تقدير مخاطر السيول في حوض كولةسور في محافظة السليمانية اقليم كوردستان العراق

م.جنان رحمان ابراهيم
جامعة سوران - كلية الآداب

المستخلص

اشارت قيم المؤشرات لتحليل الهيدرومورفومتري الخاصة بحوض كولةسور، والذي تبلغ مساحته ٥٥٦.٠٢ كم٢ كنسبة الاستطالة، نسبة الاستدارة وعامل الشكل، إلى أنه من الأحواض المستطيلة بدرجة عالية. في حين اشارت قيم المؤشرات التضاريسية، والتي تتمثل بنسبة التضرس، التضاريس النسبية ودرجة الوعورة، إلى الجريان السطحي العالي وانخفاض نسبة المياه المترشحة في الحوض. اضافة الى المؤشرات الاخرى كالتردد النهري، الكثافة التصريفية ونسبة التشعب. كان لهذه المؤشرات الهيدرومورفومترية، استجابة هيدرولوجية انعكست على حجم الجريان السطحي، وقت التأخير ومعدل التصريف، مما أدى إلى انخفاض إمكانات الحوض الخزنية للمياه الجوفية، ومساهمة عالية في الجريان السطحي. وبالتالي، فإن زيادة فرص تجمع المياه في مجرى النهر الرئيسي يؤدي إلى زيادة فرص الفيضان، ومع ذلك، فإن طول المسافة التي تقطعها المياه من أعلى الحوض إلى المصب جعلت من المياه الجارية، موجات معتدلة الخطورة ذات وصول متأخرة.

الكلمات المفتاحية: الخصائص الهيدرومورفومترية، الحوض النهري، الفيضانات وقوة الموجات الفيضانية.

Estimating the hazards of floods in the Gulasur Basin in the Sulaymaniyah Governorate - Kurdistan Region of Iraq

Instr.Jinan Rahman Ibrahim
Arts Faculty - Soran university
DrKhalidakber@gmail.com

Abstract

The indicators values of the Morphometric Analysis of the Gulasur Basin, which has an area of 556.02 km2, as the ratio of elongation, rotation ratio and form factor, indicated that it is a highly rectangular basin. While the values of the relief aspects, which are represented by the relief ratio, the relative relief and Ruggedness number, indicated the high runoff and the low percentage of leachate in the basin. In addition to other indicators such as stream frequency, drainage density and bifurcation rate. And other hydromorphometric indicators had a hydrological response that reflected the volume of runoff, leg time and discharge rate, which led to a decrease in the reservoir potential of groundwater, and a high contribution to surface runoff. Thus, increasing the chances of water gathering in the main riverbed leads to an increase in the chances of flooding, however, the length of the distance traveled by the water from the top of the basin to the downstream makes the running water, moderately hazards waves with a late arrival.

Key words: hydromorphometric aspects, river basin, floods and flood strength.

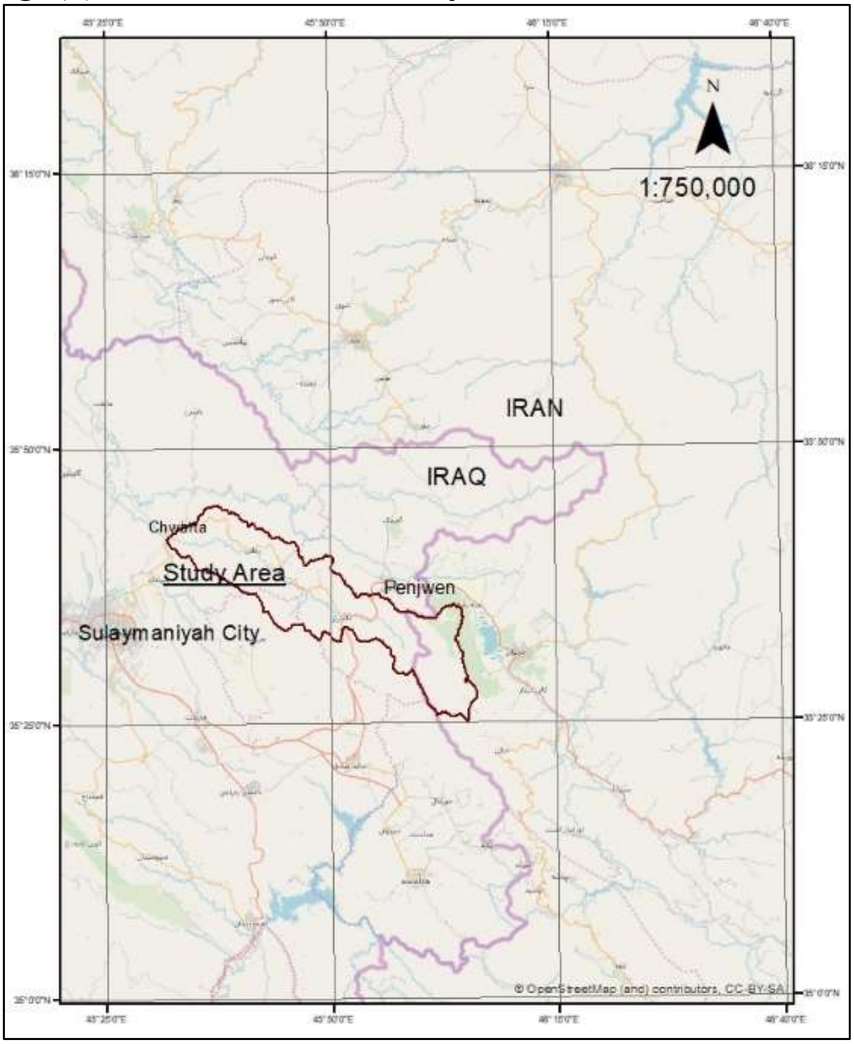
Introduction

Flooding is part of the hydrological cycle and has a great capacity to displace or cause thousands of deaths for humans, to cause complete damage to the environment and to destroy livestock and agriculture, which could endanger economic development. As a geomorphological factor, humans, directly and indirectly, have played a major role in increasing the frequency and risk of floods. The river basin is the basic unit for carrying out quantitative research, as it is a basic unit according to which measurable characteristics are determined, and results can be obtained according to which both hydrological characteristics and indications, the amount of water discharge and its prediction and the characteristics of river flooding are defined [1]. Morphometric studies are the essential of geomorphological studies of any region, through which the quantitative and standard aspects can be investigated to determine the properties of water flow [2]. The morphometric characteristics of the water basins are related to a quantitative morphology study of the water basins, knowledge of the correlative relations between their area and their dimensions, quantitative analysis of their characteristics and their water drainage networks, determining the volume of running water and the type of flow, seasonal or permanent, and the flow between it and the occurrence of torrents and floods [3]. Morphometric analysis, such as drainage density, water current size and ratio of relief, are practical indicators of the potential for flooding in small river basins and sub-basins. Most researchers have determined this possibility using indicators or morphological aspects of the river basin 4,5]]. Others used both morphometric parameters and morphometric indicators [6]. It was observed that there was a relationship between the morphometric parameters of the river drainage network and the possibility of flooding. The morphometric information of the river drainage basin is very important in any project to control the occurrence of floods. In this study, morphometric parameters, using geographic information systems, were used to investigate the potential of floods in the Gulasur river basin. This will provide information about floods in the drainage basin and morphometric data for the basin. Thus, enhancing flood management in the area. Among the notable studies in this field is the study of Al-Hamdani (2015) [7] "Spatial analysis of the risks of torrents and floods in the Tangro Valley basin using remote sensing and geographic information systems", which is one of the large basins adjacent to the study area from the west. Because the study area falls within the scope of creeping faults, which were reflected on the topographical type and climate in addition to the rocky cliffs, the need has risen to know the possibility of exposure of the Gulasur river basin to flood risks according to morphometric data related to the morphological data of the river basin, terrain characteristics and linear characteristics, in addition to natural characteristics of the basin such as climate, geology and topography. The research problem was determined by the following question: What is the extent of the level of flood risk in the Gulasur basin? Is the morphometric characteristics of the basin related to an increase or decrease in the risk of flooding? Are flood peaks with long or short periods?.

Study area

The study area lies between longitudes ((45 `30- -46 `10) east, and two latitudes (^{o}36 `25-$^{o}$36 `45) northeast of Sulaymaniyah, Kurdistan Region of Iraq. The Gulasur Sour River is one of the important basins of the Qashlan river that meets the Bana River, which comes from the Iranian lands. At the Iraqi-Iranian border, the small Zab River is formed in Iraq. The total area of the basin is (556.02) km southeast of the city of Sulaymaniyah, within the administrative boundaries of the Penjwen and Chwarta districts. The river originates from the Iraq-Iran border region, from the Haoraman mountain range and the Surin Mountains. The river runs northwest, after covering a distance of (75.5 km) from its source and at the Qalqachwalan area it meets the Takaran River, to form the Qalqawalan River. The area of the basin that is located within the Iraqi lands is ((2429.7 km) at a rate of (77.3%) of the total basin area. See fig. (1).

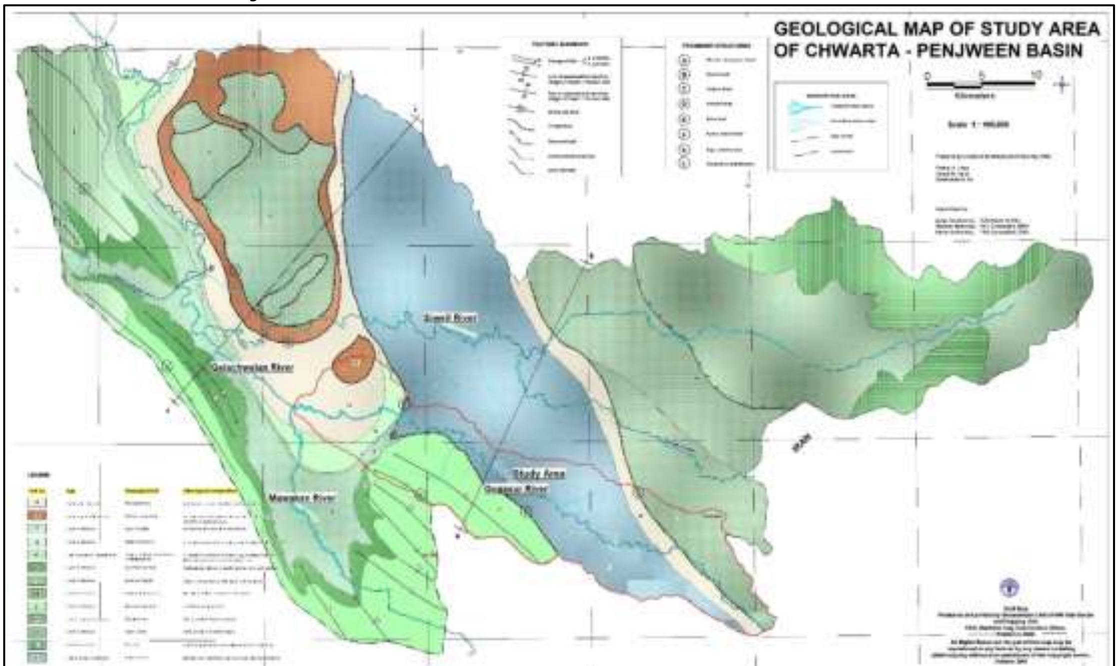
fig. (1) the location of the study area



By analyzing the climatic data of the Pengwen and Chwarta stations for the years (1941-2016), we find that the rainfall is (1864.649) mm. The average annual temperature for the study area is (14.8 ،), and a monthly average ranges between (0) for the month of K1 and (28.7) for the month of May. [8] In his message on "Spatial Variation of Spring Water in Sulaymaniyah Governorate," he found that the Penjwen station is the lowest in Sulaymaniyah governorate in terms of the rate of evaporation / transpiration, which made the area receives a water surplus of (1122.5 mm) and (578.5 mm) for the Chwarta Station, and this places the area in a very wet and humid climate.

Geologically, the region is located in the area of Miogeosyncline located to the west of the Eugeosyncline range, and is represented by the secondary Balambo-Tanjaro range, which is formed within the Alpine Geosyncline basin, the slipway sector in northern Iraq [9], to distinguish the region by containing sliding and reverse faults as a result of movement and tectonic pressure coming from the east (Iranian plate) [10], which affected along the convex and concave folds in the area towards northwest-southeast. As for the rock formations, their geological ages in the basin varied between the formations of the Jurassic era (the formation of Qulqula), the Cretaceous formations, and the fourth time formations of Paleocene, see fig. (2.(

fig. (2) geological formations and geology of the study area in the Chwarta-Penjwen basin



Geology has left its mark on the soil properties in the study area, which was generally characterized by red chestnut soils that spread in mountain valleys and mid-sloping foothills, and it contains organic materials that range between (1-4%) and less than (9%) of lime materials [11]. As for the surface layer, it is brown-red, and with its depth its texture becomes muddier, and it contains more calcium carbonate. [12] This is due to the predominance of Cretaceous formations represented by limestone rocks. And, there is the soil transferred from the higher areas to the lower slopes and to the flat areas where it mixes with rocks and various sediments to transform its characteristics into mountain soil, leaving the mountain slopes bare from the soil. Also, the soil of river banks that spread in the flat areas through which rivers and waterways pass, and around the course of the river in the lower parts of it, that the thickness of this soil varies from place to place between shallow to medium-thickness soils.

Methodology

The study adopted the topographic maps of Penjwen -NW E-38-1, Mishaf E-NW -38-1, Halabja 1-38-D-SE, and Khormal I-38-E-Sw on a scale of 1/100000, issued by Military Survey Directorate - Baghdad, first edition, for the year 1989, and the Sulaymaniyah map NI-38-3 on the scale 1/250000, Military Survey Directorate - Baghdad, for the year 2000. Geographical information systems (10.4.1) have also been relied upon in defining the area of the river basin terrain analysis using SRMs extracted from the US Geological Survey (USGS) Open Online Resources, UTM Display Type, for WGS_1984_UTM_Zone_38N. After performing some treatments on it to get rid of negative values, and then using the Tools Analysis Spatial, Hydrology tool, to determine the linear, morphological, and terrain properties of applying morphometric equations and finding the correlations between them and the possibility of flooding and the extent of flood peaks, Table (1).

Table 1. Standard Methods of Morphometric parameters

Morphometric Parameters	Methods and Descriptions	**References**
Stream order (Nu)	Hierarchical ordering	Strahler (19٦٤)
Stream length (Lu)	Length of stream	Horton (1945)
Mean stream length(Lsm)	Lsm= Lu/Nu Lu=stream length of order, (Nu)= number of stream order	Strahler (19٦٤)
Bifurcation ratio (Rb)	Rb = Nu/Nu+1 Nu+1= number of next higher order	Horton (1945)
Drainage density (Dd)	Dd = ΣLu/ A ΣLu =Total stream length(km), A=Basin area (km^2)	Horton (1945)
Stream frequency (Fs)	Fs = ΣNu /A ΣNu= Total number of stream segments	Horton (1945)
Texture ratio (T)	T=Nu/P P = basin perimeter	Smith (1950)
Form factor (Ff)	$Ff = A/Lb^2$ Lb = basin length	Horton (1945)
Elongation ratio (Re)	$Re = 2*(\pi/A)^{0.5}/Lb$	Schumm (1956)
Circularity ratio (Rc)	$Rc = 4\pi A/P^2$	Miller (1953)
Infiltration number	If = Dd*Fs	Singh (2006)
Compactness Coefficient (Cc)	Cc = 0.2841* P/A0.5	Gravelius (1914)
Overland Flow Length(Lg) Kms	Lg = A / (2 * Lu)	Horton (1945)
Longest Dimension Parallel to the Principal Drainage	GIS Software Analysis	-

Line (Clp) Kms		
Relief ratio (Rh)	Rh= H/Lb H= the difference in the elevation between the highest point of a watershed and the lowest point on the valley floor	Schumm (1956)
Relative Relief ratio (Rhp)	Rhp= H/P*100	Melton (1957)
Ruggedness number (Rn)	Rn = H*Dd/1000	Strahler (1958)
Melton Ruggedness Number (MRn)	MRn = H / $A^{0.5}$	Melton (1965)
Geometry Number (Gn)	(Gn)= Rn / Rh	Abo Reaa (2007)
Total Contour Length (Ctl) Kms	GIS Software Analysis	-
Contour Interval (Cin) m	GIS Software Analysis	-
Mean Slope of Overall Basin (ϴs)	ϴs = (Ctl * Cin) /A	Chorley (1972)
Average Slope (S) %	S = (Z*(Ctl/H) /(10*A) Z= Highest point in the Basin (m), and H= Basin relief (m)	Wenthworth's (1930)
Channel Gradient (Cg) m /Kms	Cg = H / {(π/2) * Clp}	Broscoe (1959)
Gradient Ratio (Rg)	Rg = (Z - z) / Lb	Sreedevi (2004)

Results and discussion:

1. Morphometric Analysis:

The results of the morphometric analysis of some pelvic indicators were found to find the correlation between the chances of floods and torrential rains in the Gulasur basin and some of its linear, formal and terrain characteristics, as follows:

a. Linear Aspects

The major linear morphometric parameters quantified for the basin including; total stream length, mean stream length, stream length ratio, bifurcation ratio, and ratio of each stream order are summarized in Table 1.

Stream order (Nu) has special importance in studying and understanding the hydrodynamic character of the river drainage basin, in terms of the amount of discharge, estimating the force, and sedimentary strength and the demolishing behavior of each of them - especially with regard to limiting the phenomenon of floods [13]. The study area consists of six levels. The first sewage's percentage is (87.2%) of the total waterways in the main basin, and the second rank is (10.1%). [14] The Law of Stream Length (Lu) proposed: that the total length of sewers is in a certain rank, and these lengths decrease with increasing ranks. It is one of the very important hydrological indicators for detecting surface runoff characteristics of the riverine network. The shortness of riverbeds indicates that the basin is characterized by smooth texture and steep slopes, while the more flat and steeper land is associated with long waterways [15]. As for the average length of sewers, it is the sum of the lengths of waterways in each rank to the number of streams in that rank [16]. It is a property that reveals, due to the decrease in the number of tributaries of the mattresses with increasing lengths, in comparison with the higher levels, the distinctive size of the components of the water drainage network and the surface of the basin, as these averages increase with increasing the rank [1]. With regard to the studied basin, it is noted that, due to the similarity in the basin morphology, in type, rock system, degree of slope and climatic conditions, the proportions of the increase in the length of the watercourses are similar. While the bifurcation ratio (Rb) for the Gulasur basin ranged from 2-8.6, which indicates that the rain in the basin collects in many streams, and therefore needs more time to reach the main stream due to the high branching rate, which makes the basin less vulnerable to the risk of flooding, because, the higher the branching rate, the less risk of flooding [17]. This is because there is a relationship between time and the rate of bifurcation and between the discharge and the bifurcation rate. [18] It is also one of the indicators that cut and damage the pelvic floor, and one of the factors that control the rate of drainage. [14] Strahler stated [1] that the high and differentiated values are the result of the geological and rocky development of the drainage basin. The higher the values, the stronger the structural disturbances to which the basin is exposed by shifting its basic geological structure from one chain to another. And the occurrence of the basin between the two ranges of bursting fractures and high folds, note fig. (2), subjected the basin to great tectonic disturbances that led to an evolution in its rocky and geological structure, which increased the strength of the activity and the severity of cutting in the upper parts of the basin (with the help of the very wet climate of the region). As a result of the severe slopes characteristic of the mountainous complex in them, and consequently in the development of the river network in terms of the number of streams and their branching height.

Figure 2. Gulasur River Basin

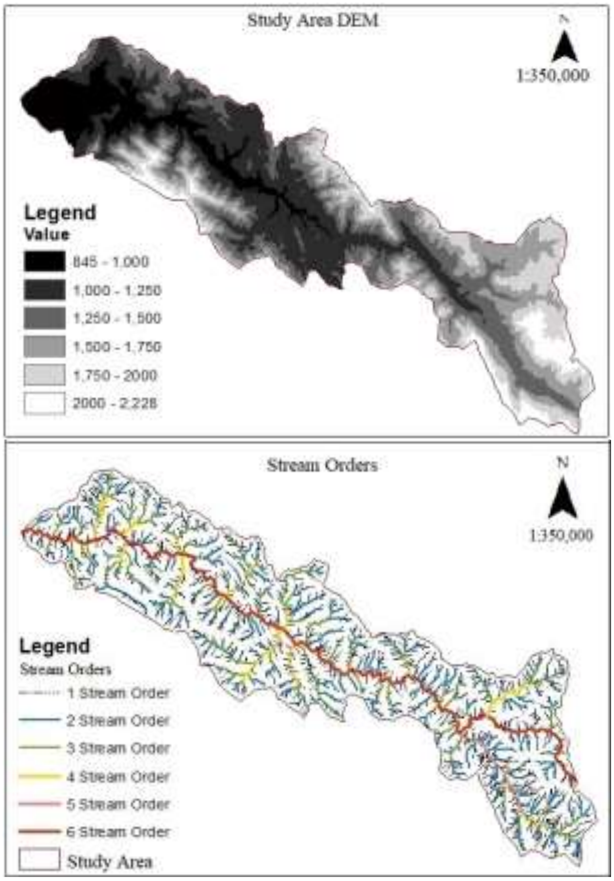


Table (1): Stream orders, stream number, and stream length of study area .

Basin	Stream Order	Stream numbers (Nu)	Its percentage of the total	Bifurcation ratio (Rb)	Total stream Length (Lu) (km)	Its percentage of the total	Mean stream Length Lsm	Stream Length Ratio(RL)
Gulasur	١	3310	87.2	8.6	1523.38	72.7	0.46	1.21
	٢	384	10.1	4.5	289.03	13.8	0.75	2.57
	٣	86	2.3	5.7	156.90	7.5	1.82	5.51
	٤	15	0.4	7.5	55.42	2.6	3.69	10.63
	٥	2	0.1	2	13.87	0.7	6.94	63.38
	٦	1	0.03		56.44	2.7	56.44	
Total		3798		Mean Rb=5.7	2095.05			

b .Areal Aspects

The value of Drainage Density (Dd) is (3.8) km / km2, which means that the Gulasur Basin, according to the classification [19], has rough texture because its values are related to direct relationships with both the terrain and the degree of slope; as the higher the degree of terrain and slope, the higher the values (Dd), and vice versa [1]. Consequently, it is an indicator of the balance between the surface force of the runoff and the rocky resistance. [15] As for Stream Frequency (Fs), it is (6.8) stream / km2, which are high values, and [4, 14] sees that the number of waterways increases with increasing drainage density due to the presence of a direct relationship between the discharge density and the river frequency in the drainage basin. It is a reflection of the topological factors, both plant and rocky, that has made it a topological feature of primary importance governing the speed of surface runoff after each torrential rain wave. The amount and intensity of rain directly affects the rate and quantity of runoff, whose speed increases with increased drainage density and river frequency. After every thunderstorm in the basin area, the amount of surface runoff that finds a path of runoff increases [20]. The pelvic texture ratio (Drainage texture ratio (T)) is an important indicator of the drainage network density, related to the quality of the subsurface rocks in the basin, its filtering capacity and the terrain side [14]. According to [19], the values of (T) are controlled by a group of natural factors, namely climate, especially precipitation, vegetation, type of rocks and soil, nomination capacity, terrain, and stage of development that has reached them. As he explained, weak rocks unprotected by vegetation are characterized by smooth texture, while hard and highly resistant rocks are characterized by rough texture. And the dry climate and sparse vegetation produces a smoother rock texture than in wet areas and for the same type of rock. According to this classification, the pelvic tissue of the study area is very fine (22.7), and this is due to its high weariness and intensity of its slopes, the spread of limestone, dolomite rocks, and the abundance of rainfall in the region.

Form Factor Ratio (Ff, Elongation Ratio (Re), and Circularity Ratio (Rc), are very important indicators in determining the shape of the basin and how close or away its shape is to the rectangular shape; which helps in understanding the hydrological behavior of a basin Drainage, and correlation [21,1] between the values of the wide diversity of geology, terrain and climate, length and frequency of waterways, land cover / land use, and patterns of water drainage. The leakage and evaporation during the flowing process from the source to the estuary, while, the circular basins are characterized by water runoffs that are not organized in time, and with relatively high expenses during the duration of the floods - as a result of the rapid arrival of high waves from the feeding area to the downstream area. That is, the duration of floods in rectangular basins lasts longer but less dangerous than circular basins whose floods are more dangerous and within a short period. [22] The values of the form factor were (0.15), (0.43), and (0.25) for the elongation, and roundness ratio respectively. According to [1] the basin of the study area is located into low value categories. That is, it extends longitudinally (with extreme elongation), surface arrogance, steep slopes, and the length of time that flood waves take to travel the distance from the feeding area to the estuary. And, despite the seriousness of the flooding, in the upper river basins due to the severity of the slopes and the degree of slope in them, the risk of flooding in the low basin. And surface runoff may be slow due to the presence of penetrating substrate layer in some parts of the basin in areas where some dolomitic Cretaceous rocks and loose fourth time deposits. As for [23], it is easier to manage floods in rectangular basins than in circular basins. The approach of the basin shape to the rectangular shape and the asymmetry between the perimeter of the basin and its area correspond to the high value of the Compactness Coefficient (Cc), which is (2.01), as the high values indicate the meandering of the pelvic circumference. That is, increasing the length of the perimeter at the expense of the pelvic area, and the approach of the shape of the basin to a rectangular shape, [24] The degree of filtering (If) Infiltration number, it reached (25.7) in the study area, which indicates a high level of runoff and a low rate of filtration in the basin. See Table (2).

Table (2) Areal Aspects of Study area

Areal Aspects	Gulasur
Area (km^2)	556.02
Perimeter (km)	166.99
Basin length (km)	61.29
Main Stream Length (km)	75.5
Drainage Density (Dd) (km/km2)	3.8
Stream Frequency(Fs)	6.8
Drainage texture ratio (T)	22.7
Form factor (Ff)	0.15
Elongation ratio (Re)	0.43
Circularity ratio (Rc)	0.25
Infiltration number (If)	25.7
Compactness Coefficient (Cc	٢.٠١

c. Relief Aspects

The major Morphometric relief aspect parameters of Gulasur River are presented in Table 3. In the study area, the Basin Relief (H) of Gulasur is (1383m), with the maximum high in the basin is (2228m) and the minimum high is (845m), which leads to high rate of runoff. The values of Relief ratio (Rh) and Relative Relief (Rhp) are, (22.58) and (828.79) respectively. Those parameters have a close correlation with hydrologic characteristics of a basin particularly the sediments loose per unit area, as well as, the high values indicate that the discharge capabilities of the basin are high [25], which reflecting the rugged topography of the area, susceptible to soil erosion and complex structures, and it indicates high discharge capabilities, due to the slope steep and the rule of the faults and fractures above the cretaceous and Jurassic rocks hardness which prevailing in the study area, which is characterized by resistance to erosion; leading to the rapid arrival of flood waves.

The Ruggedness Number (Rn) is the product of the basin relief and the drainage density. The value of (Rn) for study area is (5.21), showing the rugged topography of the area, susceptible to soil erosion and complex structures. The Melton Ruggedness Number (MRn) is an indicator of spatialized representation of basin relief ruggedness [26]. The (MRn) Gulasur River Basin is (58.7). According to [27] classification, the high value of MRn indicates that there is easy sediment production and transportation that dominated by bed loads due to basin steeper slope and rough topography. Gradient ratio (Rg) is an index to channel slope and it’s assess of runoff volume [28]. The slope of the basin and the rock characteristics control the gradient ratio. High and low values of (Rg) indicate the hilly and plain or low relief in the basin, while, the high (Rg) value reflects the mountainous nature or high relief of the terrain [29]. The main stream maximally flows through the high relief and mountainous area, and the high value of (Rg) of the study area which is (20.6) confirms the same.

Table 3. Relief aspects of study area

Relief aspects	Gulasur
Maximum high (m)	2229
Minimum high (m)	845
Basin Relief (H)	1384
Relief ratio (Rh)	22.6
Relative Relief (Rhp)	828.8
Ruggedness Number (Rn)	5.21
Melton ruggedness number (MRn)	58.7
Gradient ratio (Rg)	20.6

2**. Runoff Analysis:**

There are many experimental methods to estimate the volume of runoff; delay time, concentration time, and the extent and possibility of hazards floods in basins where field data are not available for floods. In terms of level, how they relate to a particular pattern of the amount of rain resulting from the rainstorm, and the number of iterations to express Degree of severity. For this purpose, some of these methods have been relied upon to study the expected surface runoff size, delay time, and concentration time in the studied pond as follows: a. Lag Time (tL)

Snyder (1938), based on a study of unaltered basin drainage systems in the Appalachian Highlands with an area ranging between (30-30000) km2, developed a method for the installation of hydrographic units, which are based on the relationship between the properties of effective rainfall duration (Tr), Direct surface runoff rate (Qp), rainstorm, or basin lag time (tL). [30] It mainly consists of two components including Lag Time (tL) and Peak Discharge (Qp). The delay time is calculated by the following formula:
tL = Ct (L * Lc) 0.03 ………………… .. (1)

Whereas: tL = basin delay time / hour Basin lag time (hr), L = basin length (km), Ct = coefficient (roughness sufficient) and depends on the pelvic properties, which are slope, pelvis shape and leakage. Its value ranges from (1.8-2.2), as high values are related to mountainous nature, low values to plains, and Lc = basin length from middle of basin (km) (23, 30, 31, 32, 33). A value of (2.2) was determined for the coefficient Ct of the study area. Snyder, also, suggested equation (2) to estimate the maximum surface runoff rate (Qp) using the storage coefficient (Cp) which represents the flood wave and storage conditions. Its value ranges from (0.3-0.93) with a decrease in this value if the value of (Ct) in equation (1) is high, and vice versa is true, [34.35].

$$Qp = 2.75 * (Cp * A) / tL \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Whereas: Qp = maximum discharge rates / m3 / s, Cp = Storage coefficient, A = Basin area / (km2), and tL = Basin delay time / hour. Because the volume of water discharges and floods was not recorded in the Gulasur basin, the maximum discharge volume was calculated, using the experimental formula Ball (1937) in [36] my agencies:

$$V = 750 * A (R-8) \quad \ldots\ldots\ldots\ldots \quad (3)$$

Where: V = maximum runoff, A = pool area / km2 and R = maximum rain depth in one day / mm) (calculated here according to the rainstorm 180.0 mm at Feb. 03, 2006). According to equation (3), the maximum surface runoff for the Gulasur Basin was (71.8 million m3) for the intensity of rainfall (180 mm / day), 9.2 (million m3 for the minimum rainfall (30 mm / day). As for the time required for the transfer of raindrops - such as shallow flow - from the farthest point of the basin to its mouth or to a specific point within the basin, which is known as the time of concentration (Tc) [37, 34]. It measures the time period between the end of the excess rain and the resulting surface water runoff point, and this requires the availability of complete data on rain and measurement monitors for valleys expenditures in water basins, and if it is not available, replaces them using the following forms:

Rational Hydrograph's Method [38]:

$$tc=0.00032L1^{.15}H^{-0.385} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

t*c* = Time concentration in hours, H = Basin Relief (m), L = length of waterway (m).

Model Témèz (1991) [39]

$tc=0.3[L/[S]^{0.25}]^{0.76}$……………….(5)

tc = Time concentration in hours, S = mean slope of main stream (m / m), L = main stream length (km). Accordingly, the risk of flooding in the studied basin is moderate to low, because the rate of water discharge in the basin is (163.9 m 3 / sec), which is moderate, and the length of the delay period of time (lag time) is (2.8) hours. Whereas, the running rain water is concentrated on the surface of the Gulasur Basin and collects at an average of (8.9) hours, which is a long time for the water to travel from the top of the basin to its estuary. These results are related to the large pelvic area with great elongation, and, thus, delayed arrival of runoff and flood waves to the main valley. See Table (4).

Table (4) Characteristics of surface runoff of Gulasur Basin.

t_L	V.max. ($M.m^3$)	V. min. (M.m3)	Q_p (m^3/scn.)	Tc Témèz (hr)	Tc Rational Hydr. (hr)	average Tc (hr)
2.8	٧١.٨	9.2	١٦٣.٩	١١.٥	6.4	8.9

CONCLUSION

Morphometric analysis is an important means in studying river floods, their severity, frequency, soil erosion and their relationship to slope, environmental data and other aspects related to the hydrological behavior of rivers. The values of the basin shape indicators such as the elongation ratio (0.39), the circular ratio (0.25), and the form factor (0.12) indicate that the basin with an area of 556.02 km2 is one of the rectangular basins with a high degree of damage in which the values of each of the basin ratio in the basin Relief ratio is raised. (Rh) (20.84), Relative Relief (Rhp) 828.19, and lower infiltration number (If) filter rate (25.74) are due to higher surface runoff and lower leaching percentage in the basin, higher discharge density, stream frequency fs (6.83), and Drainage density Dd (3.77). Also, the high rate of branching Rb, and its average height increased to (5.7) which had a hydrological response such as volume of runoff, delay time and discharge rate creating low groundwater potentials, and a high contribution to runoff. Thus, increasing the chances of water gathering in the main river course leads to increase the chances of flooding, however, the length of distance that it travels from the top of the basin to the estuary due to the morphological characteristics of the basin which made this running surface water a moderate waves of moderate danger late. This raises the surface water supplies needed for various development projects; especially, the development of water resources in the eastern part of the Kurdistan Region of Iraq such as water energy, and agricultural projects.

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