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ESTIMATION SIZE OF WATER EROSION IN A BASIN OF AL-DOUIGI VALLEY BY USING GEOGRAPHIC INFORMATION SYSTEMS

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ABSTRACT

The AL-Douigi basin is one of the seasonal basins in the northeast of the Ali Gharbi district. It is affected by its climatic characteristics within the arid and semi-arid regions and by the nature of rainstorms of varying intensity. It has contributed to the variation in the level of rain falling on the basin areas. In addition, to the contribution of other natural area characteristics to the process of water flow in the basin, especially the terrain, slope, soil and natural vegetation, which affected the form of surface runoff and the occurrence of torrents in the basin. The digital (DEM) using the (ArcGIS) program to extract some of the hydrological characteristics of the basin. The hydrological soils were analyzed using the (SCS-CN) method in classifying land uses. The two layers of hydrological soils and land uses were merged using the (Combine) function in the ArcGIS program, where the value of (CN) was (74-98). The study showed an estimate of the surface runoff depth (Q), which ranged between (119.04-190.23) mm, and the surface runoff volume (QV), which ranged between (0.72-1.61) m3.

KEYWORDS

Al-Douigi Valley, remote sensing, surface runoff, SCS-CN method.

Introduction

Estimate the runoff that resulting from rain is the basis for many hydrogeomorphological studies. This is for develop the necessary plans for the development and exploitation of water resources in arid and semi-arid environments. The process of measuring the volume of surface runoff of water basins faces many problems in the process of making those measurements. They are due to the variation in the natural environments in which these basins are located. It indicates that the analysis of the components of most hydrological methods and models is characterized by inaccuracy. There is a lack of statistical data due to the variation in patterns precipitation and other environmental issues.

By combining models and experimental methods using Geographic Information System (GIS), many coefficients can be obtained for estimating and calculating runoff, (Mishra and Singh, 2004). The rain that falls as a result of the rainstorm is exposed to the loss of part of it as a result of the leakage of part of it into the ground through cracks and joints and the nature of the permeability of the soil. However, the other part is exposed to evaporation at high temperatures that contribute to increasing evaporation rates in the lands of the basin. The remaining part flows as a thin sheet of water above the surface of the earth, which is called the above-ground flow, (Moglen, ,2000).

The identification of climatic phenomena in terms of their intensity and duration, as well as the spatial distribution of precipitation and the runoff formed as a result, helps to analyze the depth and size of torrents and their impact on soil and natural vegetation (Schulze and Schmidt 1992). In Spain, the semi-arid regions were studied, according to the determination of the volume of runoff, the method of its formation, and the factors affecting it by relying on two groups of soil groups. In addition, the volume of runoff is determined by using the method (SCS-CN) (Shrestha,2003)(Hassan & Al-Asadi, 2023a).have focused on estimating the volume of surface runoff by applying the SCS method to measure the size of the rainstorm that occurs within a period not exceeding 24 hrs. They have showed that the natural geological factors, natural vegetation and the intensity of the storm, plays a major role in the flow rate of the Qara Gay basin(Hassan & Al-Asadi, 2023b)(Hassan & Al-Asadi, 2023b) (Kumar and Singh ,2004).

There is also a study that relied on the analysis of surface runoff with the influence of the grazing factor and its pressure on the nature of runoff in the highlands of Ethiopia. It turned out that grazing pressure has a significant effect on the rise in runoff values, as well as increasing the area exposed to erosion (McCuen ,1989). The valleys in dry areas still lack more studies and research through which it is possible to identify their different geomorphological aspects and characteristics in preparation for their exploitation. These studies are hydrological studies, which are of particular importance because they are related to the areas of water resources development and agricultural development projects with unavailable water resources. It has hydrometric stations to measure runoff.

In these areas, it relies on measuring runoff to estimate the volume of runoff by recognizing the volume of rain. It is considered one of the most important hydrological characteristics as well as other important factors. Surface runoff is measured in different ways, including measuring water runoff using soil permeability, the method of elicitation and inference, the Daken relationship, Bush curve, Foleer's empirical relationship, Cooke's, and CN-curve methods. It is worth noting that the curved number method is one of the best and most accurate methods. It is widely used in most parts of the world. It is the method that will be adopted in this study. Despite the many studies that dealt with this method, Sherman is considered the first person to use this method in (1949) (Kowalik and Kowalik,1981)(Hassan & Al-Asadi, 2023b).

The study has proved the relationship between rain and water flow through his experience in the hydrographic framework, which proved its worth. Following this study, the US Soil Conservation Authority developed in 1954 this method for measuring heavy rain precipitation, marked by the curved number (CN) method, which the value of (CN) is taken from the tables. It is one of the most important factors in preparing a map of the hydrological aggregates of the soil of the water basin to be studied (Hawkins, 1993).

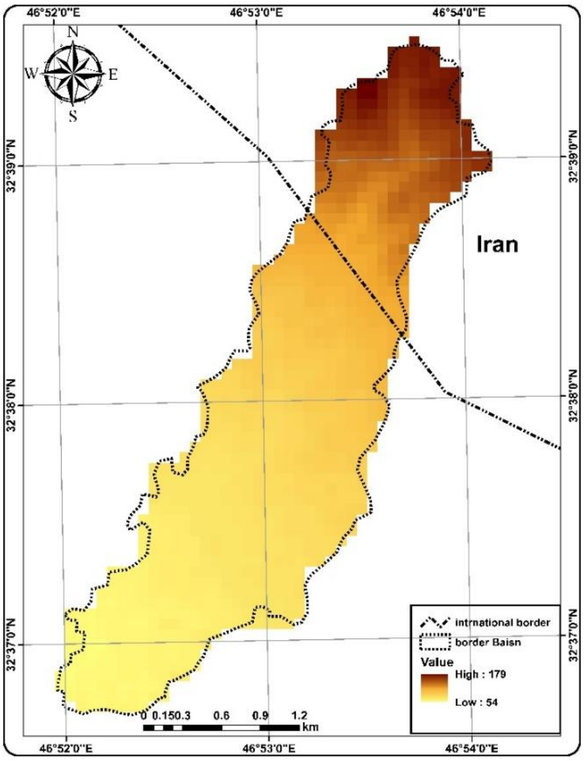
The aim of studying the surface runoff of the study area is not limited to providing drinking water, irrigation or groundwater recharge, but rather it goes beyond benefiting from this information in planning programs, environmental conservation management, flood control and the erosion and losses. In addition, to the construction of engineering projects such as the construction of earthen dams and diversion dams for areas at risk of flooding and submersible dams to save flood waters.

4.Location of the study area

The basin of Al-Douigi is located in the northeastern part of Ali Al-Gharbi district, Maysan province. Its coordinates are between latitudes (32 36 45- 32 39 0) to the north, and between longitudes (46 52 0

- 46 54 0) to the east. The basin of the study area is about (6.12) km^2. The basin is also one of the basins that share between Iraq and Iran. We indicated that the southern and southwestern part of the basin is located within the administrative borders of Maysan province, specifically the western Ali Al-Gharbi district. The basin's slope is directed from the southern parts of the Hamrin Hills as well as the western parts of the Zagros Mountains located in Iran.

Map(1)study area



Source: Depending on the outputs of the program (ArcGIS10.8)

2.The Study Problem

The study problem was as follow:

- Do natural factors influence the surface runoff in the basin?
- What is the volume of surface runoff in Al-Douigi basin?
- Can GIS techniques determine and estimate surface runoff volume?

2.1.Study Hypothesis

- Natural factors have an effect on the volume and velocity of surface runoff in the basin.
- GIS techniques have the ability to track and estimate the volume of surface runoff in the basin.

2.2.The aims of the study

- To estimate the volume of surface runoff and select the main methods to be relied upon in building a system to extract some of the hydrological characteristics of the basin instead of the traditional method based on paper maps.

- Efficiency and effectiveness of modern technologies specialized in the derivation and processing of space data. As well as the DEM model to extract some hydrological characteristics of the basin in the study area.

3.Explanation of the (SCS-CN) method

The American Soil Conservation Service hypothesis was relied on to estimate the volume of surface runoff, which is called as the (SCS-CN) method. It is one of the most mathematical methods that simulate reality and used to calculate the depth of surface runoff as a result of the basin's exposure to an influential rainstorm (Zhan and Huang, 2004). It deals with several variables such as soil type, land uses, soil moisture or geological nature and vegetation to show the extent of its ability to absorb water, as well as the ability of the basin to absorb water surface runoff events (Yamani and Mehrjounezhad ,2012).

This indicator was developed by the Natural Resources Conservation Service (NRCS) to represent the probability of rainwater runoff within the drainage area and to estimate the amount of rainwater that seeps into the soil and the amount of surface runoff (Verma, and Bindu,2012). On the other hand, the main disadvantages of this method are that it does not take into account the intensity of precipitation and its temporal distribution, and does not deal with the effects of the humidity. The method of working (SCS-CN) was based on (Arc GIS 10.8) software, on satellite visuals (Landsat 9), and remote sensing data with pixel units with a discriminatory accuracy (30×30), in order to obtain satisfactory results with high accuracy and simulating reality.

5.Extract method (CN):

The calculated CN values that value ranges between (0-100), express the amount of water permeability to the surfaces of the water basin. When the values go towards zero, it indicates high permeability to the surfaces of the basin, but if it goes from (100) indicates that the surfaces of the basin have little permeability ,Taher and Mozahem (2013). It has been relied on (Arc GIS 10.8) and remote sensing techniques to obtain the (CN) index. It is an effective use of time by merging the two layers of hydrological soil groups with the land uses layer, after coding (Gode). Each layer has different values from the other so as not to merges the program that has the same value. The combine function in the (Arc GIS 10.8) program, the soil groups and land uses were merged, including the values of (CN) for the Al-Douigi basin. The most important requirements that were studied and analyzed to obtain the values of (CN) in the study area:

6.Hydrological characteristics of the soil of the Al-Douigi basin

The (CN) method has become the focus of a lot of discussion among many specialists in modern hydrology. The soils have been classified into four hydrological groups (A, B, C, D) according to the US Soil Conservation Service guide. They are called the Hydrologic Soil Group, which was developed by US Department of Agriculture. It is according to the degree of its permeability, or it is done according to the rate of water transmission in the lowest soil after wetting. The soil properties contribute a major role in estimating the volume of runoff, based on the map of soil types for the study area and the results of laboratory analysis and based on the texture and components of those soils. It is clear that there are two types of soils based on to Lebornek's soil map data.

The map of the hydrological soil groups was prepared, as shown in map (1) and table (2). It has become clear from its observation that the hydrological group of soil (B) is the category that represents the study basin, as it prevails in most parts of the basin. It occupies an area of (4.48) km^2 at a rate of (73.26%) of the area of the study area. The soil in this group has a fairly low runoff rate and a moderate infiltration rate when the soil is completely wet and the water transmission through the soil is moderately (Al-

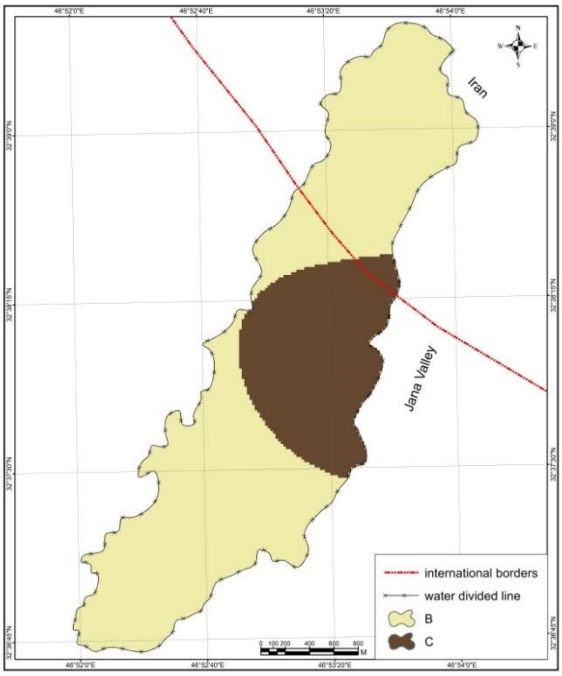
Badiri ,2021). It often soils this group is one of the weakest hydrological groups in the ability to absorb water. The class (C) has covered an area of (1.64) km^2, with a rate of (26.74%). This type of soil appears in areas that have poor permeability to well-drained when wet. It mainly consists of soil covered with a layer that impedes the downward movement of water and the rate of transmission the water during it ranges between (1.27-3.81) mm/h. The presence of this category is concentrated in the center of the study area, which extends parallel to the river basin (Map 1).

Table (1) Soil hydrological classes in Al-Douigi basin

Soil type	Area km^2	Percentage %
A	-	-
B	4.48	73.26
C	1.64	26.74
Total	6.12	100

Source: according on Map (1).

Map (2) Distribution of the hydrological soil group of Al-Douigi basin



Source: Depending on the outputs of the program (ArcGIS10.8) and on the soil classification map issued by the United Nations Organization (FAO) and the results of laboratory analysis of soil samples in the study area.

6.2.Classification of ground cover:

The classification of the land cover in the study area is one of the basic requirements through the results can be studied and analyzed in order to reach the (CN) values. It includes the natural and human characteristics that cover the surface of the earth despite the change of the cover according to human needs that change through the time. The detection of the types of land cover in the basins of the study area reflects the ability of the basin to generate rain off and groundwater recharge. It was made on the satellite visual (Landsat.9) on (25/7/2021) with an accuracy of (30) m for the area and through the use of classification, the wave with the natural spectral colors or the existing color categories in the visual, and from the research and interpretation information of the continuous field study in the region.

This data to processing through (ArcGIS10.8) program, after merging the seven bands (RBG), which are bands (3, 5, 7), then the classification of the land cover becomes clear, and from it the land uses are determined through:

Raster ➡ Tool Box ➡ Datamangement tools

Processing ➡ Composite Bands Landsat

It is possible to identify the types of land cover in the Al-Douigi basin, through map (2), after using and applying these tools on visual evidence. They will be studied according to their division as follows:

Table (2) Distribution of land covers classification in the study area

type	Area km2	Percentage %
Barren lands	3.45	56.32
Natural vegetation	1.45	23.76
Cultivated vegetation	0.47	7.69
Sand dunes	0.02	0.35
rocky outcrops	0.73	11.88
the total	6.12	100

Source: according on Map (2)

6.1.Barren lands

It is lands unsuitable for human or agricultural use due to the presence of rocky excavations as a result of the exposure of those lands to erosion processes. The main reason is attributed to the fact that these lands are completely devoid of vegetation cover (Al-Nafi'i,1984). These lands occupy wide parts, especially the northern parts and the western parts near the Hamrin Hills. In addition, to separate parts overlapping with other varieties, especially the southern and western parts of the basins of the study area. This category covers an area of (3.45) km^2 with a rate of (56.32%), as shown in the map (2) and table (3).

This type of cover is characterized by the speed of surface runoff, except for sandy or gravel soils where water seeps in and then affects the runoff during the rainy period with the opportunity to increase the slope of the surface. The cohesion of the rocks with the short period required for the occurrence of runoff during the rains works to reduce leakage amount (Hameed. 2016).

6.5. Natural vegetation cover:

They are covered with seasonal and perennial herbs throughout the year, which grow intensely after the rains, such as al-Khabaz, al-Humaid, al-Handukuk, as well as wild Sidr trees. They are spread in this region with the extension of the sources of the waterways to the north of the Hamrin mountain range, as well as within the unit of the aggregation plain at the valleys. The available water contains suitable conditions for its growth. This species occupies most parts of the study area, especially the upper parts in the north, in the central sections and separate parts of the basin area. This type occupies an area of (1.45) km^2 and a percentage of (23.76%) of the total area (Map 2 and Table 3).

6.6.Cultivated vegetation

This category includes agricultural lands represented by green color and includes large parts of the selected basins and includes agricultural lands that were cultivated with grain crops. The presence of this species is concentrated in the northwestern parts near the dividing borders at the slopes, as well as in the central parts and in the southern part near the mouth of the basin. It is found in small percentages in the region due to the lack of water sources, and the area of this species is about (0.47) km^2, at a rate of (7.69%) of the total basin area.

The presence of vegetation cover has a direct impact from the hydrological point of view on the surface runoff. The amount of runoff decreases with the increase in the density of vegetation cover flow (Al-Rayani,2019). Most of the cultivated plants are winter crops such as wheat and barley, or permanent trees. It became clear through the field study that there are (4) wells in the study area that are relied upon to irrigate some agricultural crops such as watermelon and cucumber (Map 2 and Table 3).

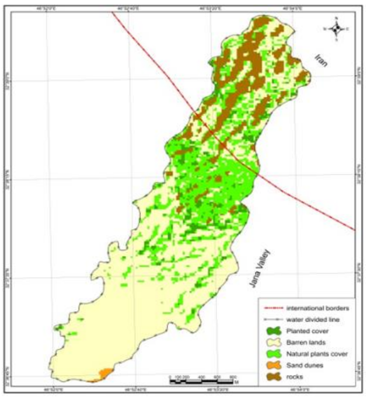
6.7. Land of sand dunes

This type of land occupies the lower parts of the study area. It extends in the form of west to east, where wind and sedimentary erosion processes prevail, which are characterized by the presence of many wind and sedimentary land forms, especially crescent and longitudinal sand dunes and some scattered sand. The wind worked to transport and deposits it over the rock and stone deposits in that region. These lands occupy an area estimated about (0.02) km^2, and with an estimated percentage of (0.35%) of the total area. This type is spread in the southern parts at the downstream area.

6.8. Lands of rocky excavations

It means the area without the soils of exposed rocky nature. The increased infiltration rates for this type of ground cover those are associated with all porosity and permeability with the difference in the nature of the linear composition that forms the exposed interface of the lower parts. The bare rocks are more solid and less porous, which allows the emergence of surface runoff, and these rocks cover the upper parts of the slopes of the hills. These lands extend in the form of a longitudinal band in the northern sections with an eastern and western direction for the study area. The area is estimated at (0.73) km^2, at a rate of (11.88%) of the total area of the basin.

Map (3) Land Cover Classification (Land Use) in Al-Douigi basin



Source: The satellite view of the American satellite (Landsat.9) with a resolution of (30) m on 9/1/2022 - using the program (ErdasImagin.14) and the outputs of the program (ArcGIS 10.8)

7.Anticedent Soil Moisture Condition

Identifying the preconceived state of soil moisture is an important requirement for obtaining CN values. It has a great effect on both the size and the rate of runoff being this case refers to the wet content before the start of the rainstorm which was mentioned beforehand (Mohsen, 2018). The SCS has been developed by specialists and working on this aspect to estimate the values (CN), so three features have been identified in determining the pre-condition of soil moisture. The first feature (AMC I), representing dry soils, and the second feature (AMC II) for dry and semi-dry areas and the third feature (AMC III) representing wet areas characterized by heavy rain and low temperatures to calculate runoff (Tali and Arziabi,2015).

So each pre-soil moisture situation has values. (CN), when calculating runoff through a merger between the ground cover layer and the soil's hydrological groups thereafter, values were obtained (CN) (Yeshewatesfa et al,2001). It is considering the pre-condition of soil moisture as the second advantage (AMC II) which represents the normal situation for calculating the running characteristics of the basins and valleys of the Jinnah area.

Table (3) Soil moisture content for the previous five days (inches)

AMC	Dry season	Grow season
I	Less than 0.5	Less than 1.4
II	0.5-1.1	1.4-2.1
III	More than 1.1	More than 2.1

Richard H. Mc Cuen, Hydrologic Analysis and Design. Prentice – Hall ,Inc. , Asimon Aviacom Company Upper Saddle River ,NewJersey,1989,P.160

8.Extract Curved Numbers (CN) Al-Douigi basin:

The values (CN) (Curve Number) are extracted as an indicator through the merger of the two ground cover layers and hydrological soils by Combine (Arc GIS 10.8), and separate values were given to each soil group. Experimental analyses showed that CN values were a function of three factors: the soil group, the moisture cover and the ground conditions (Donker. 2001).

The CN values show the state of the land cover and the quality of the soil according to its water absorption capability and thus demonstrate the capacity of the basin to generate surface runoff. The high values of CN indicate that the surface of the basin is low in permeability. The lower values indicate high permeability ratios (Table 4). The values are derived according to the following (Mwendera and Saleem, 1997).

Table (4) Derivation of the (CN) curve values according to the tables prepared from the (SCS) method

HSG				Description of land
A	B	C	D	Cultivated land
72	81	88	91	Without soil protection treatment
62	71	78	81	Soil protection treatment
Lands of artificial pastures and natural pastures				
68	79	86	89	poor conditions
39	61	74	80	Very rich conditions
Grass lands				
30	58	71	78	Good conditions

Forest lands					
45	66	77	83	Light wing - little cover - no diseases	
25	55	70	77	Thick, rich cover	
Grass lands - golf courses – cemeteries					
39	61	74	80	Good conditions: grass cover 75% or more	
49	69	79	84	Medium conditions: grass cover 75 - 50%	
89	92	94	95	Commercial and professional areas 85% non-permeable	
81	88	91	93	Industrial provinces 72% are not enforceable	
Residential lands					
				Size of land	non-access rate
77	85	90	92	65	More than 1-8
61	75	83	87	38	More than 1-4
57	72	81	86	30	More than 1-3
54	70	80	85	25	More than 1-2
51	68	79	84	20	More than 1
98	98	98	98	parking lands for cars - roofs - paths -- etc	
streets and roads					
98	98	98	98	sidewalks for rainwater drainage	
76	85	89	91	Unpaved gravel roads	
72	82	87	89	abandoned roads	

Source: Vijay P. Singh. Donald K. Frevert, Watershed Models, CRC Press is an imprint of Taylor& Francis Group .2006,P364 .

In order to obtain accuracy in identifying areas with runoff and water collection areas in selecting the optimal location of water harvesting methods. This study was provided by working with Pixel units and dimensions (15×15) m, allowing for accurate results covering the study area. Table (5) and map (3), have been showed that the values are classified based on (ArcGIS 10.8) in the area study. The values (CN) were in the basin, which amounted to more than 70 to 80, estimated at 0.84 km^2 and 13.72% of the total basin area. The lowest category of which is characterized as low-hardness porosity land, characterized by water permeability so as to contain its land on a high percentage of sand which reduces runoff.

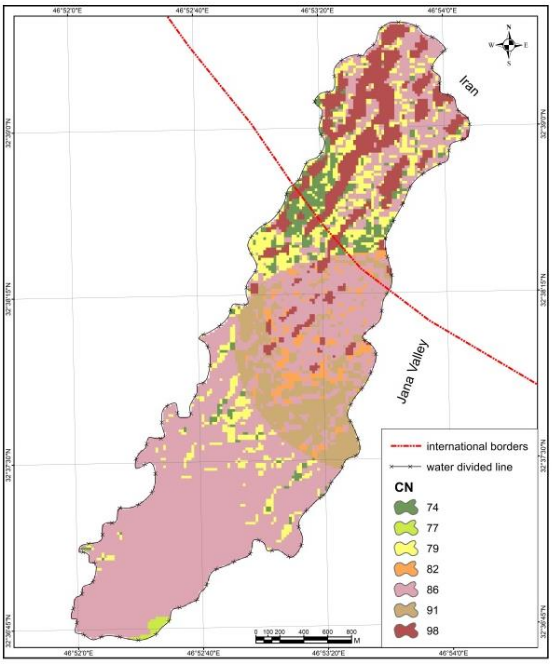
They are visibly spread as layers in the part of the basin, and are CN values ranging from more than 80 to 3.46 km^2, and 56.5% to the total area of the basin. This category is characterized by its moderate hardness and its permeability is between small and medium. However, it allows water to run off during the fall and increases the amount of sediment transported by this flow, covering large parts of the basin. The values of the CN recorded more than (90) which were estimated at 1.82 km^2, and at 29.7% of the total basin area. The lands of this category are more rigid because they do not allow water to run through them and increase the speed of runoff and appear as small layers in most parts of the basin.

Table (5) Categories of Curve Values (CN) for Al-Douigi basin

CN	Area km^2	Percentage %
74	0.24	3.9
77	0.22	3.5
79	0.38	6.2
82	0.29	4.7
86	3.17	51.7
91	0.88	14.3
98	0.94	15.3
Total	6.12	100

Source: based on (ArcGIS 10.8) and Map (3).

Map (4) Distribution of Curve (CN) Values in Al-Douigi basin



Source: The satellite view of the American satellite (Landsat.9) with a resolution of (30) m on 9/1/2022 2 - using the program (ErdasImagin.14) and the outputs of the program (ArcGIS 10.8)

9.Calculation of the coefficient of the maximum possibility of retaining water after the start of flow (S):

This parameter means the maximum possible extent of water retention in the soil or water retention in the soil after the start of surface runoff. This parameter (Potential Maximum Retention After Runoff) (S) may describe the condition of the soil saturated with water after the start of surface runoff after the cessation of the seepage process. There appears a variation in the thickness of the soil layer saturated with water depending on the soil type and its ability to absorb water during rain, however, this coefficient is directly related to the soil type and the nature of land use, which is reflected through the values of the curve (CN).

High values of this coefficient (S) indicate a high potential of the soil to retain water and thus a decrease in the amount of surface runoff, while values close to zero indicate a decrease in the ability of the soil to retain water, which is reflected in the provision of a larger amount of runoff water (Shukur,2017). The value of (CN), which is known as the surface agglomeration, is calculated after the start of runoff, as shown by the following mathematical equation (Bansode and Patil,2014):

$$S = \frac{25400}{CN} - 254$$

It turns out that the number (254) represents the median value of the coefficient (S), and the ability of the soil to retain water increases when the value of (CN) decreases, but if the value of (CN) increases, we notice an increase in the amount of surface runoff (Soulis and Valiantaz, 2012). According to the above equation, the value of (CN) was calculated and the results of the equation were extracted in the program (Arc GIS 10.8), and using (Raster Calculator). The results were obtained and then a map was extracted to determine this value, its area and its percentages. The value of the coefficient (S) ranged of Al-Douigi basin for the category (75) mm.

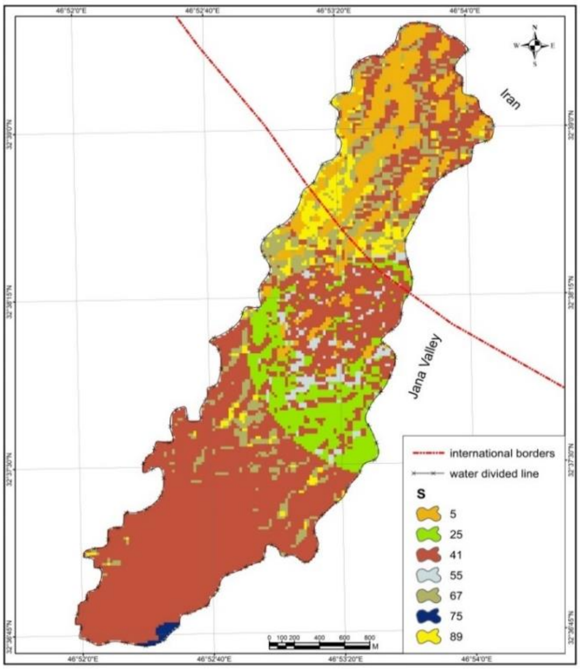
The area occupied by the basin was (0.22) km^2, with a rate of (3.9%) for the part that has the least ability to retain water on its surface, which indicates the weak ability of the soil to retain water and the increase in surface runoff velocity. The category (41) mm occupied an area of (3.17) km^2 and a percentage of (51.7). %) for the parts that have the most ability to retain water, as they indicate the ability of the soil to store rainwater and weak runoff for those areas that are characterized by a high retention coefficient. The observation of map (4) and table (6), we conclude that most parts of the study area fall within the high values of the (S) coefficient. Especially since most of the coefficient values are above (50). This indicates that they are high values for the (S) coefficient has the ability to retain water, and have a rapid response to surface runoff.

Table (6) Distribution of maximum retention values (S) mm in Al-Douigi basin

Class	Area km^2	Percentage $
5	0.94	15.3
25	0.88	14.3
41	3.17	51.7
55	0.29	4.7
67	0.38	6.2
75	0.22	3.9
89	0.24	3.9
Total	6.12	100

Source: Based on Map (4) and the output of (ArcGIS10.8).

Map (5) Distribution of the values of the coefficient (S) mm in Al-Douigi basin



Source: 1- The satellite image of the American satellite (Landsat.9) with a resolution of (30) m on 9/1/2022 2 - using the program (ErdasImagin.14) and the outputs of the program (ArcGIS 10.8)

10.Calculating the initial extraction coefficient (La)

The coefficient (La) expresses the lost quantities of rainwater before the start of surface runoff through evaporation or through rainwater encountered by plants, or through leakage. There is also a strong correlation between each of the soil type, its porosity, and the density of vegetation cover. It has a direct correlation with the coefficient (S) that was mentioned earlier. The initial extraction represents one-fifth of the value of (S) (Almasri, 2010). The low values of the coefficient (La), which are close to zero, indicate a decrease in the amount of rainwater lost before the start of surface runoff, which helps to accelerate the surface runoff process.

However, the value (50.8) mm represents the median condition. The initial extraction rate is equal to the rate of running water on the surface, but in the case of an increase in this value. It indicates an increase in the amount of rainwater lost and thus a decrease in the amount of surface running water (Schiariti and,CPESC,2012). It is calculated the initial extraction coefficient according to the following mathematical equation:

La = 0.25

Where:

La = initial extraction before the start of runoff (mm).

S = maximum retention value after starting flow (mm).

0.25 = constant value

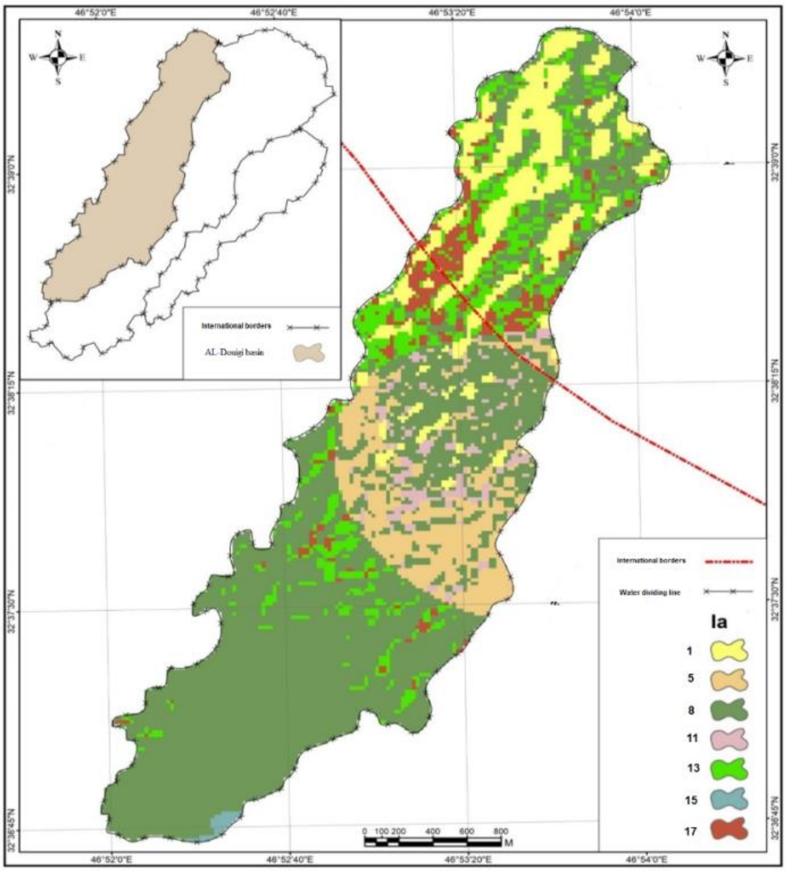
When applying the (La) equation in (ArcGIS10.8) and using the (Raster Calculator) tool within the spatial analyzer menu, to obtain a (Raster) map. It is showed us the values of similar pixels in a specific color for the purpose of obtaining the initial extraction values. It is noted in Table (8), we find that the values of the (la) coefficient recorded a decrease ranging between (8-15), where the results of the application of the equation (la) showed the possibility of generating surface runoff in most parts of the region. All of these areas were closer to zero than the average values. The lowest low value occupied the largest area in the region, amounting (3.17) km^2, with a rate of (51.7%). It was concentrated in the central and southern parts of the region.

Table (7) Distribution of (la) values of Al-Douigi basin

Class (mm)	Area km^2	Percentage %
1	0.94	15.3
5	0.88	14.3
8	3.17	51.7
11	0.29	4.8
13	0.38	6.2
15	0.22	3.5
17	0.24	3.9
Total	6.12	100

Source: Based on Map (7) and the output of (ArcGIS10.8).

Map(6)Distribution of the values of the coefficient (la) mm in Al-Douigi basin



Source: 1- The satellite image of the American satellite (Landsat.9) with a resolution of (30) m on 9/1/2022 2 - using the program (ErdasImagin.14) and the outputs of the program (ArcGIS 10.8).

11.Estimate of annual (Q) runoff depth

Surface runoff depth is the summary of the interaction between a specific rain wave with the components and characteristics of the drainage basin. The difference in the type of ground cover and the amount of its soil permeability, the depth of the runoff formed on its surface varies. In this case, with the constant rain waves over the entire basin concerned with the study, and the curved numbers are the variable and controlling element in the variation in surface runoff depth between parts of the region (Richard and Cuen, 1989).

It also expresses the amount of depth of the water running on the surface during rain falling on it, which depends on the natural data of the area, which we infer from the values (CN - la - S) (Shukar,2017), and the depth of surface runoff can be expressed (Q), according to the following equation (Elena et al,2008):

$Q= ((P\text{-}la)^{2}/ (P\text{-}la+s)$

Where:

Q = runoff depth (mm)

P = rain (mm)

la = losses before the start of flow, including water retained in depressions (surface, evaporation, leakage)

S = maximum surface accumulation after runoff starts (mm)

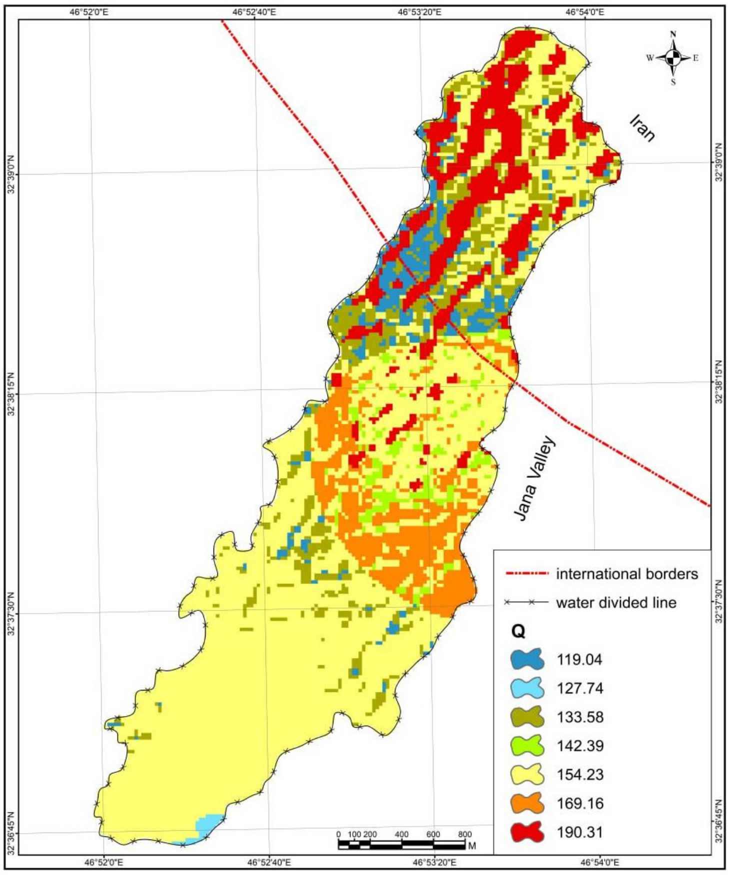
When applying the (Q) equation in (ArcGIS10.8) and using the (Calculator Raster) tool within the functions of the spatial analysis and according to the above equation. The surface runoff depth (Q) was calculated (Table 9) and Map 6). The values of (Q) for the Al-Douigi basin, which recorded the category (154.23) mm, ranged as the area reached about (3.17) km^2, with a rate of (51.7%), as the highest values were recorded in the downstream area. However, it was recorded below in the upstream area, which represented the category (127.74) mm, with an area of (0.22) km^2, with a rate of (3.6%). This indicates that there is a state of discrepancy in the value of the depth of runoff between the upstream and downstream areas, resulting in the occurrence of surface runoff accumulated in the upstream area of the basin.

Table (8) Distribution of (Q) values of Al-Douigi basin

Class (mm)	Area km^2	Percentage %
119.04	0.24	3.9
127.74	0.22	3.6
133.58	0.38	6.2
142.39	0.29	4.7
154.23	3.17	51.7
169.16	0.88	14.3
190.31	0.94	15.3
Total	6.12	100

Source: The researcher's work based on ArcGIS 10.8.

Map (7) Distribution of (Q) values in Al-Douigi basin



Source: 1- the American satellite (Landsat.9) with a resolution of (30) m on 9/1/2022 2 - using the program (ErdasImagin.14) and the outputs of the program (ArcGIS 10.8)

12.Estimation of Runoff Volume (QV)

There is a close relationship between the volume of surface runoff and the intensity of rain and the length of its fall period. The continuation of a rain storm for a short period of time does not lead to the occurrence of surface water runoff, while the persistence of the intensity of the rain storm for a longer period of time causes the occurrence of surface water runoff (Almasri,2010). This is what characterizes the study area with a dry climate with little precipitation, and estimating the volume of runoff is one of the important calculations when carrying out any hydrological study, which expresses the total runoff in relation to the area of the basin to know the extent of its use in determining the places that are exposed to torrents and methods of water harvesting.

The current study of the basins and valleys of Al-Jana region relied on calculating the surface runoff depth that was previously obtained, using the (Calculator Raster) function within the layers of the spatial analyzer and by (ArcGIS 10.8) program. Each pixel has an area of (30x30) m per cell. Thus, it helps to give a fixed area for all pixels of (900) m^2.

The runoff volume was calculated according to the following equation (Mishra and Singh,2004):

$QV = (Q \times A)/1000$

So that,

QV = Runoff volume (m^3)

Q = runoff depth (mm)

A = area of the drain pan (m^2)

1000 = conversion factor

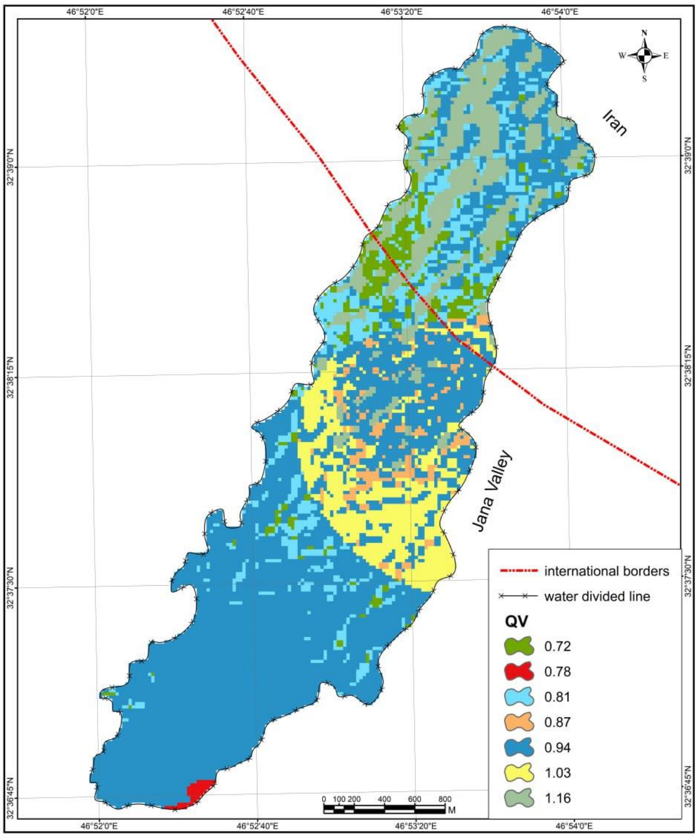
It is clear from the results of the above equation that the highest amount of water runoff in the Al-Douigi basin reached (1.16) m^3, which covers an area of (0.94) km^2, with a rate of (15.3%) (Table 10). The lowest amount of surface runoff in the aforementioned basin was represented in the category (0.72) m^3, with an area that occupied about (0.24) km^2 and a rate of (3.9%). As for the remaining surface runoff values, they were distributed (0.24 to 0.88) (Table 9).

Table (9) Distribution of Runoff Volume Values (QV) in Al-Douigi basin

Class	Area km^2	Percentage %
0.72	0.24	3.9
0.78	0.22	3.6
0.81	0.38	6.2
0.87	0.29	4.7
0.94	3.17	51.7
1.03	0.88	14.3
1.16	0.94	15.3
Total	6.12	100

Source: Based on the (QV) equation and the output of ArcGIS 10.8.

Map (8) Distribution of Runoff Volume Values (QV) in Al-Douigi basin



Source: 1- the American satellite (Landsat.9) with a resolution of (30) m on 9/1/2022 2 - using the program (ErdasImagin.14) and the outputs of the program (ArcGIS 10.8)

13.Conclusions

The study concludes that the total area affected by surface runoff was about 6.12. The depth of surface runoff in the study area was about 0.94. The value of the soil's ability to retain water was 0.24. According to the Burring classification, the soils of the Al-Douigi basin fall within the hydrological group of soil (B) and constitute (73.26%). Thus, the soil infiltration rate is medium to low runoff in its areas. The satellite visual classification showed the presence of (5) varieties in the study area. The barren land category occupied the highest area (3.45) km^2 with a rate of (56.32%). The values of (CN), which ranged from more than (80), which is a high value indicating the possibility of generating high water flow in the Al-Douigi basin. The highest amount of runoff was (1.16) m^3 and covers an area of (0.94) km^2 and constitutes (15.3%) of the total area of the basin. It has the ability to produce runoff. The spatial accuracy of collecting information in the current study in calculating the hydrological characteristics of a photovoltaic cell unit is (30x 30). It is considered important in these studies when the information extracted is more detailed, the results are more accurate in the occurrence of runoff.

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