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The use of GIS in the exploitation of rainwater running in the region from Fouka to Ras Alam al-Rum in the northwestern coast of Egypt

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Abstract
The aim of the study is to employ geographic information systems in the exploitation of rainwater runoff in the region from Fouka to Ras Alam al-Rum in the northwestern coast of Egypt, where this region is characterized by highly variable precipitation, and the northwest coast depends entirely on rainwater for agriculture, drinking and domestic uses. Therefore, rainwater must be exploited during periods of rain interruption by selecting the optimal sites for its collection, depending on the geology of the region, the climatic and hydrological characteristics, the surface characteristics, and the topographical characteristics. We used the GIS program to analyze and process the data. It is located south of Ras El Hikma and includes part of the Fuka Basin, The study data spans the period 1990-2019.

Keywords: Rainfall, geographic information systems, surface runoff

Introduction
Water is the most important requirement for building and developing societies, Water is one of the most environmental elements that need management and construction [1]. So it is necessary to manage water resources, especially in arid and semi-arid regions that are affected by a lack of rainfall, As the appreciation and management of water resources gains a great place in the strategic planning of all peoples of the world [2, 3, 4] and one of the solutions to overcome this shortage is building dams and watersheds to collect rainwater [5].
Dams are among the largest water installations and have positive and negative effects. One of the positive effects is the provision of water needed for economic and social growth [6].
The selection of these catchment sites in dry areas is a complex process because these areas lack infrastructure and means of transportation, as the valleys of the region have large areas, and here comes the role of geographic information systems in studying water resources and how to exploit them and search for the best places to build The watersheds in the study area, which positively affects the population of the region socially and economically, The link between geographic information systems and spatial data analysis is an important matter in research and exploration [7, 8].
And the harvested rainwater can be used in all domestic and agricultural uses, Rainwater harvesting methods differ according to the prevailing climate and geographical location, where the best method must be chosen technically, economically and climatically for the region [9, 10, 11], as the northwestern coast region of Egypt depends on rainwater as a main source of drinking water for humans and animals and for agriculture, and the annual average rainfall is 140 mm, which makes this area one of the promising areas for harvesting rainwater, especially with the state's tendency to develop the northwest coast in light of the lack of groundwater and seawater leakage into some of its layers.

Study area
The study area extends between latitudes 30º55' and 31º23' north of the equator and longitudes 27º17' and 28º00' east of Greenwich meridian. Geologically, due to its recent formation, it is affected by marine influences coming from the Mediterranean Sea in the north, which helps in precipitation, which is the main source of surface runoff as it has an effect on temperatures. Figure (1)

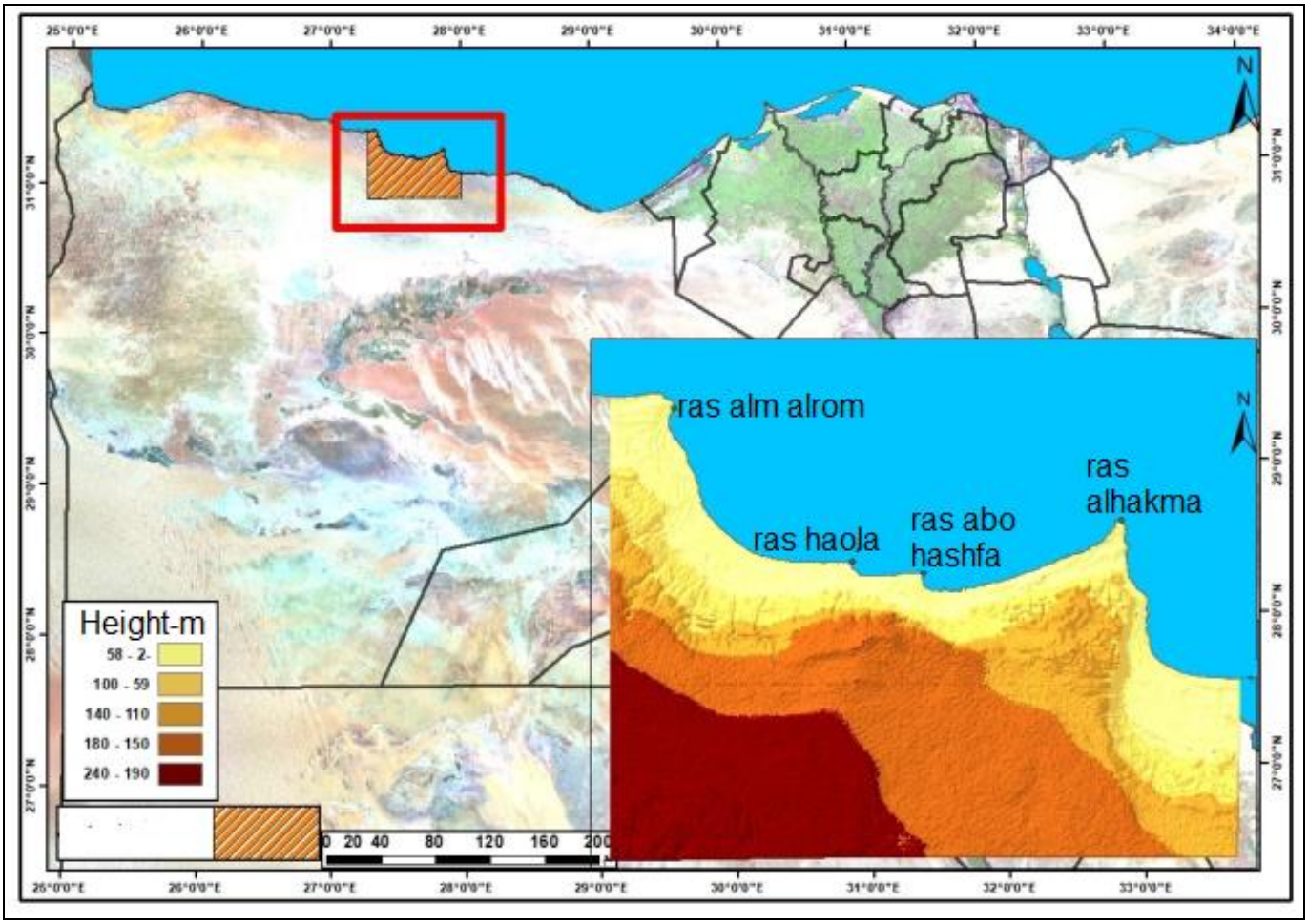


Fig 1: The location of the search area

The study Problem

The study area relies mainly on rain to meet domestic, agricultural and other needs, as the source of groundwater is unreliable due to the intrusion of sea water into the coastal aquifers, and the average annual rate of rainfall is 140 mm, so it is considered one of the areas suitable for water harvesting, especially with regularity. Rainfall in it and benefit from the harvested water in the field of agriculture and livestock breeding and for human use according to the implemented method of water harvesting, which contributes to the integrated management of water resources in this region.

The aim of the research

Choosing the optimal sites for collecting rainwater and using it to benefit from it later, based on the GIS program, to achieve water security for the residents of the region.

Study methodology

The study relied on the GIS program in conducting the necessary analytical operations and on the Google Earth pro program in drawing the necessary plans and satellite maps. The map return process, where the Global Mercator projection (UTM, WGS-84) was used, and these maps were digitized using GIS software. Spatial data was linked to Attribute data, and then the data was analyzed. Hydrological modeling was used and the Model Builder was used to determine the suitability of natural and human conditions. To choose the best sites for rainwater harvesting.

Criteria for determining optimal sites for water harvesting

1. Surface properties

The surface characteristics include the structure, geological composition, and degrees of slope, and they have a significant impact on the collection of rainwater. The area is characterized by its recent geological formations Figure (2). The geological map of the area. The terrain has a direct impact on surface runoff and rain harvesting. Figure (3) shows the digital elevation model of the study area.

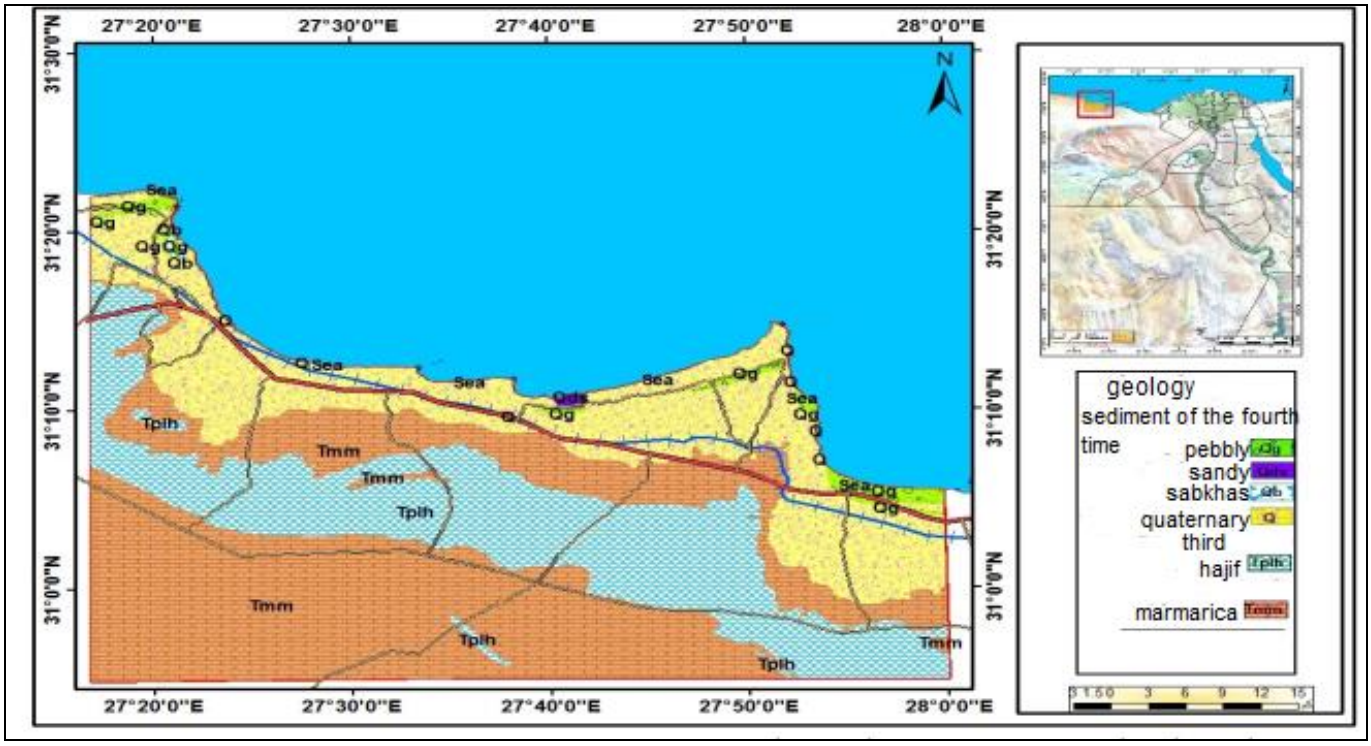


Fig 2: The geological map of the area

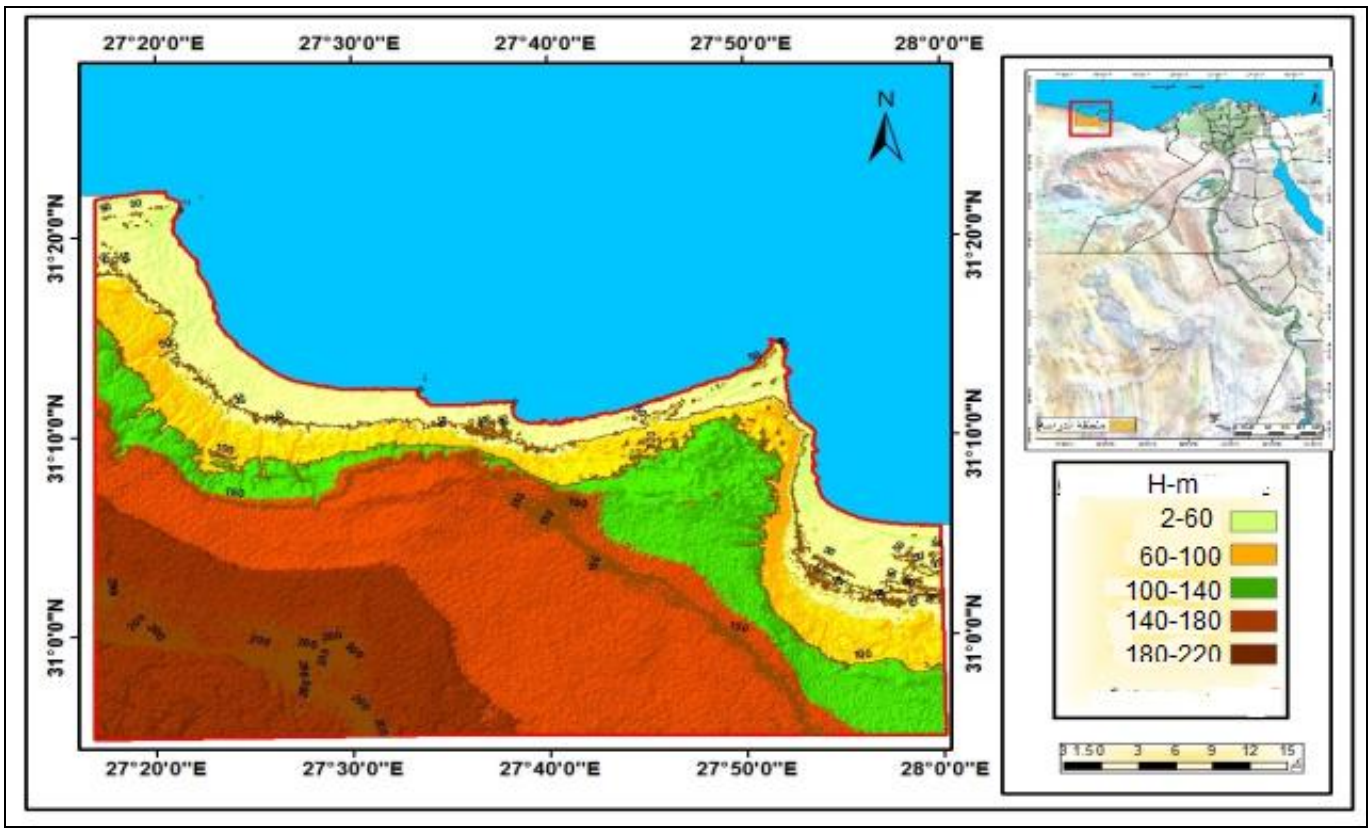


Fig 3: The digital elevation model of the study area

- **Degree of regression**

The degree of slope has a major role in choosing water collection sites, as the degree of slope is directly proportional to the velocity of flow, Figure (4) shows the degree of slope in the study area, according to [12] division of the categories of slope, the area is dominated by light and medium slope, and the higher the speed Slope The flow velocity increases during rains, which leads to an increase in net runoff and groundwater recharge, which is located in the mouths of the valleys.

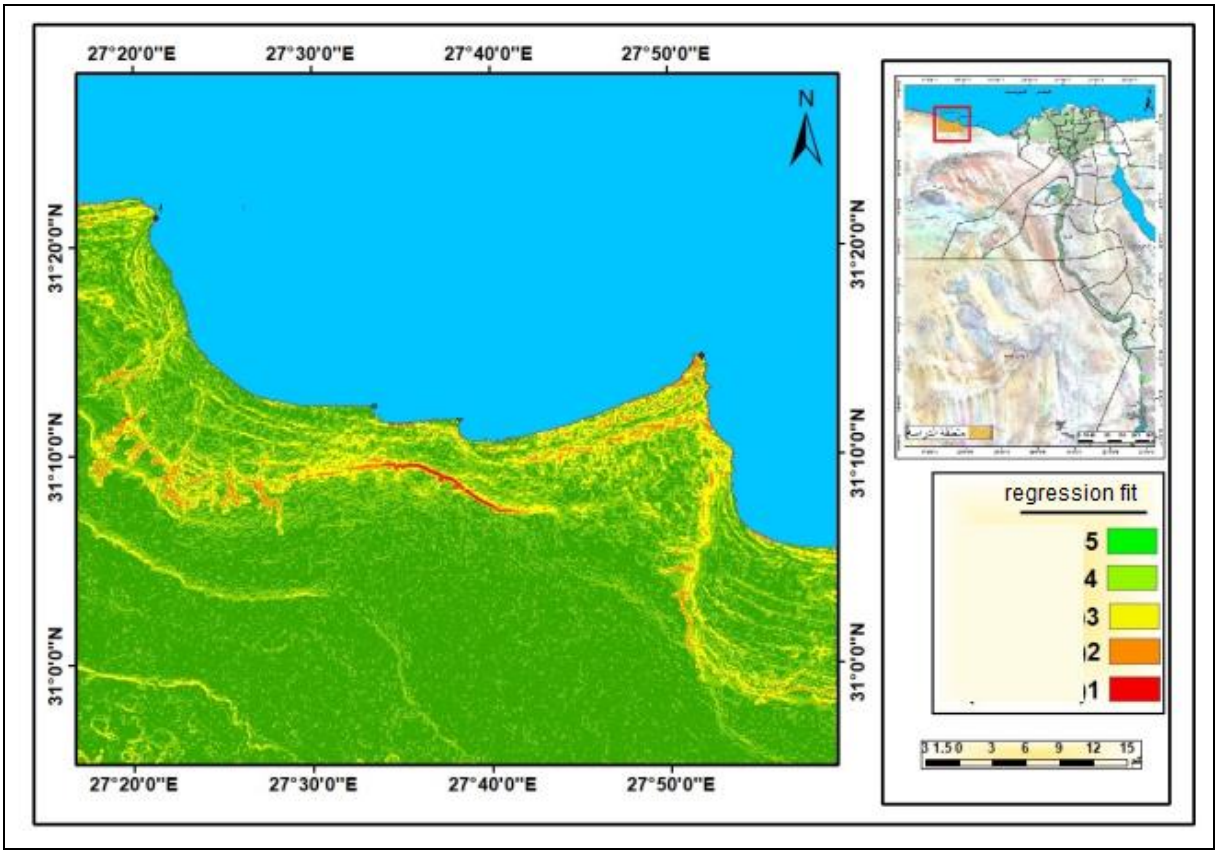
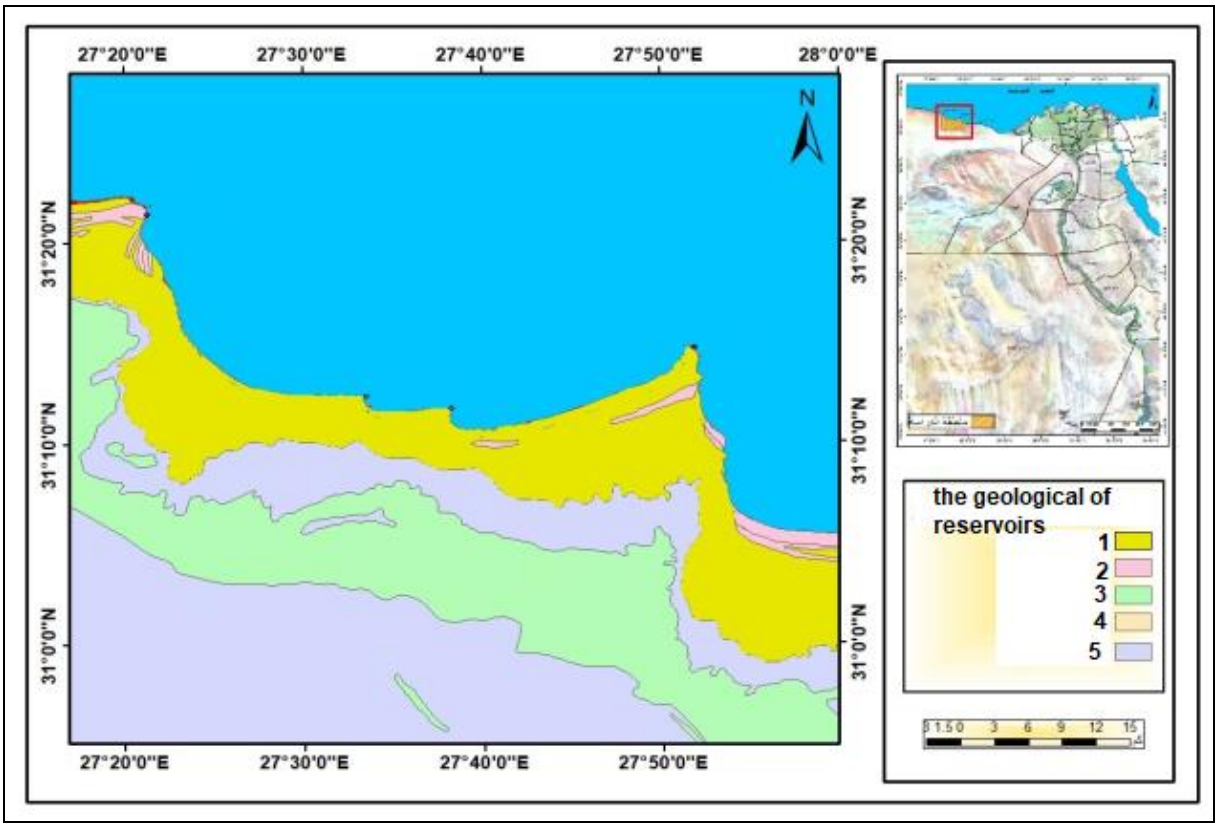


Fig 4: The degree of slope in the study area

- **Structure and geological structure**

We need an area with a strong geological composition that does not allow landslides to construct wells and water collection reservoirs. Figure (5) shows the suitability of the study area for drilling wells and reservoirs according to the characteristics of the geological structure.



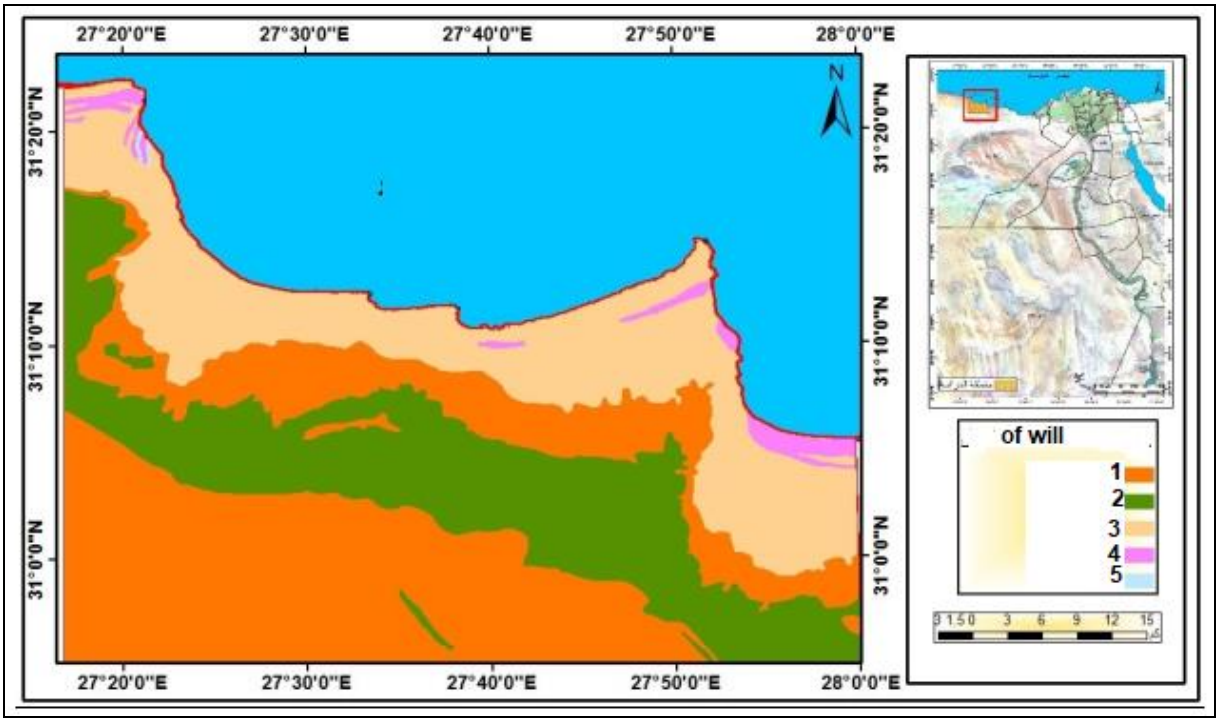


Fig 5: The suitability of the study area for drilling wells and reservoirs according to the characteristics of the geological structure

We notice from the previous figure that most of the study area is suitable for the construction of wells, especially the southern parts of it. The area of the first degree amounted to approximately 45% of the region's area, while the area of the second region amounted to 28.4%, and the third 25%, while the area of the fourth and fifth degrees together amounted to about 2% due to the smallness of these formations in the region.

1. Climatic variables

- **Rains**

The amounts of rain in the northwest coast stations were as follows:

Table 1: The amounts of rain in the northwest coast stations

Station	Alexandria	Marsa Matrouh	Salloum	Siwa
Precipitation mm	192,8	153,2	115,8	5,1

Meteorological Authority data for the period 2000-2019

The amount of rain decreases from the north to the south, and the residents of the region depend on the rain as a result of its heavy fall on the northwestern coast in general.

Figure (6) shows the evaluation of the area according to its suitability for constructing rainwater harvesting tanks.

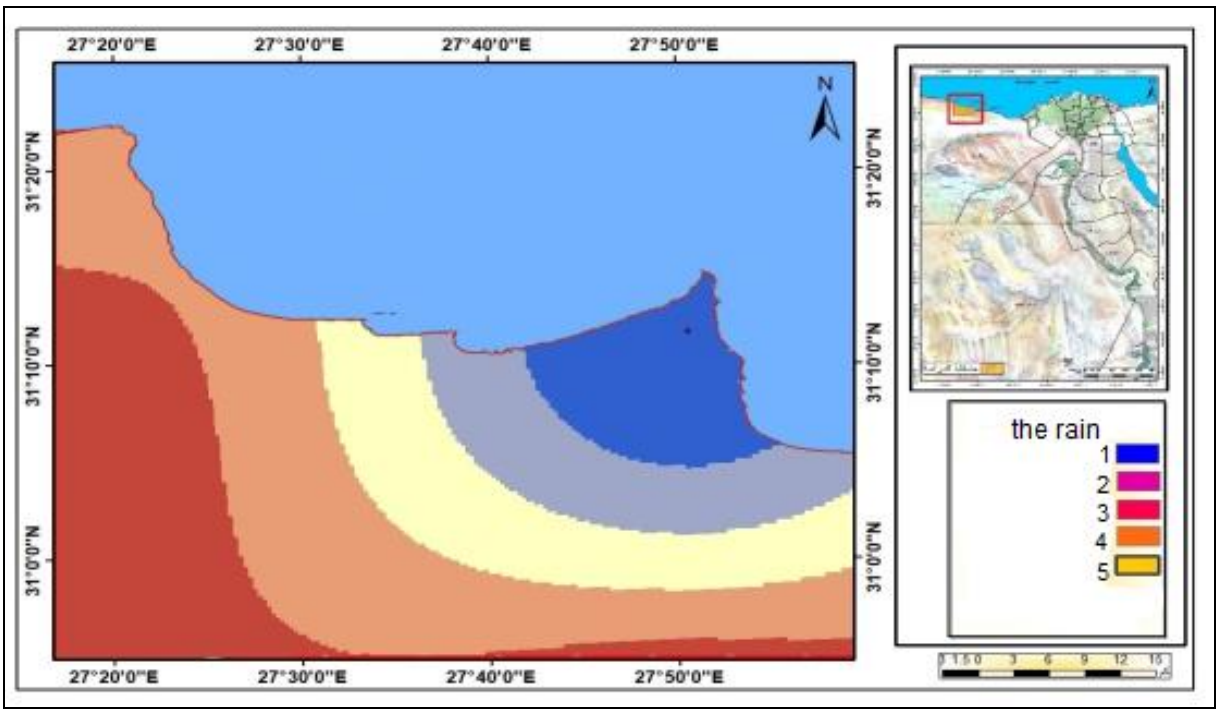


Fig 6: The evaluation of the area according to its suitability for constructing rainwater harvesting tanks

We note that the first degree of suitability is given to the areas in which the amount of rain exceeds 210 mm per year, which is in the Ras al-Hikma area. We note that the south of the study area is less suitable due to the low amount of rain.

- **Temperatures:** Temperatures affect all climatic elements, as they affect the amount of water stored behind dams and affect the amount of evaporation, and greatly affect the selection of rainwater collection sites. Water depending on the temperature.

The following figure shows the region's assessment of its suitability for drilling wells and reservoirs according to the temperatures in the region in the period (1990-2019).

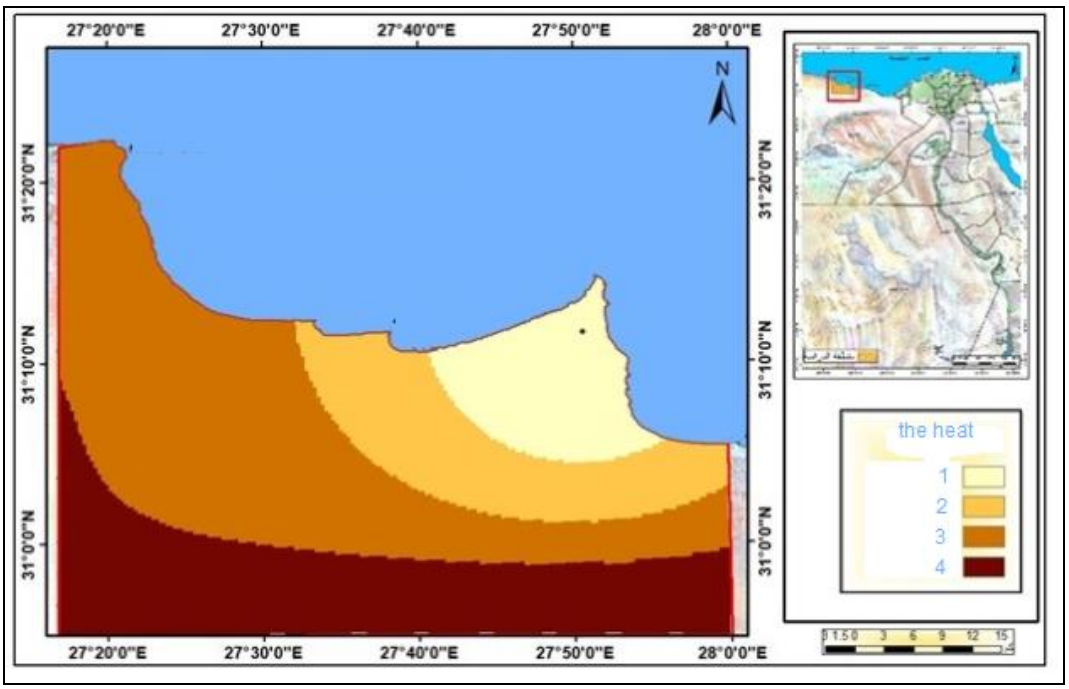


Fig 7: Evaluation of the area according to its suitability for constructing water collection tanks according to temperature.

- **Evaporation**

Evaporation is a form of water loss, and it is considered one of the obstacles facing the construction of water collection reservoirs. Figure (8) shows the evaluation of the area according to its suitability for the construction of water collection reservoirs, depending on the amount of evaporation in the period 1990-2016.

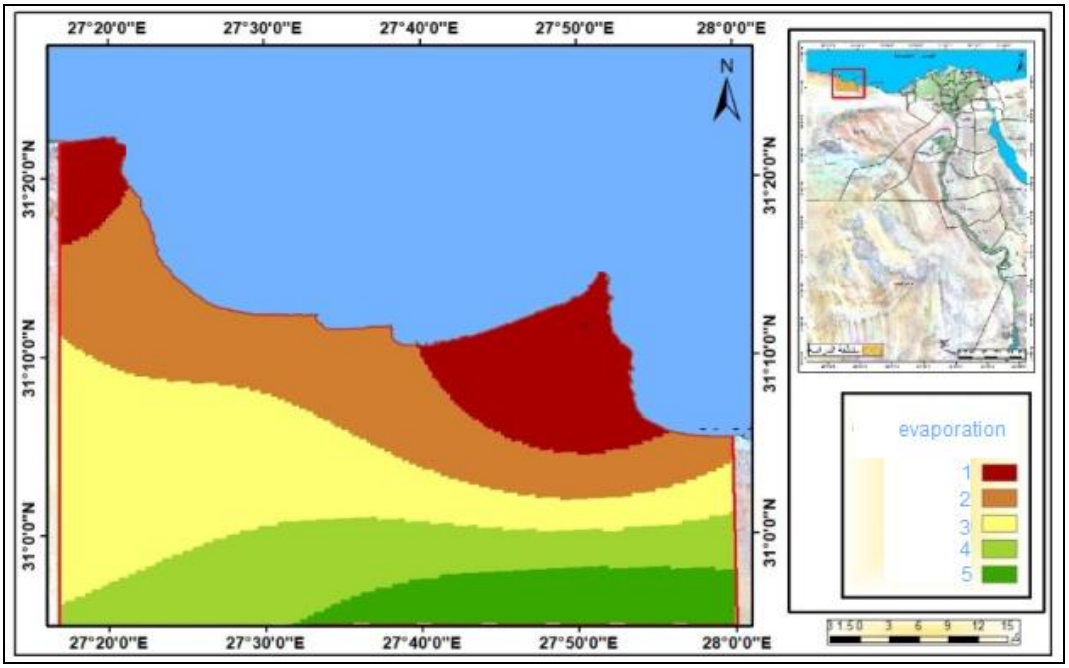


Fig 8: Shows the evaluation of the area according to its suitability for the construction of water collection reservoirs, depending on the amount of evaporation

The previous figure shows that more than a third of the region's area is in the first and second degree of suitability, and the northern parts of the region are the most suitable regions according to the amount of evaporation.

- **Soil properties**

Soil properties affect rainwater runoff. Soils of low permeability reduce the amount of infiltrated water, i.e. their degree of suitability for constructing water collection tanks decreases. Figure (9) shows degrees of suitability for water collection according to soil permeability.

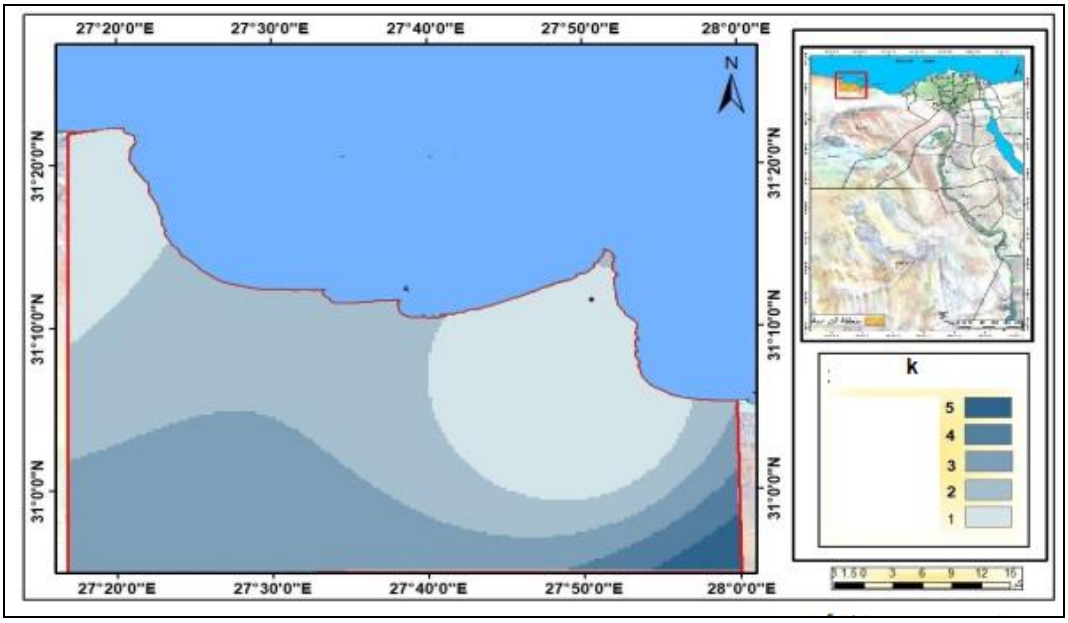


Fig 9: Degrees of suitability for water collection according to soil permeability

2. Hydrological variables

Hydrological variables are among the factors affecting the degree of suitability for constructing water collection tanks. The most important of these variables are:

1. The amount of leakage during the discharge time.
2. The volume of surface runoff.
3. Net flow.

Applying the Model Builder model and obtaining the most suitable place to construct water collection tanks in the region.

We used Gis 10.3 to build the Model Builder as follows

1. We divided the region based on the criteria and classifications (Classification and Reclassification), where it was divided into 5 grades, and we gave grade 5 to the high-priority areas and grade 1 to the rejected areas.
2. Merge all layers into one layer.
3. Giving weight to each layer separately according to its importance.
4. Producing a new layer divided according to its degree of priority to the optimal sites.
5. Determine the areas that take grade 5 as ideal areas for water storage facilities.

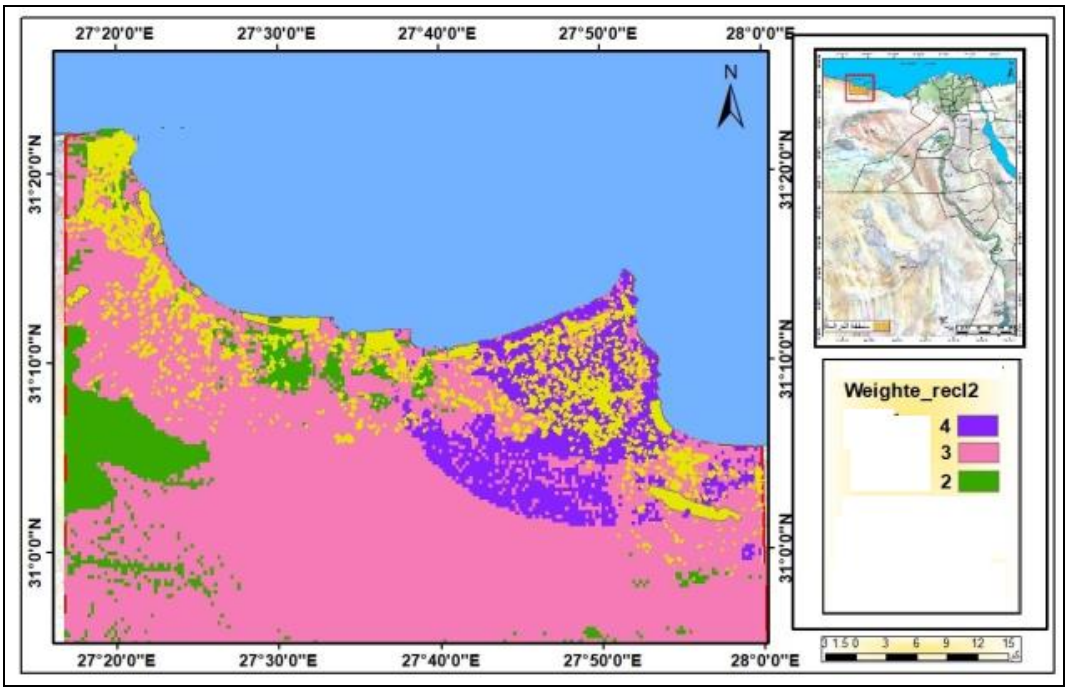


Fig 10: Classification of the study area according to its suitability for constructing water collection tanks according to the Model Builder

Results

Depending on Figure (10), we suggested the most suitable sites for collecting rainwater so that it is collected before it is lost by leakage and evaporation. By analyzing the previous data, we reached the following results:

- The study area lacks the first degree of suitability, and the reason for this is that the area does not contain a place that meets all the conditions and criteria necessary for the construction of water collection tanks.
- The area of the second degree was estimated at 310.48 km2, or 13.6% of the area of the region, which is the areas with heavy rains and little evaporation, which is the area south of Ras al-Hikma and parts of the Fouka Basin.
- The area of the third degree was 145.18 km^2 and was represented in the southern parts of the region, which is characterized by the hardness of its rocks.
- Based on the previous study and the spatial and geological analyzes of the study area, we proposed the construction of wells and reservoirs to collect rainwater within the second-class appropriate area that extends south of Ras al-Hikma and parts of the Fouka Basin, taking into account the residential communities and the various activities spread within this area.
- As for the southern region of the study area, which is considered a third category because of its rock hardness, it can be relied upon to build water collection tanks only.
- As for the fourth study areas, they are areas that extend away from the coast towards the southeast. In these areas, water collection tanks can be constructed, but in a small number due to the lack of appropriate conditions.
- The study area is dominated by the third degree, and therefore the construction of collection tanks is the ideal solution for rainwater harvesting.
- As for the prohibited areas, they included residential communities, agricultural lands, and areas near the coast, and this is what makes us rely on building reservoirs within the third area instead of digging wells within the second-class areas.

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