Open Access

Contemporary Research Analysis Journal

e-ISSN: 3050-5909
p-ISSN: 3050-5895

Volume 02 Issue 07 July 2025
CrossRef DOI: 10.55677/CRAJ/05-2025-Vol02I07

Page no: 410-430

Hydromorphological characteristics and the impact of climate change mathematical simulation by Support Vector Machines Algorithm (SVM) for Valley of the Marj Basin, an applied study

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ABSTRACT: The phenomenon of climate change has become a reality that the international community has to deal with seriously, and climate change is distinguished from most other environmental issues by its global nature, but its local effects are more severe. Studies have shown that there is an increase in surface air temperatures on the globe as a whole by about (0.7 m) during the past 100 years, and studies by the Intergovernmental Panel on Climate Change (IPCC) indicated that this continuous rise in the global average temperature will lead to many serious issues such as drought, desertification and change in all current landforms, and to show the impact of changes.

KEYWORDS: Climate change, Impact of changes, International community, Change in landforms

The results showed :
The area of Wadi Al-Marj basin is (2062.33 km2) and is located in a region characterised by a dry climate for most months of the year except for some short rainy periods that provide good water discharges that can be exploited for water harvesting purposes, Wadi Al-Marj extends over a plateau surface varying in height between (57 m) at the mouth and (380 m) The research showed that the drainage network of the basin is of the sixth order and the drainage density and river frequency are high due to the high permeability of rock formations .

While the results of the special algorithm in analysing the impact of climate change on the studied characteristics by 2050 showed that by 2050 temperatures will increase by 2-3 m by 2050, which means increased evaporation rates, and as for rainfall, it is expected that rainfall will decrease by 10%. This will lead to a decrease in the amount of water available for agriculture and human use and an increase in soil salinisation due to a decrease in the natural washing of salts. As for the soil, its salinity will increase due to decreased rainfall and increased evaporation, especially the calcareous and gypsum desert soils and will be vulnerable to degradation and erosion due to the lack of vegetation cover, which will decrease by 20-30% due to drought and increased heat. As for running water, it is expected that the amount of running water will decrease by 15-25% due to reduced rainfall and increased evaporation, and this will lead to changing the paths of watercourses due to the reduced amount of water, resulting in changing the landforms caused by water erosion.

The research question :

Does climate change have an impact on the nature of the water network in Wadi al-Marj and its impact on the water network, the water revenue of the basin, the quantities of that water, the nature of its distribution, the amount of losses, and the extent of the impact on soil characteristics and quality?

The answer is as follows:

Climate change has a significant impact on the hydromorphological characteristics, as it affects the water network and the nature of its longitudinal extension, especially since the research area is characterised by its low slope compared to the nature of the extension, as well as the impact of the climate with its various elements and the lack of water runoff in dry seasons, which leaves a clear impact on the chemical characteristics of the soil and the nature of its composition, whether it is calcareous or gypsum, as well as the extent of its organic matter content .

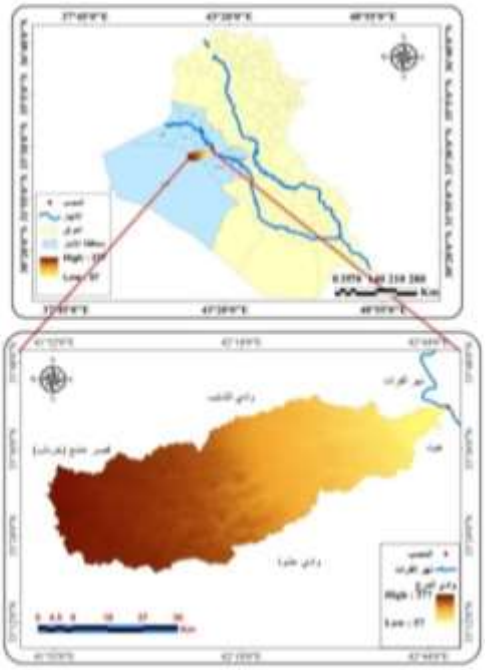
Research goal :

The researchers aim to identify the impact of climate changes expected to occur by 2050 on the natural, morphological, and quantitative characteristics of the Wadi Al Marj basin, to build a geographic database containing morphometric variables and other

variables related to the nature and characteristics of soils, as this database is characterised by the accuracy of its details that are not provided by topographic maps, due to the importance of these characteristics in hydrological .
geomorphological studies.

Location of the research area

Wadi al-Marj is located in the western plateau of Iraq within Anbar province, and the valley ends in the Euphrates River at the border of
Heet district between two latitude circles (″0'120°33 - ″0'833°04)in the north and (42°44'0″E - 41°52'0″E) in the east Map **(1)**
Location of the search area in relation to Iraq



Source: Based on DEM2007 satellite imagery using ARC GIS software

Introduction: Hydromorphometric analysis of river basins is one of the types of quantitative geomorphology, which is used to study the phenomena of the earth's surface comprehensively in order to know the impact of the structural geology of the region, slopes, drainage, climate, topography, on river basins, relying on data obtained from maps and space visualisations, to build a geographic database containing morphometric variables derived from advanced data sources such as the digital elevation model, Arc GIS 9.3 and Global Mapper. It can be utilised in several fields that have a positive impact on human beings.

The first section: Natural Characteristics

I: **Geological formations:** The research area is located within the Western Plateau of Iraq, which is characterised by being covered by different geological formations belonging to different geological eras with similar characteristics in terms of their formation conditions and features and will be interpreted as follows:

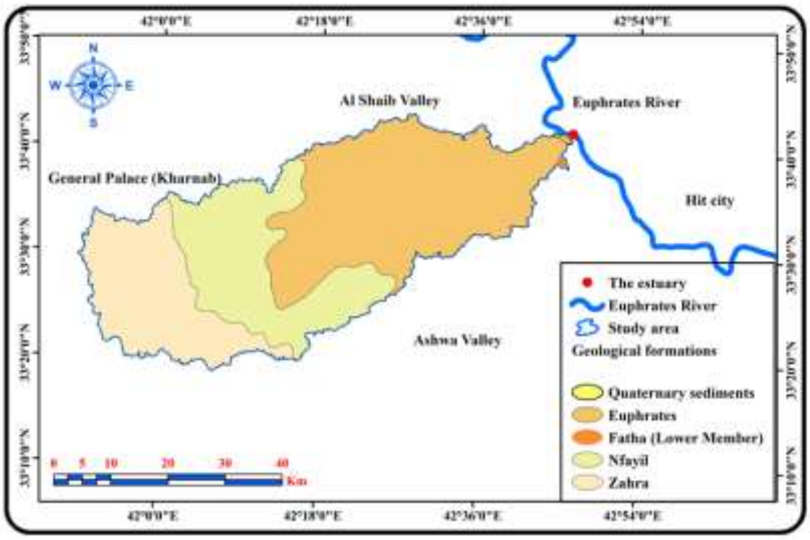
1. **Quaternary deposits**: It is prevalent in the eastern parts of the basin in the areas where the river meets the valley, where its deposits mix with the deposits of the Euphrates River, especially during the season of heavy rains, and these areas have good soils suitable for agriculture. The thickness of these deposits reaches (5 m) and consists of limestone with a mixture of metamorphic igneous rocks and rounded pebbles with medium-sized grains consisting of flint, these deposits occupy an area (2.21 km2) by (0.010%) of the area of the valley.

2. **Euphrates Formation:** This formation is exposed west of the Euphrates River in the central and eastern parts of the research area with an area of (986.55 km2) and (47.97%) of the area of the basin (Map 2) and is exposed in the form of rocky ledges on the course of the Euphrates River up to (17.5 m)[1] in some parts, and most of its components are breccia and dolomitic limestone.

3. **The Fatha Formation:** The age of this formation dates back to the middle Miocene Triassic period. This formation appears west of the Euphrates River east of the valley, occupying an area of (3.5 km2) by (0.16%) of the basin (Map 2) The cycle of deposits of this formation is characterised by its heterogeneity, but it often starts with green shale, followed by limestone, then gypsum, and ends with red mudstone, the average thickness of this formation (60-75 m).

4. **The Nafayel Formation:** This formation dates back to the Lower Miocene Triassic, this formation is exposed in the centre and east of Wadi Al Marj, occupying an area of (574.64 km2) by (27.86%) (Map 2) and with a thickness of (7-15 m), in the form of isolated and separate hills consisting of green shale, limestone and gypsum..[(2)]

Map (2) Geological formations detected in the research area



Source: Based on DEM2007 satellite imagery using ARC GIS software

5. The AL Zuhra Formation: It appears in the southern parts of the basin, occupying (495.87 km2) and (24%) of the area of the basin (Map 2), with a thickness of (20-25 m) covered with Quaternary sediments, consisting of (4-5) depositional cycles, each of which includes the succession of sandstone and limestone to form white limestone sandstone with pink and light brown spots, thin and highly fragile, which makes it vulnerable to weathering [(3)] .

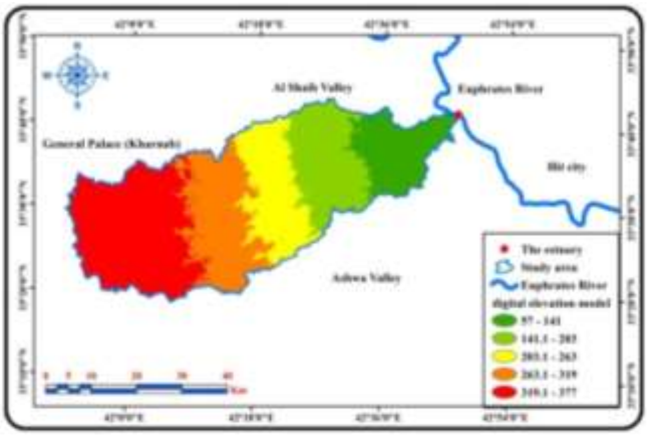
A. Secondly, the surface: The research area is characterised by its undulating plateau surface, which forms an extension of the western Iraqi plateau, and the height of this area varies between (57 m) near the mouth of the valley and (380 m) in the northwestern parts. To clarify the nature of the surface in the basin area, data derived from the digital elevation model DEM and ARC.G.I.S 10 software were relied upon to clarify the nature of the surface in the basin area. 4 and the use of topographic maps to analyse the height and slope of the area. By observing and analysing (Map 3) and (Table 1), it was found that the research area ranges in height from (57-380 m) above sea level and the height from the eastern parts of the area increases as we move towards the west and southwest until we reach the highest level ranging from (320-380 m) above sea level.

Table (1) Elevation classes and their areas

	Height	Area km2	Percentage
1	141 - 57	269.71	13.08
2	203 – 141.1	349.16	16.93
3	263 – 203.1	349.14	16.93
4	319 – 263.1	449.19	21.78
5	377 – 319.1	644.95	31.27
	Total	2062.33	%100

Source: Based on the elevation map.

Map (3) Topographic map of the research area



Source: Based on DEM2007 satellite imagery using ARC GIS software

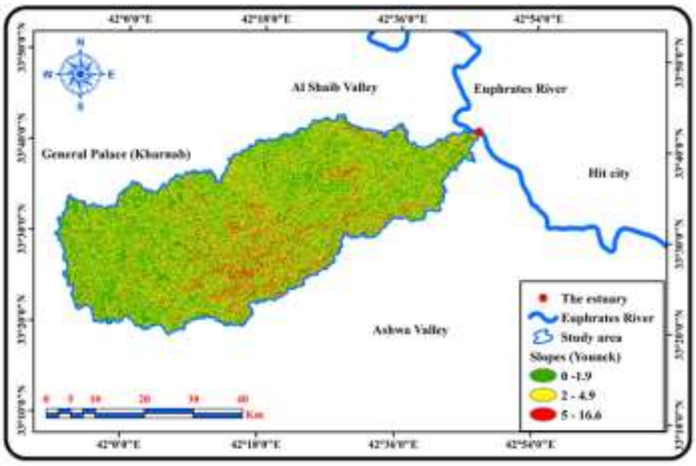
B. Analysing the characteristics of slopes: (Young 1975) classification was adopted to determine the nature of the slope of the terrain in the research area, see (Table 2) and (Map 4), where the first class included plain lands with relatively thick soils that are exposed in most parts of the valley, the second class is distributed in the south, north and centre of the research area and can be exploited by permanent agriculture or grazing, and the third class appears significantly in the centre of the basin where deep valleys with sharp edges are clustered .

Table (2) Classification of regressions in the research area according to Younk's classification

	Degree of slope	Type of slope	Area km2	Percentage
1	2 – 0	Semi-planar land	1069.71	51.87
2	5 – 2	Slightly steep terrain	639.18	30.99
3	16.69 – 5	Light to moderately steep terrain	353.44	17.14
		Total	2062.33	100.00

Source: Based on regression map (4)

Map (4) The nature of the slope of the research area



Source: Based on DEM2007 satellite imagery using ARC GIS software

Third: Climate: It contributes to the formation and development of river basins through its elements that increase the interaction of geomorphological work, as geomorphic processes are related to the climatic features of any region, as the impact of climate elements on geomorphic processes in varying proportions according to the nature of the land surface forms and the extent to which these processes respond to each of the different climate elements, as well as the impact of these elements combined with each other, which in turn activates the geomorphological processes carried out by the river, such as sculpting and sedimentation processes, as well as increasing the effectiveness of mechanical and chemical weathering [(4)] .

1. Temperature: One of the most important elements of climate because of its effect on atmospheric pressure, which in turn controls the distribution of winds and their blowing system, It is also the main cause of evaporation from water bodies, which causes condensation of steam and the occurrence of precipitation in its various forms, which in turn will reflect on the effectiveness of the weathering process, as its rise and fall results in the contraction and expansion of the percentage of minerals in rocks and soil [5] By analysing the data of the table (Table 3), it is clear that the temperature values gradually increase from the end of spring, reaching its peak in July and then decline at the end of autumn, as the two research stations recorded a thermal annual average of (20.9o,20.8o). The lowest temperature recorded was during January (7.7 and 8 m) and July recorded the highest temperature (32.7 and 33.4 m), due to the long daylight hours accompanied by increased hours of actual brightness and clarity of the sky. [6] .

(Table (3) Temperatures for Al-Qaim and Anah stations for the time period (2020-1990

The station	Jan	Febr	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Avg
Al Qaim	7.7	9.8	14.8	20.5	25.6	30.4	32.7	32.1	28.4	23.0	14.8	9.4	20.8
Anah	8	9.9	14.2	20.4	26	30.4	33.4	32.5	28.8	22.6	14.5	9.7	20.9

Source: Ministry of Ministry of Transport General Authority for Iraqi Meteorology and Seismological Monitoring, Climate Department, data Unpublished, 2020.

2. **Rainfall:** By analysing the data (Table 4), we can see that rainfall starts from October and ends at the end of May, and rainfall amounts vary between the two research stations, where Anah station recorded the highest annual total rainfall of (145.9 mm), while Al-Qaim station recorded an annual total of (139.8 mm).

Table (4) Total rainfall at the stations in the area (Al-Qaim - Anah) for the period (2020-1990)

The station	Jan	Feb r	Mar	Apr	May	Jun e	July	Aug	Sep	Oct	Nov	Dec	Avg
Al-Qai	26.0	22.7	25.4	13.4	4.0	0.0	0.0	0.0	0.0	9.1	19.2	20.0	139.8
Anah	28.2	21.8	27.7	11.9	3.1	0.0	0.0	0.0	0.0	11.7	20.3	21.2	145.9

Source: Ministry of Ministry of Transport General Authority for Iraqi Meteorology and Seismological Monitoring, Climate Department, data Unpublished, 2020.

The nature of rainfall in the research area is characterised by varying dates and quantities between seasons and days, and this has a great impact on the surface of the land in the research area, which suffers from drought for long periods of up to eight months when the rain falls in large quantities and concentrated over sloping lands with bare rocks from vegetation cover, causing flooding of low-lying areas and the occurrence of water runoff in desert valleys, causing destruction of human property, such as erosion of arable soil and demolition of buildings. [7]

Fourth: Soil:

A dynamic and evolving natural body with biophysical and biochemical qualities and properties that originated and developed from materials of different origins and within different climates that gave it its properties and the most important of these factors (climate, parent rocks, time, slope, organisms, erosion and weathering) and its depth ranges from a few centimetres to metres, and it is the main resource by which humans, animals and plants live and are affected and influenced by it [8]

The soils of the basin are characterised by their novelty, as they are the result of sedimentation processes of rock fragments transported with flood waters drifting from the western plateau within the flats of the Euphrates River, which made them somewhat developed and contain some diagnostic horizons of calcareous and gypsum. In terms of colour, which is an indication of the state of drainage, degree of ventilation and content of organic minerals, it appears that the yellowish brown colour is dominant in the soils of the research area with the presence of calcium carbonate ($CaCO_3$) and sometimes red colour, which indicates some oxides [9] ..

As for the nature of the soil structure, the soil structure affects the movement, flow and diffusion of water and air in the soil and thus the quality of soil management. Through observation and characterisation, it was found that there is an evolution in the structure of soils in the research area and that the predominant structure is the semi-blocky medium structure in the case of the lack of gypsum and organic matter. While the soils are unstructured, brittle and weak as in gypsum and rocky soils.

1. Soil Chemical Characteristics: The results of the laboratory analyses listed in (Table 8) showed that the soils of the research area are characterised by slightly high reaction values, where the values of the degree of soil reaction (PH) were distributed between (7.7-7.9) as for salinity, the soils of the research area were distributed between low saline to highly saline soils in their electrical conductivity, where these values ranged between (1. They were also characterised by low positive ion exchange values, very little organic matter and decreased with increasing soil depth and high sodium exchange rate, which explains why most of the samples of the research area fell within the category of sodic saline soils.[10] .

Table (5) Chemical and physical characteristics of the soil sections of the study area

Lime%	Gypsum%	cEc mmEq/100	Soil texture	Size distribution of soil arthropods			(ECe)	PH	depth	sample
				Clay %	Green %	Sand %				
32.4	0.63	21.4	SiL	6.5	69.9	23.6	7.6	7.8	20	1
51	0.67	15.4	L	13	51	41	3.2	7.7	20	2
37	0.42	16.8	L	17	48	37	1.8	7.9	20	3
42	0.36	13.2	siL	18	52	3	2.7	7.8	20	4
39	0.75	11.7	cL	27	42	25	5.8	7.6	20	5
48	1.8	13.2	L	22	46	32	6.9	7.9	20	6

Source: Field study as samples were analysed at the Anbar Agriculture Directorate, Soil Department, Laboratories.

2. Physical attributes: According to the It is clear from the tissue triangle that the hydrological soils of the study area are limited to type (B, D):

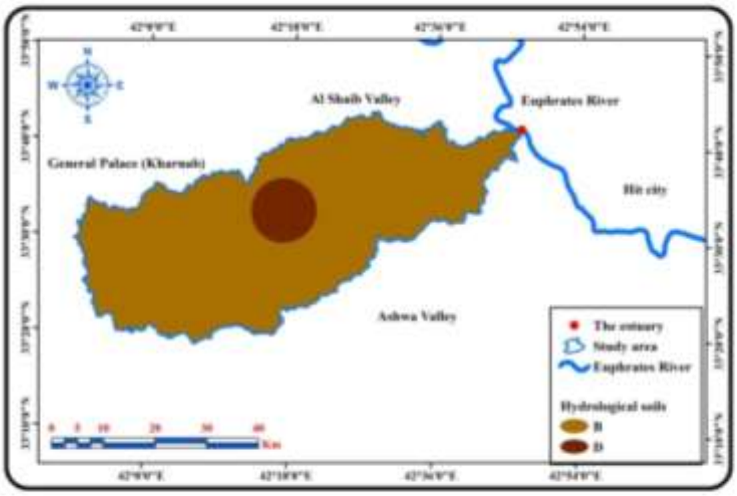
1. Hydrological soil (D): It represents a clay layer with a high swelling rate with the presence of a shallow layer of soft soils in the surface characterised by high surface runoff, so the infiltration rates are low and the water transfer from these soils is very low ranging from (0.505 to 2.54 mm / hour). In the study area, this type of soil was within the sample (5), see map (5)
data of Table (8) and after applying it to the soil texture triangle as shown in Figure (1), it was found that four samples (1, 2, 3, 4 and 6) were within the mixed texture, while sample (1) was within the mixed alluvial texture, and sample (5) was within the mixed clay texture, the reason why most of the samples of the study area fell within the mixed texture (clay loam). Because the depth of the samples ranged from (0 to 10), which represents the surface layer of the basin soil

Figure (1) Soil texture triangle

Source: Based on Table (8).

2. Hydrological soils (B): This group included all the samples of the study area if it is characterised by containing a sandy layer less deep than the hydrological soils groups with an average infiltration rate after the soil is exposed to precipitation, the water transfer rate ranges from (12.7 to 25.4 mm/hour), this is an indicator that the soils of the study area have the ability to increase water infiltration to the depths of groundwater and this is a positive factor that gives the relevant authorities the possibility of establishing water harvesting projects in the study area.

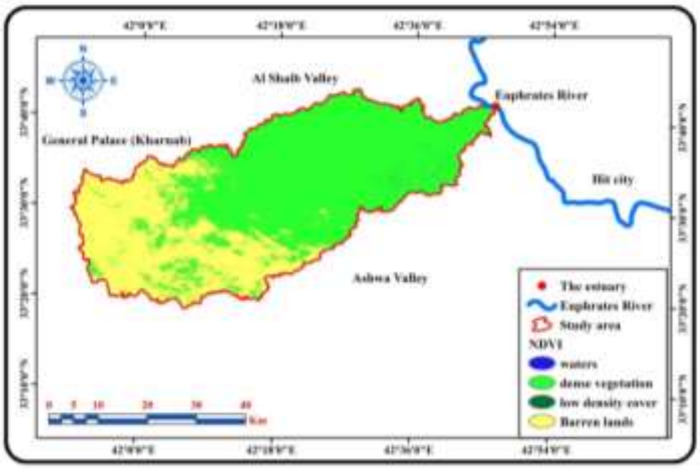
Map (5) Hydrological Soils in the Study Area



Source: Based on DEM2007 satellite imagery using ARC GIS software

V: Vegetation: An important natural resource for humans that contributes to saving the land from potential dangers represented by soil erosion, landslides and floods resulting from heavy rains, and helps to infiltrate rainwater into the ground and increase groundwater storage, In order to assess the state of vegetation in the Wadi Al Marj basin, the Natural Difference Vegetation Index (NDVI) was adopted to know the state of vegetation in the area, see Table (10) and Map (6) showing that there are three areas of vegetation density.

Map (6) Nature of vegetation cover according to NDVI



Source: Based on DEM2007 satellite imagery using ARC GIS software

Table (6) - Vegetation Cover Areas

	Cover type	Area km^2	Percentage
1	Water	0.001229	%0.02
2	Dense vegetation	10.32	% 0.45
3	Low Density Cover	1201.51	%58.23
4	Barren land	850.5	%41.30
	Total	2062.33	%100

Source: Based on Map (7) and ArcGIS software.

1.Dense vegetation: It occupies a very small area of the research area estimated at (10.32 km2), and appears in the eastern parts of the research area (see map (6)). The reason for the density of vegetation in this category is due to the availability of plain lands with fertile soil that provides a good environment for plant growth as well as its proximity to the Euphrates River which provides it with sufficient moisture.

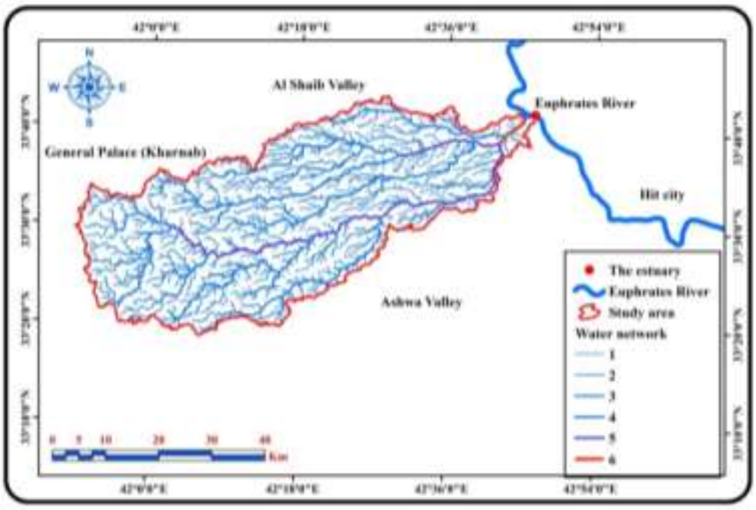
2.Low-density vegetation: It occupies an estimated area of (1201. The researchers attribute the reason for the spread of this category significantly east of Wadi al-Marj to the lack of slope and the prevalence of plain lands adjacent to the Euphrates River. It is known that the more plain the land becomes, the more favourable it is for the growth of vegetation, in addition to the nature of good soils that have the ability to store water in their surface layers due to their good **permeability that helps plants grow if favourable climatic conditions are available.**

3.Barren lands: This category occupies a very large area of the research area, as it appears in all central and western parts, occupying an area estimated at (850 km2) See map (6) The reason for the scarcity of vegetation cover in this category is due to desert soils devoid of organic matter, complex terrain, high temperatures and drought conditions prevailing in the region, and even if plants grow within this category, their growth will be temporary and coupled with seasonal rains.

VI: Characteristics of the drainage network:

- **Riverbeds**: A basic tool for understanding the drainage network directly and is related to the size and density of the network, which provides valuable information on the hydrological and geomorphological characteristics of the basin, and relied on the digital elevation model (DEM) with a resolution of 30 m and then analysed in the program (ARC.Gis) to extract a map of Wadi Al-Marj basin and by observing map (7) and applying the Straler method to the valley basins of the region and table (14), it is clear that the total total number of mattresses in Wadi Al-Marj basin was (9046) and their total lengths (2212). 6) The number of first-order sewers (4220) and the total lengths (1053.58), the number of second-order sewers (2159) and the total lengths (539.75), the number of third-order sewers (1153) and the total lengths (280), and the number of third-order sewers (1153) and the total lengths (280). 40), the number of sewers in the fourth rank (975) and the total lengths (221.75), the fifth rank (507) and the total lengths (107), and the sixth rank (41) and the total lengths (9.82).

Map (7) River ranks of the study area basins



Source: Based on DEM2007 satellite imagery using ARC GIS software

Table (7) Characteristics of the drainage network for the basins of the study area

Mattresses	***Number of valleys***	***Total lengths***	***Total lengths Percentage of bifurcation***	***Average valley length***
First rank	**4220**	**1053.58**	**1.95**	**4**
Second rank	**2159**	**539.75**	**1.87**	**4**
Third rank	**1153**	**280.40**	**1.18**	**4.11**
Fourth rank	**975**	**221.75**	**1.92**	**4.39**
Fifth rank	**507**	**107**	**12.3**	**4.73**
Sixth rank	**41**	**9.82**	**1**	**4.17**
Seventh rank	**-**	**-**	**-**	**-**

Source: Researchers' work based on data extracted from the Digital ElevationModel (DEM*)*

- **Bifurcation ratio**: The branching ratio is an important indicator of the nature of a river basin. It reflects the resistance of rocks to erosion, their permeability, and the topography of the area. Its value usually ranges between (3-5) and based on applying the formula for calculating the bifurcation ratio to the Wadi Al-Marj basin, and checking the results of Table (7),, it was found that the value of this ratio is equal to (3.37). [11] This value indicates that the basin enjoys relative homogeneity in climatic and geological conditions, especially since the ratio is close in the first and second ranks. However, a slight variation was observed in the ratios associated with the higher ranks, which may reflect differences in the quality of the rocks within the basin

- Drainage Density: A measure that expresses the extent to which rivers and wadis spread and branch in a given area. After applying the two equations to the Wadi Al Marj basin, we found that the longitudinal density was (2.115) and the numerical density was (3.051) (Table 8). These two values indicate that the basin is characterised by a moderate drainage network density, reflecting the large area of the basin and the lack of rugged terrain.

- Stream survival rate: This rate refers to the area fed by each unit length of stream in a basin. The higher this rate, the larger the area of the basin compared to the length of the sewerage network, which means the lower the density of the drainage network. Based on the application of the equation to the Wadi Al-Marj basin, as shown in Table (8), the calculated value of this ratio is (0.93), which is considered a low value, and this can be explained by the unique natural characteristics of the study area.

Table (8) - Linear and Numerical Drainage Density and Stream Persistence Ratio for Al-Marj Basin

Basin	Total Streams	Total Stream Length (km)	Area (km^2)	Linear Density (km^2)	Numerical Density (km^2)	Stream Persistence Ratio (km^2/km)
Al-Marj	9046	2212.6	2062.33	1.07	4.384	0.93

Source: Based on the previously mentioned tables.

-***Coefficient of curvature:*** This ratio expresses the extent to which the watercourse is curved compared to an idealised straight course. This ratio helps us to understand the evolutionary stage of the basin and estimate the ability of the river to sideways dig and change its course, and thus its impact on neighbouring lands Based on the results of applying the curvature coefficient to the Wadi Al-Marj basin (Table 9), the value of the stream twisting reached (1.28) This high value indicates that the valley stream is significantly meandering, and the main reason for this is the nature of the brittle rocks in the area, which facilitates the process of erosion and formation of curves in the stream.

Table (9) Sinuosity Index for the Basins in the Study Area

Sinuosity Index	Ideal Length (km)	Actual Length (km	
1.28	**69.8**	**89.86**	**Al-Marj**

Source: Based on the Digital Elevation Model (DEM) with a 30×30 resolution and ArcMap 10 software.

The second section: Hydrological characteristics

The study of the hydrological characteristics of dry wadis is of great importance, especially in light of the possibility of exploiting them for water harvesting purposes. Given that water resources are an essential pillar of any development plan, this research aims to study the hydrology of Wadi Al Marj to identify a set of important hydrological characteristics, including the volume of rainfall, which is the main factor affecting runoff in the region. Therefore, the researchers aim to study the hydrology of Wadi Al Marj to identify the following hydrological characteristics by studying each of the following:

First: The volume of rainfall in the study area:

Runoff in the research area depends mainly on rainfall, and runoff disappears when rainfall stops, so the researchers relied on an equation that takes the total annual rainfall of the research area stations and the area of the basin for each depression to find the annual precipitation volume, namely:

$$\textbf{Annual precipitation (billion } m^{3)} = \frac{\text{Total Annual Precipitation (mm)}}{1000} \times \frac{\text{Basin area km} \times 1000000}{1000000}$$

When applying the equation to the research area Table (10), it was found that the highest amount of precipitation was in the Wadi Al-Marj basin, where it reached 589.207681 m3.) This is due to the large area of the basin, which contributed to the basin receiving large rainfall imports.

Table (10) shows the amount of rainfall at the research stations and the volume of rainfall in billion

The valley	Area of the valley basin	Amount of rainfall in mm at Al-Qaim station	Amount of rainfall at Anah station in mm	Annual Precipitation Volume (million (m3)
Marj	2062.33	139.8	145.9	589.207681

Source: Based on the data from the above equation

II: Estimating the basin's water storage capacity:

The storage capacity of the basin is directly related to its area and depth. The average depth of each depression was estimated by studying several vertical sections using Global Mapper software. Depths were measured at the top, centre and bottom of the depression, and then the arithmetic mean of these values was calculated. Thus, the product of the area multiplied by the average depth gives an estimate of the volume of water that the depression can accommodate and the researchers extracted the carrying capacity of each depression by:

Basin Area (km2) x 1000000 x Average Depth (m)

By applying the above equation to the Wadi al-Marj basin, we found that the absorptive capacity of the basin reached (9692951000) million m3. This is due to the large area of the basin, which is characterised by being surrounded by many lines of equal heights, which helped its absorptive capacity to increase the water flowing towards it, which contributed to the arrival of large water imports, as well as the depth of the basin (4.7 m.)

Third: Estimating the volume of surface water runoff for the Wadi Al-Marj basin:

The research area suffers from a severe scarcity of permanent surface water resources, as a result of the predominance of an arid climate, and surface runoff in this area is limited to seasonal rainfall periods, which are characterised by severe fluctuations in quantities and dates. Due to the lack of standard records of runoff in the basin, due to the importance of water in sustainable development, and to estimate the volume of runoff based on the available rainfall data, the empirical Berkeley equation was used to estimate the volume of runoff, using rainfall data from the two nearby monitoring stations: Climatic and topographic data, both of which were used to formulate the equation, which states:(12)

$$R=(C\ I\ S)^{1/2}\ \{W/L\}^{0.45}$$

By applying the Berkeley equation to the Wadi al-Marj basin (Table 8), it was found that the highest annual runoff volume in the basin (2. 80 million m3), which means that the volume of annual water flow constitutes a good value and this is due to the large area of the basin of the research area, which provides sufficient water income to activate various development projects, especially since the region suffers from severe drought during the summer months, noting that there is a variation in the volume of annual flow, mainly because it depends on the amount of rainfall falling on the region, and the variation in the volume of revenues affects the variation in the rates of erosion processes, as these processes increase with increasing slope rate, and increasing the rates of flow volume.

Table (11) shows the expected annual runoff volume in the basin.

Basin Variables	Area km²	Stream Length km	Stream Width ((km	Width/Length Ratio	Average (%) Slope	Annual Rainfall Volume (billion (m³	Expected Runoff Volume (billion (m³
Marj	2062.33	89.86	21.7	0.295	2.49	589.207681	1.428

Source Based on the data from the equation above.

IV: Flood coefficient, response and flow velocity for the Wadi Al-Marj basin:

The morphometric and morphological features of basins play a crucial role in determining their hydrological behaviour. Changes in the shape and size of the basin directly affect the velocity of water runoff, either increasing the speed at which floods reach the estuary or delaying them. Thus, these features not only determine the flood pattern, but also affect the response time of the basin, i.e. the time interval between rainfall and the arrival of the peak flood.

It is clear from Table (12) that the average flood coefficient for the Wadi Al-Marj basin reached (4.515). This factor was extracted from the product of the basin discharge density in km times the frequency of the first order streams (Hungary km2), and the results indicate a low value of the flood coefficient due to the approach of the shape of the basin to the rectangular shape and the convergence of the number of river ranks in the first and second order. As for the response time and flow speed, which are the most determinant of the hydrological characteristics of the basin, the response time (concentration) can be measured by the time it takes to run water from the farthest point in the basin to its end or any location along the main stream extension. The response time of a meadow basin can be calculated by the following equation:[13] :

Tc=3.76S/i

After applying the above equation to the basin, it was found that the response time (concentration) reached (862.89) minutes, a value that indicates its inverse relationship with the rate of slope of this small basin, as for the runoff velocity, which is expressed in metres/second, which was extracted through the following equation

V = L (M) /3.6 TC (S): [23]

V = Runoff speed

L(M) = Main stream length in metres

TC (S) = Response time is represented in seconds

The results of applying the equation shown in Table 13 showed that the average runoff velocity reached (3.538.3) m/s, which is a low rate, as this runoff velocity reflects the high slope rate in the basin, as the water velocity rate increases as the slope rate rises .

Table (12) shows the flow velocity and response time for the al-Marj basin

Basin Name	Basin Area (km^2)	Main Stream Length (km)	Highest Basin Elevation (m) |	Lowest Basin Elevation (m)	Basin Slope (%)	Response Time (min)	Surface Runoff Velocity (m/s)	Flood Coefficient
	2062.33	89.86	380	57	2.39	862.89	129.232.15	4.515.4

Source: Based on 1/100000 scale topographic maps of 1993. Radar Visualisation Dem for Research Logic, 2007

Chapter Three

Climate change and its impact on the general trend of temperature and rainfa

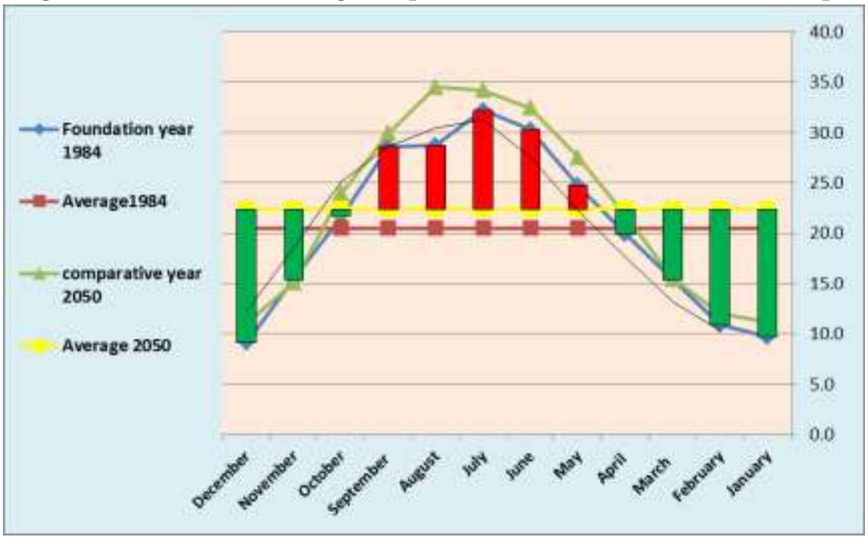
The phenomenon of climate change has become a reality that the international community must deal with seriously, especially after recent studies have proven the existence of a close link between climate phenomena and global warming, as climate change is often global in nature, but its local effects are more severe and harsh, and this varies from place to place according to the nature and sensitivity of the ecosystem of this or that region. Studies conducted by the Intergovernmental Panel on Climate Change (IPCC) have indicated a steady increase in surface air temperatures, with a global average of about (0. 7°C) over the past 100 years, and it is still rising continuously, which may lead to several issues such as drought, which will lead to the transformation of fertile agricultural lands into wastelands due to the encroachment of sand dunes, 7°C over the past 100 years, and it is still rising, which may lead to several issues such as drought, which will lead to the transformation of fertile agricultural lands into wastelands due to the encroachment of sand dunes [14] Therefore, the researchers aim to show the impact of changes in temperature and rainfall on the hydropedomorphic characteristics and demonstrate this through a graph and a general trend line after processing the data with statistical methods and artificial intelligence algorithms.

First: The general trend of the annual average temperature: To find out whether the trend is going towards rising, falling or in a state of stability, and through the study of the time series of the Anah climate station until 2050, it is clear from (Table 13) and (Figure 2) and after a comparative study between the year 1984 as a base year, shown in the figure in blue, and the year 2050 as a comparison year, shown in green, where the average temperature for this year (20.5), it is clear to us that the general trend is going towards rising, as the trend deviated by (0. 8 cm) during the period from 1984 to 2010, the temperature deviated from a high temperature event, with an increase in the annual rate, and that this rise will continue and reach its highest level in 2050 and the rate may reach (22.4), which means that the deviation in temperatures will increase by (2 m) than in the base year, and this can be distinguished by the two lines of the series where the blue colour represents the base year and the green line is the comparison year and the nature of the difference between them.

Table (13) Temperature and rainfall rates and their future projections (1984-2050) for Anah station

	Temperature		Rainfall	
	Base Year 1984	*Comparison Year 2050*	*Base Year 1984*	*Comparison Year 2050*
January	**9.7**	**11.2**	**40.10**	**17.50**
February	**10.9**	**12.0**	**32.30**	**16.25**
March	**15.4**	**15.5**	**35.36**	**15.26**
April	**19.9**	**21.8**	**6.97**	**13.84**
May	**24.7**	**27.5**	**2.50**	**5.18**
June	**30.3**	**32.5**	**0.04**	**0.07**
July	**32.2**	**34.2**	**0.00**	**0.00**
August	**28.7**	**34.5**	**0.00**	**0.29**
September	**28.6**	**30.0**	**0.00**	**0.19**
October	**21.7**	**24.0**	**0.00**	**7.17**
November	**15.4**	**15.1**	**39.01**	**14.51**
December	**9.1**	**11.0**	**21.00**	**17.23**
	20.55	22.43	14.77	8.96

Figure (2) The general trend of the average temperature of the Anah station for the period 1980-2050

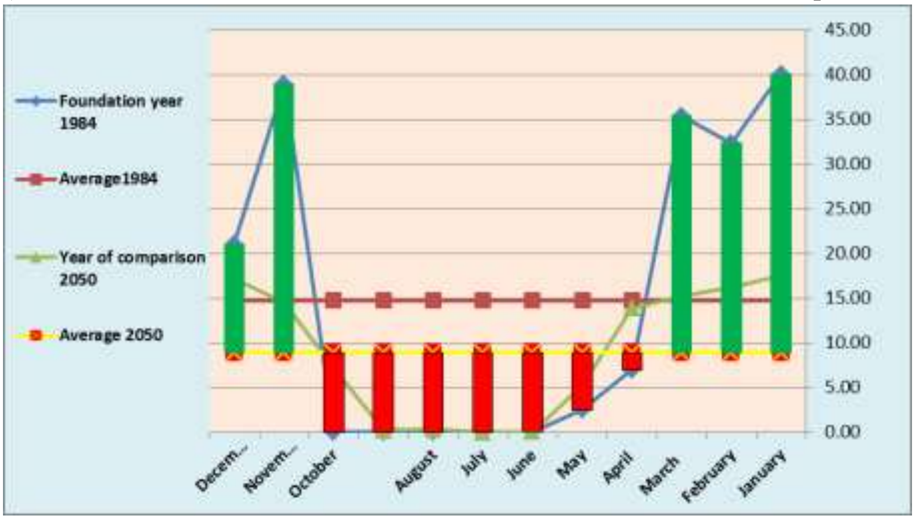


Source: Based on Forecas data

II: The general trend of rainfall at Anah Station: The change in the amount of rainfall, if it occurs in an area, will be more severe than the change in temperature, in which the averages rise very limited, it may be a few tenths of a degree or in the extreme cases does not exceed five degrees or a little more than the general average, but it may increase or decrease tens or hundreds of millimetres, and the rainfall is more fluctuating than the temperature. Rainfall may increase or decrease by tens or hundreds of millimetres, and its fall is more fluctuating than the temperature, and it is known that the fluctuation in subtropical regions is more than other regions, which results in more severe effects, that the general trend of rainfall in Anah station is relatively low, as the degree of change reached (5, 5 mm, the trend deviated from (199-118) mm between (1984-2050), see Figure (3), and this reflects the state of great fluctuation in the amounts of rainfall for this station and this is clear through the figure below through the clear difference between the base year series line in blue and the comparison year line in green:[15]

.

Figure (3) General trend of total annual rainfall in mm for Anah station for the period 1980-2050



Source: Based on Forecas data

From the above, we find that the general trend of temperature has deviated towards an increase, and the general trend of rainfall has deviated towards a decrease, especially during the past 31 years (1984-2025), which came in line with the global general trend of temperature and rainfall in most regions of the northern hemisphere, so this is considered an alarming climate change that threatens the environmental future of the study area and Iraq as a whole. This is an alarming climate change for the environmental future of the study area and Iraq as a whole, as these changes will result in serious environmental effects leading to the prevalence of drought, desertification, decline in vegetation cover, extinction of some species of living organisms, and hydrological effects that are no less dangerous than these mentioned effects(16) .

III: Effects of climate change on landforms in the research area

After describing the climate changes in the two study stations and knowing the magnitude of this change, especially in the elements of temperature and rainfall, which are the main elements of climate, which will result in the magnitude of this climate change will have some environmental effects that have a bearing on all aspects of economic, social and political life in Iraq, and to demonstrate the impact of climate change on the hydropedomorphological characteristics of the Wadi al-Marj basin, the researchers resorted to using the support vector machine algorithm as one of the artificial intelligence tools that can guess the impact of climate change on soil, water and landforms.(17) .

1. Support Vector Machine Algorithm (Support Vector Machines - SVM)

A machine learning algorithm used in Classification and Regression, but more commonly used in data classification. It is based on finding the best hyperplane between different classes in the data, so that the hyperplane is as far away as possible from the nearest data points.

Applications of SVM in climate change and runoff

- Land Use Classification in ArcGIS based on satellite imagery with runoff forecasting based on rainfall, soil and terrain data, as well as the ability to identify flood-prone areas based on weather and terrain data

Applications of SVM in climate change and runoff

- Land Use Classification in ArcGIS based on satellite imagery with runoff forecasting based on rainfall, soil and terrain data, as well as the ability to identify flood-prone areas based on weather and terrain data .

Detecting Climate Patterns Through Historical Data Analysis

Researchers provided the algorithm with the

Data Used:

- **Climate Data:** Temperature and ra
- **Topographic Data:** Elevation and slope classifications.
- **Hydrological Data:** Soil distribut

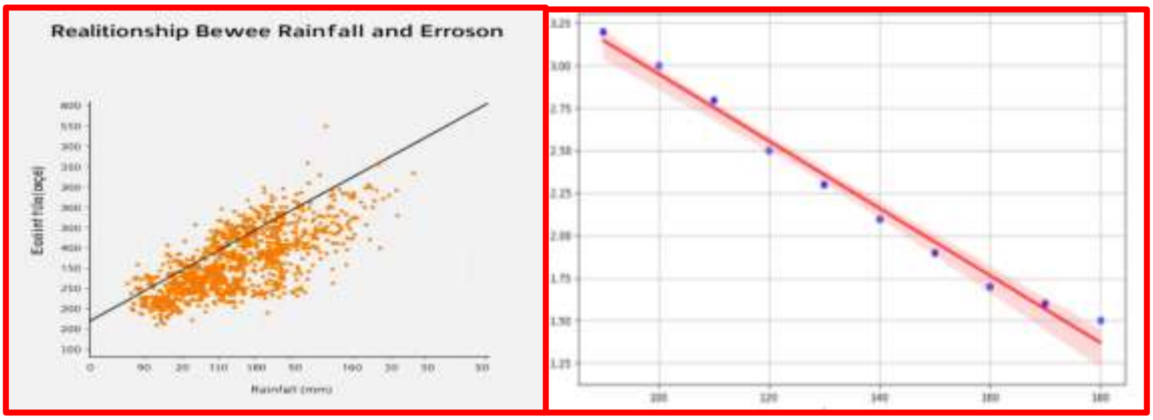
Future Predictions*:* Expected temperature and rainfall

Figure (4) shows the Python programming code provided by artificial intelligence

```python
import pandas as pd
import matplotlib.pyplot as plt

# بيانات الارتفاع
data_elevation = {
    'فئات الارتفاع': ['380 - 321', '320 - 261', '260 - 201', '200 - 141', '140 - 57'],
    'المساحة كم2': [644.95, 449.19, 349.14, 349.16, 269.71],
    'نسبتها': [31.27, 21.78, 16.93, 16.93, 13.08]
}

# تحويل البيانات إلى DataFrame
df_elevation = pd.DataFrame(data_elevation)

# عرض البيانات
print(df_elevation)

# تصور توزيع الارتفاعات
plt.figure(figsize=(10, 6))
plt.bar(df_elevation['فئات الارتفاع'], df_elevation['نسبتها'], color='skyblue')
plt.title('توزيع الارتفاعات في منطقة وادي المرج')
plt.xlabel('فئات الارتفاع (متر)')
plt.ylabel('النسبة المئوية (%)')
plt.show()
```

After processing the data and geographical information, the results were as follows:

Title:" Figure 5 Relationship Between Rainfall and Erosion in 2050."



The provided image shows a scatter plot with a linear regression line, illustrating the relationship between rainfall (in mm) and erosion. Here's an analysis of the graph:

Axes:

- X-axis: Represents the amount of rainfall in millimeters (mm).
- Y-axis: Represents the amount of Erosion,

Data Points:

- The orange dots represent individual data points showing the measured values of erosion for different amounts of rainfall.
- There is a clear positive correlation between rainfall and erosion, meaning that as rainfall increases, erosion also tends to increase.

Linear Regression Line:

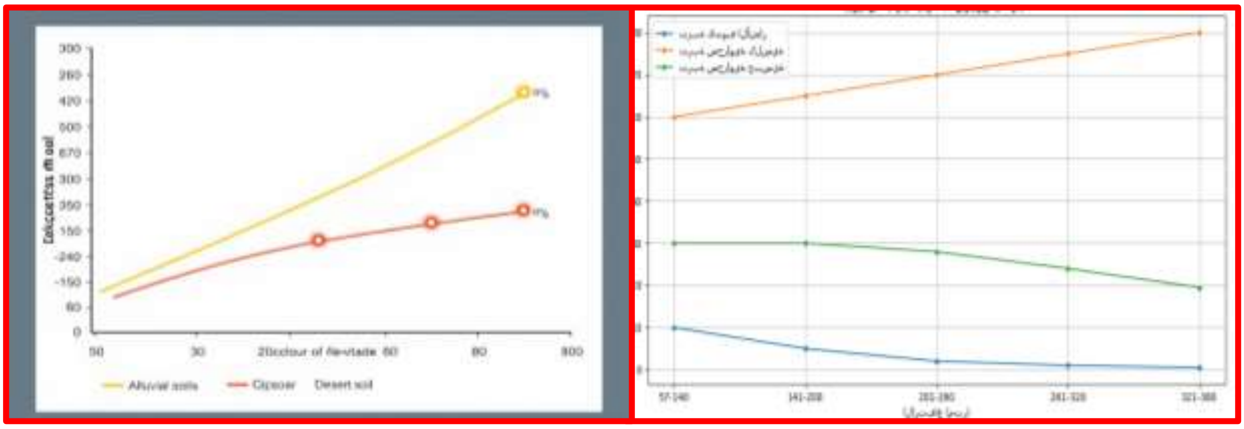
- The black line represents the linear regression model fitted to the data points. This line helps visualize the overall trend in the data.
- The slope of the line indicates the rate at which erosion increases with increasing rainfall. A steeper slope would suggest a stronger relationship.

1. Positive Correlation: The data points are generally clustered around the regression line, indicating a strong positive correlation between rainfall and erosion. Higher rainfall leads to higher erosion rates.
2. Scatter: While there is a general trend, there is also some scatter in the data points, suggesting variability in erosion for a given amount of rainfall. This could be due to other factors influencing erosion, such as soil type, vegetation cover, and topography.

3. Outliers: There are a few data points that deviate significantly from the main cluster, which might be outliers. These could be due to unusual conditions or measurement errors.

The graph effectively demonstrates that there is a significant relationship between rainfall and erosion. As rainfall increases, so does the amount of erosion. However, the presence of scatter suggests that other factors also play a role in determining erosion levels. Further investigation into these additional factors could provide a more comprehensive understanding of the erosion process.

Title: " Figure 6: Soil type and nature of erosion.in 2050



. Here's an analysis of the graph:

Axes:

- Y-axis: "Effectiveness of Soil."
- X-axis: " Flood Frequency"

Data Representation:

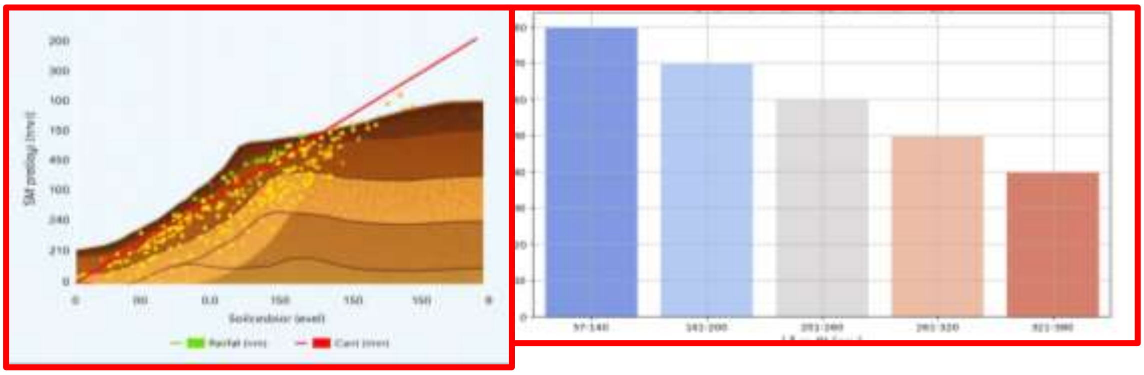
- There are two lines representing different soil types:
- Yellow Line (Alluvial Soils): Shows a positive trend, indicating that the effectiveness increases as the X-axis value increases.
- Red Line (Gipsoar Desert Soil): Also shows a positive trend but at a lower level compared to alluvial soils.

1. Positive Correlation: Both soil types show a positive correlation between the X-axis variable and the Y-axis variable (effectiveness).
2. Comparison Between Soil Types: Alluvial soils appear to be more effective than Gipsoar desert soil across the range of the X-axis values.

Conclusion:

The graph aims to compare the effectiveness of two soil types (alluvial soils and Gipsoar desert soil) based on an unclear X-axis variable. Alluvial soils seem to be more effective overall.

Figure 7 The Relationship Between Rainfall and Erosion Processes According to Elevation in 2050



Corrected Axes:

- Y-axis: Represents "Soil Moisture (mm)."

- X-axis: Represents "Elevation."

Corrected Data Representation:

- The graph contains two main lines:
- Green Line: Represents the distribution of rainfall across different elevations.
- Red Line: Represents soil moisture levels or another variable related to erosion.
- The scattered yellow points around the red line represent individual data points, indicating variability in soil moisture levels at each elevation.

Detailed

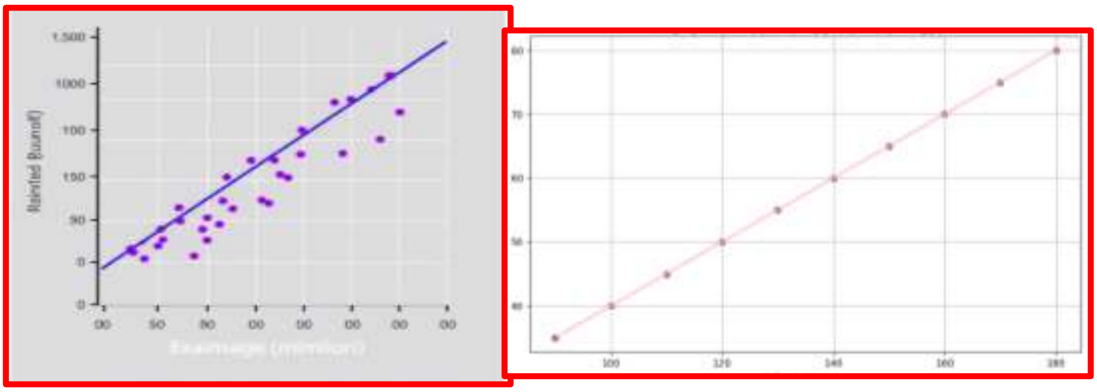
1. Positive Correlation:
   - Both lines (green and red) show a clear positive trend, indicating that:
   - As elevation increases, rainfall also increases.
   - As elevation increases, soil moisture or the associated variable also increases.
2. Data Variability:
   - The yellow points show slight variations in soil moisture levels at the same elevation, which may be due to other factors such as soil type, vegetation cover, or wind exposure.
3. Impact of Rainfall on Erosion:
   - Increased rainfall with elevation enhances erosion processes, as water contributes to soil stripping and material transport.

Conclusion:

The graph illustrates the relationship between rainfall and erosion processes based on elevation. It can be concluded that:

- An increase in elevation leads to an increase in both rainfall and soil moisture.
- This relationship has a direct impact on erosion, as excess water increases the rates of soil stripping and material transport.
- However, other factors such as soil type and vegetation cover must be considered for a complete understanding of these processes.

Figure8: "Relationship Between Rainfall and Surface Runoff in 2050."



The image shows a scatter plot with a linear regression line, illustrating the relationship between rainfall and surface runoff. Here's an analysis of the graph:

Axes:

- X-axis: Represents"Rainfall (mm)
- Y-axis: Represents . "Surface Runoff (mm)."

Data Points:

- The purple dots represent individual data points showing the measured values of surface runoff for different amounts of rainfall.
- There is a clear positive correlation between rainfall and surface runoff, meaning that as rainfall increases, surface runoff also tends to increase.

Linear Regression Line:

- The blue line represents the linear regression model fitted to the data points. This line helps visualize the overall trend in the data.
- The slope of the line indicates the rate at which surface runoff increases with increasing rainfall. A steeper slope would suggest a stronger relationship.

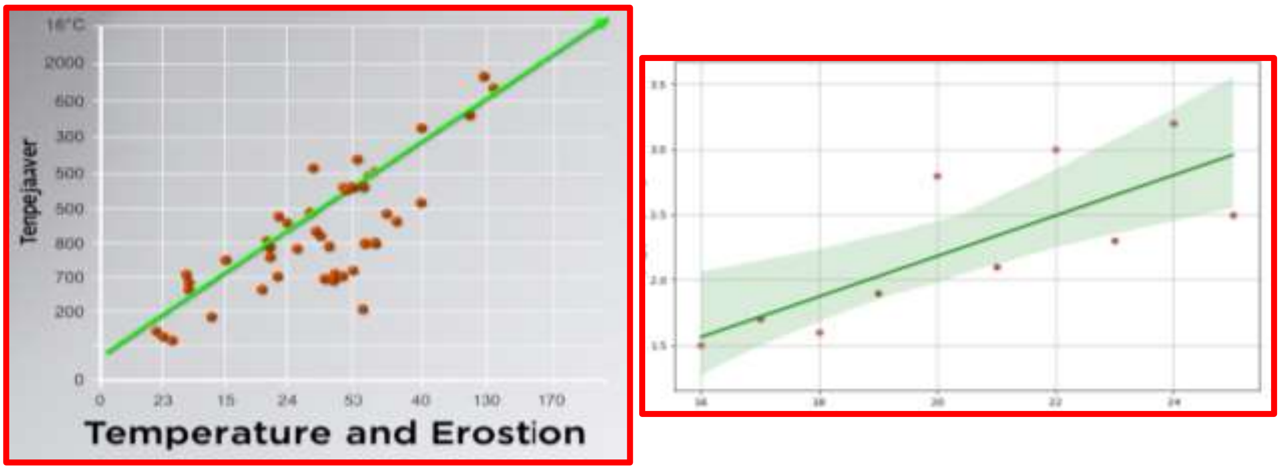
1. Positive Correlation: The data points are generally clustered around the regression line, indicating a strong positive correlation between rainfall and surface runoff. Higher rainfall leads to higher surface runoff rates.

2. Scatter: While there is a general trend, there is also some scatter in the data points, suggesting variability in surface runoff for a given amount of rainfall. This could be due to other factors influencing surface runoff, such as soil type, vegetation cover, and topography.
3. Outliers: There are a few data points that deviate significantly from the main cluster, which might be outliers. These could be due to unusual conditions or measurement errors.

Conclusion:

The graph effectively demonstrates that there is a significant relationship between rainfall and surface runoff. As rainfall increases, so does the amount of surface runoff. However, the presence of scatter suggests that other factors also play a role in determining surface runoff levels. Further investigation into these additional factors could provide a more comprehensive understanding of the surface runoff process.

" Figure 9 The Relationship Between Temperature and Erosion ."



The image shows a scatter plot with a linear regression line, illustrating the relationship between temperature and erosion. Here's an analysis of the graph:

Data Points:

- The orange dots represent individual data points showing the measured values of erosion for different temperatures.
  - There is a clear positive correlation between temperature and erosion, meaning that as temperature increases, erosion also tends to increase.

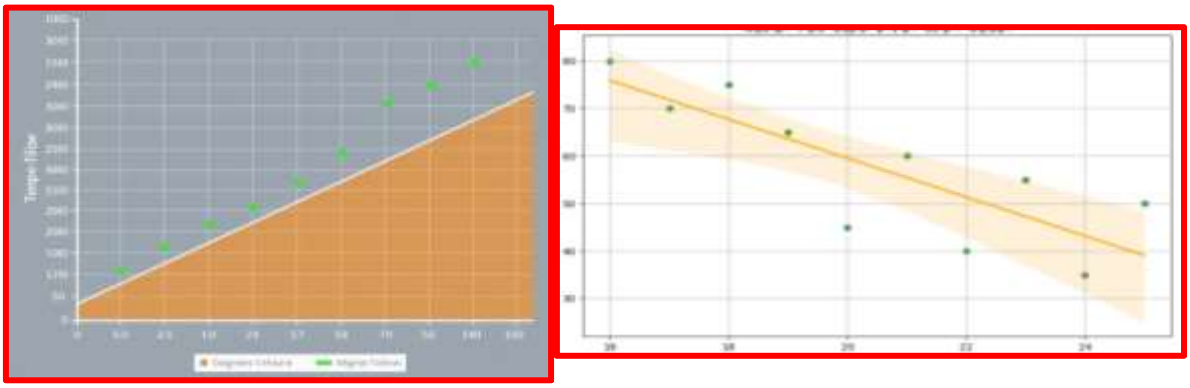
Linear Regression Line:

- The green line represents the linear regression model fitted to the data points. This line helps visualize the overall trend in the data.
- The slope of the line indicates the rate at which erosion increases with increasing temperature. A steeper slope would suggest a stronger relationship.

1. Positive Correlation: The data points are generally clustered around the regression line, indicating a strong positive correlation between temperature and erosion. Higher temperatures lead to higher erosion rates.
2. Scatter: While there is a general trend, there is also some scatter in the data points, suggesting variability in erosion for a given temperature. This could be due to other factors influencing erosion, such as rainfall, soil type, and vegetation cover.
3. Outliers: There are a few data points that deviate significantly from the main cluster, which might be outliers. These could be due to unusual conditions or measurement errors.

The graph effectively demonstrates that there is a significant relationship between temperature and erosion. As temperature increases, so does the amount of erosion. However, the presence of scatter suggests that other factors also play a role in determining erosion levels. Further investigation into these additional factors could provide a more comprehensive understanding of the erosion process.

Figure10 ": "Relationship between Temperature and Water Flow in 2050



The image shows a graph with some typographical errors in the title, labels, and legend. Here's an analysis of the graph:

Axes:

- Y-axis: Marked by "water flow."
- X-axis: Represents "degrees Celsius."

Data Representation:

- The graph shows a linear relationship between temperature and water flow.
- There are green dots representing data points for "Migrot Callow."
- The orange shaded area represents the range of temperatures in degrees Celsius.

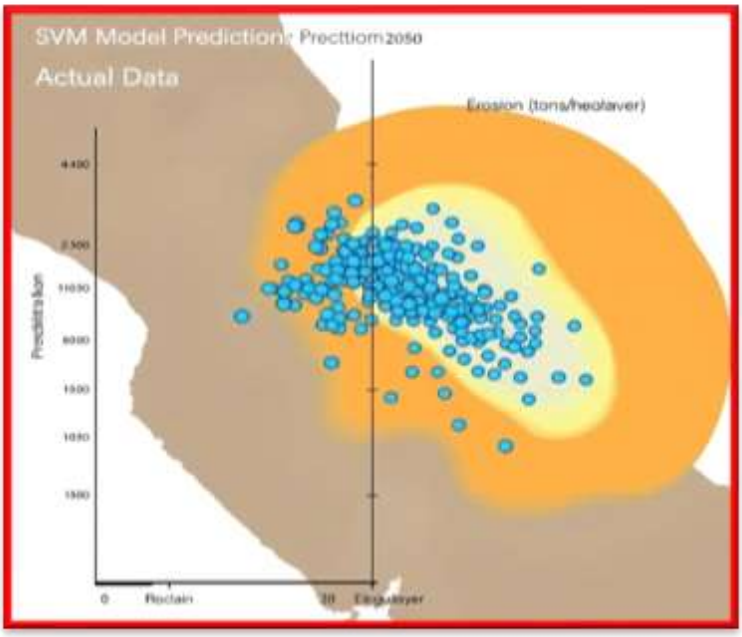
1. Positive Correlation: The data points show a positive correlation, indicating that as temperature increases, water flow also tends to increase.
2. Linear Trend: The data points form a straight line, suggesting a linear relationship between the two variables.
3. Shaded Area: The orange shaded area indicates the range of temperatures, providing a visual representation of the temperature scale.

Legend:

- The legend includes two items:
- "Degrees Celsius" represented by the orange shaded area.
- "Migrot Callow" represented by the green dots.

The graph effectively demonstrates the relationship between temperature and water flow. As temperature increases, so does the water flow. The linear trend suggests a direct proportionality between the two variables

Figure10: "SVM Model Predictions Precision 2050."



The image shows a scatter plot with an overlay of a Support Vector Machine (SVM) model prediction, illustrating the relationship between precipitation and erosion. Here's an analysis of the graph:

Title:

- The title "SVM Model Predictions Preccttion 2018" contains some typographical errors. It should be corrected to: "SVM Model Predictions Precision 2018 ."

Axes:

- Y-axis: Labeled as "Precipitation."
- X-axis: Represents "Erosion (wathrning) (tons/healaver),"

Data Representation:

- The blue dots represent actual data points showing the measured values of erosion for different levels of precipitation.
- The orange and yellow shaded areas represent the SVM model predictions, with the intensity of the color indicating the confidence level of the prediction.

1. Data Distribution: The blue dots are clustered around the center of the plot, indicating that most of the actual data points fall within a certain range of precipitation and erosion values.
2. Model Prediction: The SVM model predictions are represented by the orange and yellow shaded areas. The darker the color, the higher the confidence in the prediction.
3. Overlap: There is a significant overlap between the actual data points and the SVM model predictions, suggesting that the model has a good fit with the actual data.

Conclusion:

The graph effectively demonstrates the relationship between precipitation and erosion, as well as the accuracy of the SVM model predictions. The clustering of the actual data points within the predicted regions indicates that the model is performing well.

Since the amount of rainfall directly affects erosion processes (such as soil stripping and material transport), a decrease in rainfall means a reduction in the strength of these processes. Consequently, erosion rates are expected to decline due to less rainfall. Additionally, reduced erosion may lead to greater soil stability, as the chances of soil being washed away or eroded decrease. However, this may have other effects, such as:

Increased soil accumulation in some areas due to reduced water flow.

Decreased soil fertility in regions that rely on rainfall to distribute organic matter and nutrients.

As for its impact on ecosystems and water:

A reduction in rainfall may lead to decreased water flow in rivers and streams, negatively affecting ecosystems that depend on this water. It may also result in reduced formation of new sediments in floodplains or water bodies.

Conclusions:

1. Climate plays a pivotal role in determining the amount of water available for basin discharge and the timing of floods. For example, high evaporation rates in arid regions reduce surface runoff. Given the projected increase in temperature and decrease in rainfall, a significant decline in flowing water is expected by 2050 compared to the present.
2. The study area is characterized by highly permeable soil and rugged terrain, significantly impacting water behavior within the basin. High permeability allows a large portion of water to infiltrate the ground, while rough terrain increases surface runoff speed and soil erosion.
3. The basin's shape and topography greatly influence erosion and sedimentation processes. Steep basins experience high erosion rates, while flatter basins tend to accumulate sediments. Since the basin elevation increases westward, those areas will be more susceptible to weathering and wind erosion, especially given the expected decline in watercourses.
4. Rainfall trends indicate a general decline at the study station, with significant variability in recent years. Rainfall patterns have shifted, now peaking in January and April, while October has seen a reduction in precipitation.
5. Iraqi lakes are drying up, transforming into valleys resembling the arid Hauran Valley. The absence of surplus water for storage is turning marshes and wetlands into barren deserts, leading to ecological system changes, species extinction, or migration outside Iraq. Additionally,there will be a significant loss of freshwater fish and other wildlife.

Recommendations:

1. Environmental Protection from Fossil Fuel Pollution: Reduce emissions from oil and gas by upgrading old factories, installing filters to minimize greenhouse gas emissions, and relocating some industries away from residential areas to mitigate pollution and its impact on climate change and drought.

2. Establishing a Specialized Climate Change Research Center: This center should collect and provide climate data on a micro-scale in Iraq, supporting experts in studying and monitoring climate change and extreme weather events. It should be equipped with the latest instruments for measuring climate phenomena, soil conditions, and air pollution.
3. Water Resource Management: Improve water use efficiency in agriculture and industry. Construct water reservoirs to store excess rainfall during heavy precipitation periods (water harvesting).
4. Soil Protection: Implement sustainable farming techniques to preserve soil fertility and cultivate drought-resistant plants.
5. Enhancing Vegetation Cover: Launch afforestation projects to increase green areas and protect densely vegetated regions from degradation.
6. Erosion Control: Implement soil protection projects, such as constructing retaining walls and planting erosion-resistant vegetation to prevent soil degradation.

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