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Hydrological Spatial Analysis of Wadi Alkuf Catchment Area, Cyrenaica, Northeastern Libya

Ammar A Ammar
CEO BeidaGeoplan Company, Geomatics Engineering, Shahhat, Libya

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Abstract: Morphometric analysis reveals that the Wadi Alkuf drainage, on the northern flank of Al Jabal Al Akhdar, Cyrenaica, northeastern Libya, is characterized by dendritic to sub-dendritic drainage pattern. The development of stream segments in the basin area is apparently affected by intermittent rainfall and geological structure control such as joints set, fractures and faults, as the general area is of limestone karstic character. The analysis reveals that the total number and total length of stream segments reach maximum of 6233 segments in first order streams but decrease to 620 segments in 6th order streams. The bifurcation ratio (Rb) between different successive orders varies between 0.7 in 6th order and 3.5 for third order passing through 2.43 in second order. A mean bifurcation ratio of 1.42 indicates a partial structural control. The stream frequency (Fs) value of 8.87 exhibits positive correlation with the drainage density value of 1.97, whereas the drainage density (Dd) indicates clearly that the region has permeable subsoil and relatively moderate vegetation cover. Calculated Circularity Ratio (Rc) of 0.215 and Elongation Ratio (Re) of 0.15 suggest that the drainage basin is typically elongated in shape, has a low discharge of runoff and relatively permeable subsoil condition. Form Factor (Rf) of 0.22, represents a flatter peak of flow for a longer duration. Flood flows of such elongated basins are easier to manage than of circular basins. It becomes evident that morphometric analysis would contribute to understanding of the dominant geo-hydrological characteristics and processing of watershed planning and management utilizing geospatial techniques based on GIS application and Digital Terrain Model (DTM) analysis.

Keywords: Wadi Alkuf, catchment area, morphometry, hydrologic, geospatial, drainage pattern, DTM.

INTRODUCTION

Numerical Morphometry is the measurement and mathematical analysis of shape behavior of the watershed and catchment area of water bodies in streams and wadies. The measurement deals with shape, dimension, location and size of landforms (Agarwal 1998, Obi Reddy *et al.,* 2002). Morphometry relevant to the fields of hydrology and geomorphology were studied by (Horton 1941) and Stahler (1950), who were the pioneers of morphometry. Morphometric studies play a key role in understanding the geological and hydrological behavior of the drainage basin and channel network. The relationship between various drainage parameters and the aforesaid factors are well recognized by many (Horton 1945, Chorley *et al.,* 1957, Melton 1958, Pakhmode *et al.,* 2003, Reddy *et al.,* 2004). Detailed morphometric analysis of a basin helps to understand the influence of drainage network on topography and their characteristics. The numerical analysis of morphometric parameters greatly facilitates watershed valuation and prioritization for soil and water conservation and natural resources management. The influence of drainage morphomet-

***Corresponding Author:** Ammar A Ammar , ammar@email.com, CEO BeidaGeoplan Company, Geomatics Engineering, Shahhat, Libya.

ric system is crucial in helping to understand the landform processes, soil physical properties, and erosion characteristics (Horton 1945, Strahler 1957, Krishnamurthy *et al.,* 1996).Recently, geospatial techniques are used for digital terrain modeling (DTM) on a 30 m grade space of (SRTM) Shuttle Radar Topography Mission in conjunction with morphometric parameters of the drainage basins and watersheds, as they both provide a flexible environment and a powerful tool for the manipulation and analysis of spatial data.

The main objective of the present study is to analyze the linear and areal morphometric characteristics of WadiAlkuf drainage basin on the northern flank of Al Jabal Al Akhdar using Geographical Information System (GIS) and arc-hydrologic tools. Lacking previous quantitative work on the morphometry of the whole of Al Jabal Al Akhdar, Cyrenaica Libya, this quantitative study calculated its hydrological parameters to help in understanding the geo-hydrological characteristics of the drainage basin, which in turn helps in the management of the water and other natural resources of the study area. Therefore, analysis of Wadi Alkuf catchment area in this manner is an integral part in its hydrological investigations, groundwater evaluation and management, as well as its soil physics. This study aspires to recognize the interconnected relationships of various morphological, hydrological, and geological characteristic of the watershed system.

Physiography and Geology: Wadi Alkuf catchment basin, which has valuable historical and economical value, covers an area of approximately 960 Km2 and has a perimeter of 222.5 km. In the heart of Al Jabal Al Akhdar, it is bounded by longitudes 21 25' 00" and 22 00' 00" and latitudes 32 32' 50" and 32 47' 17" (Figure 1) and reaches a maximum elevation of 860 m whereas its lowest is that of mean sea level. Elongated in shape and exhibiting variable topography, it comprises six orders of streams that mainly trend east-west.

The drainage dendritic pattern reflects the effects of physical and chemical weathering characteristic of karstic, joint-dominated carbonate geology of Eocene to Holocene age (Figure 2). Details of the geology of this region can be found in El Hawat and Abdulsamad (2004), Anketell, J.M.,(1996) Mediterranean to subtropical mid- latitude climates conditions are prevalent in the region whereby annual precipitation is more than 550 ml.

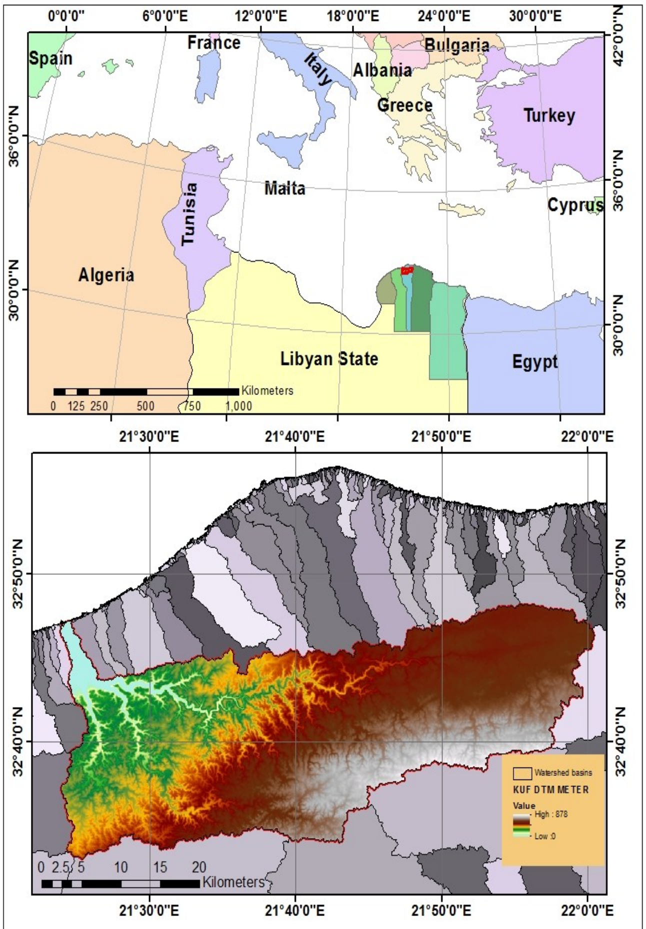

Fig.1 Location Map Wadi Akuf Basin and Adjacent Watersheds

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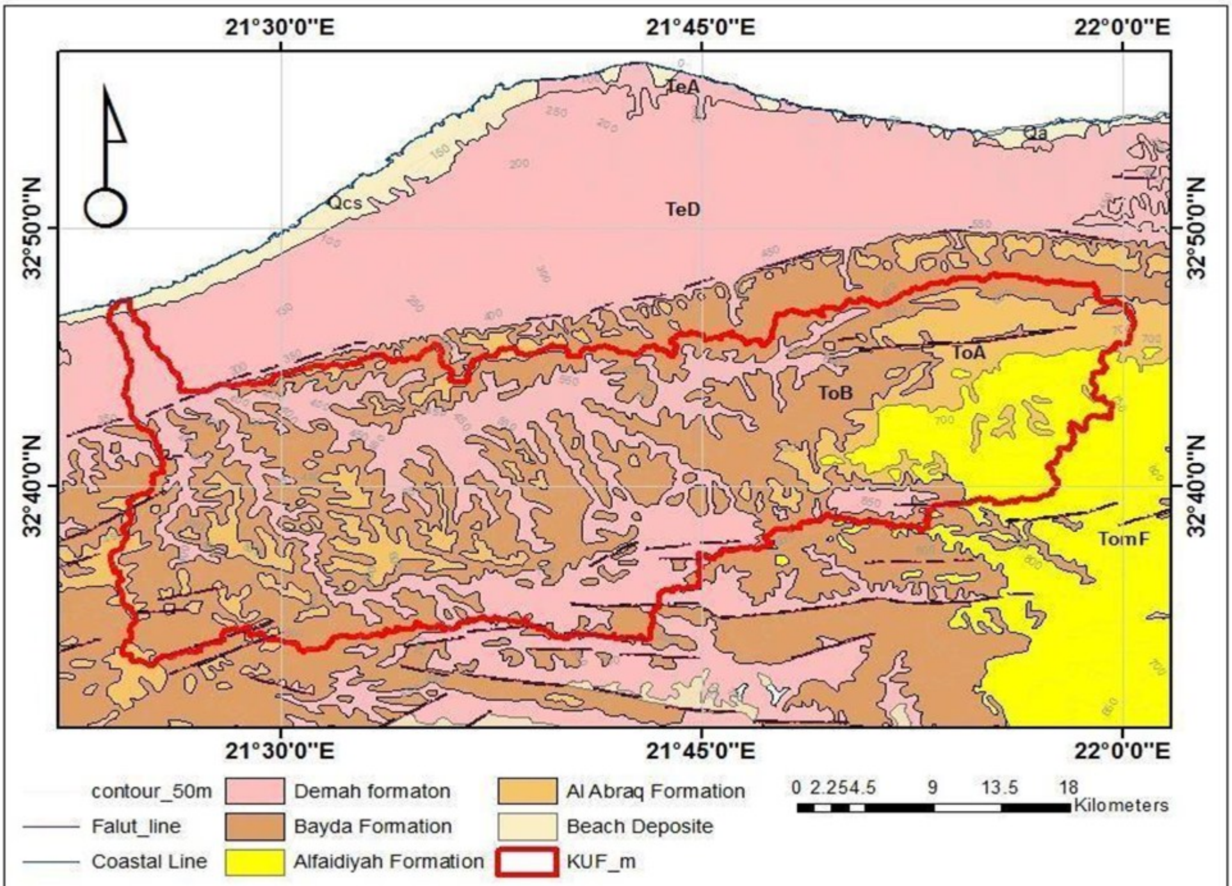

Figure 2 Geological and Tectonic Map of Wadi AlKuf Catchment Area

Methodology and Techniques

It was deemed important that to understand the watershed basin behavior of Wadi Alkuf catchment, one needs to calculate its morphometric parameters and network geometry as well as runoff of water and sediments throughout. The logical description of the geometry of a drainage basin and stream channel requires measurement of its linear and spatial factors in addition to assessment of channel network relief (gradient) and contributing ground slopes (Strahler, 1964). Emphasis was placed in this morphometric study on the hydraulic parameters that enable some understanding of the watershed basin behavior of Wadi Alkuf as derived from mathematical formulae, geomatics analysis of digital terrain models based on 30 m grid space, as well as a review of pertinent geomorphological literature of the region.

Several calculations were needed for this present morphometric analysis and parameters such as stream order, stream length, bifurcation ratio, stream length ratio, basin length, drainage density, stream frequency, elongation ratio, circularity ratio, form factor, etc. Other morphometric parameters such as relief, shape, and length strongly influence basin discharge pattern through their varying effects on lag time (Gregory and Walling, 1973). The natural run-off is one of the most potent geomorphological and geological effects shaping the landscape, drainage pattern, stream orders, and shape of a drainage basin. Röhlich (1974,1980). An assortment of topographic and geologic maps as well as satellite imagery were use in this study. Satellite imagery included Landsat 7 TM imagery at 14 m resolution, Spot 5 at 5 m resolution, Quickbird imagery at 60 cm resolution,

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SRTM 30 m grade. The area stream system was delineated as required by morphometric analysis. Delineation, in turn, required that topographic maps published by the Survey Department of Libya in 1978 at a scale of 50,000 be mosaiced and rectified. ArcGIS 10.4.1 was used to assign UTM, WGS 1984, 34N zone projection systems. Digitization of the drainage basin was carried out using ArcGIS' HydroArc tool. Attributes were assigned to create the digital database for the drainage layer of the catchment basin. Various morphometric parameters such as linear and aerial aspects of the drainage basin were computed. The different morphometric parameters have been determined as per the standard methodology shown in Table1.

Table (1). Linear morphometric parameters of Wadi AlKuf Catchment Area drainage network

Stream Order	Stream Segment	Stream Length Km Lu	Bifurcation Ratio	Main Bifurcation Ratio	Main Stream Length (Lsm)	Cumulative Mean stream length (CLsm)	Stream length Ratio RL
1	6078	1040.39	0.00		0.17	0.17	0
2	2529	555.45	2.40		0.22	0.39	1.29
3	1377	310.91	1.84		0.23	0.62	1.04
4	820	154.06	1.68	1.50	0.19	0.80	0.83
5	455	95.01	1.80		0.21	1.01	1.11
6	357	74.63	1.27		0.21	1.22	1.00
	11616	2230.44					

RESULTS AND DISCUSSION

Parameters and Calculations: According to Strahler (1964), the smallest fingertip tributaries in a stream system are designated as order1. Where two first order channels join, a channel segment of order 2 is formed and where two of order 2 joins, a segment of order 3 is formed, and so on. The trunk stream through which all discharge of water and sediment passes is, therefore, the stream segment of the highest order. The study area is a 6 order drainage basin. It is observed that stream frequency decreases as the stream order increases. Thus, the law of "lower the order higher the number of streams" is implied throughout the catchment area. This is expounded upon in several following sections. In the following section, linear and spatial parameters are first explained briefly and basin's values calculations-measurements are introduced thereafter.

Linear Morphometric Parameters: Linear factors of the basin are related to channel patterns of the drainage network wherein the topological characteristics of the stream segments (i.e., open inks of the network system) are analyzed. The morphometric investigation of the linear parameters of the watershed basin includes stream order (Sμ), bifurcation ratio (Rb), stream length (Lμ), mean stream length (Lsm), stream length ratio (RL), length of overland flow (Lg), basin perimeter (P), basin length (Lb), index of Gravelius (KG), fitness ratio (Rf), wandering ratio (Rw), sinuosity indices, etc. Some of the important linear factors have been computed as shown in (Tables 3 and 4).

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Table (2). Stream order and Drainage Texture and its classification

Stream Order	Segment	Length,km	Percent %	Drainage Texture	*Texture Category*
1st	6078.00	1040.39	0.52	27.30	very fine
2nd	2529.00	555.45	0.22	11.36	very fine
3rd	1377.00	310.91	0.12	6.19	fine
4th	820.00	154.06	0.07	3.68	Coarse
5th	455.00	95.01	0.04	2.04	Coarse
6th	357.00	74.63	0.03	1.60	Very Coarse
	11616.00	2230.44	1.00	8.70	very fine

Table (3). Hydrologic parameters with formula for the Wadi Alkuf watershed basin.

Parameter	Formula	Results	Reference
Linear Morphometric parameters			
Bifurcation Ration Rb	Rb=Nu/Nu+1, Nμ = No. of stream segments of a given order	See table 1	Schumn(1965)
Mean Bifurcation Ratio	Rbm = Average of bifurcation ratios of all orders	1.5	Stahler(1964)
Stream Length Lu	Length of the stream (kilometers)	2236.7 km	Horton (1945)
Mean Stream Length Lsm	Lsm = Lμ/Nμ, Where, Lμ = Total stream length of order 'μ', Nμ = Total no. of stream segments of order 'μ'	0.204	Stahler(1964)
Stream Length Ration RL	RL=Lsm/Lsm-1, Where, Lsm=Mean stream length of a given order and Lsm-1= Mean stream length of next lower order	0.4291 84549	Horton (1945)
Length of Over Land Flow Lg	Lg=1/2D Km, Where, D=Drainage density (Km/Km2),	0.4288 16467	Horton (1945)
Basine Perimeter P, Km	P=Outer boundary of drainage basin measured in kilometers	222.53k m	Schumm (1956)
Basin Length Lb, Km	(Lb) $Lb=1.312*A^{0.568}$	64.81 km	Gregory and Wal-lig (1973)
Spatial Morphometric Parameters			
Basin Area A, Km^2	Area from which water drains to a common stream and boundary determined by opposite ridges.	959.26 km2	Stahlar(1964)
Drainage Density Dd Km/km^2	Dd=Lu/A, Where, Dd = Drainage density (Km/Km2), Lμ = Total stream length of all orders and A = Area of the basin (Km2).	2.33	Horton(1932)
Stream Frequency Fs, $1/km^2$	Fs=Nu/A, Where, Fs = Drainage frequency, Nμ = Total no. of streams of all orders and, A = Area of the basin (Km2).	12.14	Smith(1950)
DraiangeTexture Dt	Dt=Nu/P, Where, Nμ = No. of streams in a given order and P = Perimeter KM	52.35	Smith(1950)
Form Ration Rf	$Rf=A/Lb^2$, Where, A = Area of the basin and Lb = (Maximum) basin length	0.228	Horton(1932)
Elongation Ratio Re	Re= √A /π / Lb, Where, A= Area of the Basin (Km2), Lb=Maximum Basin length (Km)	0.152	Schumm(1956)
Circularity Ration Rc	Rc = 4πA/ P2, Where, A = Basin Area (Km2) and P= Perimeter of the basin (Km)	0.24	Miller(1953)

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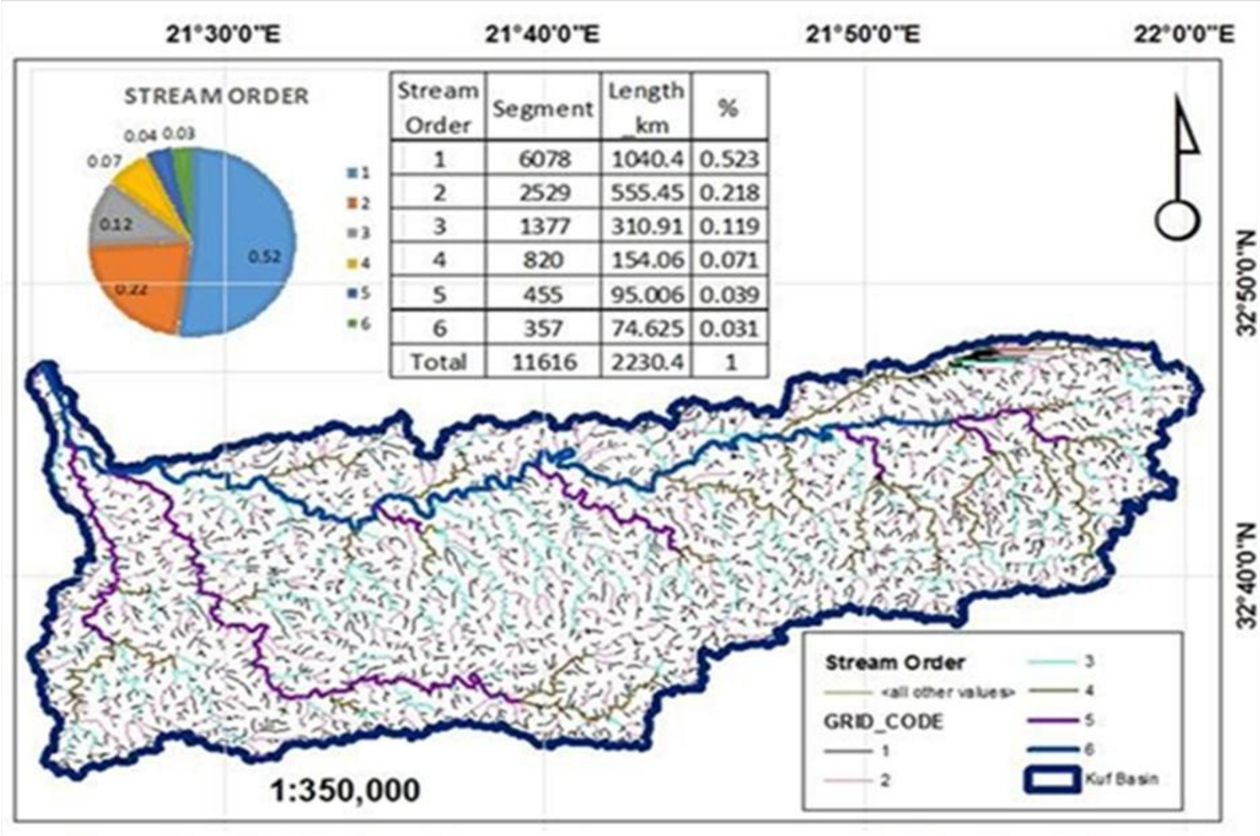
Stream Order (Sµ): Stream order starting at the mouth defines a Wadi's place in the network, which suites general cartographic purposes. Nature of stream order is the first step to understand the drainage basin

analysis. It is defined as a measure of the position of a stream in the hierarchy of tributaries (Leopold *et al.,* 1964). In the area under consideration, there are 11616 stream segments linked with 6 orders of streams. Total stream length is 2230.4 km covering about 959.26 km^2.First order tributaries constitute more than 52 % of all segments at a stream length of about 1040 km (see the table in Figure 3).



Stream Order	Segment	Length _km	%
1	6078	1040.4	0.523
2	2529	555.45	0.218
3	1377	310.91	0.119
4	820	154.06	0.071
5	455	95.006	0.039
6	357	74.625	0.031
Total	11616	2230.4	1

Figure 3. Stream Order and Stream Segments Percent of Wadi Alkuf Basin

Bifurcation Ratio (Rb): Bifurcation ratio is related to the branching pattern of a drainage network, and is defined as the ratio between the total number of stream segments of one order to that of the next higher order in a drainage basin (Schumm 1956). It is a dimensionless ratio that varies from one region of one environment to another that has a different environment, except where powerful geological control is dominant (Strahler, 1964). The bifurcation Values of Rb for Alkuf basin reflect control of the dominant geological features of the region's joint system, where joint distribution and trends have somewhat impacted the drainage pattern. The lower values of Rb are characteristics of watersheds or drainage basins that suffer little structural disturbances and consequently the drainage patterns are less deformed (Strahler, 1964; (Nag 1998). Table 1 shows that the bifurcation ratio values for the Alkuf Basin drainage vary from 1.27 to 2 and a mean bifurcation ratio of 1.5 reflecting the average of bifurcation ratios of all orders. The highest Rb found (2.4)

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characterizes 2nd and 3rd order, which indicates corresponding highest overland flow and discharge due to more topographically elevated (high slope configuration), less permeable rock formation. The mean bifurcation ratio, which is relatively low, suggests geological heterogeneity, higher permeability, and only mild structural control.

Stream Length (Lµ): Stream length is an indicative of the geomorphological development processes of stream segments including weathering and tectonics of Al Jabal Al Akhdar watershed basins. In Wadi Alkuf Basin, stream lengths of various orders were measured using Arc View 10.4.1. The analysis found that stream segment lengths are inversely related to the increase in the stream order except for the 6^{th} order stream, whose length is greater than the total length of the 6^{th}order stream segments. Table 3 shows percentages of each stream order as follows: first order at 52 percent of the total, whereas second order at 22 percent, third order at 12 percent, 4^{th} order at 7 percent, 5^{th} order at 4 percent, and 6^{th} order at 3 percent. Generally, the higher the order, the longer the length of streams.

This was also attested to in the Wadi Alkuf drainage basin. Correlation of order to the percentage, as shown above, appears to reflect flow from high altitude, change in rock type, and variation in slope and topography (Singh and Singh, 1997; Vittala*et al.,* (2004). When the logarithm of the number of streams is plotted against the order, most drainage networks show a linear relationship, with a small deviation from a straight line (Strahler, 1964). According to Horton's principle, the number of streams is negatively correlated with the order (Horton 1932). Wadi Alkuf-basin river basin shows a near perfect correlation with the plots falling near the regression line.

Mean Stream Length (Lsm): Mean stream length is an expression of the characteristic size of components of a drainage pattern network and its contributing surfaces (Strahler, 1964). The mean stream length is calculated by dividing the total stream length of a given order by the number of streams of that order. In the study area, it is noted that Lsm (Table 1) varies from 0.17 to 0.23 km, and that its value for any given order is greater than that of the lower order and less than that of its next higher order in the whole drainage basin.

Stream Length Ratio (RL): The stream length ratio can be defined as the ratio of the mean stream length of a given order to the mean stream length of next lower order, and it has an important relationship with surface flow and discharge as well as the erosional stage of the basin (Horton 1945). It is also noted that the RL values among successive stream orders within a basin vary because of differences in slope and topographic conditions (Srinivasa *et al.,* 1998). The values of RL vary erratically from 0.80 to 1.29 from one order to another in Wadi Alkuf Basin. Such conforms to the state of the basin, which is of late youth to an early mature stage of geomorphic development.

Length of Overland Flow (Lg): Length of overland flow is defined as the length of flow path, projected to the horizontal. Open channel flows from point on the drainage divide to a point on the adjacent stream channel (Horton 1945). For the sake of convenience, it is taken to be roughly equal to half the reciprocal of the drainage density. Overland flow is significantly affected by infiltration (exfiltration) and percolation through the soil, both varying in time and space (Schmid, 1997). In this study, the length of overland flow of the Wadi Alkuf drainage basin is 0.22 kilometers, which indicates low surface runoff.

Basin Perimeter (P): Basin perimeter is the outer boundary of the drainage basin network that encloses its area and reflecting the boundary of the stream divide as the line that separates neighboring drainage basins. In Al

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Jabal Al Akhdar Mountain, the divider separates two topographically prominent ridges in the form of mountain escarpments (Figure 1). The present work used Arc map10.4.1 to compute the basin's perimeter, the subject of this study, and found it to be 222.26 km.

Basin Length (Lb): Basin length (Lb) has been given different meanings (Schumm 1956) Gregory and Walling (1973); Gardiner (1975) and Cannon (1976). The Lb is the longest length of the basin measured from the catchment to the point of confluence (Gregory and Walling, 1973). From the point of confluence in the south-east of the study area, Wadi Alkuf meets the Mediterranean Sea northward. The length of Wadi Alkuf Basin is 64.81 kilometers.

Fitness Ratio (Rf): Fitness ratio is the ratio of main channel length to the length of the basin perimeter and thus, is a measure of topographic fitness (Melton 1958). The Rf for Wadi Alkuf catchment drainage basin or watershed is 0.30.

Gravelius's Index (KG): Different geomorphologic indices can be used for the analysis of a watershed if its shape is taken into consideration. The most frequently used index is the Gravelius's index KG, which is defined as the relation between the perimeter of the watershed and that of a circle having a surface equal to that of a watershed. A KG of 2.07 suggests that the watershed basin is more elongated than circular.

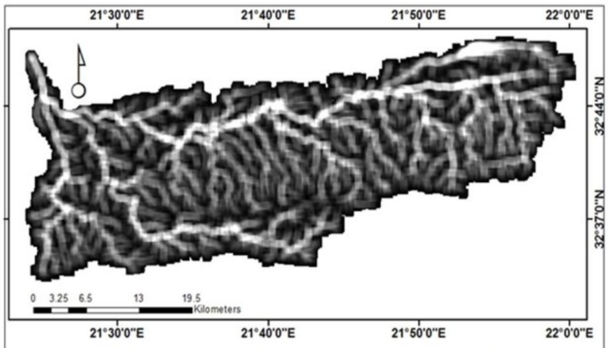


Figure 4 Drainage Density Distribution of Wadi Alkuf Basin

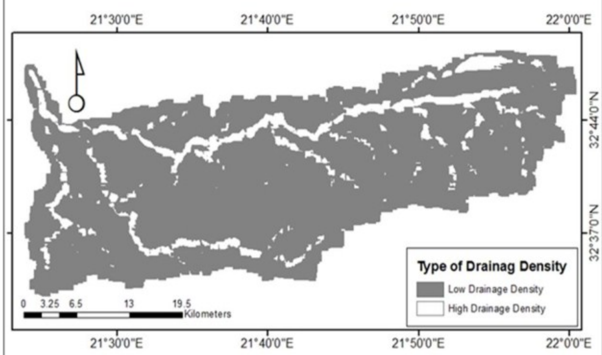
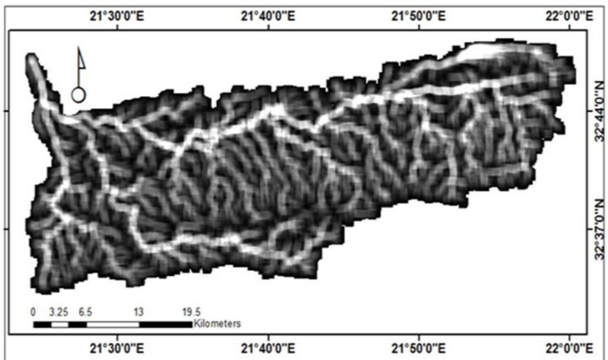


Figure 5 Classfication of Drainage Density of Wadi Alkuf Basin



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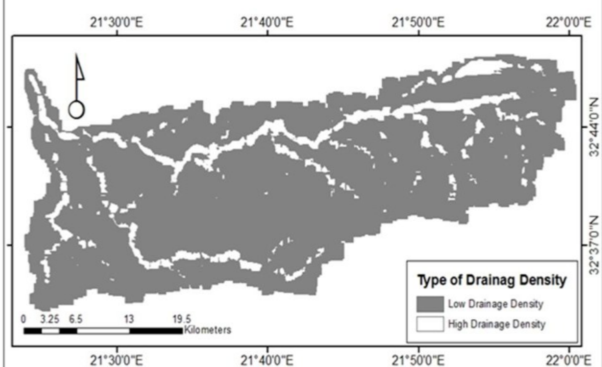

Figure 5 Classfication of Drainage Density of Wadi Alkuf Basin

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$KG = P / 2\sqrt{\pi A}$

KG Gravelius's shape index
A watershed area [km^2]
P watershed perimeter [km]

Spatial Morphometric Parameters General
The area of a basin is a significant morphometric parameter affecting the spatial distribution of several morphometric attributes and controlling factors such as drainage density DD, drainage texture Dt, stream frequency Fs, slopes, Elongation Ratio Re, circularity ratio Rc, etc. (Anderson 1957).

Drainage density (Dd) : The density of stream network in a basin has long been recognized as a topographic characteristic of fundamental significance. It is an expression of the closeness or spacing of channels (Horton 1932). The significance of drainage density is recognized as a factor determining the time travel by water (Schumm 1956). The measurement of Dd is a useful numerical measure of landscape dissection and runoff potential Chorley,(1969). On the one hand, the Dd is a result of interacting factors controlling the surface runoff; on the other, it is itself influencing the output of water and sediment from the drainage basin (Ozdemir and Bird 2009). Dd is known to vary with climate and vegetation, soil, rock properties, relief, and landscape evolution processes (Kelson and Wells 1989, Oguchi 1997, Moglen *et al.,* 1998). The Dd of the Wadi Alkuf- watershed basin is 2.33 km/km2. Figure 4 shows that the drainage density in the study area, which is relatively low, clearly indicates that the region has permeable subsoil, relatively moderate vegetation cover, and gentle to medium relief (Nag 1998). Drainage density in the study area varies between low and high as shown in Figure 5. Furthermore, the illustration shows aggregation around and in the main trunk of first and second order streams.

Drainage frequency (Fs): Like drainage density, the stream frequency is also one of the most important morphometric parameters of the drainage basin. Horton (1945) introduced stream frequency (or drainage frequency Fs) as the number of stream segments per unit area. Stream frequency is calculated by the total number of streams in a drainage basin divided by the area of the basin. In other words, it is a calculation of the total number of streams in a unit area per a drainage basin. For determination of stream frequency, the Hortonian formula FS=(N/A) is used whereas N is the total number of streams and A is the area of the basin. A figure of 959.26 km^2 is adopted for the study area. For convenience and expediency, the entire Wadi Alkuf drainage basin is transformed into 30X30 m grid space resolution of SRTM radar image and topographic maps sheets at a scale of 1:50,000. A general overview of the frequency distribution of drainage net of the basin indicates high frequency as one moves from the foothill zone to the floodplain. (Table 3) shows the spatial pattern of drainage frequency distribution and area, the FS value is 12.14.

Drainage Texture (Dt): Drainage texture is simply the relative spacing of drainage lines within a basin. It is believed to be the most promising and useful variable in the morphometric analysis of drainage basins because it relates to the dynamic nature of the network of the stream segments and the area of the catchment area. In WadiAlkuf basin, this variable can be usefully used in the classification of drainage basin order architecture to determine processes and interpret temporal changes of the drainage network. Drainage texture may be regarded as a function of climate and catchment characteristics (Table2). Horton (1945) defined drainage texture based on stream frequency (number of streams per unit area). In fact, the term texture has been used loosely and no success has been made to search out a quantitative parameter for its calculation. According to Singh and Srivastva (1974), the term texture is indicative of the

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relative spacing of streams per unit area along a linear direction. For the present study, the basin is divided into grids. Then the numbers of streams crossing along both the diagonals are counted and averaged. Further, the number of streams crossing should be calculated per km length based on Savindra Singh's formula. (Table 2) suggests the main texture of the basin to be very fine texture because the formula yields a number greater than 8. However, in some higher stream order, the texture is mainly coarse to very coarse, especially in the 6^{th} and 5^{th} order streams.

Form Factor Ratio (Rf): A quantitative form of the outline of a drainage basin may be illustrated through a form factor ratio (Rf), which is the dimensionless ratio of a basin area to the square of basin length (Horton 1932). Basin shape may be indexed by simple dimensionless ratios of the basic measurements of area, perimeter, and length (Singh, 1998). The form factor value of Alkuf basin equals a low value of 0.23, which represents an elongated shape. The elongated basin with low form factor indicates that the basin will have a flatter peak of flow for a longer duration. Flood flows of such elongated basins are easier to manage than those which are circular (Christopher *et al.,* 2010).

Elongation Ratio (Re): Elongation ratio (Re) is defined as the ratio of a diameter of a circle of the same area as the basin to the maximum basin length (Schumm 1956). It is a very significant index in the analysis of basin shape that helps to shed light on the hydrological character of a drainage basin. Re= √A /π / Lb, where A= Area of the Basin (Km2), Lb=Maximum Basin length in km's. If values are near 1.0, the region is typical of low relief (Strahler, 1964). The elongation ratio in the study area was found to be 0.15 indicating relatively moderate relief of the terrain and elongation of the drainage basin (Table3).

Circularity Ratio (Rc): The circularity ratio (Rc) has been used as a quantitative measure for visualizing the shape of the basin and is expressed as the ratio of basin area (A) to the area of a circle (Ac) having the same perimeter as the basin (Miller 1953; Strahler 1964). It is affected by the lithological character of the basin. However, the ratio is more influenced by length, frequency (Fs), and gradient of streams of various orders rather than slope conditions and drainage pattern of the basin. It is a significant ratio that signifies the dendritic stage of a basin. The Circularity Ratio Rc= 4πA/ P2, Where A = Basin Area (Km2) and P= perimeter of the basin (Km). Low, medium and high values indicate youth, mature, and old stages of the life cycle of the tributary basins, successively. The calculated Rc value for the study area is 0.24, which affirms that Alkuf drainage basin is elongated in shape and is characterized by medium to low relief. Such drainage systems are partially affected by structural disturbances (Zavoiance, 1985).

CONCLUSION

Wadi Alkuf catchment basin is being frequently selected as a unit of hydrological morphometric analysis because of its topographic and hydrological unity. As a part of the region of Al Jabal Al Akhdar, it has been affected by its geologic evolution and tectonics that contributed to its elongation and size of its drainage catchment area. The morphometric analysis (linear parameters) of Wadi Alkuf was greatly aided and enhanced through the use of geospatial tools (spatial parameters) that resulted in a better understanding of the hydrologic configuration of the drainage basin. It was found that an ArcGIS-based approach facilitates analysis of different morphometric parameters and exploration of the relationship between the drainage morphometry and effects of lithology, soils cover and eroded lands and karst features. Based on drainage orders, WadiAlkuf Basin has been classified as 6th order tributaries basin. The mean Rb indicates that the

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dendritic and sub- dendritic drainage pattern systems is much influenced by geologic structures. The study reveals that the drainage area of the basin is passing through an early amateur stage of the fluvial geomorphic cycle. Lower order streams mostly dominate the basin. The development of stream segments in the basin area is somewhat affected by rainfall. Circularity Ration Rc, Stream Frequency Rf, and Elongation Ratio Re show that the elongated shape of the basin is characterized by low discharge of runoff. It is noted that stream segments up to 4th order traverse parts of the high altitude, comparatively flatland, and maximum infiltration of runoff occurs and is aided by gentle slopes.

As karstic limestone lithology controls the behavior of the underlying rocks (Eesterbrooks, 1969), the drainage pattern of Wadi Alkuf watershed basin is dendritic in nature and geometry. The details of stream characteristics conform to Horton's (1932) ''laws of stream numbers'' which stated that the number of streams of different orders in a given drainage basin tends closely to approximate an inverse geometric ratio. There is also an attestation in this study to the validity of his law, which stipulates that the average length of streams of each of the different orders in a drainage basin tends closely to approximate a direct geometric ratio.

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التحليل المكاني لهيدرولوجيا حوض وادي الكوف، برقة، شمال شرق ليبيا

عمار عبد المطلب عمار

الرئيس التنفيذي لشركة البيضاء غيبلان لأعمال الجيوماتكس الهندسية، شحات –ليبيا

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المستخلص:التحليل المورفومتري لحوض تصريف وادي الكوف في برقة بالجزء الشمالي من الجبل الأخضر في شمال شرق ليبيا يكشف نمط خواص الحوض شجيري إلى شبه شجيري. تطوير وتنمية القطاعات النهرية لوادي الحوض وادي الكوف متأثرة بكميات هطول الأمطار والتراكيب الجيولوجية للمنطقة مثل الفواصل والصدوع والشقوق وغيرها من السمات الجيولوجية الكارستية للحجر الجيري المكون الرئيسي لجيولوجيا الجبل الأخضر، وهذا التحليل يكشف وجود إجمالي 6233 قطعة نهرية من الرتبة الأولى، وتتناقص إلى 620 قطعة نهرية في الرتبة السادسةّ ومعدلات التشعب النهري (Rb) متغيرة بتغير رتبة التصريف ما بين 0.7 في الرتبة السادسة و3.6 للرتبة الأولي، مروراً 2.4 للرتبة الثانية وتوسط التشعب النهري 1.42 وهذا مؤشر لتأثر التراكيب الجيولوجية عليه، ومؤشرات التردد النهري للحوض(Fs) بقيمة 8.87إيجابية بالترابط مع الكثافة النهرية (Dd) والتي تبين بقيميتها 1.97 والتي تكشف عن السماحية الهيدروليكية للترب السفلية والغطاء النباتي متوسطة، وحساب معدل الاستدارة للحوض (Rc) 0.215 ومعامل الاستطالة للحوض (Re) 0.15 وهذا يعكس رياضياً أن الحوض مستطيل وهذا واضح من الصور الفضائية والتخريط الحقلي لمنطقة الدراسة، وغيرها من المعاملات المورفومترية الهامة والتي تم دراستها في حوض الكوف والجبل الأخضر لأول مرة باستخدام التقنيات المكانية وتطبيقات نظم المعلومات الجغرافية وتحليل الصور الرادارية لنموذج الارتفاعات الرقمية للمنطقة والمناطق المجاورة لكي تستخلص تلك النتائج الهامة للدراسات الهيدرولوجية والجيومرفولوجية للحوض لتساعد على الاستغلال والتحكم الأمثل لمياه الأمطار الجارية وحركة المياه الجوفية من بداية الحوض إلى بلوغ مرامه في البحر.

الكلمات المفتاحية: وادي الكوف، حوض التصريف، المورفومتري، الهيدرولوجي، المكانية، شبكة التصريف، نموذج الارتفاع الرقمي.

*عمار عبد المطلب عمار ammar@email.com, الرئيس التنفيذي لشركة البيضاء غيبلان لأعمال الجيوماتكس الهندسية، شحات – ليبيا.