spring, the highest rate in the month of December is 81.6,The area of study is characterized by moderate temperatures during the summer, and the relative humidity of the evaporation intensity is high because of the temperature, Wind speeds increase evaporation and reduce water bodies in the region at a rate of 3.50 in December as shown in **Table 2.**

2. Morphometric Analysis of the Study Area

2.1 The spatial characteristics and formality:

1) Basin length
(LB) = Straight-line distance from a basin`s mouth to point on the water divide intersected by the projection of the direction of the line through the source of the main stream, **[4]**.

Basin length (LB) = 11.370

Table 2: Climatic data of Duhok Meteorological Station 2009, [5]

Criteria		Jan.	Feb.	Mar.	Apr	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Total of Rain / Depth mm		4	67.9	64.2	30.4	0.2	0	0	0	3.3	18.6	76.6	81.7
Humidity% Avg.	Max	78	84	87	79	59	43	36	33	51	74	68	84
	Min	40	39	23	31	27	17	17	19	25	29	40	34
Temperature C^o	Max	12.6	15.85	20.1	22.3	30.75	39.5	37.3	37.15	35.4	29.5	17.8	14.3
	Min	0.65	6.55	6.9	12.2	17.45	26.8	30.7	32.4	19.6	17.9	12.45	5.55
(Max)Wind Speed. M/S		2.55	3.01	3.92	2.27	1.4	2.21	1.13	1.77	2.1	3.03	2.5	3.52
Total of Pan evap. mm.		44	62.7	94.5	132.6	285.1	351.5	379.8	368	249.4	132.5	57.8	44.1

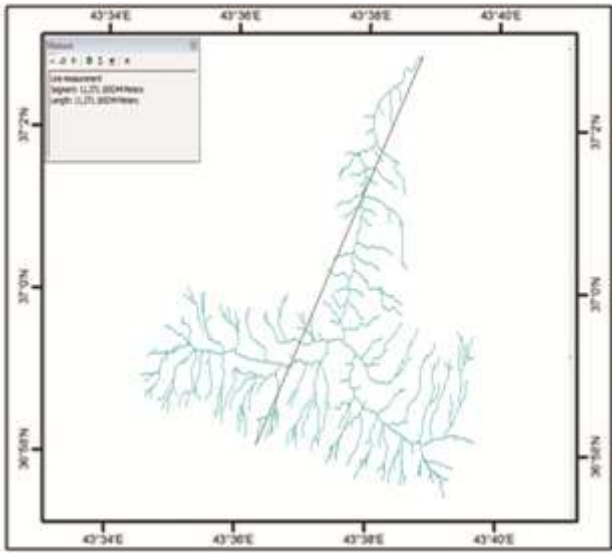

Figure 2: Basin length (LB)

1) Perimeter
Perimeter (P) = Horizontal projection of its water divide, **[6]**.
P = 49682.78

2) Basin area
Basin area (Ba) = the entire area drained by a stream or system of streams, **[7]**.
Ba = 67.451658

3) Form factor
The relationship between area of basin and its length the closer one approximates the distance from the from, **[8]**.
Form factor (Rf) Rf = Ba/Lb2; Ba = Area of the basin (km2); Lb2 = Square of basin length

$$R_f = \frac{B_a}{L_b^2} = \frac{67.451658}{129.2769} = 0.52176$$

4) Compactness coefficient (Cc)
Cc = 0.2841 * (P/Ba 0.5), P = Perimeter (km), Ba = Area of the basin (km2), **[9]**.

$$C_c = 0.2841 \times \frac{49682.78}{67.351658} \times 0.5 = 104.62958$$

5) Elongation ratio
If the shap of river basin, which take an geometric shape if approached by a rectangular shape, **[10]**.

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Elongation ratio=$\frac{the\ diameter\ of\ the\ circle\ is\ the\ same\ as\ the\ basin}{maximum\ basin\ length\ km}$

$$R_e = \frac{2\sqrt{\frac{B_a}{\pi}}}{L_b} = \frac{2\sqrt{\frac{67.4516}{\pi}}}{11.370} = 0.202$$

Represents the rotation of the basin, and the extent to which water lines are approading, as the rotation of the basin describes the extent of the zigzagging or overlapping area of the water division of aparticular basin with the adjacent basins.

6) Circularity ratio (Rc)

Perimeters coherence ratio (1-0), if the result of the equation is closer to one, the shape means closer to the rotation, **[11]**.

$$Area\ cohesion = \frac{Basin\ area\ (km^2)}{The\ area\ of\ circle\ equals\ the\ circulr\ ference\ of\ the\ perimeter\ of the\ basin\ itself\ (km^2)\ itself\ (km^2)}$$

$$R_c = 4 \times \pi \frac{B_a}{P^2} = 4 \times \pi \frac{67.451658}{49682.78^2} = 0.000000342$$

7) Lemniscate shape ratio

$$L_s = L_b^2 \times \frac{\pi}{4B_a} = 1.574187$$

3. Characteristics of Impending Discharge

3.1 Stream Order

The water courses are distributed in the basin in away that is less numerous and increases in size from one level to the next, it starts with small squares to many of which represent the first rank and the streams met of that rank with each other to be the second rank which is loss numerous and more efficient then the first, then the third, fourth, **[12]**. See**Figure (3-7), Table 3.**

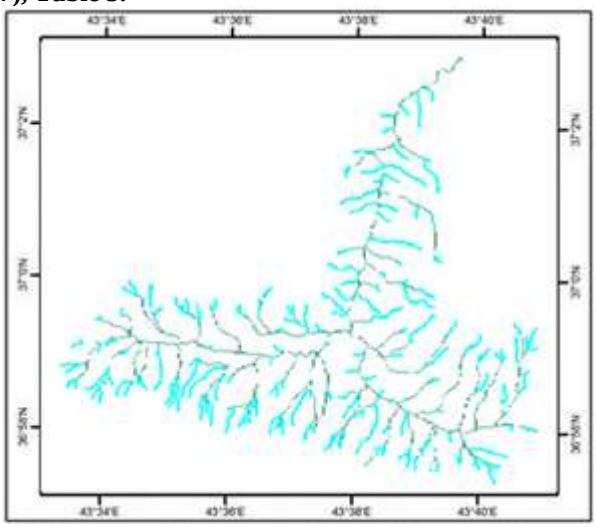

Figure 3: Order 1

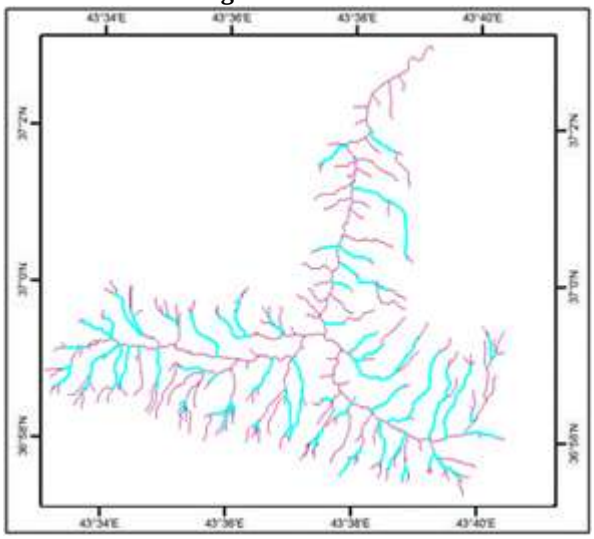

Figure 4: Order 2

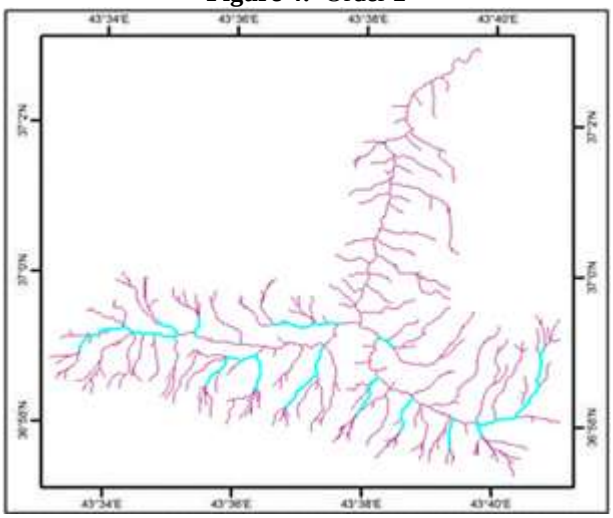

Figure 5: Order 3

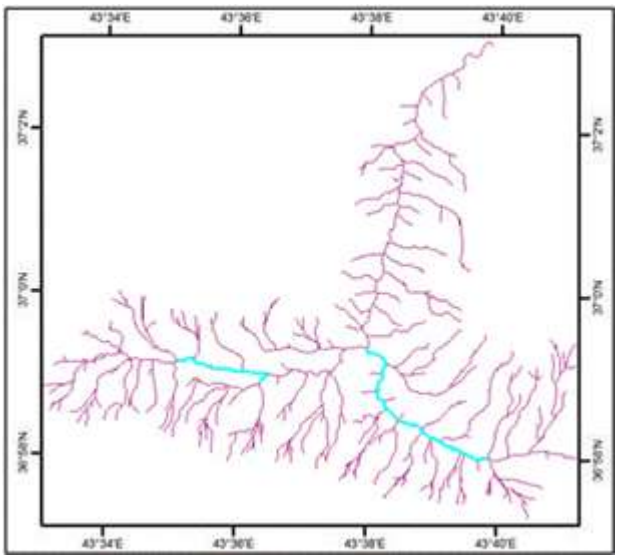

Figure 6: Order 4

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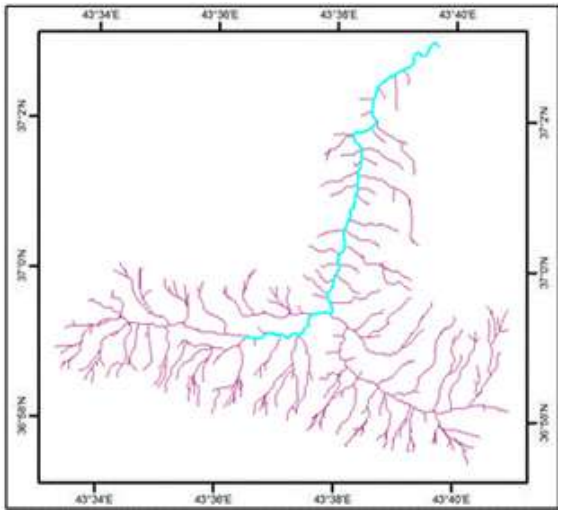

Figure 7: Order 5

3.2 Bifurcation Ratio

Bifurcation Ratio, [13]=$\frac{Nu}{Nu+1}$ = $\frac{Number\ of\ water\ ways\ in\ a\ given\ rank}{Number\ of\ water\ courses\ in\ rank\ for}$

- **Bifurcation Ratio Order (1) =** $\frac{234}{62} = 3.774$
- **Bifurcation Ratio Order (2) =** $\frac{62}{12} = 5.166$
- **Bifurcation Ratio Order (3) =** $\frac{12}{3} = 4$
- **Bifurcation Ratio Order (4) =** $\frac{3}{1} = 3$
- **Mean Bifurcation Ratio =** $\frac{3.774+5.166+4+3}{5} = 3.188$

Table 3: Bifurcation Ratio in study area

Stream Order	NO.	Bifurcation Ratio
Order (1)	234	3.774
Order (2)	62	5.166
Order (3)	12	4
Order (4)	3	3
Order (5)	1	1
Sum.	312	15.94

3.3 Drainage Density

Drainage density (Dd) Dd = Lu/Ba; Lu = Total stream length of all orders (km); Ba = Area of the basin (km2), **[4]**.

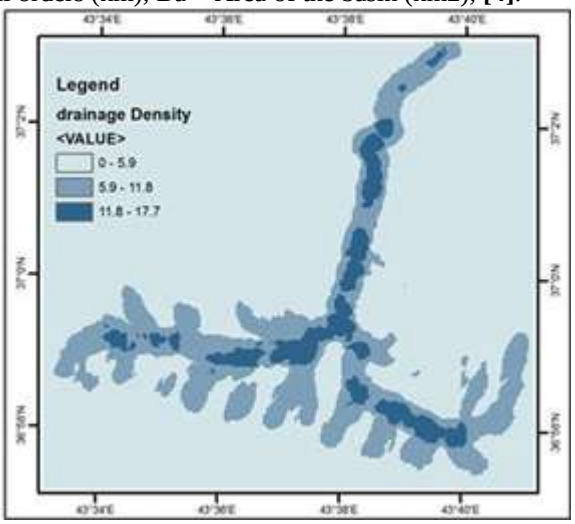

Figure 8: Drainage density

3.4 Stream frequency

Stream frequency (Fs) Fs = Nu/Ba; Nu = Total no. of streams of all orders
Ba = Area of the Basin (km2), **[4].**

FS $= \frac{312}{67.451658} = 4.625$

Their high value indicates that the basin is affected by erosion due to rain and runoff, which is at the peak of its activity.

Drainage texture

Drainage texture (Dt) Dt = Nu/P; Nu = Total no. of streams of all orders; P = Perimeter (km), **[8]**.

$$Dt = \frac{Nu}{P} = \frac{312}{49682.78} = 6.279$$

Drainage texture is indicative of the relative spacing of streams across a terrain. Texture is affected by natural factors such as climate, rainfall, vegetation, rock and soil type, infiltration capacity, relief and stage of development of a watershed. Texture values can be grouped into descriptive classes of very course, course, fine, and very fine.Texture values for the five sub watersheds are 7.28, 3.33, 3.30, 3.07, and 2.86 for Ramain, Gata, Taraka, Masiu, and Agus. All these sub-catchments are considered to have a fine texture .

4. Conclusions

From a morphometric study of the WadiAdirishbasin, and measuring many factors such as basin length, basin circumference, basin area, application of spatial and morphological characteristics, and drainage Characteristics:

1) From the application of the elongation ratio, we find that the shape of the basin is far from the rectangle shape, with an elongation ratio of 0.2.
2) The shape of the basin is far from the rotation, As it was the result of applying the circularity ratio zero.
3) The number of stream order in the study area was five, the number of first order was 234, while the second order 62, the third order 12, the fourth order 3, and the fifth 1.
4) The Bifurcation ratio of the study area was 3.188, which is the normal rate of the river basins developed by Strahlarbetween (3-5).
5) Stream frequency of the Edirch basin, which reached 4.625, showed that the basin was affected by erosion Caused by rain and surface runoff, And indicates that the basin has reached an advanced stage of activity even during the stages of its development.
6) It is found that the dominant drainage pattern is the dendritic pattern of the tributary of tree branches. The intensity of the river branch varies depending on the nature of the land, the general slope, the homogeneity of the rock layers and the type of climate.
7) Results of application of drainage structure was 6.279, Texture values can be class of very course, Which has a fine texture.

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