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Correlational relationships between morphometric and hydrological variables of the norther mountion Bekhir Basins, a comparative study (SCS-CN) using modern technologies

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***Abstract*---**The research aims to reveal the analysis of the hydrological characteristics of the northern mountain Bekhair Basin within the Sulaymaniyah belt, and its area is estimated (264.22 km2). Its rocky and sedimentary formations date back to the triple and quadruple periods of sandstone, limestone and gypsum rocks located astronomically between two latitudes. (37o01’00”-37o08’00”) north And longitudes (42o20’00”-42o50’00”) east, while administratively in Dohuk Governorate it extends from Dohuk to Zakho, along the village of Fishkhabur at the Iraqi-Turkish border, and lies within the semi-arid climate that is characterized by high temperatures and its average during the month of July (34, 33.7) centigrade respectively for the two stations of Dohuk - Zakho and the annual rainfall amounted to (512.7, 559) mm respectively The hydrological characteristics of the basins were studied showing the possibility of generating water flow in the study area, in addition to the possibility of constructing additional dams to store water and benefit from it for the daily uses of shepherds and drinking Animals in the Chided period. It was found that the basins have shapes that tend to elongate and this reduces the possibility of flooding, and the slope is very steep as the slope of the study area reaches to (11.5) m/km.

***Keywords*---**poly aromatic hydrocarbons, modern technologies, relationships, vegetables.

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Introduction

River drainage basins are the basic spatial unit for conducting quantitative research of river basins for the purpose of measuring the natural characteristics of river systems or valleys. Of the laws, most of which are based on Horton's 1945 laws, in addition to the different methods of many researchers such as Streller 1952, Shum 1965, Miller 1985 and others. The researcher used the descriptive and analytical method together, using the quantitative method and field work, and relied on topographic maps with a scale of 1:2,500,000 for the year 2010 and digital elevation maps (DEM) from which the water network was derived. Morphometry is defined as the science of measuring the geometric properties of the earth's surface resulting from river erosion factors and depends on the analysis of elevations and slopes directions. The groundwork in order to lay the correct scientific foundations to take advantage of the available resources within the study area.

From this point of view, the study came during this research to analyze the hydrological characteristics in the study area and a comparative study (SCS-CN) and study the correlational relationships between the morphometric characteristics as well as the statistical analysis of the correlation between the hydrological variables and the characteristics morphometric. Hydrological studies are one of the branches of geomorphology that has attracted the interests of geomorphology due to the available scientific and accurate measurements of basins and helps the researcher understand many phenomena and land forms in order to lay the correct scientific foundations to take advantage of the resources available within the study area. From this point of view, the study came during this chapter an analysis Hydrological characteristics in the study area and a comparative study (SCS-CN) and a study of the correlational relationships between the morphometric characteristics as well as the statistical analysis of the correlation between the hydrological variables and the morphometric characteristics

The study is the main and main axis in all studies, including geomorphological and morphometrics , which are drawn according to accurate scientific steps, the aim of which is to find treatments and possible solutions to them. The main research problem is (what are the prevailing geomorphic factors and processes in the study area and what is their role and impact in determining the hydrological characteristics of the basins). It can be focused on sub-problems of them.

- What are the morphometric characteristics of the basins of the study area?
- What are the hydrological characteristics of the basins of the study area? Is it possible to generate water flow in the study area?
- What are the correlations of morphometric and hydrological variables?

Research hypothesis

A hypothesis is defined as a guess or conclusion reached by the researcher and temporarily adheres to it based on what he possesses of scientific explanations and ideas related to the research problem.

- The characteristics of the basins of the study area vary in terms of the difference in extension, area, perimeter, gear ratio, ruggedness value, relative topography, hypometric integration, stream survival coefficient and inflection.
- The values of concentration time, deceleration, speed and volume of flow, duration of gradual rise, time of floods, time of concentration and duration of maximum flow of torrents vary, and it shows the possibility of generating water flow in the study area.
- The correlational relations between the morphometric and hydrological properties vary, they are positive, significant and insignificant, and inverse, significant and non-significant.

Research Objectives

Knowing the natural and influencing factors in determining the geomorphology of the northern basins of Mountain Bekhair?

Studying the quantitative analysis of the hydrological characteristics of the basins of the study area and highlighting their hydrological characteristics. Uncovering the potentials and investing them economically, as well as studying the human uses of the land and their relationship to the geomorphological characteristics of the study area.

Research Methodology and Stages

The study followed the descriptive and quantitative analytical method, and this methodology passed through several stages, including:

- The first stage - data and information collection: Information and data were collected at this stage from scientific and international books and published and unpublished government statistics. Satellite images of the study area were collected by the American satellite (TM 2010 Land sat) and various thematic maps of the study area were collected.
- The second stage: work The field study is considered the main pillar of the research, and this stage was carried out through repeated field visits during the study period on (9/13/2021AD until 9/20/2021AD) and the second period from the date of 3/26/2022 until 1/4/2022AD
- Fifth- The area and limits of the research: From the administrative side, the study area is located within the governorate of Dohuk, and it is limited to two latitudes (37 02 00– 37 09 35) 42 20 10-42 49 50) in the north and longitudes (to the east, but from the natural point of view the basins of the study area are In Dohuk and Zakho, an extension of the village of Fishkhabur on the Iraqi-Turkish border, and its area is (264,22) km2 (Map - 1, 2).

Natural factors affecting the morphometric of the basins
Geological Structure

(Map-3) The study of the geological situation is important in geomorphic studies, as the structure is the dominant factor in the development of land forms that

William Morris Davis referred to, that the land forms are controlled by the structure. And the process and the stage and that the stage is the dominant factor in the development of the manifestations of the forms of dry land, while the structure shows the characteristics of the rocks and the extent of their exposure to movements of torsion and fractures and what appears on them from the cracks and breaks (Karbal, 1986).

Geological formations in the study area

(Geological Formations: the exposed rock formations in the study area vary according to the different environment of their deposition, as some were deposited in continental conditions resulting from marine decline, while others were deposited under marine conditions resulting from marine progress , The ages of these formations range from the Eocene and Middle Miocene eras in the Tertiary period and the Pleistocene and Holocene eras in the Quaternary time. The following geological formations are revealed in the study area from the oldest to the most recent (Map-4).

Triple time formations

Five geological formations are revealed and they are as follows:

- First: The formation of the vent (Middle Miocene Fatha Formation) (Fouad & Wafa'a, 2009). The geological age of the vent formation dates back to the Miocene era, whose date is set at (20) million years (Wicander & Monroe, 2015). It consists of gypsum, limestone, sandstone and clay. In the eastern part of the study area.
- Second: Mukdadyah formation (lower Miocene-Pliocene mukdadyah formation): Mukdadyah formation is revealed in simple parts from the western side, while the largest part is concentrated in the eastern part in the study area and consists of gravel sandstone and alluvial mudstone with complex rocks occupying an area of (42 km2). And the percentage (16%) (Hritz et al., 2020).
- Thirdly, the Upper Miocene Enjana Formation: This formation is revealed in the eastern part of the study area and in separate parts along the study area and occupies an area of (9 km2.9), and (3.8%) consists of lead brown sandstone (Benedek & Ivan, 2018).
- Fourth: The Bey Hasan Formation (The Upper Bakhtiari) Pleistocene: This formation is revealed in the east and north-east of the study area and consists of a thick layer of coarse dams with a thickness ranging between (50-80) m. It contains a layer of brown mudstone and another of sandstone and forms an area. (29.8 km2 at a rate of (11.3% (Benedek & Ivan, 2018).
- Fifth: Pilaspi formation (middle and late Eocene pilaspi formation): This formation unfolds in the southern part of the study area in the form of a strip extending from east to west, consisting of applied limestone. The rocks of this formation are solid, non-porous, occupying an area of (51.22). km2 at a rate of (20%) (Benedek & Ivan, 2018).

Quaternary Time Deposits

Quaternary time deposits in the study area are not strictly limited due to the lack of absolute age data for the ages of the main stratigraphic divisions. The sedimentation period goes back to the Pleistocene and Holocene eras. The sediments of the study area appear in the following forms, including:

- First - Slope deposits: Pleistocene and Holocene deposits: These deposits appear in the northeastern and central part of the study area and consist of silty clay materials and gravels of different sizes and occupy an area of (43.65 km2) and a percentage of (15.6% (Deikran, 2008).
- Second - Mixed deposits (Pleistocene and Holocene): They are found in flat lands, slopes, and undulating plains, and they are of many types consisting of silt and clay with mixed sand, gypsum, large and small local rocks and some broken and crushed rocks and occupy an area of (73.42 km2) and a rate of (27.9%) (Ogg et al., 2016).

Surface features

The surface features and the degree of its slope play an important role in knowing the speed of flow in the study area and the activity of geomorphic processes, as well as the influence on the elements of climate, soil formation, density and diversity of vegetation cover. The study area is located within the mountainous region in northern Iraq. Within the alpine system. and the Sulaymaniyah Belt of Zakho. Dividing the study area on the basis of height into three main units:

- Plain land units: This unit occupies a large part of the study area as it reaches (150,62) by (57%) of the total area, and the lands of this unit are confined between the elevation lines (330-608.3) m above the level The sea surface, and they are known as low areas formed by the sediments transported from the highlands and crossed by a network of valleys (Benedek & Ivan, 2018).
- Mountain foot units: They are lands with open terrain and reach a height of (600) meters above sea level, located to the south of the plain land units area, and extending from the southeast to the southwest to the west. 866.7 meters above sea level and occupies an area of 89.41) km2 and a percentage of (33.8%) of the total area of the study area) (Benedek & Ivan, 2018).
- The unit of heights (high mountains): they are high areas with a height of more than (866.8-1125) meters. These lands form areas that divide water into the basins of the study area and are confined between two contour lines (970-1125) meters above sea level and occupy an area It reached (24.19) km2 or (9.2%) of the total area, and it consists of slopes that form many watercourses, especially the first and second lower riverine ranks because they are areas with high altitudes, because they receive very high rainfall and are a source of superficial nutrition for valleys and basins. The study area occupies the southern part, which is in the form of a strip extending from east to west of the study area The gradient of the study area is (11.5) m/km (Benedek & Ivan, 2018).

Map 1. The location of the study area from Iraq and Dohuk Governorate and Map 2. The location of the study area

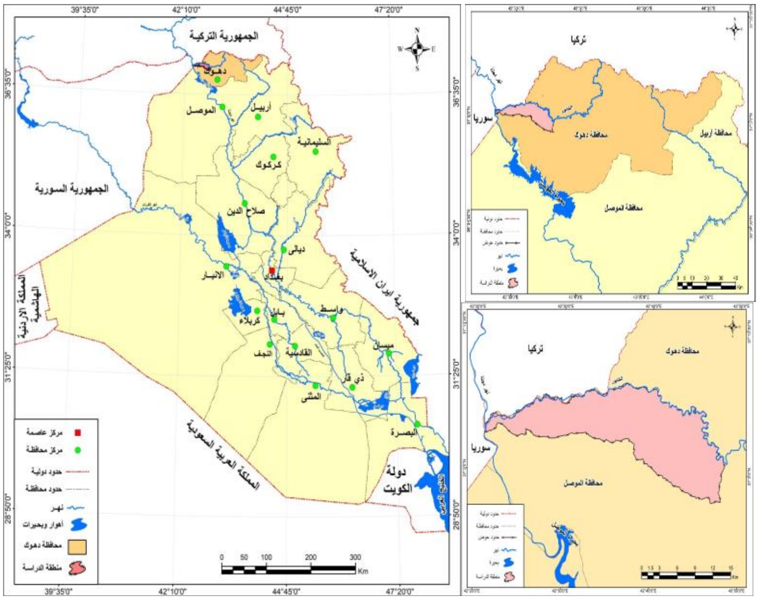

Figure 1. The location of the study area in Dohuk Governorate, Iraq
Source: the researcher's work based on the administrative map of the Republic of Iraq, the radar visual of the study area DEM, accuracy (30) based on the (Global Mapper 18) program

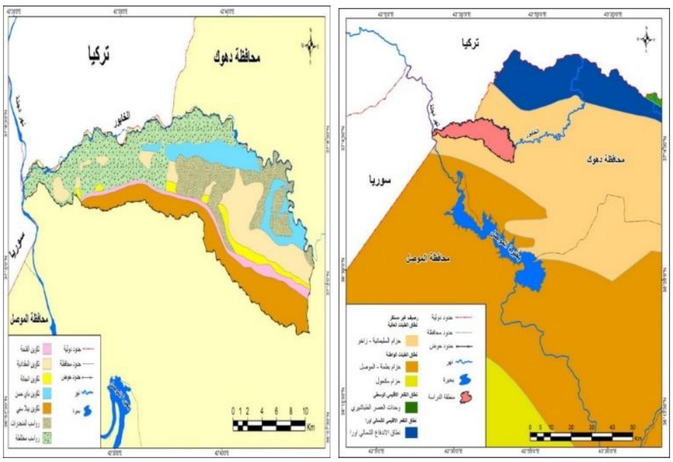

Figure 2. Map 3. Structure of the study area and Map 4. Formations in the study area
Source: The researcher's work with the approval of the ministry of industry and minerals, the general organization for geological survey and mining, the structural map of Iraq, the radar visual for a scale area of 1: 1000000, 1996, the american satellite Landsat based on the satellite image (oli 8)

Climate characteristics

To show the impact of climate in the study area, the available data were analyzed in the two climatic stations of Duhok - Zakho for the period from (1990-2019) according to the elements of climate and my agencies (Table 1-2):

Solar Radiation

It is evident from the data (Tables 2-3) for the two stations of Dohuk - Zakho. The climatic elements vary. We note that the monthly average of the angle of incidence of solar radiation varies, as it was recorded in December (30.5 and 29.92) degrees, respectively, and the highest values during The months of June reached (77, 76.42) degrees, respectively, due to the fall of the rays perpendicular to the orbit of cancer in the month of June. While we note that the monthly average of the amount of solar radiation varies between the months of the year, where during the month of December it reached (4.7, 4.1) milliwatts / cm2 and in the month of June it amounted to (11.5, 11.4) milliwatts / cm2, respectively. As for the theoretical brightness hours, we notice an increase in the monthly average of the theoretical brightness hours starting from the month of March for the transmission of the sun's rays to the equator, as the number of theoretical brightness hours reached (11.23, 11.1) hours / day in a row, and it continues to increase during the month of June to reach (12.44, (12.4 hours / day) respectively due to the vertical fall of the solar rays, and then begins to decrease during the month of January 9.45, 9.6) hours / day respectively, given Due to the presence of clouds and weather changes, the number of hours of actual brightness was (4.5 .). , (3.09 hours / day in a row for the month of March, and it continues to increase during the month of June to reach (10.4, 10.48) hours / day in a row, due to the vertical fall of solar rays, while the annual average of temperatures reached (20.35, 20.3) Celsius, respectively While the average maximum temperature reached (26.12, 26.4) Celsius, respectively, and the average minimum temperature (14.54 and (14.3 Celsius) respectively, with the lowest monthly average maximum temperature in January (11.5 and 12 Celsius) respectively, while the highest average The monthly maximum temperature in July was (41.5, 41.3 degrees Celsius, respectively, while the lowest monthly average for the minimum temperature was in January, 3.1, 3.2 degrees Celsius, respectively, and the highest monthly average minimum temperature was recorded in July Also (26.5 and 26.1 degrees Celsius, respectively, while the highest average monthly temperature range was in July, 15.2 degrees Celsius, and the lowest was in January, where it reached (8.3, 8.6) degrees, respectively, while the temperature range recorded The annual temperature is (11.48, (11.9). As for the winds, we notice that the wind speed varies in the study area, as the rates range Its monthly rate is according to the months of the year, and its highest speed is in the summer months (April and May-June), as it reaches (1.6, 1.6, 1.7) m/s respectively for the Dohuk station, while the Zakho station recorded less for those months (1.24, 1.62, 1.62) m/s During the winter, the lowest months were recorded for the month of December for the Dohuk-Zakho station (1.2), (0.87 m/s, while the annual rainfall amounted to (512.7, 559) mm, respectively, as the rain falls in the month of September and ends in July and is absent in the summer months due to the fact that the region falls within the semi-arid climate, which is characterized by high amounts of solar radiation and temperatures. As for the relative humidity recorded during the winter season, the highest percentages were recorded in January, reaching (67%, 55%) respectively, while the relative humidity decreases during the summer months. The summer season due to the high temperatures, the increase in wind speed and the lack of rain so that it is less valuable during the summer in the month of August, when its lowest rates were recorded (20.07, respectively), while the total annual evaporation amounted to (1861.9, (1914.78 mm) respectively and to calculate the evaporation rates / Transpiration and application of Najib Kharoufa equation as follows (Chenoweth et al., 2011).

$$\mathbf{ETO} = \frac{\mathbf{P}}{\mathbf{3}}\,\mathbf{C}^{\mathbf{1.31}}$$

ETO: latent evapotranspiration (mm), P: the percentage of the number of hours of sunshine per month in relation to the number of hours in a year. C: the average monthly temperature (°C). It is clear according to Najib Kharoufa's equation for the study area, the total evaporation / transpiration amounted to (2669.9), 2736 mm, respectively, and to determine the type of climate, the following Köppen equation was applied (Shehab et al., 2014).

$$\mathbf{R} = (\mathbf{0.44\,T} - \mathbf{14})/\mathbf{2}$$

R: dryness indicator, T: average annual temperature (F) = (68.63 .68.62)

The drought index reached (8.09) and (8.07), respectively, according to Köppen classification, so the study area is a semi-arid area.

Characteristics of Soil: (Characteristics)

A developed natural body that has certain chemical, physical and biological characteristics. The formation of the soil from the interaction of multiple factors, some of which are geomorphic and others are related to soil science, and the soil is the direct product of the various weathering processes and the word soil is applied to The upper layers of the surface (Saha, 2012). Buring classified the soil of the study area into the following sections (Map-5) (Lohani, 2016).

- Deep chestnut soils: These soils have developed in areas with little rain, as the vegetation cover is in the form of short weeds and is rich in calcareous materials, minerals and calcareous materials, and occupied an area (141.18 km2) and a percentage (53.8%) of the total area (Chen et al., 2022).
- Cracked rocky soil: They are cracked rugged, shallow, shallow rocky soils that are newly formed, with a dark brown color that tends to several changes in the sloping areas and increases slightly at the feet of the mountainous slopes, forming an area (65.13 km2) and a percentage (24.6%) of the total area (Benedek & Ivan, 2018).
- Chestnut shallow stony sloping soil: characterized by its dark brown color in its upper sections, its thickness (0-3 cm), and it is fragile and contains organic matter, and it occupies an area (35.16 km2) and a percentage (13.3%) of the total area (Benedek & Ivan, 2018).

- River shoulder soil: They are located in the north of the study area, which extends from thenortheastern part to the northwestern part in the form of a strip. (5.6%) [18] of the total area.
- Soil in the stomachs of valleys: This type of soil is found in the northwestern part and some scattered parts are scattered in the study area. It is characterized by the presence of clay, silt and sand, and because it is movable soils that are deposited in the mouths of the valleys, occupying an area of (3.63 km2) and a percentage of (1.4%) (Benedek & Ivan, 2018). of the total area.
- Depression soil: the largest part of it is concentrated within the northern central part of the study area, while there are other parts within the southwestern part of the study area, occupying an area of (3.4 km2) and a percentage of (1.3%) of the total area (Benedek & Ivan, 2018).

Analysis of morphometric characteristics

We note from (Table -3, 4) that the values of the basins of the study area vary. We note the lowest values of the molar ratio reached at the eleventh basin, which amounted to (25.3) m / km, while the highest values recorded within the eighth basin, as It reached (115.6) m/km. As for the texture of the basins, the lowest value was recorded in the tenth basin, which amounted to (1.9) watercourses / km, while the highest value in the eighth basin was (8.2) watercourses / km, while the terrain reached The relative lowest value was at the fourteenth basin (16.2 m/km), while the highest value was recorded at the seventh basin (60) m/km. As for the roughness value, we note the variation in the values. The lowest values were recorded for the first basin, which amounted to (0.1) in the highest values. At the seventh basin, as for the hypometric integration, the lowest value was recorded in the ninth basin, which amounted to (0.008) km 2 / m. The highest value recorded at the fourteenth basin was (0,08) km 2/ m.

Analysis of the hydrological characteristics variables

The study of the hydrological characteristics of the drainage basins is a reflection of the climatic and topographical conditions of the basins of the study area, and understanding these characteristics helps to know the quantities of the torrential water of the basins and the extent to which they are useful, as well as knowing the dangers of torrential rains on lives and property, and the hydrological characteristics are analyzed Through (the study area reached 16 basins). It is represented by:

Factors affecting the torrential rains
Time of concentration

It is one of the hydrological variables to know the time covered by the water to reach the estuary, which shows the estimation of the level of water flow, whether it is high, medium or weak. There are statistical methods for calculating The concentration time and the fact that the study area is located within the semi-arid region, it was relied on the following (Jaton) equation in extracting the concentration time according. Map-5 Soils in The Study area

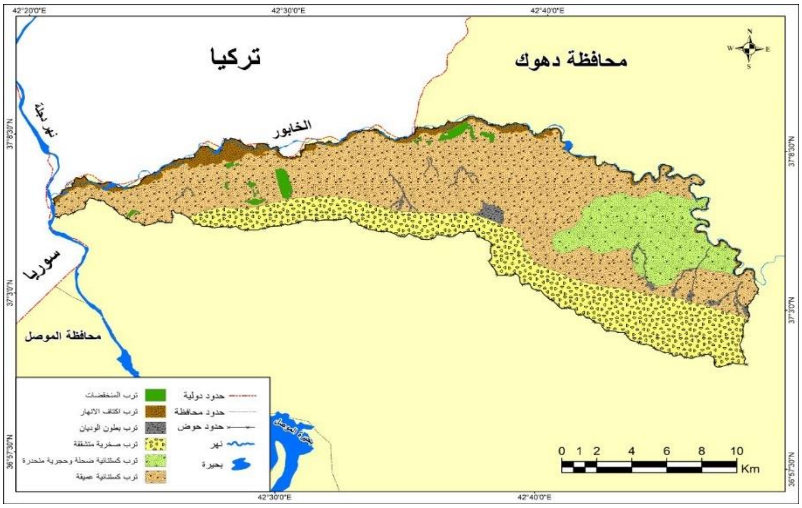

Figure 3. Soils in the study area .
Source: Ministry of Industry and Minerals, General Organization for Geological Survey and Mining, geological map of Dohuk and Zakho at a scale of 1: 25000, Dohuk, 2012, based on Bjornck classification

To the following equation * We note that the values vary between the basins of the study area (Table-3) (Al-Dujaili, n.d.).

$$Tc:\ \frac{\begin{matrix}1.15*\\(L)\end{matrix}}{\begin{matrix}0.38\\7700(H)\end{matrix}}$$

TC: time of concentration (hours), L: length of stream (m), H: rate of height of the basin (m).

Lag time

It represents the time interval between the beginning of rain and the beginning of the peak flow, and it is called the response time.
The aim of the study of the deceleration time is to know the time required for the beginning of the flow and to calculate the loss of leakage, as well as to know the loss of the drainage basins in the study area. Study area (Table-4) (Raghunath, 2006).

TP(hr):Ct (Lb*Lca)^0.3

TP (hr): deceleration time Ct . : The peak flow time coefficient, which is specific to the nature of the basins and its slope, its value is (1,2).
Lb: the length of the stream (km). Lca: the distance between the mouth of the basin and its center of gravity (km).

Flow Velocity (V)

It is one of the hydrological variables that measures the velocity of the flow, and it is an important indicator in knowing the danger of the drainage basins during the surface run-off. In addition to calculating the speed and the distance it travels when dividing the distance by time, and the speed of the flow can be calculated, we note that the values vary between the basins of the study area (Table-5) (Tsanakas et al., 2016).

v: the velocity of the surface runoff of the basin. L (M): the length of the basin (m). Tc (S): time of concentration (hour, second, minute).
V(M/S): 〖(L(M))/(3.6 TC(S).(

Base time for torrential flow (Tb)

It means the time period for the occurrence of the flood from the source to the drain basin, this period is similar in its changes with the changes of the delay time (hour), and the results are extracted according to the following equation, and we note that the values vary Among the basins of the study area (Table-5) (Raghunath, 2006).

Tb:(days):3+ (Tp) (hr) /8
Tb (days): the base time of the torrent (day). Tp (hr): the response period of the water basin to rainfall, an hour (the time of deceleration).

The duration of the gradual rise of torrential flow

The duration of the gradual rise of torrential flow Tm (hr) means the time period from the beginning of the flow at the bottom of the watercourses to its peak period, and the longer the period of the gradual rise of the torrential flow in the area becomes shorter, which led to the lack of water for much In the bottoms of sewers and valleys at the time of precipitation until the beginning of the run-off, the results are extracted according to the following equation, and we note the discrepancy in the values for the basins of the study area (Table-4) (Mohideen & Rahaman, 2021).
Tm(hr): (1)/3 Tb (hr).(
Tm: The duration of the gradual rise of the torrent flow (hours) is the time period from the start of the torrent to a peak period on the curve, TP (hr): the base time of the torrent (hour). The duration of the gradual decrease in the flow of torrents (Td):

- It is defined as the period of time that takes during the process of the basin water flow from the source to the estuary, and it is calculated according to the following equation.
- When the equation is applied to the basins of the study area, we notice that the values of the basins vary (table-5)
- Td(hr): 2/3 tb (hr)
- Td(hr): duration of the gradual decrease in torrent flow / calculated / hours, tb (hr): base time, calculated in hours.

Estimation of the duration of the torrential runoff:

- It means the time period that the water takes through the basin courses and their tributaries from the source to the estuary, and it is extracted according to the following equation(el-fakharany & mansour, 2021).
- When applying the equation to the basins of the study area, we note that the values of the basins (table-5).
- T:n*tp(hr)
- T: the time taken to complete the flow process until the end of (hour). N: a second value of (5) tp (hr): lag time (hours)

The flood coefficient

- It is one of the hydrological variables that increases the flow of water towards the sewers and basins, and then the arrival of the flood peak to the end of the basins. The flood coefficient was calculated using the jaton equation (perdibon, 2021).
- *flood coefficient: the longitudinal drainage density of the basins (km/km2) x the frequency of the first-order sewers (stream/km2) for the basins of the study area..
- When the equation is applied to the basins of the study area, we notice that the values of the basins vary (table-5).

Hydrological budget for the basins of the study area (rainfall concentration Rain concentration for peak stream flow

- It shows the amounts of the lowest amounts of rain that occur surface run-off in the basin, and it is estimated in (cm/hour) and is extracted according to the following equation.
- When the equation is applied to the basins of the study area, we notice that the values of the basins vary (table-5)
- (i(cm / hr):1/ tr(hr
- I(cm-hr): precipitation concentration (cm/hr) / tr(hr): the ideal time period of precipitation calculated (hour).

The ideal time period for rain falling in the drainage basins (tr (hr)

- Shows the period to know the sufficient time for the falling rains that lead to the occurrence of run-off in the valleys after the losses by leakage and evaporation, and it is used when the period of rain does not exceed the time of concentration for the water basins, it is measured in the basins of the study area (white, 2002).
- When applying the equation to the basins of the study area, we note that the values of the basins (table-5).
- Tr (hr): tp (hr) /5,5
- Tr(hr): the ideal time of rainfall (in hours) / tp(hr): the period of response of the water basin to rainfall (hours).

The value of the maximum flow of torrents

- This value is used to indicate the maximum flow of torrential water that reaches the peak of its flow that reaches the streams of the valleys and is a strong torrential activity, which produces torrents and is extracted according to the following equation * (alley et al., 1999).
- When the equation is applied to the basins of the study area, we notice that the values of the basins vary (table -6).
- Qp(m3/s) : (cp*a)/(tp(hr)
- Q p (m3/s): the maximum flow rate of torrents in the drainage basin (m3/s). Cp: a coefficient that relates to the capacity of a drainage basin to store water, its value between(4,5). A: basin area km2: tp(hr): duration of drainage basin response to rainfall (hour).

The specific peak flow of the water basin QP

- The value of the maximum flow of torrents per one square kilometer and it is extracted (Salman, 2014).
- Qpm3/s/ km2): (Qp(m3/s)/(A(Km2).
- qp(m3/s/km2): the specific peak flow of the water basin. Qp(m3/s) : the value of the maximum flow rate of the water basin (m3/s). : A(Km2) The area of the basin (Km2).
- When the equation is applied to the basins of the study area, we notice that the values of the basins vary (Table -6).

The volume of flow (QT)

It is the amount of water that flows into the drainage network in the basins, and it occurs when the rainfall exceeds the amount of losses and the quantities of leakage, when large quantities of water are concentrated in the basins or in part of them, and when That is, the speed of water flow is high during the rain storm due to the lack of evaporation losses, which leads to the occurrence of flooding, and to measure the volume of flow in the basins of the study area, we apply the following equation .(Shuster et al., 2005)

$$QT\ (m^3\ /s): \sum L\ (KM)^{0,85}$$

QT (m3/s): volume of flow (thousand m3). L(km)∑: the sum of the lengths of the basin's ducts (km). 0.85: a constant exponent .When the equation is applied to the basins of the study area, we notice that the values of the basins vary (Table -6).

Fixed seepage value Fp

It means the maximum rate of water penetrating into the soil, and the rate of leakage varies according to the type of soil, as it is low in wet soils when a rain storm occurs, and the filtration speed varies for a specific rainstorm during a period of time and reaches To the constant value when a long period of time has passed, and it is called the final filtration speed, and it is extracted according to the following equation *(MOHYELDEEN, 2020).

Fp: A*Td*0.0158

Fp is the constant leakage value (m3) / A. Area (km2): Td the gradual decrease in torrential flow (hour). When the equation is applied to the basins of the study area, we notice that the values of the basins vary (Table -6).

The volume of the torrent flow AL

The torrent flow is calculated through the following equation (Dawod & Al-Ghamdi, 2017).

$$\mathbf{AL\ (Hm3)(10^{6}\ m^{3})}: \boldsymbol{Qp(m/\,s)}\ \mathbf{(TM(}\boldsymbol{S}\mathbf{)\ \ 10-6\ )}$$

AL: (Hm3) (10 m) volume of torrent flow: Qp(m/s) value of maximum flow of the water basin (m3/s): (TM(S) 10-6) Gradual rise of torrent flow (sec.(When the equation is applied to the basins of the study area, we notice that the values of the basins vary (Table -6).

The strength of the torrent (A)

It occurs as a result of heavy rain on sloping and weak surfaces because it is rocky. The strength of the torrent varies based on several factors, the most important of which is the suitability of the surface, the amount of rain and the intensity of rain, which is the relationship between the amount of torrential flow and the area of the basins is calculated The strength of the torrent through the following equation * (Khalifa et al., 2022).

$$\mathbf{A(m3/}\boldsymbol{km2}\mathbf{)}\frac{\boldsymbol{QP}\mathbf{(}\boldsymbol{M3/S}\mathbf{)}}{\sqrt{\mathbf{A(KM2)}}}$$

A(m3/km2): torrential force QP(M3/S): the maximum flow value of the water basin (m3/s). A(.km2): area (km2). When the equation is applied to the basins of the study area, we notice that the values of the basins vary (Table -6).

Hydrological Model of Soils Comparative Study (SCS-CN)

The study of drainage basins in any area, whether dry or semi-arid, receives quantities of rain that are seasonal or semi-seasonal, which is represented by the intensity of rain. The most intense and sudden and the most amount on the generation of runoff in the study area, and it is not possible that the basin's reception of rain generates surface runoff due to the overlap of a group of different factors working to lose part of that water received by the basins of the study area, and these factors (evaporation, Surface storage, seepage) and human factors, as well as the natural components of the basins, as they work to increase the losses or increase the quantities of surface runoff, as the natural components of the basin work, including the increase in porosity, which weakens the ability to generate runoff.The (SCS - CN) method requires many equations and procedures to obtain accurate surface runoff estimates to complete the selection of water harvesting. The approved equation for measuring the runoff curve according to (USDA,1986,p,2-3) is (U. S. Department of Agriculture, 2009).

$$Q=((p-La)^2/((p-La)+s) \ . \ . \ . \ .(1)$$

Q = depth of runoff (inches)
P = Rainfall (inches)
La = the initial objections by the soil and plants before the start of the runoff such as (seepage and evaporation)
S = maximum runoff after runoff (in).
And found (La) is equivalent to one-fifth of the value of S)) and calculate La according to the following equation:

$$La=0.25*S \ . \ . \ . \ .(2)$$

In order to calculate the value of (S) in the following mathematical formula:

$$S=1000/CN-10. \ . \ . \ . \ .(3($$

It is noted from the data input that it was in inches, so it requires reformulating the equation to match the metric scales.

$$S=25400/CN-25......................4$$

And the numbers (P, Q, La, S) The equations were entered in the program (ARC GIS 10.4) and through the cellular calculator (Paster Calculator), within the functions of the spatial analyzer to extract the volume of surface runoff through the following equation (Hameed, 2013):

$$QV=(Q+A/1000) \ . \ . \ . \ . \ (5)$$

QV = runoff volume (m3/year)
Q = runoff depth (mm)
A = the area of the area (km2), and the unit (9000 m2) was used, which represents the size and argument of the cell, in order to calculate the volume of flow at the cell level.
100 = conversion factor results in meters (m3).
The method is disposed of in the following stages:-

Extraction method (CN)

This method is used to distinguish the characteristics of rain and for a specific type of hydrological soil, land covers and land uses (Combine, and the value ranges between (0-100) expresses the water response of the components of the study area basins between permeability High and low, the higher the value towards (100), the surfaces of the basin are less permeable, and if the value heads towards zero, the surfaces of the basins are highly permeable (Elezovic, 2021).

Classification of vegetation cover and land uses for the basins of the study area

It was relied on satellite visuals of the European moon (2A Sentinel) and dated (20-1-2022 AD) with an accuracy of (30 AD), a process aimed at clarifying the types of vegetation cover spread in The basins of the study area and the land cover was classified on the basis of the following relationship (Map-6) (Table-6) (Mohamed et al., 2008).

(B8+B4)/ NDVI=(B8-B4)

- Agricultural lands: The lands that have been cultivated without treatment and soil protection and are concentrated within the plain lands in the middle and at the mouths of the basins selected from the study area because the soil has a clay texture and is rich in organic matter. Underground (eyes and wells) Agricvlture, Washing Gton D,C (1986) .
- Rocky lands: These are rocky lands that are bare of soil and open lands and are unsuitable for agriculture or human use. The rocks are exposed. The surface run-off and the rate of infiltration are determined by the rate of porosity and the degree of permeability for this type of land cover.
- Residential use: It means urban growth lands, transportation network roads, paved roads and irrigation for the basins of the study area.
- Slopes soils: These soils were formed as a result of sediments that were washed away by torrents and rains, most of which are silt and clay.
- E - Transportation routes: They are concentrated in the study area near the sources of the valleys in the regions.
- Forests: Forests are spread over the steep slopes of the Bekhair mountain chain, and they are concentrated in the middle of the study area.

Hydrological Soils

The classifications of land cover and land uses in the study area were previously specified as it affects the surface runoff and its nature in the region, so the identification and classification of soils in the study area in terms of porosity, permeability and their ability to retain water according to the rate of velocity Water transfer or infiltration into the soil or the distinction between water levels within the soil (Map-7 and (Table-7).

- Hydrological group (A): These soils are highly permeable, have a high percentage of sand, gravel and boulders, and low adhesive substances.
- Hydrological group (B): This group consists of soils with a coarse texture to a medium texture, with depths and permeability between medium to fine, and it consists of a mixture of boulders, pebbles, rock fragments and gypsum.
- Hydrological Group (C): These soils consist of pebbles, boulders and stones covered with a layer of fine sand and clay, with high permeability and porosity, dark brown in color because they contain oxides.

- Hydrological Group (D): This type of soil is found in the southwestern part of the basin and at the first level. It consists of a clay layer with a shallow soft layer close to the surface.

Extracting the value of the curve (CN) for the basins of the study area

that these levels have values of (CN) in the study area that determine the level of soil moisture in order to calculate the characteristics of surface runoff and by integrating the above from the layer (hydrological soils and land cover) (Map-8) (Table-7).

Rain intensity

Rainstorms occur suddenly and have varying impact on the course of geomorphic processes when torrential rains occur that may cause unexpected environmental risks. The aim of the study is to know the intensity of rain to identify the pressure systems and the most variable and impact on the risks of geomorphic processes. The data were based on the daily precipitation of the ground monitoring stations. (Map -9) and (Table -8).

Calculation of the maximum water retention capacity after the start of the runoff (S).

Potential maximum retention after runoff is an indicator of the maximum possibility of water retention in the soil after the beginning of the runoff, i.e. the coefficient describes the saturation of the soil with water completely after the runoff, i.e. in the stage of stopping the leakage, and the variation in the thickness of the soil saturated with water depending on the type of soil and the extent of its susceptibility It absorbs the largest amount of water during the rain wave, and that this coefficient is related to the relationship between the land cover and the diversity of the soil and this is reflected in the values of (CN) and when the high values of the coefficient (S) are closer to zero, it indicates the low ability of the soil to retain water after the run-off on the surface (Map 10 and Table-8).

Calculation of the initial extraction coefficient (La)

(La) means the amount of rainwater lost before the start of surface run-off from evaporation processes and the rain that plants encounter, as well as the water that collects in low-rise lands at depressions or seepage Also, the initial extraction coefficient (La) is one of the elements of great importance for extracting the amount of runoff (Map-11) and (Table-8).

Depth of run-off (Q)

It means the amount of running water that flows on the surface when rain falls, and through what was shown from the natural data of the basins of the study area, which cross it through the values (S, CN, La) and by calculating The annual average of each cell, and based on the annual rainfall data for the two stations (Dahuk - Zakho) (Map-12) and (Table-10).

Estimation of the volume of surface runoff (QV)

The volume of surface runoff is an important calculation in hydrological studies. Through it, it is possible to know and determine the areas that form the depth of runoff (a). The annual runoff volume was calculated (Runoff Volume) (Map- 13) and (Table-10). (Map-7) Hydrological soils of the selected basins from the study (area Map-6) Land uses for the selected basins. (Map-7)Hydrolgical Soils of the Seested Basins Form the Sutdy area

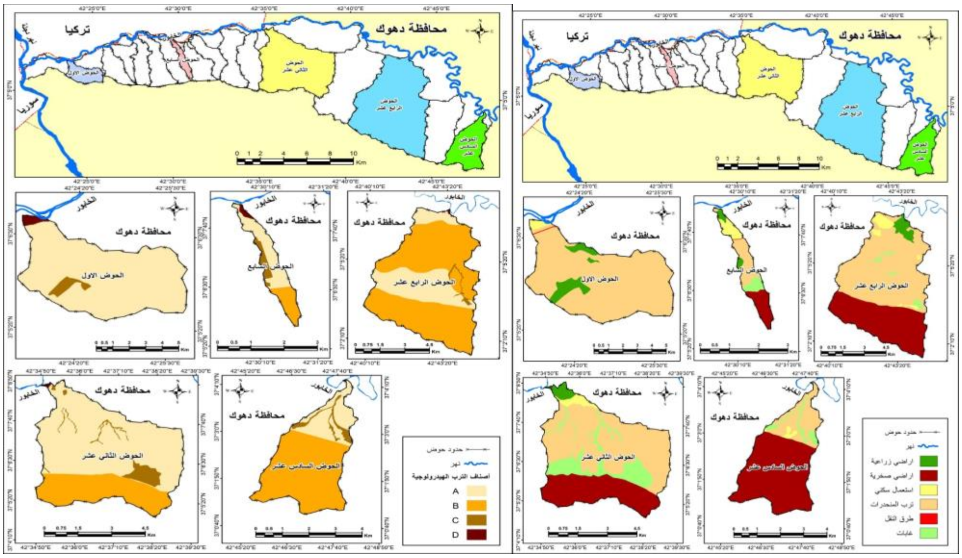

Figure 4. Hydrological soils of the selected basins
Source: Space Shuttle Endeavor, the radar visualization of the study area DEM (30) m, the researcher's work based on the program (18) Global mapper), the American satellite (4 Landsat), the visible (OLI) beams (7, 11, 12), accuracy (30) meters), 2020 AD

(Map-8) CN values for the selected basins in the study area (Map-9) Rain intensity of the selected basins for the study area

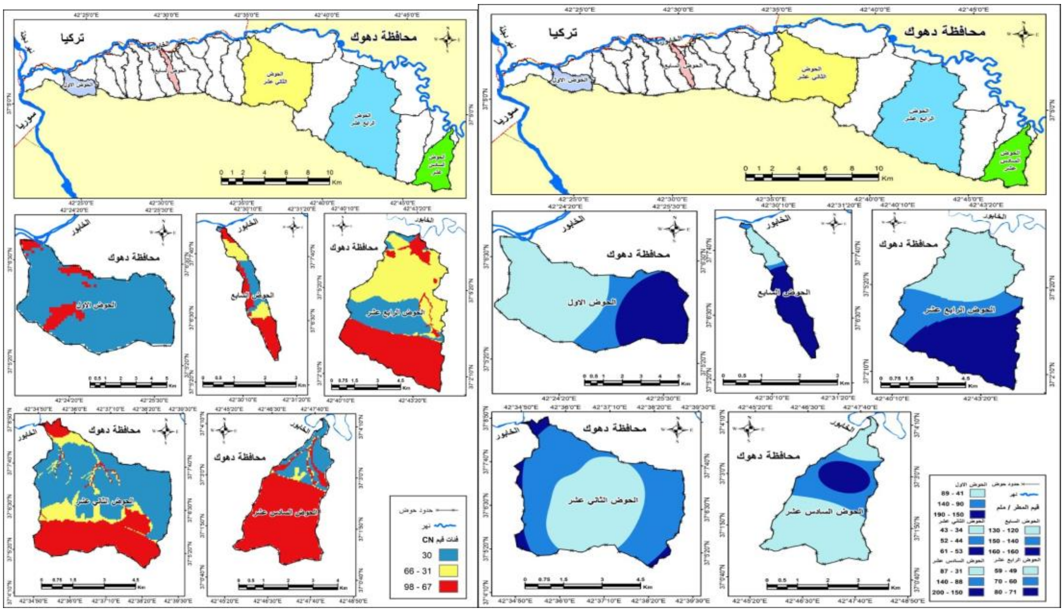

Figure 4. Rain intensity and CN values of the selected basins
Source: The American satellite (Landsat), visible (OLI) beams (7, 11, 12), accuracy (30) meters, 2020 AD

Statistical analysis of the relationship between hydrological variables and morphometric characteristics

The study of the relationship between morphometric characteristics and hydrological variables for the purpose of understanding the hydrological work of the study area, and the Pearson correlation coefficient was relied on to know the relationships between hydrological and morphometric variables using the statistical analysis program (SPSS) and the results showed as follows:

Concentration time

The results (Table - 10) showed a very strong direct relationship between concentration time, area, average width, perimeter, hypometric integration and the number of sewers, as the correlation values for each of them reached (0.91, 0.88, 0.93) , 0.89 and 0.90) respectively.

Deceleration

We note from (Table -10) that there is a very strong direct relationship between the time of deceleration, the pelvic area, the average width of the basins, the perimeter, the hypometric integration and the stream survival coefficient, as the values reached (0.93, 0.90, 0.98, 0.88, 0.80 and 0.84) respectively.

Volume of Flow

We notice from (Table-10) that there is a very strong direct relationship between the volume of flow and some of the spatial characteristics represented by (area, average width, perimeter, hypometric integration, and sewer lengths), as the correlation values amounted to (0.96, 0.89, 0.92, 0.94, 0.99), respectively, and a weak and acceptable direct relationship between the volume of flow, the length of the basins, the elongation rate, the rotation rate, the shape coefficient and the topography of the basin.

Flow velocity

The results (Table-10) showed a weak inverse relationship between flow velocity, pelvic area, average width and perimeter, as the values reached (-0.23, -0.35, -0.19), respectively, And an acceptable inverse relationship between flow velocity, elongation rate and shape coefficient, as the correlation value was (-0.55, -0.53), respectively.

Base time

We note from (Table 11) that there is a direct relationship (strong and very strong) between the base time of the torrents and some spatial characteristics represented by area, average width, hypometric integration, and the survival rate of the stream and the ocea.

The duration of the gradual rise

We note from (Table 11) that there is a weak direct relationship between the period of the gradual rise and some of the spatial and topographical characteristics represented by (area, length, average width, elongation rate, roundness, length to width ratio, shape factor, dents, and basin topography.

The duration of the gradual decline

We note from (Table 11) that there is a weak direct relationship between the duration of the gradual decline and some of the spatial and topographical characteristics represented by (length, average width, elongation rate, roundness, length-width ratio, shape factor, dents, basin topography, hypometric integration, and numbers of and sewer lengths and inflection coefficient).

Estimation of the duration of the flow

We note from (Table 11) that there is a very strong direct relationship between the estimate of the duration of the flow and some of the spatial and topographical characteristics represented by (area, average width, perimeter, hypometric integration, stream survival rate, and sewer lengths, as the correlation values reached (0.93, 0.90, 0.98, 0.83, 0.85, 0.88) respectively .

Table 1
Dohuk Climatic Station for the year (1990 – 2019)

months/ items	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	rate or sum
Radiation angle degree	32.5	40.5	51	62.9	72.1	77	75.2	67.9	57	43.3	35.1	30.5	53.28

8983

Amount of radiation in milli watts/cm2	4.3	5.6	5.9	6.7	9	11.5	11.6	11.1	9,9	7.3	5.8	4.7	7.8
Theoretical brightness rate h/day	9.45	10.12	11.23	11.86	12.30	12.44	13.25	14.43	13.12	11	10.56	9.34	12.56
Average hour/day for actual brightness	4.5	4.9	5.6	9.3	9.9	10.4	11.9	12.2	8.6	6.5	6.2	4.1	8.6
Average maximum temperature (C)	11.5	13.6	18.5	22.6	30.1	37.4	41.5	40.3	35.3	28.9	19.6	14.2	26.12
Average minimum temperature (C)	3.1	4.9	8.5	12.7	17.4	23.09	26.5	26.2	21.7	16.7	9.6	5.2	14.54
Average Monthly Temperature (C)	7.3	9.2	13.5	17.6	23.7	30.2	34	33.1	28.6	22.8	14.6	9.7	20.35
Range (m)	8.3	8.7	10	9.9	12.7	14.31	15	14.1	13.6	12.2	10	9	11.48
Wind speed m/s	1.4	1.4	1.5	1.6	1.6	1.7	1.5	1.5	1.4	1.4	1.2	1.2	1.5
Rainfall (mm)	118.8	82.4	80.7	50.1	15.8	0.8	0.1	0	1.5	22.6	53.3	86.6	512.7
Ice quantity	0.77	0.65	0.40	0	0	0	0	0	0	0	0	1.88	3.7
Relative humidity %	67	64	58	53	40	28	24	24	29	39	55	64	45
Evaporation (mm)	29.6	40.6	75.3	127.3	206.4	285.8	322.1	295.8	219.9	144.5	73.2	41.4	1861.9
Latent Evapotranspiration (mm)	42.1	55.5	116	172.7	290.5	398.6	486	431.1	311.6	208.4	99.8	57.5	1669.9

Table 2
Zakho Climatic Station for the year (1990 – 2019)

Months/ items	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Rate or sum
Radiation angle degree	31.92	39.92	50.42	62.32	71.52	76.42	74.62	67.32	56.42	44.72	34.52	29.92	53.33
Amount of radiation in milli watts /cm2	3.8	5.6	6	7.9	9.01	11.4	11.7	10.8	10	7	5.9	4.1	7.7
Theoretical brightness rate h/day	9.6	510	11.1	11.3	12.9	12.4	12.3	14.11	13	12	10.3	8.9	11.5
Average hour /day for actua	3.09	3.99	5.11	5.51	8.77	10.48	11.02	10.57	9.21	6.73	5.32	4.33	7.01

	8984												
l brightness													
Average maximum temperature (C)	12	13.6	18.1	24.1	30.7	37.6	41.3	40.9	36.2	28.4	19.8	14.3	26.4
Average minimum temperature (C)	3.2	4.9	7.8	12.6	16.8	22.5	26.1	25.8	21.4	16.3	10	5.2	14.3
Average Monthly Temperature (C)	7.6	9.2	12.9	18.3	32.7	29.9	33.7	33.37	28.8	22.3	14.9	9.7	20.3
Range (m)	8.8	8.7	10.3	11.5	13.9	15.1	15.2	15.1	14.8	12.1	9.8	9.1	11.9
Wind speed m/s	0.97	1.11	1.16	1.24	1.62	1.62	1.23	1.9	0.98	0.96	0.87	0.87	0.93
Rainfall (mm)	117.61	94.35	76.77	65.96	21.19	2.11	0.00	0.03	1.8	24.65	58.17	96.48	559
Ice quantity	2.2	5.2	0.2		0	0			0	0	0	0.4	8
Relative humidity %	55	55.21	48.5	46.29	33.93	21.36	20.07	21.07	24.71	35	47.64	54.86	38.63
Evaporation (mm)	36.7	48.7	93.7	113.49	149.38	298.5	343.95	313.06	228.21	146.72	62.25	35.12	1914.78
Latent Evapotranspiration (mm)	44.2	55.5	109.3	168.9	290.6	393.4	480.4	435.8	314.5	202.4	102.5	57.5	2736

Source: Directorate of Meteorology and Seismic Monitoring, in Zakho District, Governorate, Climate Department, unpublished data, monthly and annual statistics 2021.

Table 3
Topographic characteristics in the study area

Basins	Gear Ratio (m/km)	basin fabric (stream/ km)	highest equal line height	Minimum equal line height	Basin topography (m)	Relative terrain (m/km(	ruggedness value	Hypsometric integration (km2/m)
First basin	39.5	6.8	525	350	175	17.5	0.1	0.02
Second basin	60.6	6.4	700	350	350	26.9	1.7	0.01
The third basin	67.1	5.3	750	350	400	28.6	2.1	0.01
Fourth basin	71.8	5	775	350	425	28.3	2	0.01
Fifth pelvis	66.4	6.1	825	350	475	26.4	2.3	0.01
Sixth basin	84.7	5.3	950	350	600	40	3.3	0.01
Seventh basin	115.6	3.4	950	350	600	60	3.7	0.003
The eighth basin	44	8.2	1000	400	600	46.2	3.2	0.01
Ninth basin	45.9	5.7	1000	375	625	44.6	3.1	0.008
Tenth pelvis	88.3	1.9	1025	375	650	34.2	1.6	0.01
The eleventh pelvis	25.3	8.1	1025	400	625	39.1	2.9	0.01
Twelfth pelvis	53.5	4.7	1000	400	600	22.2	1.6	0.05
Thirteenth basin	49	3.7	950	425	525	18.1	1.3	0.05
The fourteenth basin	44.2	4.4	1025	475	550	16.2	1.21	0.08
The fifteenth basin	63.1	3.05	1100	550	550	27.5	1.3	0.03
Sixteenth basin	78.2	2.4	1125	525	600	31.6	1.4	0.02

Source: The researcher’s work based on digital elevation maps (DEM) and the program (10.4 arc GIS map)

Table 4
Concentration time, deceleration and flow velocity in the study area basins

Docks	Duct length (m)	slope m/km	Basin height rate (m)	Focus time (hour)	Ct	Lb	Lca	TP (hr) slowing down	Total lengths of sewers (km)	FLOW SPEED (M/H)
First basin	3790	39.5	475.5	0.17	1.2	3.79	2.03	2.16	26.68	6192.8
Second basin	5100	60.6	525	0.22	1.2	5.1	2.51	2.5	28.89	6439.4
The third basin	4890	67.1	550	0.20	1.2	4.89	2.43	2.5	23.57	6791.6
Fourth basin	5160	71.8	562.5	0.21	1.2	5.16	2.68	2.6	28.13	6825.4
Fifth pelvis	6280	66.4	587.5	0.27	1.2	6.28	3.6	3	38.14	6460.9
Sixth basin	5500	84.7	650	0.22	1.2	5.5	2.57	2.6	32.88	6944.4
Seventh basin	4830	115.6	650	0.19	1.2	4.83	2.69	2.5	13.63	7061.4
The eighth basin	4470	44	700	0.16	1.2	4.47	2.69	2.5	32.64	7760.4
Ninth basin	4810	45.9	687.5	0.18	1.2	4.81	2.47	2.5	27.49	7422.8
Tenth pelvis	6460	88.3	700	0.25	1.2	6.46	3.05	2.9	24.72	7177.7
The eleventh basin	6260	25.3	712.2	0.24	1.2	6.26	3.09	2.88	41.72	7256.9
Twelfth pelvis	8720	53.5	700	0.36	1.2	8.72	4.8	3.6	83.22	6728.4
Thirteenth basin	9630	49	687.5	0.41	1.2	9.63	4.84	3.8	65.71	6524.4
The fourteenth basin	10880	44.2	750	0.46	1.2	10.8 8	5.39	4.1	106.19	6570
The fifteenth basin	7520	63.1	825	0.29	1.2	7.52	3.84	3.2	38.94	7203.1
Sixteenth basin	4490	78.2	825	0.16	1.2	6.49	3.79	3.1	29.54	7795.1
TABLE I. OTAL OR AVERAGE	TABLE II. 8790	TABLE III. 0.425	TABLE IV. 0550	TABLE V. .24	TABLE VI. .2	TABLE	TABLE VIII. 2.47	TABLE IX. .90	TABLE X. 39.08	TABLE XI.

Source: the researcher's work based on data from the program (ARC GIS10.4)

Table 5
The base time for torrential rain, the duration of the gradual rise and fall of the torrent, the estimation of the duration of the runoff, the coefficient of flooding, the concentration of rain and the ideal period.

Basins	Area (km2)	Base time for torrential day	Duration of gradual rise of torrent hour (TM)	Duration of gradual decrease in the torrent one hour (Td)	Estimate d run-time km/h(T)	flood coefficien t	Rain concentr ation to peak torrential flow (I)	The ideal duration of rain is an hour (Tr)
First	4.75	3.27	0.04	0.08	10.8	190	2.6	0.40

basin								
Second basin	5.93	3.3	0.04	0.08	12.5	1888.6	2.2	0.45
The third basin	4.54	3.3	0.04	0.08	12.5	1298.4	2.2	0.45
Fourth basin	5.88	3.3	0.04	0.08	13	1693.4	2.1	0.47
Fifth pelvis	7.86	3.4	0.04	0.08	15	3466.3	1.9	0.55
Sixth basin	5.99	3.3	0.04	0.08	12.5	2141.4	2.1	0.47
Seventh basin	2.25	3.3	0.04	0.08	12.5	398.02	2.2	0.45
The eighth basin	6.12	3.3	0.04	0.08	12.5	2724.6	2.2	0.45
Ninth basin	5.5	3.3	0.04	0.08	12.5	1650	2.2	0.45
Tenth pelvis	9.83	3.4	0.05	0.1	14.5	663.3	1.86	0.53
The eleventh basin	9.04	3.36	0.05	0.1	14.4	4407.9	1.9	0.52
Twelfth pelvis	31.76	3.35	0.05	0.08	18	8175.02	2.1	0.47
Thirteenth basin	26.5	3.4	0.05	0.1	19	5035	1.4	0.69
The fourteenth basin	48.7	3.5	0.05	0.1	20.5	12321.1	1.4	0.75
The fifteenth basin	16.69	3.4	0.05	0.1	16	784.4	1.7	0.58
Sixteenth basin	12,46	3.38	0.05	0.09	15.5	1076.5	1.8	0.56

Source: the researcher's work based on data from the program (ARC GIS10.4)

Table 6
The maximum flow value, the specific peak flow of the water basin, the volume of flow, the constant leakage value, the volume of the torrent flow and the strength of the torrent

Docks	Max Flow Value (Qp) (m3/s)	SPECIFIC PEAK FLOW OF THE WATER BASIN (QP (M3/S)	FLOW VOLUME Thousand (m3)	Constant Leakage Value (m3) (Fp)	Torrent flow volume AL	Torrent force (A)
First basin	8.8	1.9	16.4	0.006	0.003	4
Second basin	9.7	1.6	17.4	0.007	0.001	4
The third basin	8.2	1.8	14.7	0.005	0.001	3.9

Fourth basin	8.4	1.4	17.1	0.007	0.001	3.5
Fifth pelvis	11.8	1.5	22.5	0.01	0.002	4.2
Sixth basin	10.4	1.7	19.5	0.007	0.005	4.3
Seventh basin	4.1	1.8	9.2	0.002	0.002	1.8
The eighth basin	11	1.8	19.4	0.008	0.002	4.4
Ninth basin	9.9	1.8	16.7	0.007	0.001	4.3
Tenth pelvis	15.3	1.6	15.3	0.02	0.02	4.9
The eleventh basin	14.1	1.6	23.8	0.01	0.02	4.7
Twelfth pelvis	39.7	1.3	42.9	0.04	0.01	7.1
Thirteenth basin	31.4	1.2	35.1	0.04	0.01	6.2
The fourteenth basin	53.95	1.1	52.7	0.07	0.01	7.8
The fifteenth basin	23.5	1.4	22.5	0.03	0.004	5.8
Sixteenth basin	18.1	1.45	17.8	0.02	0.003	5.2
Total or average	17.04	1.56	22.69	0.018	0.095	4.7

Source: the researcher's work based on data from the program (ARC GIS10.4)

Table 7
Land use classes (land cover and hydrological soil classes according to the (SCS) method) and extracting the value of the curve (CN) for the selected basins from the study area

Classification of the first basin	Area (km2)	percentage(%)	Categories of the first basin	Area (km2)	percentage(%)	Categories of the first basin	Area (km2)	percentage(%)
Soil slopes	4.32	90.9	B	4.27	89.9	30	4.63	97.5
Residential use	0.08	1.7	A	0.21	4.4	31 – 66	0.12	2.5
Agricultural land	0.34	7.2	C	0.07	1.5	the total	4.75	100
Transfer	0.01	0.2	D	0.2	4.2			
The total	4.75	100	The total	4.75	100			
Classification of the seventh	Area (km2)	percentage(%)	Seven Basin Categories	Area (km2)	percentage(%)	Seven Basin Categories	Area (km2)	percentage(%)

basin								
Soil slopes	1.76	33.3	B	0.63	28	30	1.3	57.8
Rocky terrain	0.48	28	A	1.19	52.8	31 – 66	0.31	13.8
Residential use	0.34	15.1	C	0.35	15.6	67 – 98	0.64	28.4
Agricultural land	0.17	7.6	D	0.08	3.6	the total	2.25	100
Transfer	0.15	6.7						
Forests	0.35	15.5	the total	2.25	100			
	2.25							
Classification of the twelfth basin	Area (km2)	percentage(%)	Twelfth Aquarium Categories	Area (km2)	percentage(%)	Twelfth Aquarium Categories	Area (km2)	percentage(%)
Soil slopes	17.44	54.9	B	8.15	25.7	30	21.83	68.7
Rocky terrain	8.21	25.9	A	21.99	69.2	31 – 66	1.55	4.9
Residential use	0.76	2.4	C	1.54	4.8	67 – 98	8.38	26.4
Agricultural land	0.77	2.4	D	0.08	0.3	the total	31.76	100
Forests	4.58	14.4	the total	31.76	100			
The total	31.76	100						
Classification of the fourteenth basin	Area (km2)	percentage(%)	Fourteenth Basin Categories	Area (km2)	percentage(%)	Fourteenth Basin Categories	Area (km2)	percentage(%)
Soil slopes	28.03	57.6	B	35.19	72.3	30	1.9	3.9
Rocky terrain	16.58	34	A	12.89	26.5	31 – 66	12.9	26.5
Residential use	1.5	3.1	C	0.55	0.02	67 – 98	33.9	69.6
Agricultural land	1.9	3.9	D	0.07	0.14	the total	48.7	100
Forests	0.69	1.4	the total	48.7	100			
The total	48.7	100						
Classification of Sixteenth Basin	Area (km2)	percentage(%)	Sixteen Basin Categories	Area (km2)	percentage(%)	Sixteen Basin Categories	Area (km2)	percentage(%)
Soil slopes	2.63	21.12	B	9.15	73.4	30	2.61	20.9
Rocky terrain	9.15	73.43	A	2.73	21.9	31 – 66	0.93	7.5

Residential use	0.18	1.44	C	0.56	4.5	67 – 98	8.92	71.6
Forests	0.5	4.01	D	0.02	0.2	the total	12.46	100
The total	12.46	100	12.46	12.46	100			

Source: the researcher’s work based on the program (ARC GIS 10.4) and (Map - 6, 7, 8)

Table 8
Calculating the rain intensities and calculating the maximum potential for water retention after the start of the surface runoff (S) and calculating the initial extraction coefficient (La) for the selected basins from the study area

Categories of the first basin	Area (km2)	Percentage %	Categories of the first basin	Area (km2)	Percentage %	Categories of the first basin	Area (km2)	Percentage %
41 – 89	2.5	52.6	48 – 115	0.02	0.4	9.6-22.9	0.02	0.42
90 – 140	1.46	30.7	116 – 323	4.55	95.8	23-64.3	4.3	90.5
150 – 190	0.79	16.7	324 – 990	0.18	3.8	64-198	0.43	9.08
the total	4.75	100	the total	4.75	100	the total	4.75	100
Seven Basin Categories	Area (km2)	Percentage %	Seven Basin Categories	Area (km2)	Percentage %	Seven Basin Categories	Area (km2)	Percentage %
120 – 130	0.3	13.3	48 – 115	0.95	42.23	9.6-22.9	0.95	42.2
140 – 150	0.33	14.7	116 – 323	1.2	53.33	23-64.3	1.13	50.2
170 – 160	1.62	72	324 – 990	0.1	4.4	64-198	0.17	7.6
the total	2.25	100	the total	2.25		the total	2.25	100
Twelfth Aquarium Categories	Area (km2)	Percentage %	Twelfth Aquarium Categories	Area (km2)	Percentage %	Twelfth Aquarium Categories	Area (km2)	Percentage %
34 – 43	10.55	33.21	48 – 115	9.7	30.5	9.6-22.9	8.3	26.1
44 – 52	13.98	44.01	116 – 323	21.2	66.8	23-64.3	22.76	71.7
53 – 61	7.23	22.76	324 – 990	0.86	2.7	64-198	0.7	2.2
المجموع	31.76	100	the total	31.76	100	the total	31.76	100
Fourteenth Basin Categories	Area (km2)	Percentage %	Fourteenth Basin Categories	Area (km2)	Percentage %	Fourteenth Basin Categories	Area (km2)	Percentage %
49 – 59	17.22	35.4	48 – 115	35.7	73.3	9.6-22.9	35.4	72.7
60 – 70	11.6	23.8	116 – 323	12.1	24.8	23-64.3	12.5	25.7
71 – 80	19.88	40.8	324 – 990	0.9	1.8	64-198	0.8	1.6
the total	48.7	100	the total	48.7	100	the total	48.7	100
Sixteen Basin Categories	Area (km2)	Percentage %	Sixteen Basin Categories	Area (km2)	Percentage %	Sixteen Basin Categories	Area (km2)	Percentage %
31 – 87	7.77	62.4	48 – 115	9.65	77.44	9.6-22.9	9.06	72.7
88 – 140	2.67	21.4	116 – 323	2.81	22.6	23-64.3	3.4	27.3
150 – 200	2.02	16.21	the total	12.46	100	64-198		
the total	12.46	100				the total	12.46	100

Source: the researcher’s work based on (ARC GIS 10.4) and (Map – 9, 10, 11)

Table 9

Classes of hydrological soils according to (SCS) method in the study area

Items	Flow depth	Types of soil
A	a little	A deep layer of sand with an amount of clay and silt
B	Average	A sandy layer deeper than A with an average infiltration rate after wetting
C	above average	A clay layer with a defined depth with a sub-median infiltration rate before soil saturation, or a rocky layer covered with a layer of soil
D	very high	A clay layer with a high rate of swelling with a shallow layer of soft soil close to the surface or a layer of bare rock

Table 10

The relationship between the morphometric characteristics and the hydrologic variables (concentration time, deceleration, flow volume, and flow velocity

No.	Morphometric features	correlation coefficient R	test result	correlation coefficient R	test result	correlation coefficient R	test result	correlation coefficient R	Test result
1	Space	0.91	intangible positive relationship	0.93	intangible positive relationship	0.96	intangible positive relationship	- 0.23	insignificant inverse relationship
2	Height	0.21	insignificant positive relationship	0.28	insignificant positive relationship	0.36	insignificant positive relationship	0.37	insignificant positive relationship
3	average width	0.88	intangible positive relationship	0.90	intangible positive relationship	0.89	intangible positive relationship	- 0.35	insignificant inverse relationship
4	Ocean	0.93	intangible positive relationship	0.98	intangible positive relationship	0.92	intangible positive relationship	- 0.19	insignificant inverse relationship
5	Elongation rate	0.55	intangible positive relationship	0.52	intangible positive relationship	0.47	insignificant positive relationship	- 0.55	inverse relationship
6	turn rate	0.30	intangible positive relationship	0.31	intangible positive relationship	0.52	intangible positive relationship	- 0.16	insignificant inverse relationship
7	ocean hold	- 0.38	insignificant inverse relationship	- 0.41	insignificant inverse relationship	- 0.60	inverse relationship	0.10	insignificant positive relationship
8	aspect ratio	- 0.25	insignificant inverse relationship	- 0.22	insignificant inverse relationship	- 0.14	insignificant inverse relationship	0.45	insignificant positive relationship
9	shape parameter	0.63	intangible positive relationship	0.61	intangible positive relationship	0.59	intangible positive relationship	- 0.53	inverse relationship

10	Integration coefficient	- 0.34	insignificant inverse relationship	- 0.37	insignificant inverse relationship	- 0.53	insignificant inverse relationship	0.11	insignificant positive relationship
11	buckling factor	- 0.26	insignificant inverse relationship	- 0.23	insignificant inverse relationship	- 0.14	insignificant inverse relationship	0.45	insignificant positive relationship
12	gear ratio	- 0.25	insignificant inverse relationship	- 0.20	insignificant inverse relationship	- 0.46	insignificant inverse relationship	0.13	insignificant positive relationship
13	pelvic tissue	- 0.27	insignificant inverse relationship	- 0.41	insignificant inverse relationship	- 0.05	insignificant inverse relationship	- 0.12	insignificant inverse relationship
14	basin topography	0.17	insignificant positive relationship	0.37	insignificant positive relationship	0.17	insignificant inverse relationship	0.70	intangible positive relationship
15	Relative terrain	- 0.59	inverse relationship	- 0.51	inverse relationship	- 0.60	inverse relationship	0.64	intangible positive relationship
16	ruggedness value	- 0.36	insignificant inverse relationship	- 0.34	insignificant inverse relationship	- 0.35	insignificant inverse relationship	0.48	insignificant positive relationship
17	Hypsometric integration	0.89	intangible positive relationship	0.88	intangible positive relationship	0.94	intangible positive relationship	- 0.32	insignificant inverse relationship
18	sewer preparation	0.90	intangible positive relationship	0.54	inverse relationship	0.79	intangible positive relationship	- 0.28	insignificant inverse relationship
19	sewer lengths	0.62	intangible positive relationship	0.75	intangible positive relationship	0.99	inverse relationship	- 0.30	insignificant inverse relationship
20	bifurcation ratio	- 0.26	insignificant inverse relationship	- 0.21	insignificant inverse relationship	- 0.28	insignificant inverse relationship	0.37	insignificant positive relationship
21	longitudinal density	- 0.42	insignificant inverse relationship	- 0.47	insignificant inverse relationship	- 0.45	insignificant inverse relationship	0.24	insignificant positive relationship
22	scalar density	- 0.66	inverse relationship	- 0.81	inverse relationship	- 0.60	intangible positive relationship	- 0.01	insignificant inverse relationship
23	Stream survival coefficient	0.68	intangible positive relationsh	0.84	intangible positive relationsh	0.63	inverse relationship	0.09	insignificant positive

			ip		ip				relationship
24	inflection coefficient	- 0.26	insignificant inverse relationship	- 0.20	insignificant inverse relationship	- 0.07	insignificant inverse relationship	0.52	intangible positive relationship

Source: the researcher's work based on the statistical program (Spss) for the Pearson correlation coefficient

Table 11
The relationship between the morphometric characteristics and the hydrological variables (base time of torrential flow, duration of rise and fall of flow, and duration of flow estimation

No.	Morphometric features	correlation coefficient R	test result	correlation coefficient R	test result	correlation coefficient R	test result	correlation coefficient R	Test result
1	Space	0.78	intangible positive relationship	0.34	insignificant positive relationship	0.51	intangible positive relationship	0.93	intangible positive relationship
2	Height	0.26	insignificant positive relationship	0.29	insignificant positive relationship	0.41	insignificant positive relationship	0.28	insignificant positive relationship
3	average width	0.76	intangible positive relationship	0.34	insignificant positive relationship	0.47	insignificant positive relationship	0.90	intangible positive relationship
4	Ocean	0.85	intangible positive relationship	0.52	intangible positive relationship	0.62	intangible positive relationship	0.98	intangible positive relationship
5	Elongation rate	0.45	insignificant positive relationship	0.16	insignificant positive relationship	0.23	insignificant positive relationship	0.52	intangible positive relationship
6	turn rate	0.21	insignificant positive relationship	0.01	insignificant positive relationship	0.17	insignificant positive relationship	0.32	insignificant positive relationship
7	ocean hold	- 0.32	insignificant inverse relationship	- 0.10	insignificant inverse relationship	- 0.26	insignificant inverse relationship	- 0.42	insignificant inverse relationship
8	aspect ratio	- 0.17	insignificant inverse relationship	0.09	insignificant inverse relationship	0.11	insignificant positive relationship	- 0.22	insignificant inverse relationship
9	shape parameter	0.53	intangible positive relationship	0.19	insignificant positive relationsh	0.30	insignificant positive relationsh	0.61	intangible positive relationship

					ip		ip		
10	Integration coefficient	- 0.26	insignificant inverse relationship	- 0.15	insignificant inverse relationship	- 0.29	insignificant inverse relationship	- 0.38	insignificant inverse relationship
11	buckling factor	- 0.17	insignificant inverse relationship	0.09	insignificant positive relationship	0.10	insignificant positive relationship	- 0.22	insignificant inverse relationship
12	gear ratio	- 0.12	insignificant inverse relationship	- 0.07	insignificant inverse relationship	- 0.20	insignificant inverse relationship	- 0.21	insignificant inverse relationship
13	pelvic tissue	- 0.44	insignificant inverse relationship	- 0.38	insignificant inverse relationship	- 0.37	insignificant inverse relationship	- 0.41	insignificant inverse relationship
14	basin topography	0.37	insignificant positive relationship	0.32	insignificant positive relationship	0.34	insignificant positive relationship	0.36	insignificant positive relationship
15	Relative terrain	- 0.43	insignificant inverse relationship	- 0.24	insignificant inverse relationship	- 0.32	insignificant inverse relationship	- 0.52	inverse relationship
16	ruggedness value	- 0.34	insignificant inverse relationship	- 0.27	insignificant inverse relationship	- 0.32	insignificant inverse relationship	- 0.35	insignificant inverse relationship
17	Hypsometric integration	0.71	intangible positive relationship	0.25	insignificant positive relationship	0.45	insignificant positive relationship	0.83	intangible positive relationship
18	sewer preparation	0.39	insignificant positive relationship	0.01	insignificant positive relationship	0.21	insignificant positive relationship	0.54	intangible positive relationship
19	sewer lengths	0.69	intangible positive relationship	0.20	insignificant positive relationship	0.41	insignificant positive relationship	0.88	intangible positive relationship
20	bifurcation ratio	- 0.15	insignificant inverse relationship	- 0.05	insignificant inverse relationship	- 0.15	insignificant inverse relationship	- 0.22	insignificant inverse relationship
21	longitudinal density	- 0.47	insignificant inverse relationship	- 0.40	insignificant inverse relationship	- 0.48	insignificant inverse relationship	- 0.48	insignificant inverse relationship
22	scalar density	- 0.76	inverse relationship	- 0.59	inverse relationship	- 0.65	inverse relationship	- 0.81	inverse relationship
23	Stream survival coefficient	0.82	intangible positive relationship	0.65	intangible positive relationship	0.71	intangible positive relationship	0.85	intangible positive relationship
24	inflection	- 0.17	insignifica	0.03	insignifica	0.05	insignifica	- 0.20	insignifica

coefficient	nt inverse relationship	nt positive relationship	nt positive relationship	nt inverse relationship

Source: the researcher's work based on the statistical program (Spss) for the Pearson correlation coefficient.

Conclusion

- When applying the hydrological equations in the basins of the study area, the concentration time for the basins of the study area reached the highest value (0.16) hours, while the lowest value reached (0.46) hours in the basin, while the deceleration time reached the lowest value in the second basin, as it was recorded (2.5) km/h, and the highest value in the fourteenth basin was (4.1) km/h, while the volume of flow was the lowest at the seventh basin, the study area (9.2) km/h, and the highest value at the twelfth basin was (42.9) thousand m3, while the flow velocity reached the lowest value in the first basin (6192.8) m/hr, while the highest values in the sixteenth basin reached (7795.1) m/hr, while the base time reached the lowest value In the first basin (3.27) and the highest value in the fourteenth basin is (3.5) days, while the period of gradual rise in the basins of the study area varies between (0.04 and 0.05) hours for the basins of the study area.
- The study showed that, throughout the region, surface runoff can be generated because the values of the initial extraction coefficient (La) are lower than the median value of (50.8), but at the downstream, the generation of average runoff is due to the higher values of the coefficient (La) than the median value and due to the low ratio The basins branch out at the estuary, and that the area is very high mountainous, with a height ranging between (350-1125) meters above sea level, with steep slopes that shortened the valleys of the basins of the study area .
- By relying on the (SCS-CN) method, through which the concentration of the runoff was estimated, as the values varied, as the highest volume of surface runoff reached (52.7) m3 in the fourteenth basin at the source and the lowest surface runoff amounted to (9.2) m3. In the seventh basin at the estuary.

The study found that when applying the Pearson coefficient, the results showed the correlational relationships between the morphometric characteristics and the hydrological variables (concentration time), which showed the existence of a direct relationship (very strong) between the area, as the value reached (0.91), and there is also a positive (medium and acceptable weak) relationship. With the stream survival coefficient, elongation rate and basin topography, the values reached (0.68, 0.55, 0.17), respectively, while there is an inverse relationship (medium, acceptable and weak) with the numerical density, relative terrain and inflection coefficient, as the correlation values reached (- 0.66, -0.59, -0.26) respectively, while the results of the study found the existence of correlational relationships between morphometric characteristics and hydrological variables (deceleration time), which showed a very strong direct correlation with the ocean, as the value reached (0, 98), while there is a direct correlation (medium, acceptable and weak) with the shape coefficient, the number of sewers and the length of the basins, as the correlation values reached (0.61, 0.54, 0.28) respectively, while there is an inverse correlation) very strong) with the numerical density as the value reached (-0.81), while the inverse relationship is acceptable and weak with the topography of the basins and the inflection coefficient, as it reached a for values of (-0.51, -0.20) respectively, while the results of the study found the existence of correlational relationships between morphometric characteristics and hydrological variables (flow volume) which showed the existence of a direct correlation (very strong) with the lengths of the sewers, as the value reached (0 , 99).

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