The Impact of Geomorphological Assessment on Soil Fertility in Al-Ba'aj District

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ABSTRACT

Soil is one of the elements of the natural environment and is the product of complex geomorphological processes and includes many chemical and physical properties, so expressing it in the form of representation and evaluation is possible, especially the development with the technical development in GIS software, and geographical phenomena carry when represented on maps with the property of spatial correlation with other phenomena that share the place with it, so the clarity of the cognitive process of its components on maps and showing them clearly is an urgent cognitive need, all of this makes it necessary for us to monitor and manage this information, so the effect of geomorphic evaluation was chosen.

Keywords: Soil - Al-Baaj District, Geomorphological Assessment

Introduction

Soil is one of the vital natural resources for the continuation of human life, as it is the basic medium for agriculture on which humans depend. Its importance lies in the fact that it contains a stock of mineral and organic elements, along with moisture and air, which makes it the main base for agricultural activity in its various forms and areas. Understanding the characteristics of the soil provides accurate indications of its positive or negative effects on crop productivity, highlighting the need to provide a suitable environment for optimal growth and production [1.[

Problem of the study

The problem of the study lies in the following :

-1Is there a variation in the physical and chemical properties of the soils of the study area and what is the impact of this variation ?

-2Is there a spatial variation in the soil assessment process between one area and another within the study area?

-3Do modern technologies such as geographic information systems (GIS) help in finding and clarifying the spatial variation?

Hypotheses :

-1The physical and chemical properties of Al-Ba'aj district soils vary spatially depending on the factors influencing their formation.

-2A set of geomorphological factors interact in the variation of soils in Al-Baaj district.

-3Modern technologies such as geographic information systems (GIS) have a great role in showing the spatial variation of soil properties in Al-Ba'aj district.

Objective of the study

The study aims to determine the role of geomorphological assessment and its

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importance in recognizing soil fertility in Al-Baaj to reach the importance of shaping the landform in the study area.

Study methodology :

Within the study plan, three sequential scientific methods were followed in order to reach the objectives of the study, namely:

-1The scientific descriptive approach to the studied phenomenon.

-2The analytical research method based on analyzing the elements of the phenomenon and finding spatial relationships between the elements of the phenomenon and linking them spatially with different geographical phenomena.

Geographical location :

The study area is located in the western part of Nineveh Governorate and the study area occupies an estimated area of 9172 km2, and the study area is 80 km away from the city center of Mosul (80 km) and is bordered on the north by Sinjar district, on the east by Tal Afar district and Hatra district, on the south by Anbar governorate and on the west by the Syrian Arab Republic. As in the map (1(

Astronomical location :

The astronomical location of Al-Baaj district is between two longitudes (42(18̊03E (41(10̊00E east, and between two latitude circles (35(40̊0N (36(00̊30N.

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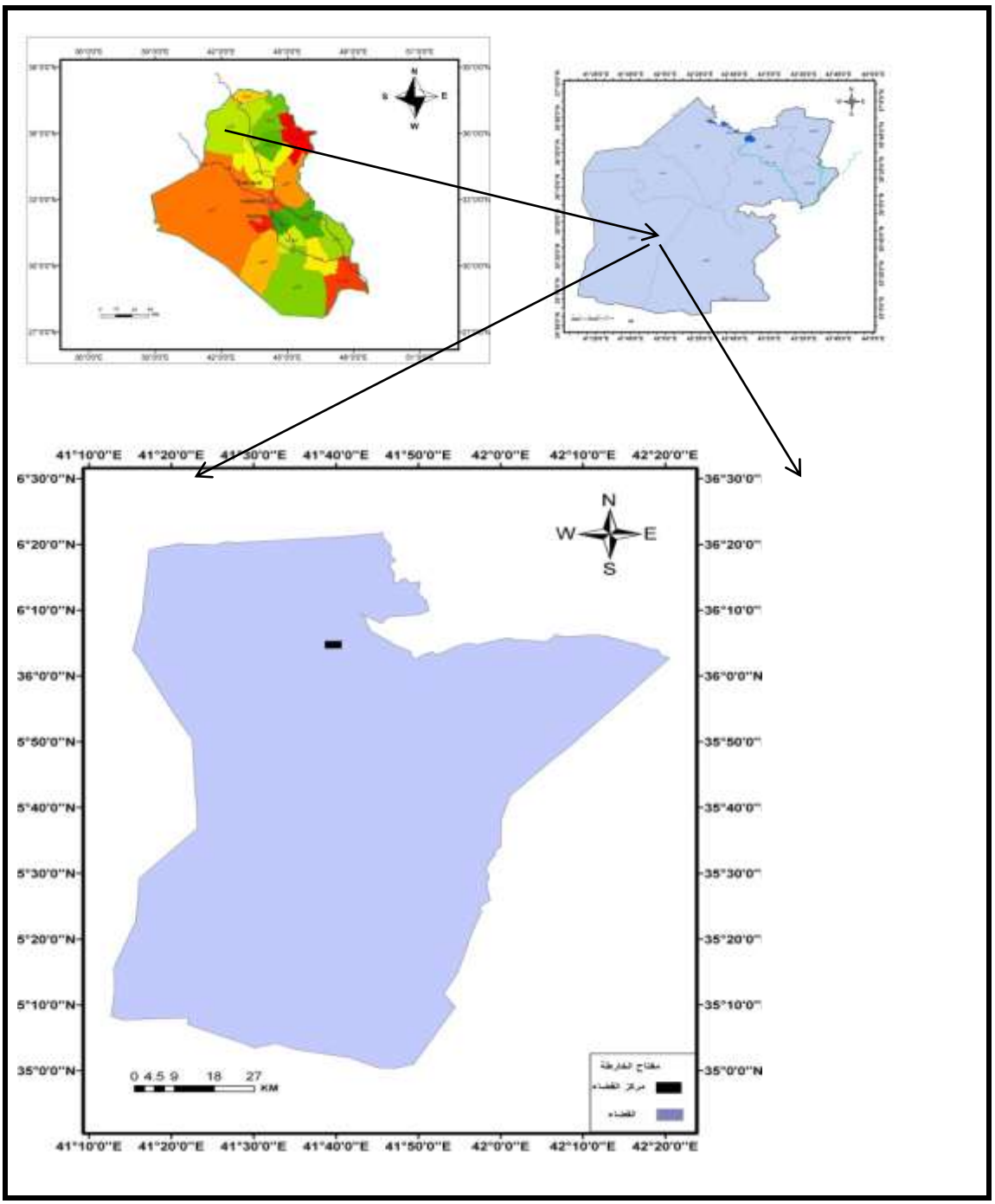
Map No. (1) Geographical location of Al-Baaj district [2[



1.1Geomorphic factors affecting soil formation in Al-Baaj district :

Soils are formed through the interaction and influence of five main influencing factors as identified by Jenny (climate, terrain, organisms and time) [3]. Humans are a sixth factor influencing the composition of soil

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parent material and altering the natural course of soil development through direct and indirect processes such as plowing, fertilization, irrigation projects, cutting and deforestation, or by changing the function of land use [4]. The relative influence of each factor varies from one place to another, so the soil varies from one place to another according to the different factors and conditions of its formation. The following are the most prominent geomorphological factors affecting soil formation in Al-Baaj district:

1-1-1Geology of the study area

The geological structure greatly affects the characteristics of the soil, and with the variation of geological formations, the type of soil changes. The material parent rocks are the material from which the soil is formed, and their properties strongly affect the development of the subsequently formed soil in terms of its physical and chemical properties, and the geological situation of the study area can be described by studying the tectonics of the region and the stratigraphic succession of rock formations.

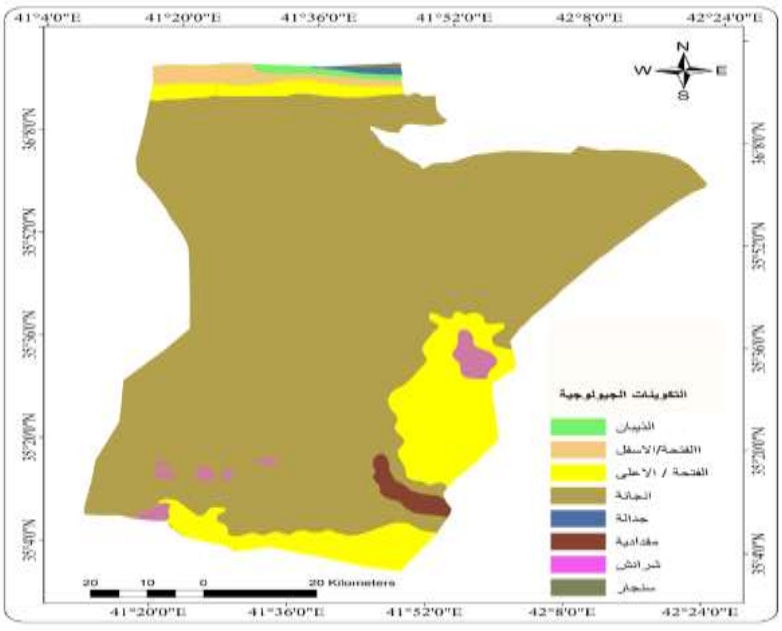
First: Tectonics of the study area

The study area is tectonically located in the Unstable Shelf, within the Foot Hill Zone, according to the tectonic divisions of Iraq .The foothill area (foothill one) is divided into two sub-bands and longitudinal units (, the first band is the Batma-Jamjamal band in the northeast) and the second band (Makhoul-Hamrin band in the southwest, and the foothill area includes four (groups) as a result of the influence of the basal faults.

II: Stratigraphic succession of geological formations

The study of stratigraphic succession is an important part in recognizing the quality of the mineral particles that formed the soil and its prevailing physical and chemical properties, as the geological formations exposed in the study area belong to several geological eras that affect their distribution and rocks[5.[

Map No. (1) Geological structure of Al-Baaj district [6[



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The oldest geological formations in the study area date back to the Lower Miocene, and the rocky sequences in the study area can be divided in terms of surface exposure and importance to the soil into two types:

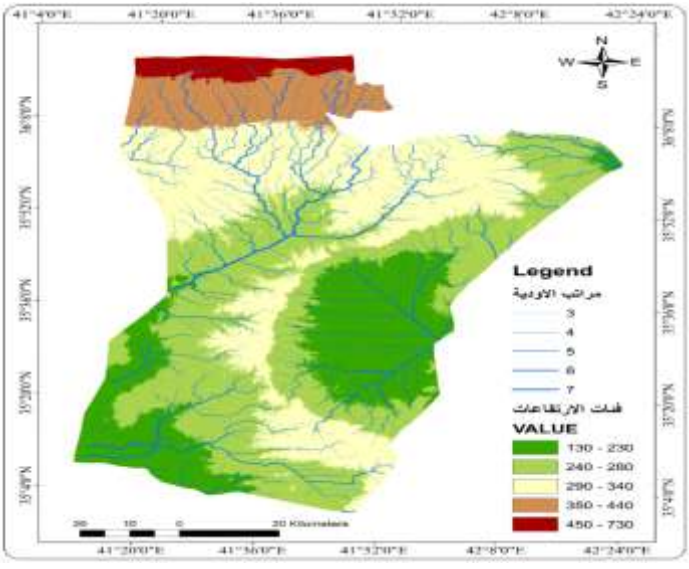
- 1The group of rock formations that are not exposed or exposed on a very limited scale, which extends the chronological age from the lower Miocene of geological time and ends with the Pliocene era of the third geological time and is represented by the formation from the oldest to the latest (Euphrates - Al-Jaribi Al-Fatha Anjana - Al-Muqdadiyah - Shirans - Jadala - Sinjar Dhiban) and its components vary in general from limestone, marl, limestone, sandstone, mudstone, collapses and gypsum [7.[

- 2The Quaternary deposits exposed on the outer surface, and the deposits of this time include both the formations of the Pleistocene era, represented by the deposits of river terraces, floodplain deposits and floodplain deposits, as well as the deposits of the Holocene era, represented by the deposits of seasonal valleys and the deposits of sabkha and soil, and the Quaternary deposits cover most parts of the study area and vary in thickness from several centimeters to several meters and consist of a mixture of sand, silt and clay with various rock pieces[8]. The properties of these rocks were reflected with other environmental variables in the study area in determining the physical and chemical properties of the soil towards a soil texture consisting of clay, silt and sand and chemically with horizons containing gypsum and lime

1.2-1Surface character :

The study area is characterized by a clear variation of land surface forms. This is due to the variation and succession of a set of internal and external factors that contributed to their formation and spatial distribution. The geomorphological factor has become the dominant factor in the spatial distribution of soil types in the study area and the development of their physical and chemical properties, and the study area is divided into three main topographic units:

Map No. (3) Surface and water network sections of the study area [9[



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Hills: There are many hills with varying heights ranging from 150 to 720 meters, such as (Awad Al-Ghazal, Um Al-Zanabir, Akola, Al-Ghanem and Asfouk)[10.[

-2Plains: The plains area of the study area is known as the southern Sinjar Plain, which merges with the part of the Jazira region, which ranges in height between (70-350) meters above sea level and gradually slopes from north to south, and the nature of the terrain of the region is dominated by a flat surface with some undulations as well as the presence of a depression in the southern part of the district

- 3Wadi network: The study area is cut by a group of wadis that vary in their lengths, sizes, amount of discharge and directions according to the variation in the slope of the surface, and that the water drainage system within the region is internal and the majority of surface water penetrates below the surface through permeable layers or through cracks, which contributes to the recharge of groundwater reservoirs, However, the majority of wadis are seasonal in flow[11], and one of the largest basins that drain the study area is Wadi Al-Ajij, which is a seasonal flow that originates from the southern heights of Mount Sinjar and the valley flows into Sabkha Al-Rawda in Syria, and some of its valleys flow into the Sinisla depression south of the study area [12.[

1.1.3Climate:

The climate is one of the important natural factors that have a fundamental role in the formation of the soil from the stage of its derivation from the mother rock to the last stages of its formation, and the climate is the active factor of soil formation and is essential in all biological reactions that occur in it, and the factors of erosion and weathering depend entirely on the elements of climate [13.[

Climatically, the study area lies between an arid (BW) and semi-arid (BS) climate in most parts of the study area, with hotter and drier summers and less rainy and warmer winters [14]. The following climatic elements (temperature, rainfall, wind, humidity, and evaporation) will be addressed and their impact on the soil characteristics of the study area.

- 1Temperature :

Temperature is one of the most important elements of the climate in the processes of soil formation and formation, as it enters the processes of mechanical and chemical weathering, rock fragments and rock debris, the first factor necessary for soil formation. It turns out that temperatures in the Jazira region start to rise gradually from March until they reach their highest rates in July and August, in which the highest average maximum temperature was recorded, and then begin to gradually decrease until they reach their lowest rates recorded in the months of December, January and February. See the table

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Table 1: Annual and monthly averages of climatic elements for Al-Baaj station (1990-2023) [15[

Annual rate	December	November	October	September	August	July	June	May	April	March	February	January	Months
20.3	9.4	14.3	22.7	28	33	33.4	30.4	25.3	18.3	12.5	9.3	7.5	Temperature rate
27.4	14.9	20.8	30.4	36.5	41.5	42	38.5	32.8	25.1	18.8	14.7	12.4	Great heat
13.3	3.9	7.8	15.1	19.6	24.5	24.9	22.3	17.8	11.5	6.2	3.9	2.7	Minimum temperature
47	73	56	39	30	27	28	28	37	50	58	68	75	humidity
222.6	39	24	11.6	0.4	0.1	0	0.9	15.3	13.9	35.8	37.2	44.4	Rain
2074.2	46.2	85.5	150.9	231.9	285.9	319.8	303.3	236.1	180	117.9	71.1	45.6	Evaporation
2.3	1.4	1.4	1.9	2.4	2.9	3.4	3.1	2.7	2.4	2.2	1.8	1.7	Wind speed

- 2Rainfall:

Water has an important role in the processes of soil formation and the effectiveness of the activity of all organisms in terms of dissolving salts, redistributing them and transporting them in the soil in all directions [16], and rainfall in the study area coincides with the arrival of frontal depressions to Iraq, especially from the Mediterranean Sea, which begins its entry in October and increases in the winter months (December - January - February) and decreases in the spring months (March, April - May) to interrupt in the summer months [17]. See Table (1(

-3Wind:

Wind is an important geomorphological factor as a factor of soil transportation, especially in dry areas through wind weathering processes by partial removal of the weathering product, which directly exposes the rock detectors to the effect of varying solar and terrestrial radiation [17] The annual rates of wind speed in the study area vary according to surface variation and varying atmospheric pressure values. See Table (1 (

-4Relative humidity:

Moisture is an important element in soil formation because of the physical, chemical and biological transformations that occur on the surface of the soil, and it is related to the presence of organic matter in the soil because it is a vital activity and depends on the presence of plant and animal life [18]. Through Table (1), it is observed that the relative humidity rates increase in the direction from the summer months towards the winter months .

-5Evaporation :

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It is the process in which water is converted from liquid to gas known as water vapor, and the rate of evaporation from any surface is defined as the liquid water that evaporates from the unit area in the unit of time, and many experiments have shown that the highest evaporation rates occur in soils whose particle size ranges between (3-5) mm [20] and the amount of evaporation in the study area for (1990-2023) reached (2074.2) mm.

Results and discussion

-2The concept of soil:

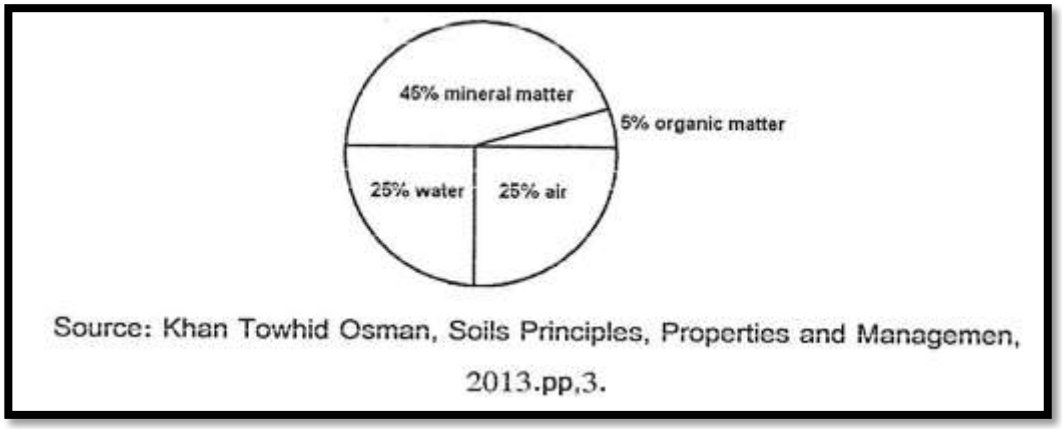
Soil is a dynamic and evolving natural body, a body with three dimensions of length, width and depth. The surface of the earth is considered the upper limit of the soil, while the lower limit is determined by the actual depth to which the soil was formed or the depth to which the roots penetrated, or both [21.[

Soil is considered a natural body because there is no human involvement in its formation, and its characteristics were formed as a result of the combined effect of climate and living matter (plants and animals) on the parent material by the effect of slope over a period of time. The weathering of rocks (decomposition and fragmentation) results in unconsolidated products that act as parent material for the development of the so-called Soil Profile*, which reflects the combined effect of climate, biomaterial, slope, and time on the parent material [22.[

3-1Soil components

Soil consists of rocky materials (mineral components in a large percentage because it was originally formed from the rocks of the crust, as well as a smaller percentage of organic matter resulting from the disintegration and decomposition of plant and animal remains that live in it, as well as from water and air contained within the pores and between the grains, so the loam-textured soil Textured soil consists of (45%) of mineral substances, (5%) of organic matter, (25%) of water and (25) of air as in Figure (2-1) and these proportions vary from one soil to another or in the same soil from time to time according to the factors affecting the soil. For example, warm tropical soils (Uitisois) contain less than (2%) of organic matter due to the speed of decomposition and organic soils (Histosols) contain more than (80%) of organic matter [23.[

Figure (1) Percentage of the main constituent elements of loam soils



Source: Khan Towhid Osman, Soils Principles, Properties and Managemen, 2013.pp,3.

-4Types of soils in the study area and their characteristics:

The characteristics and characteristics of the soil vary from one region to another according to the factors that led to its formation, and the characteristics and characteristics of the soil in the study area were affected from the natural side by a number of factors that controlled its formation, and the most prominent of these factors were climatic characteristics, surface characteristics and geological formations, it is clear from map (4) the types of soils in the study area in light of their formation factors and according to their geographical distribution in order to determine the quality and characteristics of these soils, and several studies have been conducted for soil classification in Iraq, including the modern Russian classification of soil and land for 1990, and this classification that depends on color as a basis for classification, color is an important characteristic in the study area.

The soils of the study area can be divided according to the Russian classification into five classes, namely:

-1Darsenic mountain soils (MD(

These are mountainous soils with steep slopes that are exposed to water erosion processes due to the rates of rainfall and the slope of the land, and contain some mountain plants, and retain quantities of water during rainfall. This type, according to the Russian classification of soils, is characterized by its deep brown color leaning towards darcene, which helps the growth of vegetation in it and the presence of weathering and erosion processes in areas that suffer from a lack of vegetation cover [24.[

-2Normal gray darcene soils (GCA(

These soils are characterized by high gypsum content and high salinity, as well as high soil temperature, so these soils are low in moisture, and are characterized by being gray in color because they contain a high percentage of gypsum and have a soft texture .

-3Light gray darcene soils (GCC(

These soils are classified as having a light texture and contain a high percentage of sand, which makes them characterized by organic matter, moisture content and good heat, and are located at the tip of the southern plain of Mount Sinjar

-4Semi-desert brown soils (B(

These soils are found in the central parts of Al-Baaj and are semi-tropical semi-desert brown soils that occupy a large area of the study area and are characterized by low organic matter, low biological capacity of the soil and weak vegetation cover: They are characterized by low organic matter, low biological capacity of the soil and poor vegetation cover .

- 5Gray brown desert soils (GB(

They are desert soils that cover large areas estimated at about half of the study area and have a high percentage of sand area. They are reactive and highly saturated basal soils, with a hot climate and little rainfall, and are good for the growth of grasses and natural plants such as salmas, caramel, and shaflah[25 .[

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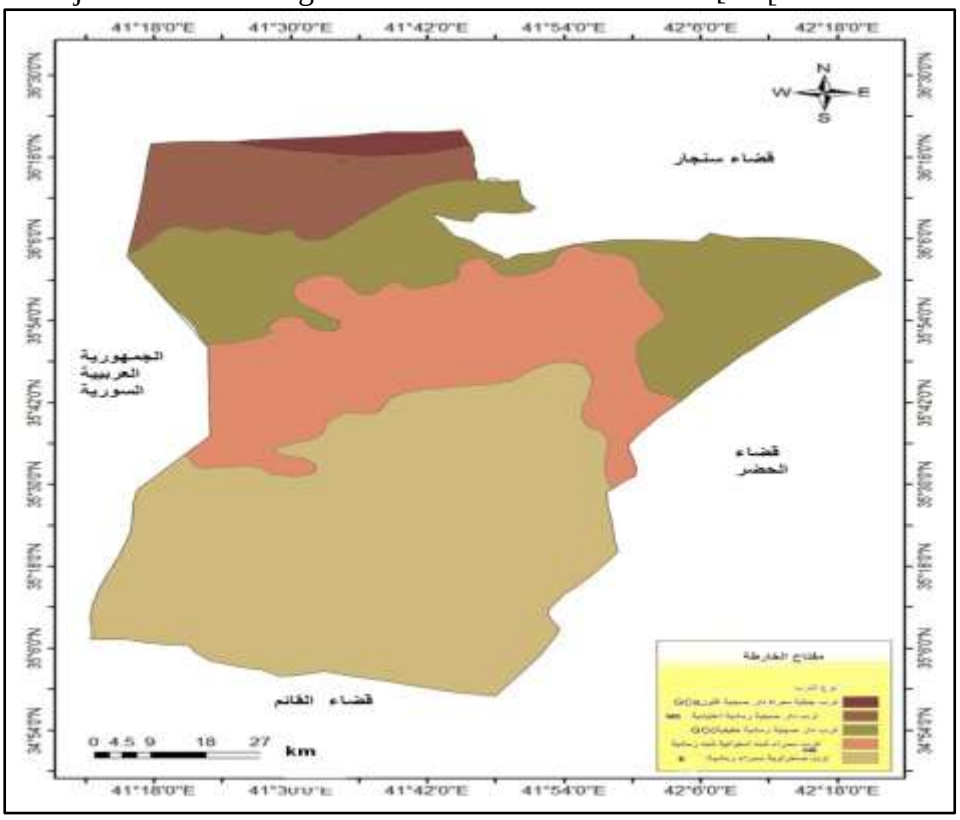
Map (4) Soils in Al-Baaj district according to the 1990 Rasi classification [26.[



-5Evaluation of soil types based on spatial analysis

The representation of spatial data and its output on scientific bases, as GIS programs provide the possibility of identifying the quality of the data and the nature of its distribution, which represents the cornerstone of the analysis and the importance of the program increases in cases where the effects of the influencing factors and the interrelated processes of the variables overlap with each other, as in the case of the soil under study. It is clear to us that the main focus of GIS management, regardless of the nature and type of work, is the amount and type of geographical data that will contain the database, make maps and conduct analyses, and these data are characterized by characteristics and qualities characterized by a digital representation of features or phenomena on the surface of the earth or close to it, and each set of data is characterized by GIS.

1-5-3Spatial interpolation of Data

Spatial data in GIS is processed in two ways, the vector method and the non-vector method. The data in the first method is represented through point coordinates that must be sequential, each point of which has a value (X,Y), and by adding one point to another, lines are built, and by closing the lines, areas appear, This method is useful in displaying spatial analysis data for precisely defined location points, such as the physical properties of the soil, both physical and chemical properties, and the possibility of linking them to the surface phenomena of the region, such as topography, map, elevation, groundwater, and others. The accuracy of

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using the methods depends primarily on the size of the data and the horizontal distances between the model locations and whether the modeling is random or grid, and the more data, the more accurate the result of applying these methods, as spatial interpolation methods provide an important means to reach the goal of guessing the values of unmodeled interfaces from the data and the correlation between them, and statistical techniques are used to address the effects of different input values among them.

The study relied on the experience of more than one method in the spatial interpolation of the soil data representation process to choose the best representation, as all methods are used in different scientific fields and it cannot be said that these methods are not good or correct. Rather, choose one of them that meets the requirements of the study and the general characteristics of the data, and each unit has its own advantages and disadvantages that differentiate it from the other [27 .[

The choice of one of these appropriate methods depends on the goal and purpose, the type of applications required of it, as well as the capabilities of the program itself and the final results with contrasting display methods that provide us with more and more accurate information compared to other methods, that is, if any continuous data appears in space (place), the points closest to the expected ones have greater weights than points far from them. Kriging is known as the best method for spatial prediction, especially in environmental and soil studies [28.[

-1Inverse Distance Weighted (Inverse Distance Weighted(

In this method, the weighting is attributed to the point to be measured, as the amount of weighting depends on the distance between this point and the other unknown neighboring point. These weights are controlled by the strength of the systematic weighting between neighboring points. It should be kept in mind to calculate the distance between points, when equal distances have equal weights. The weighting factor in this method is extracted according to the following formula [30:[

λi=d_io^(-p) I ∑_(i=1)^N▒d_iO^(-p (

The

d_iO^(-p)point weighting and distances between points

N unknown points

)_∑i=1)^Nweighting with decimal exponent.

Through inferential analysis of soil data in the study area, it was found that the method of inverse weighted distance (one of the methods of deterministic interpolation techniques) is suitable for the data of the study area and the map (3) was obtained through the use of this method. We can notice that the best types of soils are found in the northern part of Al-Baaj, which can be invested in agricultural production in the district, while areas with fragile soils that contain valleys with increased salinity and rocks are in the central areas. It has become clear to us that the soil is

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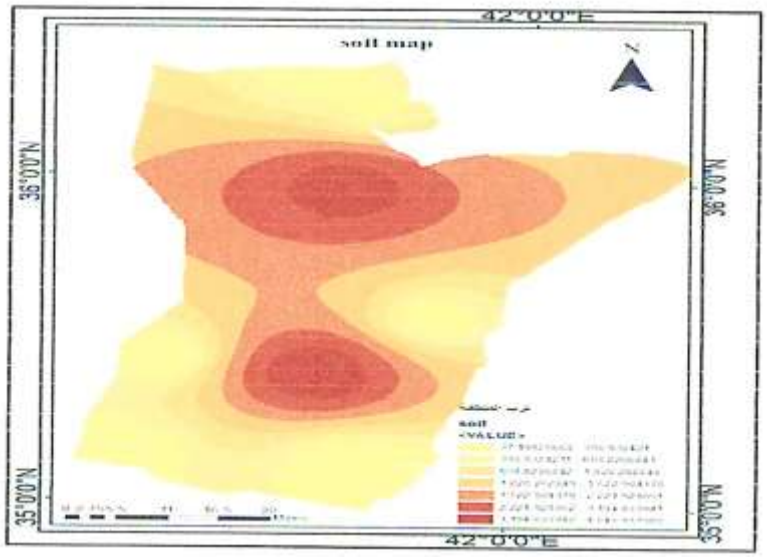
distributed across three levels based on the analysis of inverse distance, and it is divided into three levels which are in the table

	Rang	Soil evalution
1	3.7 498-3.9 917	Littlie
2	10.20 252 – 15.22 904	Mudime
3	41.94 033 – 43. 45 922	High

Through this assessment, we find that the less productive soils appear significantly in the northern and southern parts, and they are of low productivity and cannot be invested in agricultural production. On the other hand, the soils in the central and southern regions are better and can be utilized for agricultural production .

Map (5) Processing soil data using the Inverse Distance Weighted method [26[



-2Radial Basis Functions (RBFs(

are a set of precise representation techniques. They pass a surface through each calculated model value. Each basis function has a different shape and different results in a different representation surface. The Gaussian radial basis function is the most common of these functions. The normal pattern provides a narrow model for the diagonal basis function that has a large response only to points near its center [28.[

$$Z = \sum_{j,1,m} [\lambda jh_j+\lambda_{\circ}+\varepsilon[$$

As the diagonal base h

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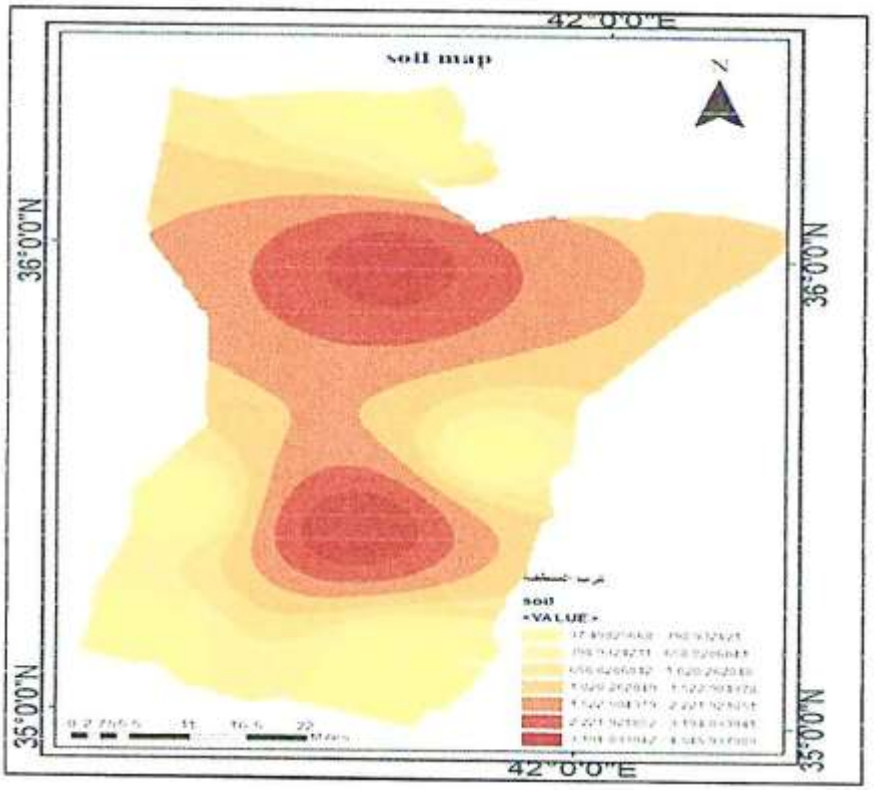
as in the map (3-2(

Map (6) Processing soil data using Rddial Basis Functions [26[



-5Local Polynomial (Local Polynomial

(

is a moderately fast but also smooth and inaccurate method of representation. However, it is more flexible than the global polynomial method. This method involves many parameter decisions. It also does not have the ability to correct guessing or prediction errors

. The method gives similar prediction areas as the kriging method with measurement errors and does not allow for checking the internal relationships of the data, making it less flexible and more automatic. The data does not require hypotheses. As in map (7(

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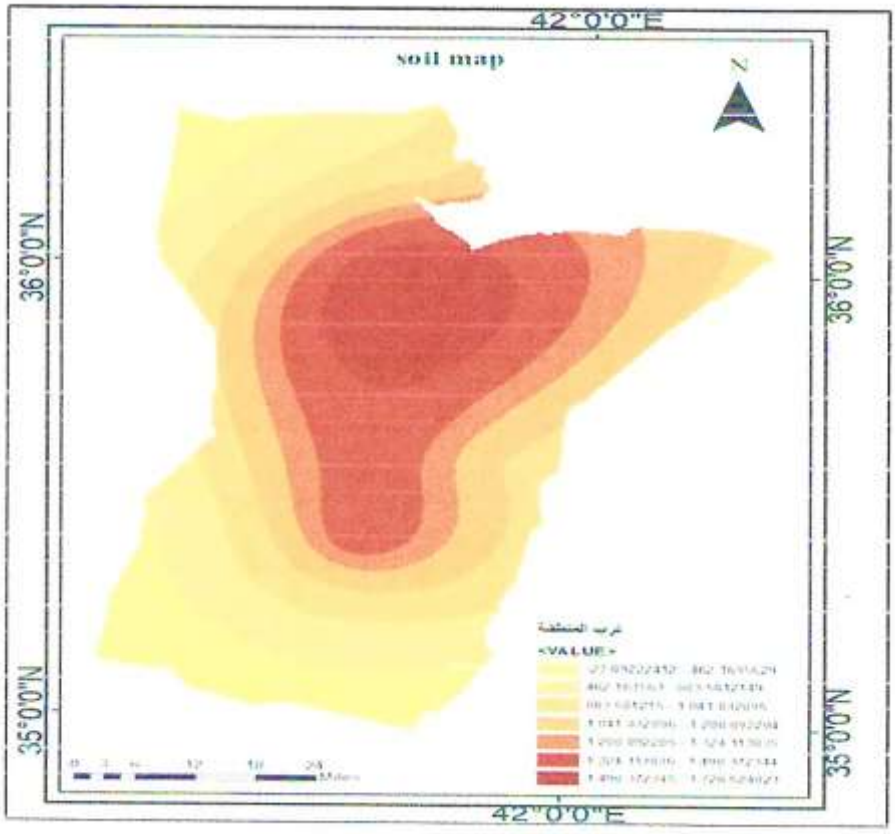
Map (7) Processing soil data using the Local Polynomial method[26[



In general, the trade-off between spatial interpolation methods is based on the average error, the square root of the square of the average error, in the statistical analysis window of the Arc Map program.

Conclusions:

-1

The current study revealed the suitability of GIS programs and its high effectiveness in its application to soil properties data

-2The study showed that there is a disparity between the parts of the study area in the physical and chemical properties of its soil, which was clearly shown in the maps representing each property, which is consistent with the natural data prevailing in the study area between the diversity of geology and geomorphology layers, climate, and the nature of the vegetation cover.

-3The spatial interpolation results showed the suitability of more than one interpolation method, such as the IDW method and the Radial Basis Functions method.

-4The geomorphological assessment of the soil in Al-Baaj district is one of the scientific methods that give a real picture of how to exploit the soil and process it to obtain an important economic resource

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