The role of artificial intelligence data in estimating the extent of gully erosion the basin is Wadi Khashm Al-Mujadar

Duha Jawad Kazem Al-Abru[1], Prof. Dr. Hussain Joban Uraybi Al-Moardah[1]

[1]*Education College for Human Sciences, Basrah University, Iraq.*

KEYWORDS

Artificial Intelligence Data, Gully Erosion, Wadi Khashm Mujadar Basin

ABSTRACT

Wadi Khashm Al-Mujadar basin is one of the dry valleys in the southern western plateau of Iraq, it is located astronomically between two latitudes (5314.191◦29) (2437.944◦29) north, and (102.327◦46) (02.79◦46) east. It is characterized by geomorphological, hydrological and natural resource characteristics, contributes to the development of the lands of the southern Western Plateau. The importance of the topic comes from the natural and human characteristics of this basin that contribute to development, with artificial intelligence data, it has become an important tool in the process of analyzing, linking, interpreting and modeling some natural risks, to which the soil and lands are exposed under varying climatic conditions that contribute to the variation in the quality and extent of erosion. The use of artificial intelligence data is an effective tool in achieving valuable and accurate results. The research aims to use artificial intelligence data to estimate the extent of erosion, determine its type, cases, and degree of severity, and model it, depending on the results of the calibrations used, especially the Bergsma criterion for determining groove erosion. Gully erosion in the basin varies from light gully erosion to high gully erosion, due to the variation in the amount of rain, its falling regime, and the characteristics of the soil in the region, in addition to the rock formations, the steepness of the slope, the density of natural vegetation and the role of humans in it. The study showed that there are (4) erosion zones: it is a very light erosion zone(13.03 km^2 and a rate of 4.28%), the area of light erosion (218.35 km^2, at a rate of 71.81%, the moderate erosion zone (68.71 km^2, at a rate of 22.6%, and the high erosion zone (3.99 km^2, at a rate of 1.31%. The majority of the area was located within the range of light and moderate erosion, requires finding ways to reduce soil erosion and the deterioration of its structure, composition and natural properties.

1. Introduction

Artificial intelligence techniques constitute one of the important tools and methods in modern geomorphological studies because geomorphological studies include a huge amount of numbers that require the use of methods and means through which this data can be extracted, analyzed and relationships between them can be found. Estimating the extent of erosion is one of the important topics that need to be extrapolated to artificial intelligence methods. Because its induction and extraction requires several complex mathematical and statistical processes, remote sensing data, and geographic information systems, as well as quantitative methods of measurement. Therefore, the study relied on the use of artificial intelligence in analyzing and extrapolating the extent of gully erosion in the Wadi Khashm Al-Mujadar basin, one of the valleys of the Western Plateau, northeast of Muthanna Governorate, southern Iraq.

1. Research problem: The main research problem is (Can artificial intelligence data estimate the extent of gully erosion by applying the Bergsma equation to the lands of the Wadi Khashm Al-Mujadar basin in Al-Muthanna Governorate)? The secondary research questions were summarized as follows:

A.- What are the geomorphic factors causing gully erosion in the Wadi Khashm Al-Mujadar basin in Al-Muthanna Governorate?

B. What is the size of the gully erosion, its erosional capacity, its distribution area, and its intensity?

2. Research hypothesis: The main hypothesis was as follows: (Artificial intelligence data can estimate the volume of erosion in the Wadi Khashm Al-Mujadar basin in Al-Muthanna Governorate using the Bergsma 1982 model to estimate the volume of erosion in water basins), which includes many secondary hypotheses, which are as follows:

A. The Wadi Khashm Muddar Basin is characterized by geomorphic factors that contribute to the flow of gully erosion processes in the basin.

B. The extent of gully erosion varies spatially in parts of the basin and is related to the type of factors

and processes stimulating gully erosion.

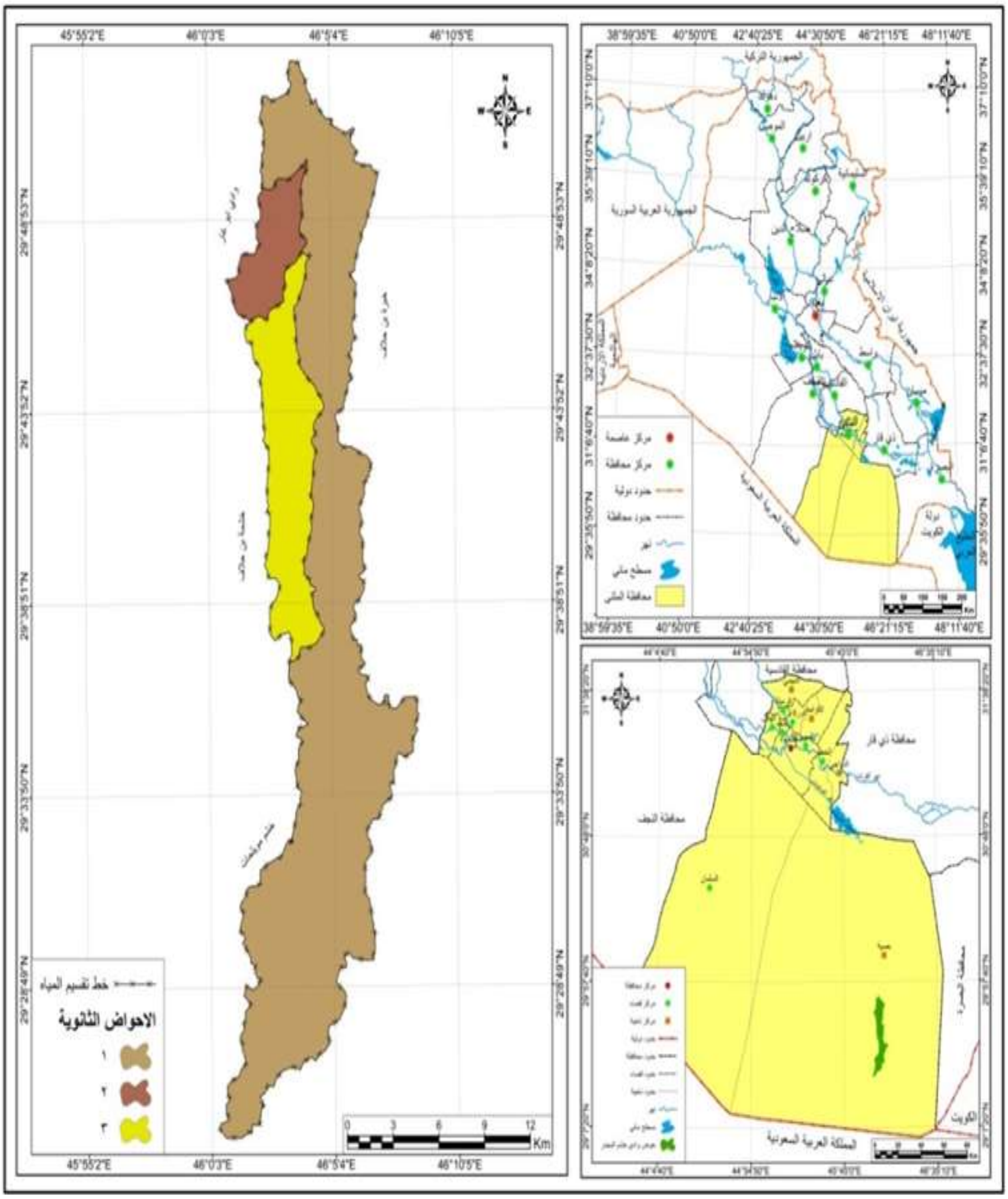
3. The goal and importance of the research: The research aims to employ artificial intelligence techniques in studying the phenomenon of gully erosion and analyzing the factors causing its occurrence, while determining its size, distribution, and intensity zones quantitatively in the study area, considering that artificial intelligence techniques are important in building a geographical database, as well as knowing The role of gully erosion in soil loss in the Wadi Khashm Al-Mujadar basin.

4. Research approaches and methods: The research relied on several approaches for the purpose of arriving at an integrated and interconnected study with its ideas, methods, and results. The land appearance approach was followed, which is concerned with the analytical description of the morphological appearance of the land and its classification into land units, and the inductive analytical approach that begins with the part and ends with the whole, and then applied for the purpose of studying the region from a geomorphological perspective. The analytical approach and quantitative method were also adopted to process the data obtained and analyze the water networks. To determine the areas of water erosion, its degrees, and the distribution of its intensity areas. The method of work was done by collecting data, sources, maps, satellite visuals, and some governmental and academic reports about the region, as well as using remote sensing data, geographic information systems, and a digital elevation model (DEM) with a resolution of 30 m in the basin plots of land, and applying the 1982 Bergsm equation on the basin lands by covering The basin is divided into a grid of squares aligned with cells (pixels), and then the lengths of the drains or gullies are measured within each square. It is possible to know the total lengths of the gullies by dividing the sum of the lengths by the total area of the basin in order to reach the most accurate results in the process of measuring and classifying erosion areas.

5. Research boundaries: The Wadi Khashm Al-Mujadar basin is located in the eastern part of Al-Muthanna Governorate, at the border areas of Basra Governorate, in the Busiyah district of Al-Salman District, whose source is located within the Iraqi border within the Samawah Desert, and its mouth ends within the borders of Basra Governorate, with an area estimated at (304.08) m. With a length of (83) km2, it is located astronomically between two latitudes (5314.191◦29) and (2437.944◦29) north.

And between arcs of length (102.327 ◦ 46) (02.79 ◦ 46) east, the basin consists of three secondary basins that vary in area, map (1) and the basin slopes from the southwest towards the northeast.

Map (1) Location of Wadi Khashm Al-Mujadar Basin in Al-Muthanna Governorate, Iraq.



Source: Republic of Iraq, General Authority for Survey, Administrative Map of Iraq, scale 1,000,000, for the year 2018.

1- Digital Elevation Model DEM.90 and ARC GIS10.8 program

2- Ministry of Water Resources, Directorate of Water Resources in Muthanna Governorate, GIS Unit, Muthanna Administrative Map, scale 25000:1, 2022.

The first section: The natural characteristics of the Wadi Khashm Al-Mujadar Basin:

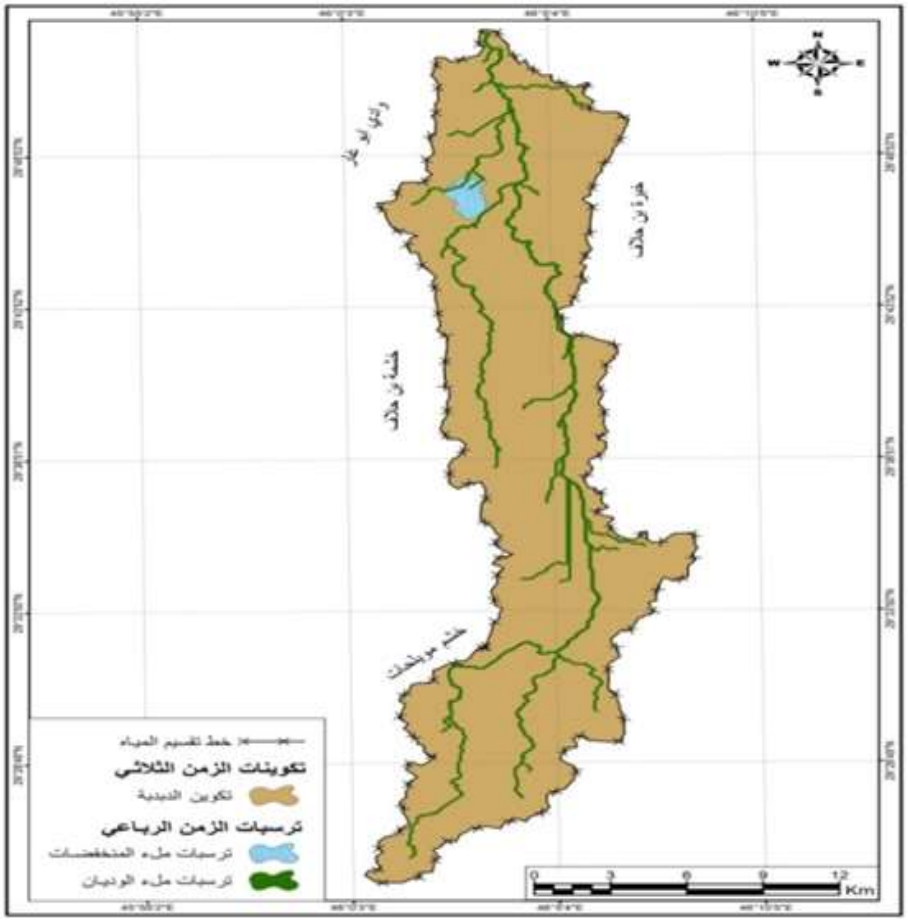
This research is concerned with studying the natural factors of the Khashm Al-Mujadar Basin by knowing the geological formation of the basin over geological times, as the ground structure has a major impact on the land appearance, and studying the characteristics of the terrain is important in shaping the geomorphological processes of erosion and sedimentation, as well as their impact on the river network. The study of the characteristics of soil, water resources, and natural plants plays a fundamental role in the emergence of landforms. The soil works to determine the extent of its response to geomorphological processes and the vegetation through which the surface is protected from the activity of geomorphological processes. We can also address the study of natural factors according to the following:

First: Geological discoveries of the Wadi Khashm Al-Majdar Basin: Studying the rock formations and surface finds helps clarify many of the characteristics that contribute to shaping the appearance of the earth with the aim of determining the extent of these rocks' response to hydrogeomorphological processes, in terms of their resistance to sculpting or dissolution processes, including the type and system of rocks and concretions. And water resources, and a group of rock formations and sediments were uncovered in the Wadi Khashm Al-Mujjar basin, which will be mentioned according to geological eras from oldest to newest, as in Table (1) and Map (2), where the sediments were divided as follows:

1. The three-time formations, which are as follows:

A. Pleistocene Dibdibba formation (Plocene): It is the most widespread formation in the study area in the northern, central and southern parts of the valley basin. This formation occupies an area of (289.4) km^2 and constitutes (95.172)% of the total area of the basin. From observing Table (1) and Map (2-1), it consists of a highly cohesive conglomerate pebble sandstone with a thickness of (8) m, followed by a slightly hard yellowish lead sandstone with a thickness of (25) m, and a pebble sandstone with a thickness of (2) m. It is a partially hardened muddy sandstone with a thickness of (0.5) m. The rocks of this formation are zircon, which contains a predominant percentage of other heavy metals (Abdel-Zahra, 2022, pp. 25-26).

Map (2) Rock formations in the Khashm Al-Mujadar Basin.



Source: Researcher based on: Digital Elevation Model (DEM 30 M) and Arc GIS 10.8 program.

Table (1) Geological formations in the Khashm Al-Mujadar Basin.

Time	Era	Geological formation	Area (km^2)	Percent (%)
Triple time	Pliocene and Pleistocene era	Bear deposits	95.172	289.4
Quadrilateral time	Holocene era	Deposits fill depressions	0.88	2.69
		Valley-filling deposits	3.943	11.99
Total			100	304.08

Source: The researcher based on: Digital Elevation Model (DEM 30M).

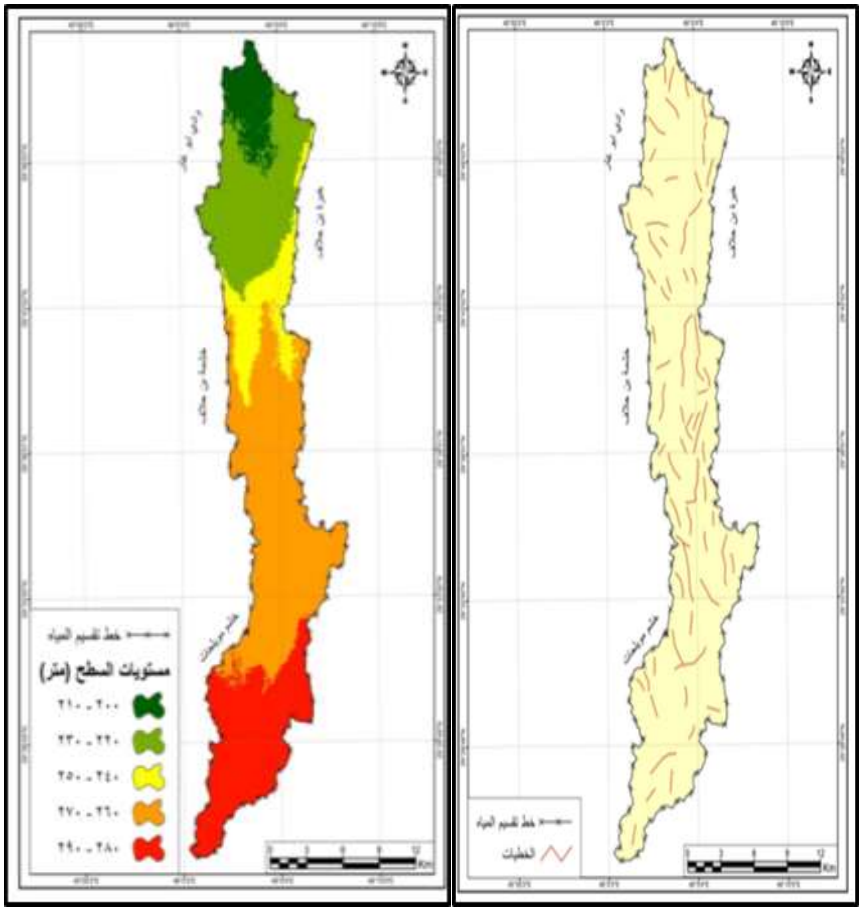
2. Quaternary Sediments: Quaternary Sediments constitute an area estimated at (14.68) km^2, at a rate of (4.83%). It consists of deposits that fill depressions and fill valleys, and include the following formations in the study area: -

A. Depression Fill Deposits: These sediments occupy a thickness ranging between (0.5-1.5) m and an area of (2.69) km^2, at a rate of (0.88%) of the total area of the study area. Note map (2) and are in the form of basins. Flood or playa (salt lakes) in which water is concentrated permanently or temporarily and is spread in the northern, central and southern parts of the valley basin. These sediments continue with a fine clay texture and a greenish-gray walnut colour. This indicates that the environmental conditions of these sediments are stagnant water covered by alluvial sediments. And Al-Ramliyya (Naji, 2019, p. 14).

B. Valley Fill Deposits: They are among the deposits of the Holocene era that are widespread in the study area, as they formed an area estimated at approximately (11.99) km^2 and their percentage reached (3.943)%. Note map (2) and these deposits are spread in the northern part. The eastern part of the valley basin. In general, the thickness of these sediments ranges from a few centimeters to 1 meter. They consist of sandy or silty gravel and sand grains. There are also clay materials that stabilize the gravel. The depositional environment for these sediments is a riverine environment and is still partially active (Al-Ziadi, 2022, p. 53).

Second: Surface properties and slope: The study area is characterized by its concretion and contrast, as the highest elevation value reached (290) m in the northwestern part of the study area at the source, and the lowest elevation value in the southeastern part of it reached (210) m in Its lower parts are at the mouth. The terrain in the basin varies between hills, plateaus, and lowlands, which are represented by lowland areas, and the surface has a significant impact on water erosion when the slope increases, which leads to an increase in the force of water erosion, lower rates of water infiltration, and increased surface water runoff.

Map (3) Linear structures and elevation classes in the Wadi Khashm Al-Mujadar basin.



Source: The researcher based on: the digital elevation model (DEM 30M) and the Arc GIS 10.8 program.

Third: Climatic characteristics: The climate of the study area was exposed to change with time, especially during the Pleistocene era, and the characteristics of the ancient climate during its wet and dry periods had the greatest role in determining the activity of geomorphological processes and delineating the features of most of the terrain in the Wadi Khashm Al-Majadar basin, but at the present time it has Climatic data from the Samawah, Nasiriyah, Basra, and Hafar Al-Batin stations indicated that conditions of drought and water deficit prevail in the study area (Table 2), as it is characterized by a lack of rain (97.5, 125.8, 124, 132.62) mm, in addition to its fluctuations and short and sudden rainfall of high intensity, in addition to High average temperatures (25.8, 26.2, 26.2, 24.8) m. The evaporation rate is (3410.4, 3505.2, 3689.0, 3540.6) mm, respectively, (35.5, 41.09, 39.5, 40.3), and the wind rate is (3.7, 3.9, 3.6, 3.2) m/ s, while the relative humidity rate is (35.5, 41.09, 34.5, 40.3), and these characteristics have an impact on the variation in the effectiveness of geomorphological processes, especially the erosion process.

Table (2) Climatic characteristics of the Wadi Khashm Al-Mujadar Basin.

St.	Items	Months												Total or mean
		Jan	Feb	Mar.	Apr.	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Samawa	Temperature	11.4	14	18.5	24.95	30.9	34.6	36.1	35.9	32.5	26.9	18.95	13.52	24.8
	Rain	30.62	18	16.5	12.9	5.2	0	0	0	0	5.9	18.8	24.2	132.12
	Wind	2.7	3.3	3.5	3.6	3.8	3.9	3.9	3.5	3.1	2.8	2.5	2.5	3.2
	Humidity	65.4	57.2	47.1	38.3	26.2	23.2	22.3	23.7	27.3	37.2	53.4	62.5	40.3
	Evaporate	68.5	118.5	204.4	280.6	392.5	499.2	555.5	522.4	390.2	267	134.4	89.5	3540.6

Nasiria	Temperature	12.2	15.1	20.3	25.9	32.5	36.6	38.1	38	34.3	28.3	19.4	14	26.2
	Rain	21.8	15.1	19.3	14.6	3.1	0	0	0	0	7.1	21.6	21.4	124
	Wind	2.8	3.3	3.7	3.9	3.9	4.8	4.9	4.3	3.6	2.8	2.7	2.7	3.6
	Humidity	66	56.8	46.2	39.3	27.9	20.5	19.5	21.2	25.3	36.3	53.7	64.6	39.5
	Evaporate	81.4	114.6	202.3	279.5	420.6	546.1	590.2	540.5	419.9	275.7	134.5	83.5	3689
Basra	Temperature	13.2	15.9	20.45	26.4	32.75	36.45	38.1	37.65	34	28.75	20.55	14.85	26.6
	Rain	26.8	17.5	19.6	11.6	3.2	0	0	0	0	5.8	18.2	23.1	125.8
	Wind	3.4	3.1	3.9	4	4.1	5.2	5.2	4.9	3.8	3.1	3.1	3	3.9
	Humidity	67.4	57.9	48.2	39.2	27.6	21.5	21.8	23.9	27.8	38.5	53.9	65.4	41.09
	Evaporate	78.4	104.9	188.5	253.2	373.3	645.5	519.5	461.2	380.6	302.9	123.1	74.1	3505.2
Hafer Al-Baten	Temperature	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
	Humidity	64	53	38	36	26	17	16	17	20	28	51	60	35.5
	Evaporate	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.

2- Kingdom of Saudi Arabia, General Authority of Meteorology and Environmental Protection, Open Data Office, Department of Information Requests, 2022.

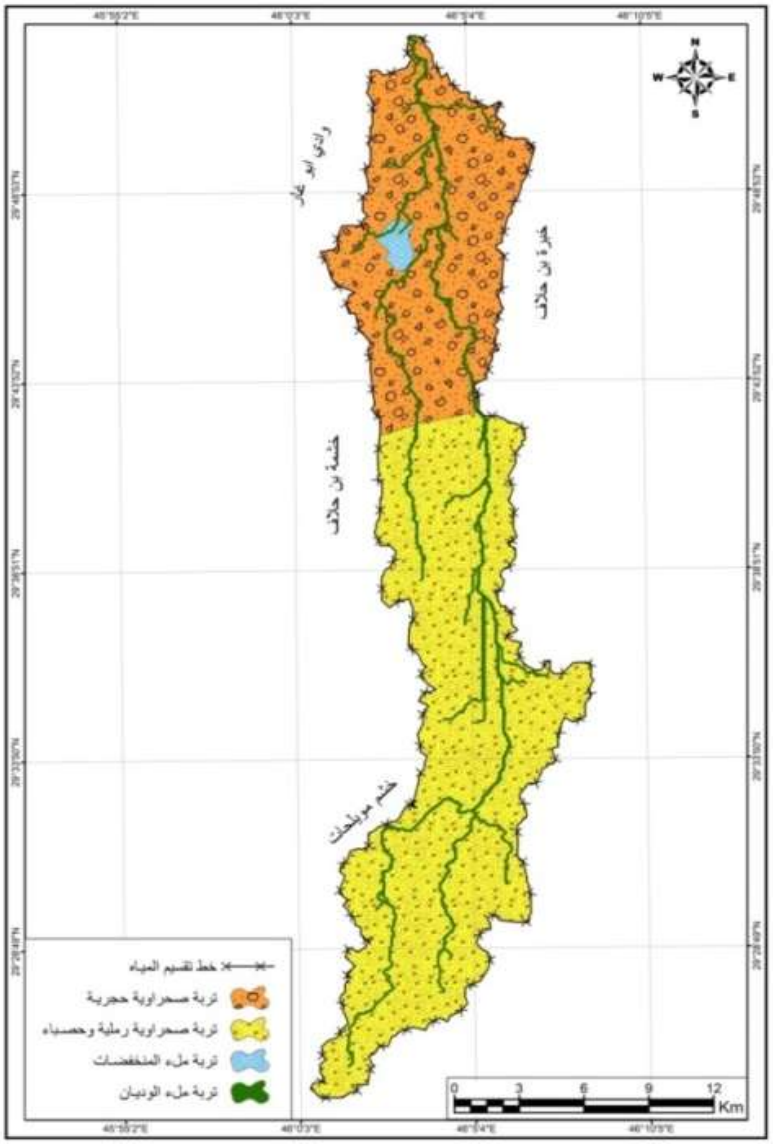
Fourth: Soil: The soil of the study area is classified according to Bjornick's classification into four types of soils, and by observing the data in Table (3) and Map (5), the most extensive and widespread soils in the study area are sandy and gravel desert soils with an area of (185.61 km2). With a percentage of (61.03%) of the total area of the study area, it came in second place in terms of area. The stony desert soil reached an area of about (103.79 km^2) and a percentage of (34.13%). As for the valley-filling soil, its area reached (11.99 km^2) and a percentage of (3.94%) of The total area of the study area, while the depression-filling soil represented the last category of Bjørnck's classification, as it recorded an area of (2.69 km^2) and a percentage that was the lowest at about (0.9%) of the total area of the study area.

Table (3) Soil types in the Wadi Khashm Al-Mujadar basin according to the Buringh classification.

Soil classification	Area (km^2)	Percent (%)
Sandy and gravel desert soil	185.61	61.03
Soil filling depressions	2.69	0.9
Soil filling valleys	11.99	3.94
Stony desert soil	103.79	34.13
Total	304.08	100

Source: Worked by the researcher based on map (5) and Arc GIS 10.8 program.

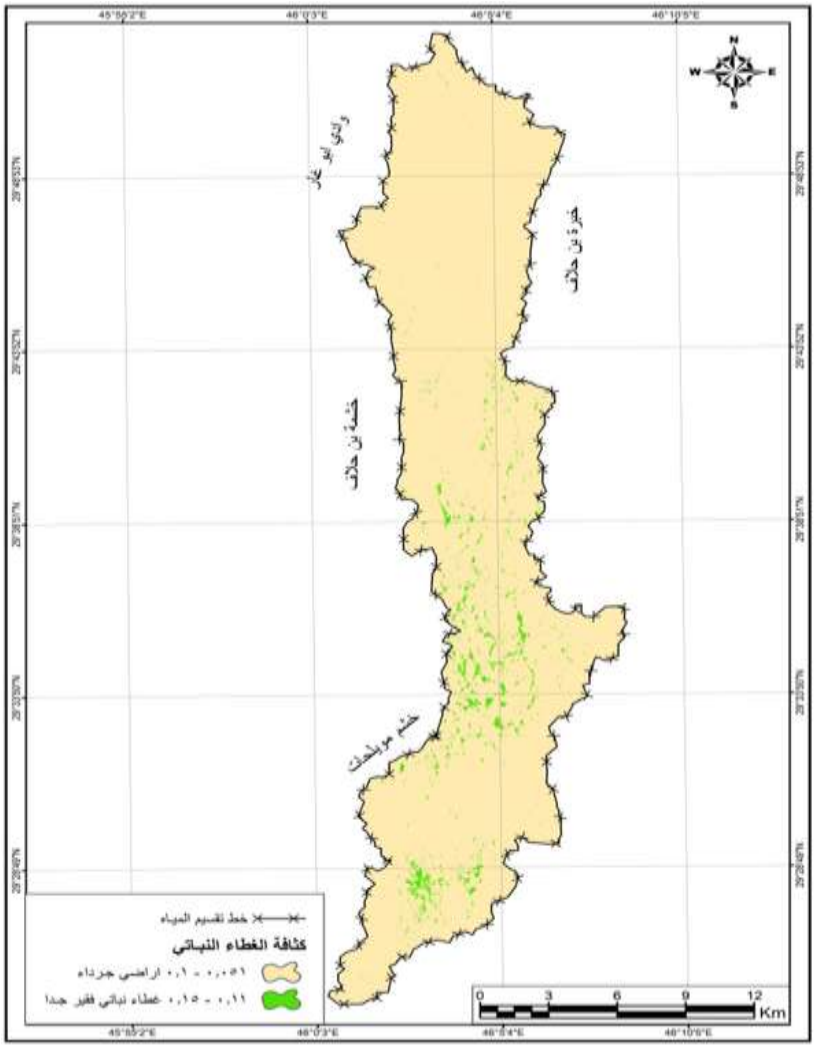
Map (5) soil types in the Khashm Al-Mujadar Basin.



Source: Prepared by the researcher based on (1) the soil map (Bjornik) (Iraq) with a scale of 1:1000000 (2) and the map (5) and the Arc GIS 10.8 program for calculating areas.

Fifth: Vegetation cover: Vegetation cover is one of the factors influencing the increase in the activity or slowness of soil erosion processes. The vegetation cover in the Wadi Khashm Al-Mujadar basin was studied using (NDVI) in the winter and relying on the satellite visualization of the satellite (9 Landsat) captured on (/8/20233) and with an accuracy of (30) metres, in addition to using (Band4.5) for the winter season of vegetation, it became clear that there are two patterns of vegetation cover in the study area, the first pattern represents barren lands and the second pattern has very poor vegetation cover, as shown in Table (4).) and map (6). The vegetation cover in the study area was divided as follows and between the highest value (0.11) and the lowest value (0.051) for the winter season of the Wadi Khashm Al-Majdar basin.

Map (6) Vegetation density index in the Khashm Al-Mujadar Basin.



Source: Based on satellite visualization of the Landsat 9 satellite, for the year 2023 and using the (NDVI) index, and the GIS10.8 program, (3/8/2023).

Table (4) Vegetation density index in the Khashm Al-Mujadar Basin.

Description	Class (NDVI)	Area (km^2)	Percent (%)
Barren lands	0.1-0.051	297.02	97.68
Very poor vegetation cover	0.15-0.11	7.06	2.32
	Total	304.08	100

Source: Prepared by the researcher based on map (5).

The second topic: Gully Erosion

Gully erosion is an advanced stage of stream erosion and increases with increasing slope and distance from the water dividing line. It consists of the confluence of short streams, then it begins to expand and lengthen, and the amount of water flowing through it increases and has the ability to cause major erosion, so that its cross sections appear, and it takes the shape of the Latin letter (V) when it passes over moderately hard rocks (sand and rock masses), while it takes the shape of the letter (U) in the plain area in the main valley streams, because the activity in lateral carving operations is greater than the activity in main carving operations because they are carried out over rocks with weak resistance (clay) (Ahmed, 2008, p. 53), and there are a group of factors that control the emergence and development of gullies, the most important of which are the intensity and continuity of rain, the length of the slope, the degree of slope, the rocky nature, the structural structures, the texture and cohesion of

the soil, the density of natural vegetation cover, and the distance from the water dividing line. In addition, valleys may be exposed to drought for a long period of time, which plays a role in the development of these valleys due to the activity of weathering processes that lead to the disintegration of their surface components at the bottom and banks, which facilitates the process of erosion with the first wave of rain and sudden floods that fall on the region or when the rainy season arrives. Therefore, the intensity of gully erosion of the Wadi Khashm Mujadar Basin was measured based on the equation (Bergsma 1982), and through it the characteristics of water erosion, its impact, and the extent of its effectiveness were identified according to the following equation (Ghathwan, 2011, p. 105).

$$AE= \sum L/(A)$$

Since:

AE = Brejsma index of the gully erosion rate per unit square (m⁄km2).

L ∑ = the sum of the lengths of the grooves in the basin within a unit area (one square b m).

A = Basin area (km^2).

The Bergsma equation was applied as follows:

1. Dividing the study area into squares, the number of which was (64 squares), the area of each square being (5).

2. Number the squares and pin them on the map to avoid oversight and error.

3. Find the product of each square by dividing the sum of the lengths of the sewers within that unit by the unit area

4. Calculating the lengths of waterways located within one unit of area, i.e. within each square, fixing the sum within each square, then multiplying it by the map scale to convert the units from (cm) to (m).

5. Find the product of each square by dividing the sum of the lengths of the sewers within that unit by the unit area.

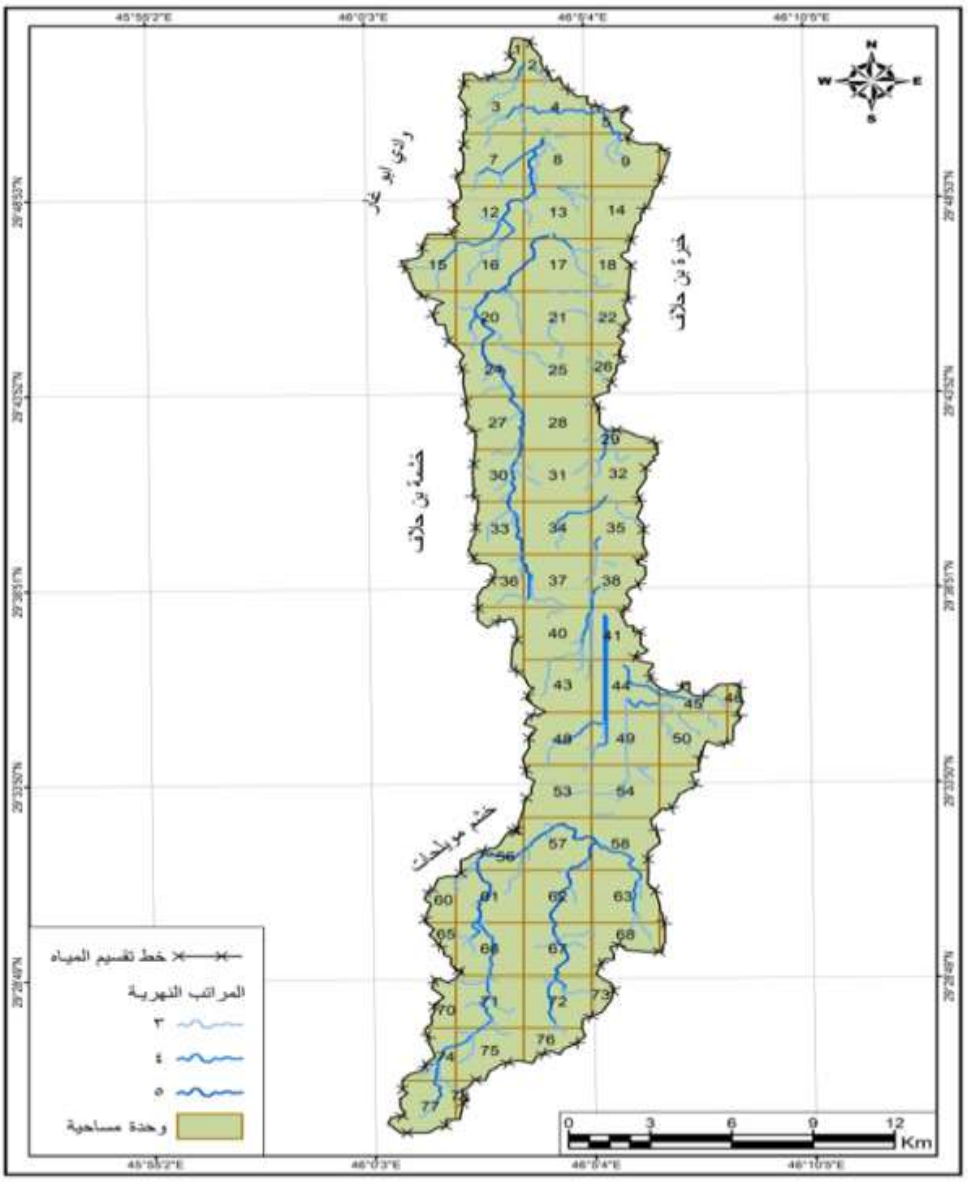
6. Each square is classified according to the extracted result based on the Bergsma classification to determine the severity of gully erosion.

Based on the values shown in Table (6) and observing the erosion map that was drawn based on these values, as well as from the results reached and shown in Table (7), it is possible to identify four erosion zones in the region, and each zone is distinguished from the other by the extent of its effectiveness. Erosion, and the amount of erosion varies from one region to another depending on the rock structure, the slope of the earth's surface, vegetation, and the permeability of the rocks (Al-Mawla, 2008, p. 133), as in Map (7) and Map (8).

1. Very light erosion zone: Very light Erosion Zone

This range is represented by erosion rates that are limited to between (1-400) m - km2, represented by the degree of erosion (1), and it spreads in a few parts of the northernmost, middle and southernmost parts of the Wadi Khashm Al-Mujadar basin, with an area of (13.03) km^2 and a percentage of (4.28%) of the basin area. College, map (8).

Map (7) determining the scope of gully erosion in the Wadi Khashm Al-Mujadar basin.



Source: Forensic visualization of the satellite (Land sat 9), and Arc GIS 10.8 program. And the digital elevation model (DEM), based on the results of the Bergsma equation.

Table (6) Gully erosion ranges according to Bergsma (1982) index.

Erosion range	Gully erosion rate	Description
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 exposure
6	3701-4700	Severe erosion
7	More than 4700	Very severe erosion

Source: Bashar Hashim Kanwan Ahmed, Geomorphology of Hamrin Dam using remote sensing techniques and geographic information systems, Master's thesis, Tikrit University, College of Education, Department of Geography, 2008, p. 54.

Table (7) Degrees of gully erosion in the Wadi Khashm Al-Mujadar basin.

Erosion No.	Description	Area (km^2)	Percent (%)
1	Very light erosion	13.03	4.28
2	Light erosion	218.35	71.81
3	Moderate erosion	68.71	22.6
4	High erosion	3.99	1.31
Mean		304.08	100

Source: The researcher based on the Bergsma equation and the outputs of the Arc GIS 10.8 program.

2. Slight Erosion Zone:

Erosion rates in this range are limited to (401-1000) m - km^2, which is represented by the degree of erosion (2), and it ranks first in terms of a large area that reached (218.35) km2, with a percentage estimated at (71.81%) of the area of the Wadi Khashm Al-Mujadar basin. It is the most widespread area in the study area, as it covers all parts of the basin, as shown in map (8).

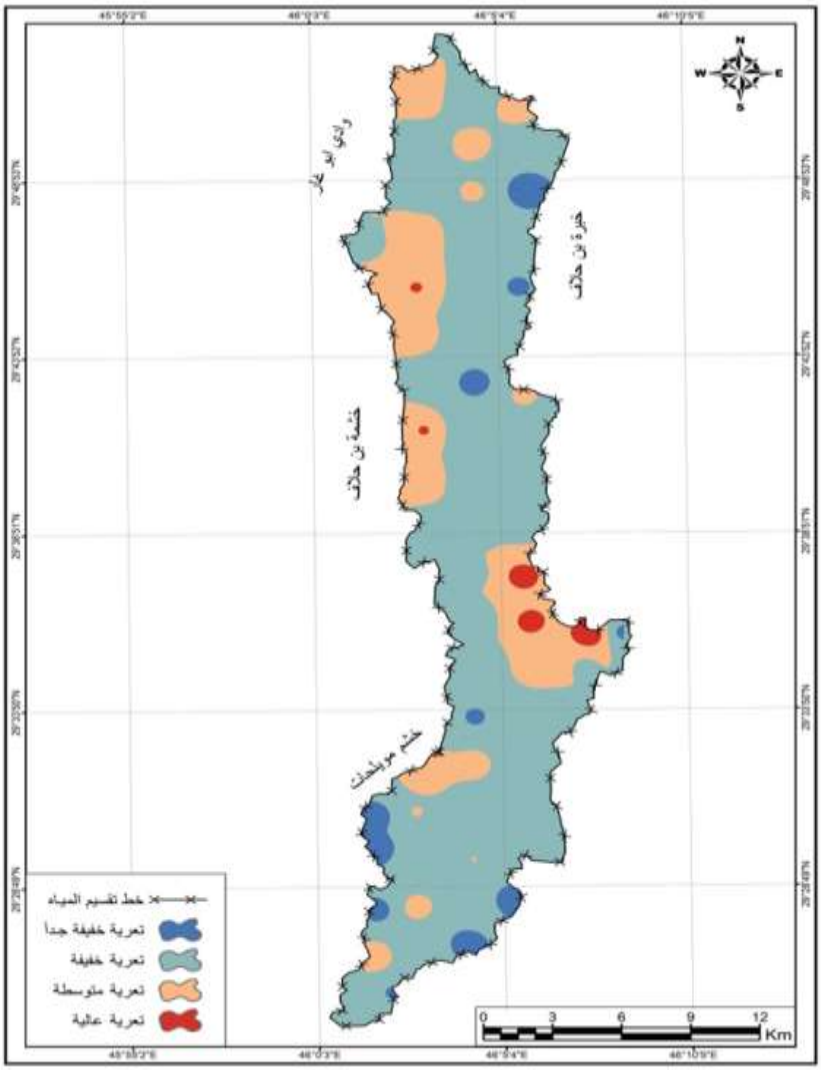
3. Moderate Erosion Zone:

The rates of erosion values for this range range between (1001-1500) m⁄km^2, which is represented by the degree of erosion (3). This is spread throughout the Wadi Khashm Al-Mujadar basin, as shown in map (8), and its area reached about (68.71) km2, with a percentage of (22.6%). Of the total area of the basin.

4. High Erosion Zone:

This range does not constitute a very small percentage of (1.31%) of the total area of the basin with an area of (3.99) km^2, and it is represented by areas where erosion rates range between (1501-2700) m⁄ km^2, represented by degree (4). We note that it only covers areas It is limited to the north and center of the basin area, as shown by map (8).

Map (8): Types of gully erosion in the Wadi Khashm Al-Mujadar basin.



Source: Forensic visualization of the satellite (Land sat 9), and Arc GIS 10.8 program. And the digital elevation model (DEM), based on the results of the Bergsma equation.

2. Conclusion and future scope

By observing the results obtained we conclude the following:

1. The natural characteristics represented by the geological structure, linear structures, surface, climate, soil, and natural vegetation are the factors controlling the nature and intensity of gully erosion, and they have a direct impact on the extent of erosion through its effect on surface runoff.
2. The distribution of gully erosion varied over four areas of different intensity throughout the study area, between the range of very light and light erosion within ranges (1) and (2), the range of medium erosion (3), and the range of high erosion (4). In general, the The majority of the area studied was located within the ranges of degrees of very light, light, moderate, and high erosion.
3. The area exposed to high gully erosion is located in the central part of the basin, especially in its northern part, so that it is not suitable for human use.

Recommendations:

1. Taking advantage of the quantities of water, especially surface runoff, by constructing small dams and activating water harvesting operations to benefit from it in agriculture and reduce its effects of erosion.
2. Investing the region in industry, especially the upper basin, which is characterized by a high

percentage of gravel.

3. Expanding afforestation operations and preserving vegetation cover.
4. Preventing overgrazing, organizing the grazing process periodically, and stimulating any biological activity that increases the organic matter (humus) in the soil due to its advantages in preserving soil moisture and cohesion and preventing erosion.
5. The area exposed to high erosion is located in the central part of the basin, especially in the northern part, so that it is not suitable for human use.
6. Accordingly, we recommend exploiting lands located in areas of light and moderate erosion in various fields, some for population centers and some for agricultural purposes

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