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RESEARCH ARTICLE

MORPHOMETRIC ANALYSIS OF ABBASAN WATERSHED BETWEEN (IRAQ - IRAN), USING (GIS) TECHNIQUE

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ABSTRACT

Morphometric analysis is the best method to understand and determine the shape, size, and dimension of a watershed. Conducting this analysis required a wide variety of quantitative measurements and mathematical analysis presenting valuable data related to hydrological characteristics of the watershed. Using GIS technique and Digital Elevation Models (SRTM-DEM) images were extremely facilitated the method and precisely boosted the results. Morphometric parameters were utilized of the Abbasan watershed determining hydrological properties and runoff assessment. The watershed area, of Abbasan covers (878.34) km^2, the calculations of dimension, shape, and compactness coefficient are done which indicated elongated shape, low runoff intensity and low erosion rates. Most of the morphometric parameters were computed and analyzed such as relief properties, stream network, and drainage pattern characteristics which is referring to (2555) m elevation, low-moderate relief, six stream orders, and three types of drainage patterns respectively. Rectangular drainage patterns occupied a large area followed by Dendritic and Trellis patterns in terms of area. This study has given a comprehensive insight into the whole morphometric aspects of the Abbasan watershed.

KEYWORDS

Morphometric, Geographic Information System, Abbasan watershed, Digital Elevation Models.

1. INTRODUCTION

The first who provided original and worthy studies and researches and thus, who laid down the first glimpses into the evolution of drainage basins and morphometric characteristics in the 19th century were Horton, Strahler, Schumm, and Morisawa (Zavoianu, 1985). Morphometric is concerned with the study of measuring the mathematical properties of drainage basins and stream networks (Diaconc, 1971), including the measuring of length, surface area, size, and slope of its landform which gives good results of flood risks and their duration (Diaconu *et al*., 1961). Hydromorphomtric analysis of the drainage basins provides a quantitative description and hydrological implications of the watersheds, such as forecasting floods and the volume of water discharge which is considered a significant aspect of watersheds characterization (Strahler, 1964).

Many factors are controlling watershed morphometry which are the relief of strata, geology, rock structure, lithology, climate, and hydrology (Mesa, 2006). The hydrological cycle has a great impact on the geometry of watersheds, through the amount of precipitation, and overland flow of water in the basin (Waugh, 1996). hydrological parameters that are used in the current study are considered utmost basis methodical tools for evaluation watershed properties, using Geographic Information System (ArcGIS) software.

Abbasan watershed elongated from Kermanshah province in Iran to Garmian area in Iraq, which is a common watershed basin between Iran and Iraq. It is astronomically located between (34° 35' 15'' to 34° 56' 45''N) latitude and (45° 36' 15'' to 46° 07' 20''E) longitudes. (Figure 1). The watershed entering the Iraqi territories from foothill zone that considered, tectonically characterized as the beginning of the folded zones. Abbasan watershed is one of the catchment basins of the Sirwan river (Diyala river), and one of the main river tributaries where its makes up of total area (878.34 km^2), by (721.73 km^2) located in Iran, and (156.61 km^2) located in Iraq.

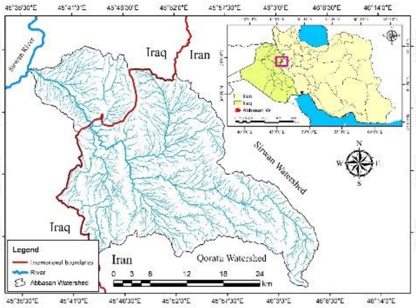

Figure 1: location map of study area

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The issue of water in Iraq is one of the complicated and sensitive issues that are shared with neighboring countries representing the upstream countries. At present, Iran has controlled the tributaries on the Serwan river by building dams currently is working on irrigation and agricultural projects. However, in the Iraqi part, there is no monitoring to the river's tributaries and streams. For this purpose, it was suggested to study the morphometric analysis of the Abbasan watershed finding out watershed characteristics and will it cause flooding during the precipitation seasons to the areas that constitute the downstream? To perform this, multiple mathematical and statistical formulas and GIS technique were used.

2. METHODOLOGY

Table 1: Mathematical and statistical methods used in evaluation of morphometric parameters of Abbasan watershed

Morphometric Properties	Morphometric Parameters	Formula	Computed value	Referencee
Watershed Geometry	Watershed area (A)	-	878.34 km²	GIS
	Watershed perimeter (P)	-	193.10 km	GIS
	Watershed Length (L_b)	-	57.87 km	GIS
	Mean Watershed Width (W_b)	-	15.18 km	GIS
	Circularity ratio (R_c)	$R_c = A / Ac$ A: area of the watershed (km²) Ac: area of a circle having the same perimeter as the watershed(km²)	0.30	Miller (1953)
	Elongation ratio (R_e)	$R_e = L_b\varnothing / L_b$ $L_b\varnothing$: the length of diameter of a circle that have the same area as that of the Watershed (km) L_b: Maximum watershed length (Km)	0.57	Schumm (1956)
	Form factor (F_f)	$F_f = A / Lb^2$	0.26	Horton (1932)
	Compactness Coefficient (C_c)	$C_c = p / pa$ P: perimeter of the watershed (km) Pa: perimeter of a circular which equals the area of the watershed (km)	1.84	Gravelius (1941)
Topographic Properties	Maximum Elevation In The Watershed (Z_{max})	-	2555 m (mts)	GIS
	Minimum Elevation In The Watershed (Z_{mix})	-	306 m (mts)	GIS
	Total Watershed relief (H)	$H = Z_{max} - Z_{mix}$	2249 m	-
	Relief Ratio (R_{hi})	$R_{hi} = H / L_b$	38.86 m/km	Schumm (1956)
	Relative Relief (R_{hp})	$R_{hp} = (H/P)(\%)$	%11.65	Melton (1957)
	Watershed Texture (W_t)	$W_t = N\mu / P$ Nμ: No. of streams in a given order P: perimeter of the watershed (km)	7.96 St./km	Horton (1945)
	Ruggedness Number (R_n)	$R_n = H \times D_d / 1000$	4.11	Strahler (1964)
Stream Network	Stream order (S_μ)	Hierarchical rank	6	Strahler (1953)
	Stream number (N_μ)	$N_\mu = N_1 + N_2 + N_3 + \dots$	1538	Horton (1945)
	Stream Length (L_u)	$L_u = L_1 + L_2 + L_3 + \dots$	1611.13 km	Horton (1945)
	Mean Bifurcation Ratio (R_b)	$R_b = N_\mu / N_{\mu+1}$	4.18	Horton (1945)
	Drainage density (D_d)	$D_d = L_u / A$	1.83 km/km²	Horton (1932)
	Stream Frequency (F_s)	$F_s = N_\mu / A$	1.75 St./km²	Horton (1945)

Morphometric analysis of Abbasan watershed was prepared and determined relied on Digital Elevation Models (DEM-STRM) images having (12.5m) spatial resolution, using Geographic Information System (GIS) (ArcMap) software. The satellite images were compiled by U.S. Geological Survey (USGS) and Earth Explorer that made available to the public with Entity ID: SRTM1N34E045V3. Based on the data, the slope and topographic elevation maps have been prepared with contours for the Abbasan watershed. Stream networks of the watershed were also prepared using (GIS) ArcMap software.

Multiple mathematical and statistical formulas have been used. These equations laid out by (Horton 1932, 1945; Gravellius 1941; Strahler 1953, 1964; Miller 1956; Schumm 1956; Melton, 1957), according to these formulas the values of the geometry of the Abbasan watershed have been calculated that are the basic formulas determining the drainage basin properties. Through (DEM-STRM) images, the quantitative analysis has also been done and generated different morphometric parameters using (GIS) Technique. The morphometric parameters were divided into four main categories: watershed geometry, topographic, stream network, and drainage pattern aspect of the basin as is shown in (Table 1).

3. RESULT AND DISCUSSION

3.1 Watershed Geometry

Watershed Geometry is including the distances, areas and shapes that are in relation to the drainage basin. The significance of the watershed area represents an effecting variable of the discharge volume through being presented a direct relationship between the area of the drainage basin and volume of discharge. The area of the drainage basin varies according to the variation of climatic conditions such as type of rocks, structural movements, terrain and time (Strahler, 1957).

Table 2: Geometry properties of Abbasan watershed

Area (km²)	Perimeter (km)	Watershed Length (km)	Mean Width (km)	Circularity ratio	Elongated ratio	From factor ratio	Compactness Coefficient (Cc)
878.34	193.10	57.87	15.18	0.30	0.57	0.26	1.84

Concerning the shape properties of the basin, there is a significant role of hydrological conditions on the watershed in particular, for example, a circular shape has an irregular discharge and has a high amount of drainage. This is occurring due to the speed arrival of flow from upstream to downstream. However, a rectangular shape has a regular discharge with a lower amount of drainage. Perhaps this is due to the exposure of the

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discharge quantities to the evaporation and leakage factors (Musy, 2001). It might be inferred that the period of the flood period in rectangular basins is longer than that of circular basins (Jaza *et al.,* 2019). The geometry characteristic of the Abbasan watershed is completely showed in (Table 2):

3.2 Watershed Area (A)

Watershed area (A) is a key watershed characteristic for hydrologic design. It is as important as watershed length which reflects water volume. A relationship between the watershed area and the stream length has been found (Schumm 1956). The total area of the watershed is (878.34) km^2. According to Sen (2008) classification, the drainage basin located within a big area, which classified the basins based on its areas (< 5 km^2= small, 5-99 km^2= medium, 100-1000 km^2= big, > 1000 km^2 = very big). In a way (721.73) km^2 which (82.17%) is a percentage of the watershed area located in Iran and the area located in Iraq is (156.61) km^2 that equals (17.83%) of the watershed area. This is, logically providing a high volume of runoff to the mainstream.

3.3 Drainage Dimension Characteristics

The characteristics of the drainage dimension are including area, perimeter, length, and width.

3.3.1 Watershed Perimeter (P)

A study mentioned watershed perimeter as a circularity ratio of the drainage basin area to the area of circumference (Miller, 1953; Strahler, 1964). Watershed perimeter can be measured along a line between the watersheds and it also gives a common estimation about the size and shape of the basin (Singh, 2018). The perimeter of the Abbasan watershed is found as (193.10) km.

3.3.2 Watershed Length (L_b)

Watershed length was defined by many pieces of research with different meanings (Gregory and Walling 1968; Gardener 1990; Cannon 1976). It is the longest dimension of the drainage basin that is passed along the main drainage line (Schumm 1956). However, all meant that the L_b has the longest length ending at the river mouth as the endpoint of the watershed. In the present study, watershed length comes out to be (57.87) Km. This indicates high runoff passing during a short time through the watershed. The length of the watershed was calculated with the help of the GIS technique tool (Table 1).

3.3.3 Mean Watershed Width (W_b)

Horton (1932) mentioned the watershed width in a mathematical equation that are the factors of the area to the length of the drainage basin. It ordinarily appears that the elongated shape of the drainage basin has small values which indicating more groundwater recharge in comparison to the large values (Khakhlari and Nandy, 2016). Because of the various shapes of the watersheds, and the abundance of sinuosities of its perimeter, the mean width was taken through the ratio of the watershed area to its maximum length. The watershed width of the Abbasan watershed is found as (15.18) km.

3.4 Shape Properties

The watershed shapes compare to its geometrical shapes such as circle, rectangle, triangle, and square, like the following:

3.4.1 Circularity ratio (R_c)

For the quantitative analysis of watershed, Miller (1953) defined it as the ratio of basin area to an area of the circle that has the same perimeter in the drainage basin, which is expressed by a standard value ranging between (0-1), (0 inline), (1 in a circle). Many variables have been taken into account affecting the circularity ratio; climate, land use/land cover, the slope of the watershed, stream length, stream frequency, and geological structure. The circularity ratio of the Abbasan watershed is (0.30). This is confirming that the watershed is Non-circular in shape, high permeability of soil components and low discharge of runoff.

3.4.2 Elongation ratio (R_e)

Elongation ratio (R_e) is the diameter length of a circle that has the same area as the maximum length of watershed. Its value varies between (0: very elongated) and (1: rounded) this is influencing by climatical and geological conditions (Schumm, 1956) as is shown in (Table 1). Strahler (1964) classified watersheds as more elongated (<0.5), elongated (0.5–0.7), less elongated (0.7–0.8), oval (0.8–0.9), and circular (0.9–1.0). The values that are close to (1.0) are very low relief, whereas values that are close to (0) are associated with high relief. The elongation ratio of the Abbasan watershed is (0.57), which is representing that the watershed is elongated in shape, low steep slope, low runoff discharge and high evaporation and infiltration capacity.

3.4.3 Form factor (F_f)

Introduced by Horton, (1932) it is the ratio of width to the length of the watershed. The value of form factor varies between (0) elongated to (1) rounded basin form (Horton 1941; Horton 1945). This parameter is suggested to estimate the flow intensity of a watershed. The value of the form factor generally remains below (0.754) in an ideal circular shape, and the low value of the form factor will be a more elongated shape (Aldharab et. al, 2019). The high form factor shows a high flow intensity, whereas the low form factor shows a low water flow for a long time. The form factor value of the present watershed is (0.26) which shows an elongated characteristic of the Abbasan watershed, and low flow intensity. In this case, in the Abbasan watershed, managing flash floods will be easy (Nutiyal, 1994).

3.5 Compactness Coefficient (C_c)

A study suggested compactness coefficient as one of the watershed shape properties which defined it as the ratio watershed perimeter to a circle of an equal area. This Coefficient is used to find out the regularity degree between perimeter and area in the drainage basin and also used to recognize the erosional phases of the watershed (Gravelius, 1941). The low values of Cc indicate that the river drainage basin has gone a long way in the stages of its geomorphological development, while the high value indicates an increase in the length of its perimeter, or simply implying that the watershed perimeter is extremely tortuous. The value of the compactness coefficient in the Abbasan watershed is (1.84), which indicates a lack of consistency between the perimeter and the area, and also points out that the watershed is at its youth stage, and also at the beginning of its erosional cycle.

3.6 Topographic Properties

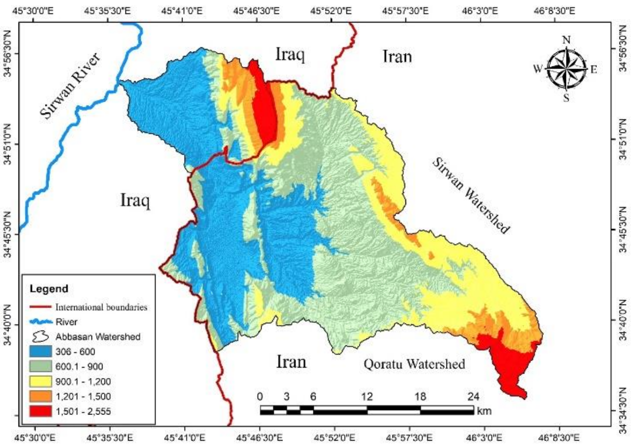

Figure 2: Topographic map of Abbasan watershed in between Iraq and Iran

Topographic properties have significant importance in Geomorphological and hydrological studies. Watershed slope determines the stream gradient, flood effectiveness, and amounts of transported sediment during the streamflow. A digital elevation model map was used in the Abbasan watershed (Figure 2) calculating topographic aspects, where the elevation starts at (306) m to (2555) m. The topographic properties involve certain elements; Relief Ratio, Relative relief, Texture Ratio, and Ruggedness no. (Table 3) which are discussed below.

Table 3: Topographic properties of Abbasan watershed

Maximum Elevation In The Watershed (mts)	Minimum Elevation In The Watershed (mts)	Total Watershed relief (m)	Relief ratio (m/km)	Relative relief (%)	Texture ratio (stream/km)	Ruggedness number
2555	306	2249	38.86	11.65	7.96	4.11

3.6.1 Relief Ratio (R_{hi})

Relief Ratio is a ratio of a difference between the stream's source elevation to its mouth divided by the total length of the stream in the horizontal dimension of the basin parallel to the basin's line (Schumm, 1956). The Relief ratio is not only important for measuring the general slope of the watershed, but it is also a good indicator of the intensity of erosion processes in the basin, as it is closely linked to the runoff intensity and the discharge amount (Kumar et. al, 2015). In the present study, the value of the relief ratio has been calculated to be (38.86 m/km) (Table 3); which is pointing that the watershed has low to moderate steepness and is characterized by a moderate value of relief ratios. Low-moderate relief ratio signs low runoff intensity and low discharge amount. However, a high value of relief ratio indicates the speed of water reaching the stream mouth, high risk of flooding, and the high amount of transported sediment which is unlikely to occur in the Abbasan watershed.

3.6.2 Relative Relief (R_{hp})

Introduced by Melton (1957), it is a measure of the total drainage basin relief from the upper point to the lower point. The advantage of relative relief over relief ratio is that it is not dependent on the watershed length which is a dubitable parameter in the irregular shaped basin. Relative relief is one of the dependable parameters of erosion rate estimation of the drainage basin (Gunnel 1998). In the current study, the relative relief was obtained from the highest point of the watershed perimeter to the lowest point based on Melton's (1957) formula: R_{hp}= (H/P) (%), P where denotes perimeter (in meter), which calculated as (%11.65). Given the mentioned relationship between the relative relief and rate of erosion, it was found that the erosion rate of the Abbasan watershed is low.

3.6.3 Watershed Texture (W_t)

The watershed texture is one of the basic parameters of watershed morphometric, it is defined as the total number of stream parts of the basin orders divided by watershed perimeter (Horton 1945). This parameter is dependent on certain physical factors involving rock and soil type, lithology, relief, infiltration capacity, climate conditions, and precipitation (Smith, 1950). Climate and vegetation factors are considered an important role in the evaluation of rock type, and thus the watershed texture. Unprotected soft rocks by vegetation with an arid climate generate a fine texture, whereas protected massive rocks with humid climates produce a coarse texture (Darnkamp and King 1971). Smith (1939) classified watershed texture into five textures which are very coarse texture (<2), coarse texture (2 - 4), moderate texture (4 - 6), fine texture (6 - 8), and very fine texture (>8). The watershed texture of the Abbasan watershed has been computed as (7.96) Stream per km (table 3). According to smith classification, watershed texture comes under the fine texture category which is known as weak or soft rock type, low vegetation and arid climate.

3.6.4 Ruggedness Number (R_n)

Ruggedness number refers to the soil erosion and structural complexity of the terrain (Altaf, *et al.*, 2013). It is associated with relief and drainage density (Strahler 1968). It is also useful for measures of the flash floods in the watershed (Patton & Baker 1976). The watershed has a ruggedness number with a value of (4.11). The low value of ruggedness number implies the effects of soil erosion have not distinctly appeared, or it might be slow and low flash flood. However, drainage basin density has complicated structural and topographical characteristics of the watershed area (Pareta, *et al,* 2011).

3.7 Stream Network

Characteristic of watershed network has a great significance in morphometric and hydrologic analysis. Delineating stream network, digital elevation model (DEM) images were used with GIS techniques. The elements of stream network have found as (Table 4):

Table 4: Stream network properties of Abbasan watershed

Stream order	Stream Numbers	Stream Length (km)	Mean Stream Length (km)	Bifurcation ratio	Drainage Density (km/km^2)	Stream frequency (St/km^2)
1	1193	831.42	0.70	1/2 = 4.42 2/3 = 4.65 3/4 = 4.83 4/5 = 3 5/6 = 4	1.83	1.75
2	270	424.51	1.57			
3	58	184.79	3.19			
4	12	99.64	8.30			
5	4	36.52	9.13			
6	1	34.25	34.25			
Total	**1538**	**1611.13**		**4.18**		

3.7.1 Stream Order (S_μ)

It is a system that measures the stream branches in the drainage basin network from upstream to downstream within a watershed. Each branch or order has a singular number that combines with its identical branch to form the next mainstream and thus continues. This system has been provided by Horton in the 1930s (Horton, 1932; Horton, 1945). And thus, others applied another scheme with some modifications. In this study, stream order is calculated with the system provided (Strahler, 1953). (Table 1,4) which are classified up to sixth orders (Figure 3). The highest stream order frequency is noted in the case of first-order streams and then for second stream order. This refers to an inverse relationship between stream frequency and stream order, where stream frequency is decreasing by increasing stream order.

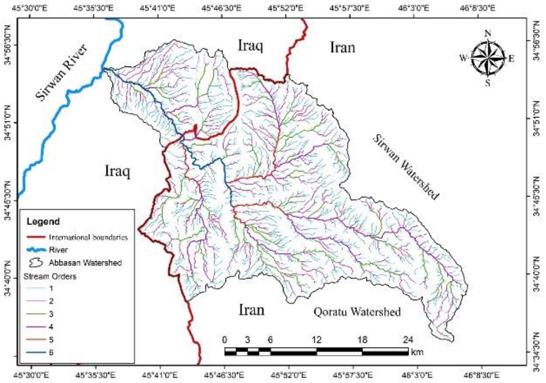

Figure 3: Stream orders and drainage basin of Abbasan area

3.7.2 Stream Number (N_u)

It may be calculated by individual stream order; the total number of stream order segments is known as stream number. In the current study, Horton's law (1945), and GIS software have been used. The law states that the stream number decreases by increases stream order as is shown in the Abbasan watershed (Figure 3). Multiple factors have affecting stream numbers such as topography, geology, rock type, slope and climate (Kuntamalla, 2018). (1538) streamlines have been calculated in the Abbasan watershed (Table 4), as the following: (1193) in the first order, (270) in the second-order, (58) in the third order, (12) in the fourth-order, (4) in the fifth-order, and (1) in the sixth order stream.

3.7.3 Stream Length (L_u)

The stream length is the total length of all the streams in a stream particular order. Horton's law of stream lengths is assisting the theory of geometric similarity in watersheds that is commonly increasing order (Horton, 1945). Stream length, generally, decreases with increasing stream order; in the first order, the total length of stream segments is high and decreases with the increasing stream order (Aldharab *et al.* 2018). Stream length in the study area was calculated depending on Horton's law with the assistance of ArcGIS tools. The total steam length is (1611) km, by (831, 424, 184, 99, 36, 34) km, for stream order (1, 2, 3, 4, 5, 6) respectively as given in (Table 4). In the Abbasan watershed, stream length greatly decreases with increasing stream order. The deviation of stream length in the Abbasan watershed is considered an indication of moderate terrain characteristics (Singh and Singh, 1997).

3.7.4 Mean Stream Length (L_{um})

The mean stream length is found as dimensionless property, it is describing the volume of a drainage network and its contributing surface (Strahler 1964). The mean stream length value is generally increasing with increasing stream order. Mean Stream Length (L_{um}) in the Abbasan watershed is computed by averaging the total length of the stream in the order which revealed an increasing trend with the increase in stream order, it is given in (Table 4).

3.7.5 Bifurcation Ratio (R_b)

The bifurcation ratio is the number of stream segments of a given order (N_u) to the number of segments in the next order (N_u+1) (Horton, 1945). This parameter has no dimension and showing the integral degree of streams of different orders in the watershed. Strahler remarkably indicated that the watersheds might not be affected by the geological structures when the bifurcation ratio is between (3-5) adding that the high bifurcation ratio reduces the possibility of a high runoff range (Strahler, 1964). The Bifurcation ratio of the present study noted variations among stream segments of different stream orders (Table 4), the variations were recorded between (3) and (4.83) values. This is can be interpreted that the high values of the ratio indicate structural control, whereas the lower values indicate less structural control and the drainage pattern has not been modified much because of structural changes (Strahler, 1964). The mean Bifurcation Ratio is found by the arithmetic mean of all orders, which is computed to be (4.18) which is within moderate values. It can be said that the Abbasan watershed is located in the normal structural affection of the drainage pattern with low range runoff.

3.7.6 Drainage Density (D_d)

A previous study defined the D_d as the total length of channels (L_u) divided by the unit area (A) of the watershed. Some studies infirmed that there is a close relationship between the climate and drainage density (Horton, 1945). Also founded the intensity of precipitation is largely increasing the drainage density (Gregory and Gardiner, 1975; Gregory, 1976). Some research indicated that climate factors are considerably affected drainage density in a complicated way (Abrahams, 1984). In fact, there are other factors affecting the drainage density such as; relief, infiltration volume, vegetation cover, surface roughness. This is a type of balance between weathering and the resistance of rocks in the watershed area (Horton, 1932). A low drainage density value is indicative of low relief, whereas a high drainage density value indicating high relief (Strahler, 1964). In the present study, the drainage density was showed a low-value drainage density of (1.83) km\km^2 (Table 4). A low value indicates that high permeable soil, low intensity of precipitation, and low basin relief.

3.7.7 Stream Frequency (F_s)

According to Horton (1932), the stream frequency (F_s) of a watershed is the total number of stream segments to the unit area of the watershed. A low value of stream frequency reflect low basin relief and less stream number, whereas higher values reflects high basin relief and vegetation scarcity (Reddy *et al.*, 2004). Stream frequency is basically relying on the runoff, temperature, and rock type in the watershed (Khakhlari and Nandy, 2016) and expresses the drainage network texture (Oruonye *et al.*, 2016). The stream frequency of the study area is found as (1.75) stream\km^2 (Table 4). The presence of low stream numbers in the Abbasan watershed is due to the maturation of the topography, low erosion rate, and rare vegetation cover.

3.8 Drainage Pattern

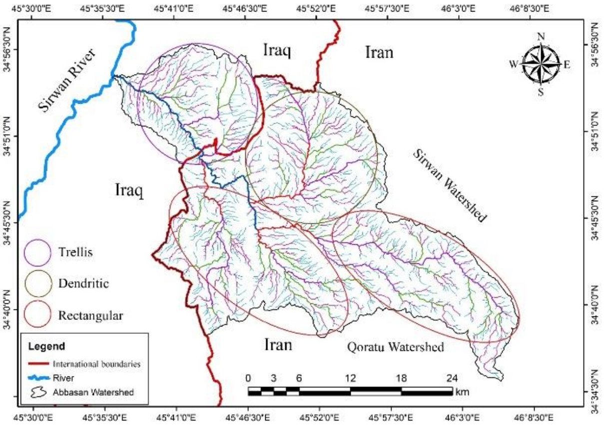

Figure 4: Patterns of drainage basin of Abbasan watershed

A set of channels connecting together and joining to the main riverbed, drainage pattern might contain one or more drainage networks (Goudie, 2006). The drainage pattern is effecting by many factors; topography, lithology, geological strata, homogeneity of the rock layers, structures of the beds, climate, and development of the drainage basins as well. There are many types of drainage patterns controlled by slop and topography that are related to the structural controls such as Dendritic drainage, Parallel drainage, Trellis drainage, Radial drainage, Centrifugal drainage, Centripetal drainage, Distributary drainage, Rectangular drainage, and Annular drainage (Morisawa, 1985). In the Abbasan watershed, three types of drainage patterns have presented; Rectangular, Dendritic, and Trellis drainages (Figure 4).

1. Rectangular drainage pattern covers vast areas within Iranian territories by different sizes of streams and tributaries. In this drainage pattern, stream and tributaries are commonly perpendicular with the mainstream at right angles (Huggett, 2017). It also reflects that the region is structurally controlled by the existence of a set of joints and liners, and has exposure to weathering as the weakness areas in the carbonate rocks (Bierman and Montgomery, 2014). Tectonically, the area of this pattern is located in the threshold of Zagros belt, which is considered as a resistant belt of Arabian plate.

2. Dendritic drainage pattern occupies modest areas within Iranian territory as well in the Abbasan watershed. This is a tree-like drainage pattern, and it has related to structural controlled drainage which comprises irregular tributaries with different angles (not at a right angle) in the areas that spreading of complex folded strata (Summerfield, 2013).

3. Trellis drainage pattern takes up a small area compared to the other two drainage patterns in the Iraq territories by parallel tributaries at right angles to the mainstream. This is indicated that the sedimentary strata of the Iraqi portion of the watershed are subjected to irregular resistance and erosion.

Generally, the drainage pattern of the Abbasan watershed is formed of homogeneous sedimentary strata that are structurally controlled by different slopes and cracks, with varying resistance to erosion. By analyzing Digital Elevation Modal (DEM (STRM) 12.5m) the basin area, it

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found that the prevailing drainage pattern in the basin is of the dendritic pattern type from the northern part of the basin, and from the upstream region is the Rectangular drainage pattern, and from the downstream areas of the basin is Trellis drainage pattern.

4. CONCLUSIONS

GIS technique has been used with the mathematical and statistical formulas that are proposed by senior researchers in the field of watershed morphology. The study concluded that the Abbasan watershed has a large area with an elongated shape, based on the shape and stream basin networks, it has no risk of flash floods. However, the topographic properties generally refer that the water flow is fast toward the mainstream of the watershed.

The total area of the watershed constitutes (878.34) km^2, which is providing a high runoff volume. The drainage basin dimension of the watershed is generally demonstrated by three main characteristics which are watershed perimeter (193.10) km, watershed length (57.87) Km, and watershed width (15.18) km. Shape properties of Abbasan watershed observed that the watershed is elongated in shape, low form factor, low Compactness Coefficient which indicates low runoff intensity and lack consistency between perimeter and area of the watershed.

A study of the topographic parameters of the basin referred that the watershed has a moderate -low slop, low relative relief, fine watershed texture, and low value of ruggedness number which refers low erosion rate. In relation to the stream network feature, the study follows the law of stream length and stream number proposed by Horton, where the stream order was classified into six orders with 1538 streamlines, and the stream length of the watershed decreases with the increasing of stream orders. As the Bifurcation Ratio of each stream appeared in a normal range, and as showed low values for each of drainage density and stream frequency attributed that high infiltration of water and low erosion rates.

Three types of drainage patterns have been found of the Abbasan watershed; Rectangular pattern; a dominant pattern and influenced by its tectonic location within the Zagros belt, dendritic pattern; is also related to structural controlled, and trellis patterns; it showed traces of erosion and rock resistance.

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