Estimating the extent of water erosion in the Wadi Al-Rumaitha Basin, northeast of Al-Muthanna Governorate

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KEYWORDS

extent estimating, water erosion, Wadi Al-Rumaitha Basin, Al-Muthanna Governorate.

ABSTRACT

The Wadi Rumaitha Basin is located astronomically between two latitudes (30° 39' 18" - 30° 29' 56") north, between two longitudes (45° 52' 4" - 45° 45' 10") east, with an area of (68.5) km2, located in the southern part of Iraq within the administrative borders of Al-Muthanna Governorate, which is characterized by a dry climate. The research aims to study and estimate the extent of water erosion in the Wadi Rumaitha basin, detect risks and conditions that affect the properties and quality of soil and land uses in the region, highlighting the role of natural characteristics affecting its activity, different types of water erosion prevail in the study area, between rain erosion, stream erosion, and gully erosion. The locations and areas of the basins of the river network and the stream, gully, and rain erosion network were determined, by adopting several criteria, including the Fournier equation to measure rain erosion, and the Bergsma 1982 equation (to measure the degree of stream and gully erosion, then, modeling the areas of spread of each of them, by the use of geographic information systems technology. It became clear through the research that the Fournier index in the stations of the study area reached (19.87, 21.66, 16.53), respectively, this indicates that the Wadi Rumaitha basin area falls within the range of weak rain erosion, while funicidal erosion included (4) cases limited to the range of high and very severe fluid erosion, gully erosion included (7) areas confined between the (very light and very high) ranges, and their geographical distribution varies in the basin lands.

1. Introduction

Water erosion is one of the basic topics in natural geographical studies because of its significant impact on shaping the features of the Earth's surface, as it works to erode rocks and soil affected by several factors, including the amount of rainfall, running water, the nature of the surface rock formations, and the amount of sediment carried by the water, in addition to Obstacles to flow, the type of slope that controls the amount of flow, and the intensity of erosion that appears in valleys, river basins, hills, and the excavated surfaces of rocks, especially in limestone rocks (1). Water erosion is considered one of the most dangerous types of erosion to which water basins are exposed, as the action of erosion has been continuous and permanent since time immemorial, with variation in intensity and impact between the ancient and current climate depending on the amount of water return (2). Since the climate in the Pleistocene era was characterized by high humidity, water erosion was more severe. It is more productive than its work at the present time, which left traces and evidence that still exist to this day (3). Therefore, the study of this topic comes from the role that water erosion plays in the formation and development of the lands of the Wadi Rumaitha Basin, in addition to its role in soil erosion, especially since the region is located in a dry desert environment characterized by distinctive sandy and stony soil.

2. Methodology

Research problem:

The research problem is considered one of the basic foundations in the course of scientific research, and the question around which the main research problem crystallizes is represented by the following question (what is the extent of water erosion, its structural capacity, its areas of distribution and intensity, what are the geomorphic factors that contribute to its occurrence, and the resulting effects? What effect does it have on the natural and human environment in the study area?

Research hypothesis:

The main hypothesis of the research is to provide a fundamental solution to the problem at hand. The research hypothesis is that the region is exposed to different types of water erosion, especially rain, stream and gully erosion, all of which vary from one location to another due to the influence of multiple geomorphological factors that contributed to the variation in the activity of water erosion processes in the study area. The extent of water erosion and its destructive capacity are related to the quantity and type of those factors encouraging it, and it certainly has effects on the natural environment and on various human activities.

Research methods and work methods:

The research relied on the descriptive approach, the analytical and inductive approaches, as well as the quantitative method and mathematical methods, processing the data obtained and analyzing the water networks for the purpose of knowing the water erosion zones, their degrees, and the distribution of their intensity zones by adopting mathematical equations, climate data, remote sensing data, and geographic information systems technology. Remote sensing data from satellite visuals and DEM with a resolution of 30 metres, the basin was cut off and measurements of the river network were made, then the standards were applied to extract the extent of erosion, which are represented by the (Fournier) and (Bergsmaa 1982) standards, and spatial modeling of its types was performed.

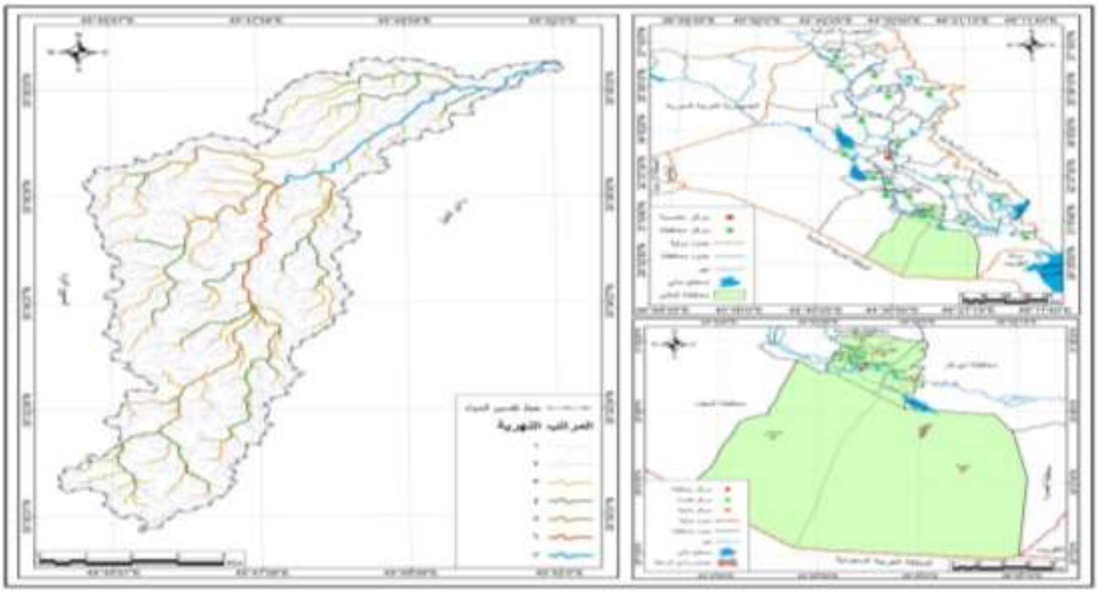
Objective and importance of the research:

The research aims to estimate the extent of water erosion, analyze the factors that lead to the occurrence of this phenomenon in a tangible way, determine its size and the distribution of its areas according to its severity in the study area, and its geographical distribution and attempt to reveal the extent of its impact on human activities in the same region. Identifying the most important methods through which the effects of water erosion in the region can be reduced.

Research boundaries:

Wadi Al-Rumaitha basin is located in the northeastern parts of Al-Muthanna Governorate in southern Iraq. Its area is (68.5) km^2 and its length is (20.47) km^2. It is geographically bordered to the north by the Sulaibat Depression and Dhi Qar Governorate, to the east by Basra Governorate, to the south by the Kingdom of Saudi Arabia, and to the west by Al-Salman District. As for astronomically, it is located between two latitudes (30°39'18.02"N) (30°29'56.073"N) to the north, and between two longitudes (45°52'4.926"E) (45°45'10.513"E) to the east, The basin consists of three secondary basins that vary in area, map (1). The basin slopes from the southwest towards the northeast.

Map (1) Location of the basin in Muthanna Governorate, Iraq.



Source: 1 - Ministry of Water Resources, Directorate, General Authority of Survey, Map Production Department, Administrative Map of Iraq, scale 1:1000000, Baghdad 2007, 2 - Ministry of Agriculture, Muthanna Agriculture Directorate, GIS Division, Map of the provinces of Muthanna Governorate, scale 1:250000. , Baghdad 1991.

The first topic: The natural characteristics of the region

First: Geology of the study area: Most of the sediments of the study area date back to the Quaternary sediments, which are modern deposits dating back to the Pleistocene and Holocene times, and a few of them date back to the Tertiary time. These sediments were formed by water processes (transport and sedimentation) dating back to the valleys descending from the Arabian Peninsula in the era. Pleistocene. The distribution of sediments varies in the study area, and it consists of several types of sediments, as follows:

First: Tertiary formations:

These formations are characterized by varying spread in the Wadi Rumaitha basin area. Tertiary formations cover an area of (11.84) and constitute a percentage of (17.28) of the total area of the study area. Their ages range from the Pliocene to the Pleistocene, and their distribution appears. Vertical order from oldest to newest, which is as follows:

A. Upper Dammam:

The age of Upper Dammam dates back to the Upper Eocene. It is geographically distributed in the central and southern part of the study area and consists of gray-coloured, lumpy limestone. It also contains fossils with siliceous bundles and flint stone necklaces in the upper part of it. It also contains gray-coloured limestone. It is leaden to yellowish leaden, and the fish here does not exceed 5 metres (4). The exposed area in the study area is (10.19 km^2) and the percentage recorded is (14.87%).

B. Al-Ghar Formation:

This formation is exposed in the Wadi Rumaitha basin area in the form of isolated spots in the central and western part and in the central and eastern part of the study area, at a rate of (1.65 km^2) and a percentage amounting to (2.41%).

Second: Quaternary sediments:

They occupy an area of (56.66) km^2 and constitute (82.72%) of the area of the study area. Accordingly, the sediments of the region can be known according to the following division:

A. Alluvial fan deposits:

These deposits date back to the Pleistocene era of the Quaternary time, and these fans are exposed at the mouths of river valleys, and the water precipitates the pebbles of different sizes that are not cohesive and pieces of carbonate rocks, in addition to sand of different sizes (5) and form Alluvial fan deposits cover an area estimated at approximately (3.67 km^2) and constitute (2.51%) of the total study area.

B. Multi-origin:

deposits that are widespread in the northeastern and southwestern parts of Wadi Rumaitha if they are found from the Suq Al-Shuyoukh geological patch. These deposits belong to the (Pleistocene-Holocene) period, and their exposed area in the study area reached (77.43 km^2), with a percentage recorded at about (53.04%) of the total area of the study area.

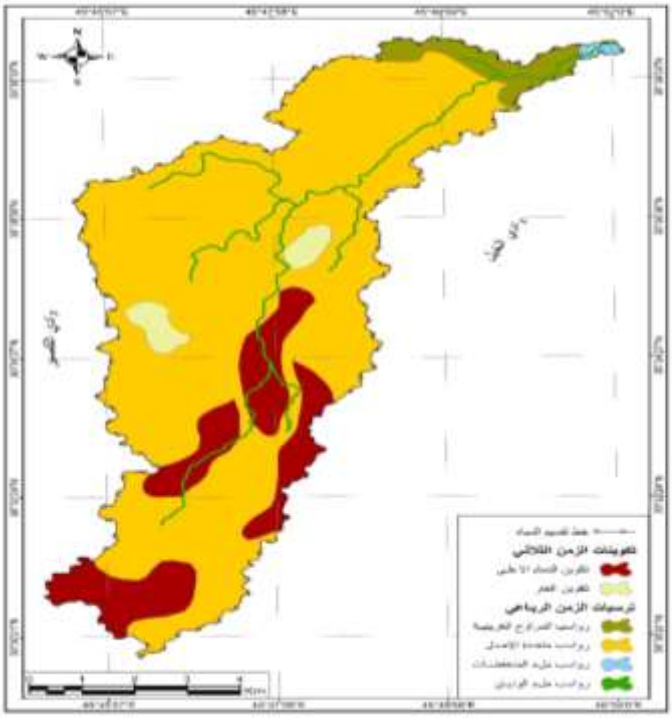
C. Depression-filling deposits:

These deposits date back to the Holocene era and their total area reached (0.25 km^2) and a percentage amounted to (0.36%) of the total area of the study area. They spread in the north of the study area. These depressions are relatively narrow and irregular in shape.

D. Valley-filling deposits:

These deposits are collected at the bottoms of valleys in the study area. They are deposits of different shapes and sizes, depending on the quality and nature of the parent rocks, depending on the strength of the convective flow (6). These deposits cover an area of (0.86 km^2) and in percentage It reached (1.26%) of the total area.

Map (2) Geological formations in the Wadi Rumaitha Basin.

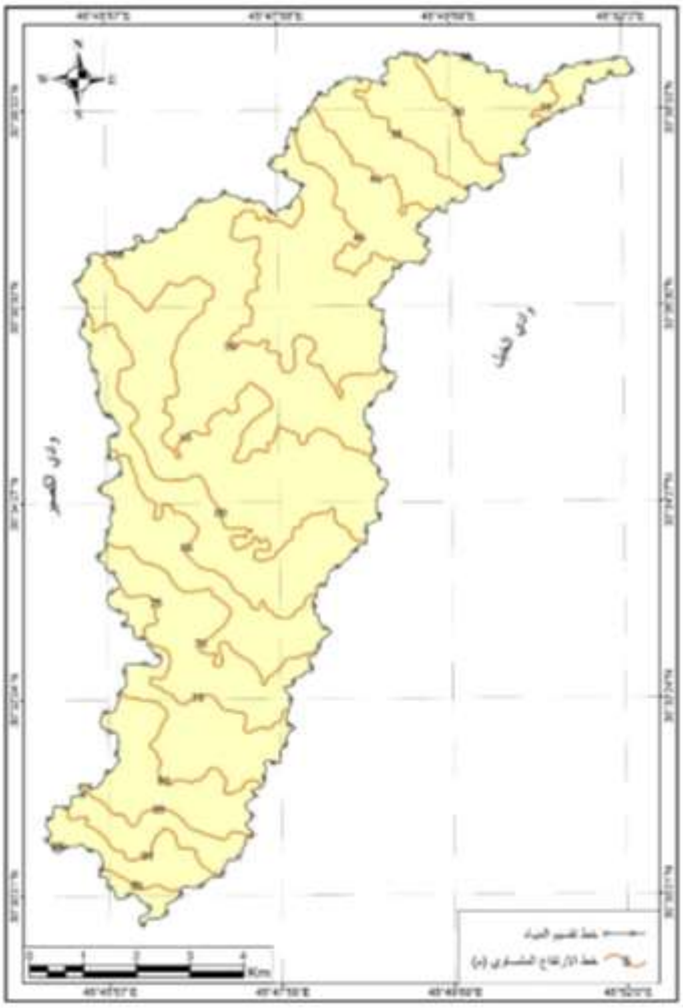


Source: Researcher with accreditation: Ministry of Industry and Minerals, General Authority for Geological Survey and Mining, geological maps (Souq Al-Shuyoukh, Al-Salman, Ansab, Nasiriyah, Najaf), scale 1:250,000, Baghdad, different years.

Second: surface and slope characteristics:

The study area is characterized by the diversity of its topography and surface topography, as the maximum elevation in the southern parts of the basin reached (95) m above sea level, and the lowest elevation of the Wadi Rumaitha Basin in the northeastern parts of the basin was (25) m above sea level. The sea surface, and this diversity includes some hills, plateaus, depressions, and other land features that constitute a small percentage of the basin's territory.

Map (3) contour lines of the lands of the Wadi Rumaitha Basin.



Source: Researcher supported by DEM and Arc GIS 10.8.

Third: Climatic characteristics:

Climate has an impact on geomorphological processes, as the shapes of the land surface in the valley basin are the production of those climatic conditions, even though most of them are due in their origin to ancient climate conditions. Therefore, studying the climate of any region is one of the important pillars on which geomorphological studies in general and the study of valley basins in particular are built. Climatic conditions have a varying impact on landforms through its various elements, and this effect is in varying proportions according to the nature of the landforms, which is a reflection of geomorphological processes, such as the speed of weathering and erosion rates, which also directly affects climatic conditions (7). Climatic data at the stations (Samawah, Nasiriyah, Hafr Al-Batin) indicated the prevalence of conditions of drought and water deficit in the study area (Table 1), as it is characterized by scant rainfall (110.6, 116.2, 97.5) mm, as well as its fluctuations and short and sudden periods of high intensity. In addition to the high rates of temperature (26.1, 26.8, 25.8) C, and evaporation (3811.4, 3746.2, 3410.4) mm, respectively, and the wind rate (3.4, 3.1, 3.7) m/s, while the relative humidity rate (35.97, 35.5, 35.5) These characteristics affect the effectiveness of geomorphological processes, including the erosion process.

Table (1) Climatic characteristics of the approved stations in the study area.

City	Item	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Mean**
Samawa	**Temp.**	12.7	14.7	20.7	25.5	32.3	36.4	38.3	37.9	34	27.5	19.2	13.9	26.1
	Rain	12.2	11.4	15.7	13.5	7.6	0	0	0	0	3.6	35.8	11.0	110.6
	Wind	3.1	3.3	3.7	3.5	3.8	4.1	4	3.5	3.2	3.1	2.8	3	3.4

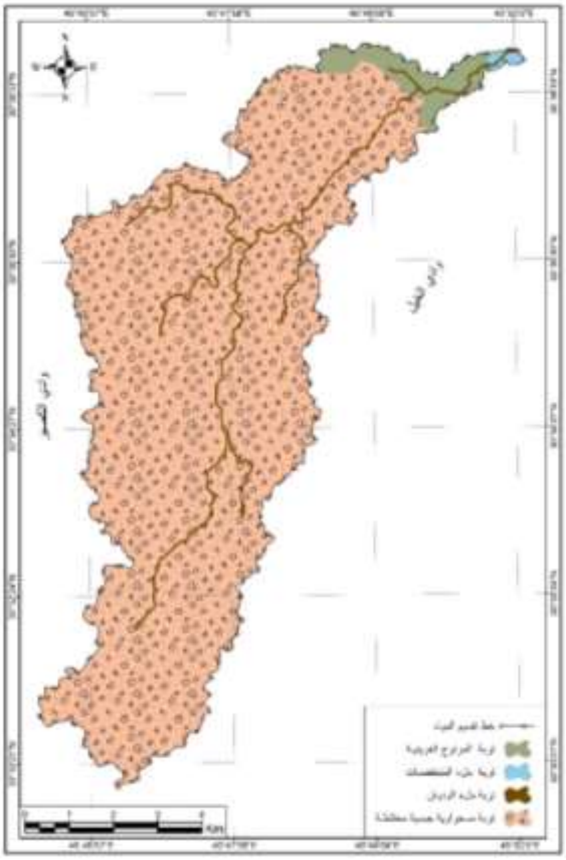
	Hum.	60.7	50	38.85	31.67	24.51	20.27	20.48	22.11	23.76	34.9	49.6	54.8	35.97
	Evap.	86.4	118.2	210.3	281.7	415.2	549.9	623.4	585.3	432.2	286	133.1	90	3811.4
Nasiria	**Temp.**	13	16	21.8	26.2	32.8	37.1	37.8	39.2	35.3	29	19.4	14.2	26.8
	Rain	12	9	16.1	12.9	7.1	0	0	0	0	6.9	40.4	11.9	116.2
	Wind	2.8	3	3.2	3.2	3.3	3.9	3.9	3.5	3	2.7	2.3	2.5	3.1
	Hum.	58.3	50	39.4	34.1	25.3	17.8	16.5	18.8	21.7	32.1	53.5	58.7	35.5
	Evap.	88.2	122.2	221.5	289.5	240.5	556.8	584.5	548.3	427.2	278.1	122.6	87.1	3746.2
Hafer Al-Batten	**Temp.**	12.8	16	20.6	26.1	31.4	34.7	36.3	36.5	33.3	28	20.3	14	25.8
	Rain	22.7	10.6	8.9	13.1	2.6	0	0	0	0	1.6	20.7	17.3	97.5
	Wind	3.2	4	4.2	4.5	4.2	4.1	4.1	3.3	3.1	3	3.4	3.4	3.7
	Hum.	64	53	38	36	26	17	16	17	20	28	51	60	35.5
	Evap.	76.7	124.1	205.3	297.6	411.1	490.7	522.3	492.8	365.6	221.7	124.9	77.6	3410.4

Source 1- Republic of Iraq, Ministry of Transport and Communications, General Authority for Meteorology and Seismic Monitoring/Climate Department Source (unpublished data), Baghdad, 2022. , - Kingdom of Saudi Arabia, General Authority of Meteorology and Environmental Protection, Open Data Office, Department of Information Requests, 2022.

Fourth: Soil:

Soil can be considered to be the thin and fragile layer that covers the Earth's atmosphere. Its height ranges from a few centimeters to several meters. It is a mixture or combination of minerals, organic and mineral particles, air and water. It is important when studying landforms because it is considered part of those forms (8). For the purpose of classifying the soils of the study area, we relied on the classification (Bjornik, 1960), which includes in the study area four types of soils, represented by mixed gypsum desert soil, which covers an area of (46.88 km^2) with a percentage of (94.72%), and alluvial fan soil with an area of (2.51 km^2), with a percentage of (3.67%), valley-filling soil with an area of (0.86 km2), with a percentage of (1.26%), and depression-filling soil with an area of (0.25 km^2), with a percentage of (1.26%).

Map (4) Soil types in the Wadi Rumaitha Basin.



Source: Researcher based on: 1- The American satellite Landsat 8, visible by OLI with a resolution of 30 m, 2023.

2- P. Burring, Exploratory Soil Map of Iraq, Scale 1:1000 000, Baghdad, 1960.

Fifth: Vegetation cover:

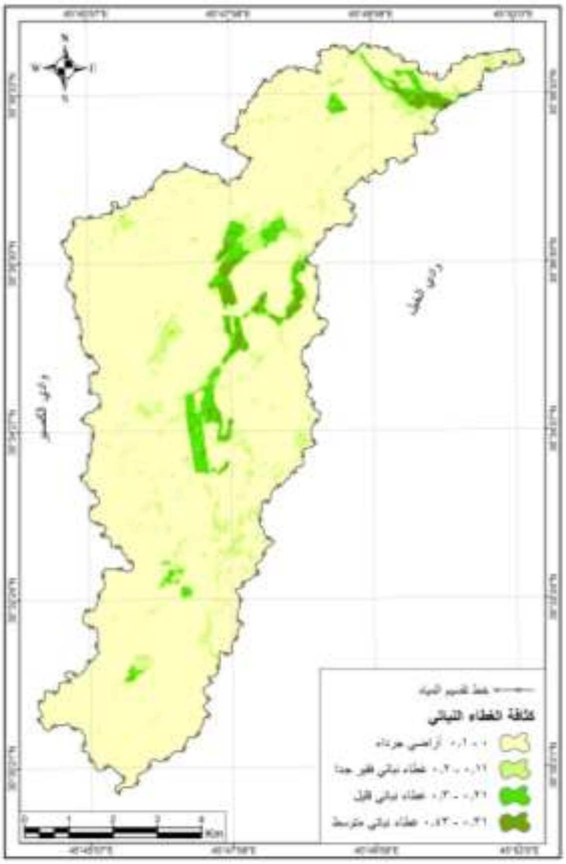
Vegetation cover plays an important role in increasing the activity or slowing down of water erosion processes, as it weakens the effects of this process by preventing the direct collision of raindrops with the soil, and even disperses their strength, thus reducing erosion. The vegetation cover in the Wadi Rumaitha Basin was studied using (NDVI).) in the winter season, and based on the satellite visualization of the Landsat 8 satellite with a resolution of (30m) taken on (05/12/2023), as well as using (Band4.5) for the winter season, it was found that there are four patterns of vegetation cover as shown in the table (2) The density of vegetation cover in the study area was divided as follows between the highest value (60.04) and the lowest value (1.14) for the winter season.

Table (2) Natural vegetation density according to NDVI in the Wadi Rumaitha basin.

Type	Area	Percent
Barren lands 0-0.1	60.04	87.65
Very poor vegetation cover 0.11 - 0.2	4.83	7.05
Low vegetation cover 0.21 - 0.3	2.49	3.63
Average vegetation cover 0.43 - 0.31	1.14	1.67
Total	68.5	100

Source: The researcher based on map (5) and the outputs of the Arc GIS 10.8 program

Map (5) vegetation density index in the Wadi Rumaitha basin.



Source: Researcher: Based on the American satellite Landsat 8, visible by OLI, bands (4 - 5) with an accuracy of 30 meters.

The second topic: Types of water erosion in the Wadi Rumaitha Basin

Water erosion is one of the important geomorphological processes that has a major impact on shaping most aspects of the Earth's surface through the processes of erosion, transport, and sedimentation. The severity of water erosion varies depending on the influence of several factors, including the amount of rainfall falling, the length of its fall, the nature of the rock formations, the amount of sediment carried by the water, and the degree of Slope and vegetation. Water erosion in the area includes several types, including:

First: Rain (collision) erosion:

This type of erosion occurs in the study area after heavy raindrops fall and collide with soft, incoherent crumbly sediments such as weathering materials and soil particles, which work to scatter these sediments and particles. In addition, raindrops falling on water in Flumes, gullies, and shallow streams disturb the flow, which has a high ability to carry sediments (9). When rain falls in the form of heavy rain showers on unprotected soil devoid of vegetation, its kinetic energy may lead to the separation of soil particles and their displacement down the slopes due to the inclination and the force of Earth's gravity, so it is more effective within these locations. This is one of the sub-processes of water erosion that is affected. Due to several factors, including the quality of rocks, permeability, and density of vegetation, in addition to the human factor represented by overgrazing and incorrect plowing, the study area is subject to this type of erosion, noting that the soil of the study area is composed of mixed sandy and silty sand materials and contains a small percentage of clay, as in the fill soil. The valleys have little cohesion and are dry throughout the months of the year. The Fournier-Arnold formula was relied upon to measure the intensity of rain erosion in the Wadi Rumaitha basin as follows (10):

$$F.A.\ I = P2/P$$

Since:

The ability of rain to erode. = F.A.I

The square of the monthly rainfall (mm).= P2

Annual rainfall amount (mm). =P

Table (3) Raindrop erosion intensity according to the Fournier-Arnoldus index.

No.	Degree	Erosion intensity
1	Less than 50	weak
2	50-500	Moderate
3	500-1000	High
4	More than 1000	Very high

Source: Abdullah Al-Sabbar Al-Ajili, The slopes of the Brannan mountain range, a geomorphological study, Journal of the College of Education, University of Wasit, Issue 15, 2014, p. 378.

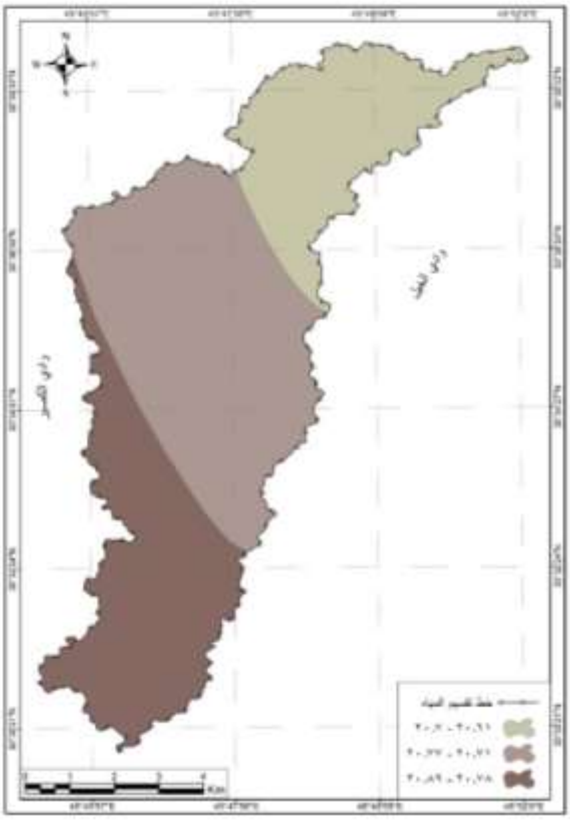
It became clear after applying the Fournier-Arnoldus equation to the climate stations used in the study (Samawah, Nasiriyah, Hafar Al-Batin) and based on the data presented in Table (1), that the ability of rain to erode in the study area is weak, as the Fournier index at the stations in the study area reached (19.87, 21.66, 16.53) respectively. This indicates that the Wadi Rumaitha basin area falls within the range of weak erosion. If the above indicates anything, it indicates that the region is subject to the dry desert climate, which is characterized by low amounts of rainfall and a high decline in the values of raindrop erosion. Thus The Wadi Rumaitha basin falls within the limits of the first degree (less than 50) according to the Fournier-Arnolds classification (Table 2).

Table (4) Rain's ability to erode according to the Fournier Arnoldus index for monthly and seasonal rates at the study stations for the period 2010-2023.

Month	Samawa		Nasiria		Hafer Al-Batten	
	Rain	Fornia	Rain	Fornia	Rain	Fornia
Jan.	12.2	1.34	12	1.23	22.7	5.28
Feb.	11.4	1.17	9	0.69	10.6	1.15
Mar.	15.7	2.22	16.1	2.23	8.9	0.81
Apr.	13.5	1.64	12.9	1.43	13.1	1.76
May	7.6	0.52	7.1	0.43	2.6	0.06
Jun.	0	0	0	0	0	0
Jul.	0	0	0	0	0	0
Auq.	0	0	0	0	0	0
Sep.	0	0	0	0	0	0
Oct.	3.6	0.11	6.9	0.4	1.6	0.02
Nov.	35.8	11.58	40.4	14.04	20.7	4.39
Des.	11	1.09	11.9	1.21	17.3	3.06
Total	110.6	19.67	116.2	21.66	97.5	16.53

Source: The researcher based on Table (1) and the Fournier-Arnolds equation.

Map (6): The annual total of rain's ability to erode according to the Fournier-Arnoldus index for the period 2010-2023.



Source: The researcher based on the data in Table (2) and the Arc GIS 10.8 program

Second: Flume erosion:

Flume erosion occurs when water flow intensifies in the first-level streams, displacing the soil due to the concentration of water flow in small water channels. The activity of this type of erosion increases in formations of low solidity, which are characterized by a steeper slope than the normal slope of the ground, resulting in This increases the speed of flow, resulting in the formation of narrow, small, parallel primitive streams, the depth and width of each of which does not exceed a few centimeters, as it represents the next stage of laminar erosion. What is striking is that these streams are often buried by the dry season, that is, after the end of the rainy season (11). Intense runoff over exposed surfaces that lack vegetation, in combination with the surface factor and its degree of slope, plays an important role in controlling the amount and shape of surface flow, especially on hill slopes, valley edges, and rocky cliffs, where surface runoff transforms from diffused runoff to concentrated runoff as a result of rainstorms and heavy showers. It consists of a fine network of flumes connected to each other in the form of a network of channels that notch the rocks to varying degrees according to the hardness of these rocks, and they have the ability to erode the soil and move it. This process is called watercourse erosion (12). To measure the intensity of the erosion, the (Bergsma) equation was relied upon, which It depends on the surface water drainage network and through the following equation (13):

$$AE = \sum L/A$$

Since:

Erosion rate (m/km2): AE

Total lengths of waterways: $\sum L$

A: cadastral unit area (km2).

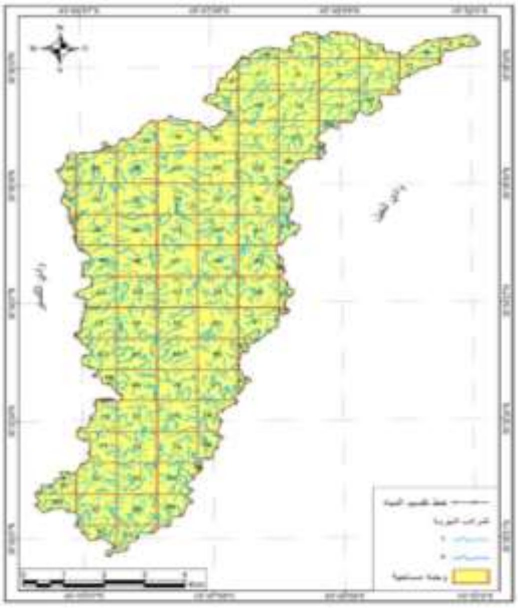
Maps representing torrent erosion in the Wadi Rumaitha Basin were prepared using the areal gradation method, the area method, the method of graduated colors, and graded shadows. It became clear that there was a difference in the classification of the intensity of torrefaction in the study area, and the reason for this could be due to the difference in geological structure, surface slope, and vegetation. Natural as well as the permeability of the rocks. After applying the previous equation (table) and maps (7) and (8), it becomes clear that the area is (0.09) km2, with a percentage of (0.13%) within the high erosion classification of the total area of the study area, while the area recorded (0.48) km2, at a rate of (0.7%) within the classification of the very high erosion zone of the total area of the study area, and an area of (4.38) km2 was recorded, at a rate of (6.4%) within the classification of the extreme erosion zone, of the total area of the basin. Finally, an area of (63.55) km2, at a rate of (92.77% of the total area of the study area is classified as very severe erosion.

Table (6) Degrees of liquefied erosion in the Wadi Rumaitha Basin area.

Degree of erosion	Area (km^2)	Percent (%)
High erosion range: 1500-2700	0.09	0.13
Very high erosion range:2701-3700	0.48	0.70
Severe corrosion range:3701-4700	4.38	6.40
Very severe corrosion range: 4701-9400	63.55	92.77
Total	68.50	100

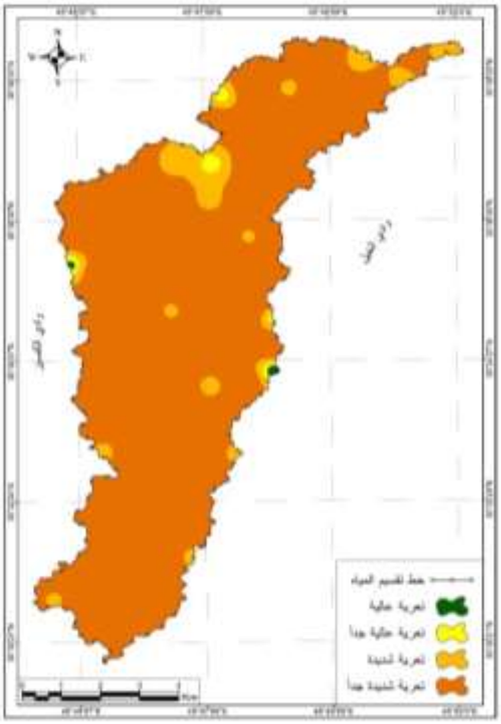
Source based on the Bergsma equation and the outputs of the Arc GIS 10.8 program

Map (7) areas of liquefied erosion in the Wadi Rumaitha Basin.



Source: Based on DEM digital data and Arc GIS 10.8 program output

Map (8) silicic erosion zones in the Wadi Rumaitha Basin according to the Bergsma classification.



Source: Based on DEM digital data and Arc GIS 10 program 8 outputs.

Third: Gully erosion:

An increase in the degree of slope results in an increase in the capacity of flowing water, which then activates a cycle in eroding and sweeping away the soil. The result is that the erosion of waterways develops into gully erosion through the merging of some of the waterways with the process of river captivity, thus forming waterways that are wider, longer, and more capable of flowing. Sweeping the soil. The shape of the furrow varies depending on the type of soil. Its cross-section appears in the form of a letter (14). Furrows, in general, have an inverse relationship with the density of vegetation cover, as they are active with the scarcity of vegetation on the sides and inactive with the presence of plants, as they work to stabilize the sides. Furrows can also be divided into Small, medium, large depending on their depth, as the depth of the medium ranges between (1 - 5 m) (15). In order to achieve the quantitative aspect in studying the geomorphological characteristics of the geographical phenomenon, the intensity of gully erosion was measured based on the equation (Bergsma 1982) which he used to measure the intensity of gully erosion in river basins, relying in his study on measuring the lengths and numbers of the grooves as well as the area occupied by these grooves, as in the equation next (16).

Gully erosion rate = total length of the grooves in the basin (m)/area of the basin (km^2)

After applying the above equation and observing table (), it becomes clear that an area of (28.0) km2, at a rate of (0.41)% of the total area of the study area, is within the range of very light erosion, while it was recorded at (45.5) km2, at a rate of (96.7). % of the total area of the basin is within the range of light erosion, and an area of (24.21) km2, at a rate of (01.31)%, is within the range of moderate erosion of the total area of the study area, and an area of (22.39) km2, at a rate of (25.57) was recorded. (%) within the range of high erosion of the total area of the basin, while an area of (26.2) km2 was recorded, at a rate of (3.3)% within the range of very high erosion of the total area of the basin, and an area of (0.05) km2, at a rate of (07.0)%. Within the scope of severe erosion of the total area of the basin, the reason for the variation in rates of gully erosion in the Wadi Rumaitha Basin area is due to many factors, the most important of which are the relative variation in the levels of surface slope and the difference in the quality and components of the rocks that help the functioning of waterways in the study area, as well as the variation and difference in Geological structure and variation in the density of vegetation cover, as maps were prepared representing gully erosion for the Wadi Rumaitha Basin area using the areal gradation method, the area method, and the gradient color method and shadows, representing the types of erosion and others representing the gully erosion points in the Wadi Rumaitha Basin, map (9).

Table (7) Bergsma criterion for gully erosion.

No.	Erosion rate (m/km2)	Describe
1	1-400	Very light erosion
2	401-1000	Light erosion
3	1001-1500	Moderate erosion
4	1501-2700	High erosion
5	2701-3700	Very high erosion
6	3701-4700	Severe erosion
7	More than 4700	Very severe erosion

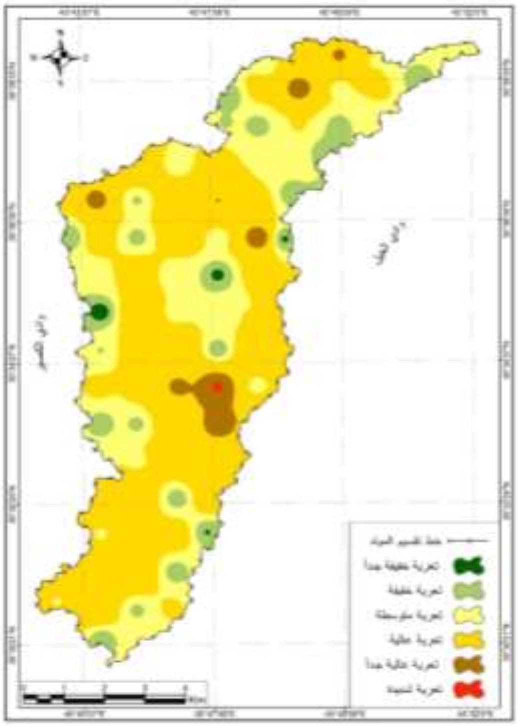
Source: Muhammad Fathi Muhammad Al-Mawla, Preparing the Gully Erosion Map of the Wadi Al-Ahmar Basin in Nineveh Governorate, Al-Takni Magazine, Volume 21, Issue 1, 2018, p. 138.

Table (8) Degrees of gully erosion, area and percentage in the Wadi Rumaitha Basin.

Erosion rate	Area (km^2)	Percent (%)
Very light erosion range	0.41	0.28
Light erosion range	7.96	5.45
Medium erosion range	31.01	21.24
High erosion range	57.25	39.22
Very high erosion range	3.3	2.26
Extreme erosion range	0.07	0.05
Total	100	68.5

Source: Researcher using map (4)

Map (9): Types of gully erosion in the Wadi Rumaitha Basin.



Source: The researcher based on DEM 30M and the results of applying the Bergsma equation

Map (10) identifying gully erosion points in the Wadi Rumaitha Basin.

3. Conclusion and future scope

The following conclusions are evident from the study and analysis of the water erosion process in the Wadi Rumaitha basin area:

1. Water erosion is one of the most important geomorphological processes prevailing in the study area and has the greatest impact on soil erosion and erosion. Natural characteristics such as geological structure, linear structures, surface, climate, soil, and natural vegetation all affect the nature and intensity of water erosion, for example slope and geology. They can directly affect the extent of erosion through their effect on the flow of surface water and thus erode soil and rocks in the area.

2. Rain erosion in the basin is weak due to the lack of rain and its fluctuations, and in general it is high at the Nasiriyah station, then the Samawah station, and then the Hafar Al-Batin station as a result of the rain and terrain difference.

3. The degrees of gully erosion ranged between (1) and (7), some of which were mild degrees of erosion, which included (1) to (5), some of which were moderate, represented by (6), and others were severe degrees of erosion, which included (7), in general. The majority of the area studied was located within the ranges of high and medium degrees of erosion, as a percentage of the total area of the basin.

Suggestions:

1. The researcher recommends constructing dams and reservoirs on the prevailing valleys in the Wadi Rumaitha Basin to activate the process of harvesting water to benefit from it in agriculture and reduce its erosional effects.

2. Preventing overgrazing, organizing the grazing process in an orderly manner, and stimulating vital activity that increases the organic matter (humus) in the soil in order to maintain soil moisture and cohesion and prevent erosion.

3. Be careful of areas exposed to severe erosion and not exploit them for agricultural or residential purposes due to their unsuitability

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