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Study The Possibility Of Harvesting Water Using Remote Sensing Technologies In The Abu Maris Basin- Iraq

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Abstract

The research aims to study the possibility of rainwater harvesting in the region and the exploitation of the various valleys therein for the purposes of storage, runoff and groundwater enhancement and the Abu maris Basin, part of which is located in the Muthanna Governorate and the other part is in the Najaf Governorate It occupies an area of 5404.132 km^2, 13 sites were identified in the study area. Soil samples were taken for two depths of 0-15 cm and 15-30 cm. The physical and chemical characteristics of the surface and subsurface layers of these sites were analyzed (soil texture, partical density, bulk density, porosity, water conductivity, acidity function, electrical conductivity, organic matter, cation exchange capacity, sodium, gypsum and lime), and the production of maps representing the spatial variability of these characteristics for each basin using the IDW method. The hydrological characteristics represented by basin area and flow curves were extracted and land classification was done using the laboratory results of soil samples and using the meteorological data provided by the Center for Meteorology and Remote Sensing at the University of California (CHRS) (Center For Hydrometeorology And Remote Sensing). By applying the US soil conservation hypothesis (SCS) (Soil Conservation Service), which is known by the Curve Number (CN) method, the runoff and surface runoff volume were estimated for two cases from rainfall data, the first case using an annual rate for 20 years and the period from (2000-2020) and the second case using The highest rain storm for each basin, and then identifying the most suitable sites for water harvesting in the region to take advantage of the water falls through the establishment of recharge barriers to enhance the strategic storage of groundwater in the region and the construction of earthen dams to invest the land in agriculture. As the results indicated that the depth of the surface runoff of the Abu maris Basin for an annual average rainfall 102.6-128.1 t ranged from 46.78-102.16 mm and the volume of surface runoff was 252852000-552060800m^3, while the highest depth of surface runoff and the volume of surface runoff for a peak in the Abu Maris Basin amounted to 10.78 mm and 58262776 m^3, respectively. Water harvesting sites have been identified in the Abu Maris Basin. The first site (30.762626, 44.339186) is located in the middle of the basin, with a runoff depth of 69.15-46.78, a surface runoff volume of 252852000-373708887.8 and a high water conductivity, and the second site (30.992141, 44.568297) in the north of the basin. Its runoff depth was 69.15-102.16 and the surface runoff volume was 373708887.9-552060800 m^3 .

Keywords: water harvesting, rainwater harvesting, remote sensing, Abu Maris basin.

Introduction :

shortage of water resources has led the world to turn to all methods that can reduce water losses, increase water use efficiency, and exploit all possible sources, including technologies that aim to collect, transform, store and utilize rainwater for agricultural purposes and human consumption. One of these technologies is water harvesting. water harvesting The idea of water harvesting is based on collecting rainwater during its fall seasons and storing it for use during the interruption period. Water harvesting (WH) or rainwater harvesting (RWH) has been promoted in recent decades as a solution to the overexploitation of groundwater resources in many countries of the world (Buraihi, 2016). Recently modern technologies have appeared to develop water harvesting systems, using remote sensing and geographic information systems (GIS) to classify areas according to their suitability for water harvesting. Aerial images are one of the The most important sources of remote sensing are effective in conducting quantitative hydrological measurements through the data and information that this technology provides to large areas in a record time compared to traditional methods, in addition to the fact that mathematical simulation has become an effective means of decision-making in the management of water resources (Bilal et al., 2019). the study of water basins is one of the most important applied achievements for the use of geographic information systems and remote sensing and the extraction of information that helps in explaining the pattern of land forms and water drainage and its relationship to the topography of the Earth's surface through the use and analysis of data for satellite images and satellite visuals (Abdul-Ghani et al., 2017).Therefore, the research aims to:

1 - Using remote sensing technologies to estimate the amount of running water (in the study area), torrential rains and the scope of their directives, and the possibility of benefiting from the rainfall in southern Iraq.

2- Determining the best sites for constructing aggregate dams to benefit from this water in water harvesting or groundwater recharge according to the characteristics of valleys to conserve water.

3- Studying the natural characteristics of the study area and the characteristics of the soil and vegetation cover to determine the appropriateness of sustainable development for these areas.

Materials and methods :

Location of the study area: The research area is located in western and southern Iraq within the administrative boundaries of the Muthanna Governorate, between longitudes 43°50'00" - 44°10'00" E and latitudes 29°50'00" - 31°10'. 00" N, as well, as 13 sites were selected from different areas of the basin, with surface and subsurface depths.

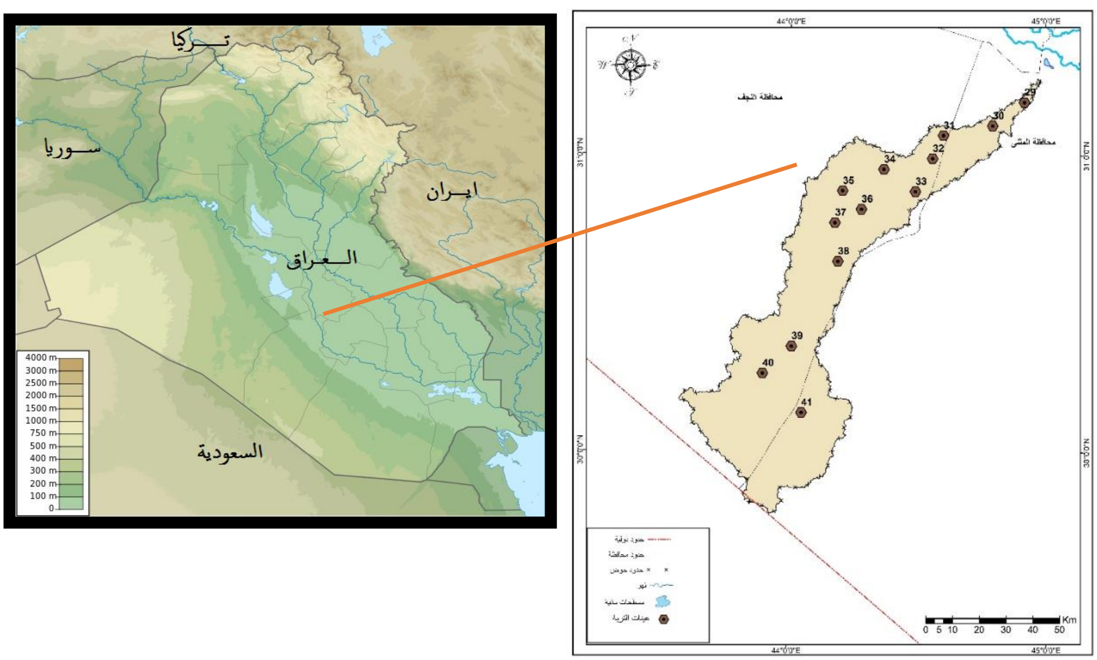
Preliminary Procedures: In order to implement the objectives of this study, some aids available from the region were used, including satellite visuals, some geological maps and climatic data, as well as some previous geological, hydrological and geographic studies of the region.

Field procedures: After defining the study area through the information available in the preliminary stage, a reconnaissance visit was conducted to the area to find out the variations in the topography. 3/2020 until 8/4/2020 and two replicates were taken for each sample from each site. Soil samples were collected by 1-2 kg bags. All sampling sites were identified using a GPS device (Garmin GPS map 60 CSX) as in (Table 1 and Figure 1).

Table1. The coordinates of the soil samples locations for the study area.

Samples	North	East	Elevation (m)
29	31.181428	44.915662	**40**
30	31.101945	44.791328	**101**
31	31.069497	44.598997	**147**
32	30.991491	44.556427	**170**
33	30.880091	44.489721	**206**
34	30.954866	44.366413	**193**
35	30.881966	44.205909	**232**
36	30.819899	44.279588	**235**
37	30.774258	44.176072	**251**
38	30.643453	44.188877	**312**
39	30.356670	44.010446	**326**
40	30.265061	43.898739	**337**
41	30.132929	44.050223	**342**

Fig 1. The location of the study area in Iraq.



4-laboratory procedures:

A. **Soil physical properties**

1. Particle Size Distribution: Distribution The volumes of soil particles were estimated by the pipette method, according to the method described in (Black, et al. 1965).
2. Particle Density (Ps): The partial density was measured using the Pycnometer Method described by Barsher mentioned in (Black, et al. 1965).
3. Bulk Density (pb): The bulk density was measured by the lab method for the incoherent samples according to what was mentioned in (Bashour and Al-Sayegh, 2007).
4. Total Porosity (f): The total porosity was calculated from the values of the bulk density and the true density from the following equation according to Vomocil method given in (Black et al,1965). It is the relationship: **%Total porosity =** $(1-\frac{\rho b}{\rho s})\times 100 \quad \ldots.\ldots.\ldots \quad (1)$
5. Saturated Hydraulic Conductivity(Ks): The saturated water conductivity of the soil was measured using the fixed water column method proposed by Klute and described in (Black et al, 1965), by applying the following equation**: Ks= V/At . L/h ………..(2)**

B. **Soil Chemical Properties:**
   1. **Organic Matter:** was estimated by Wilky Black method mentioned in (Page et al, 1982).
   2. **Cation Exchange Capacity:** It was estimated by the simplified methylene blue method, which is presented in (Savant, 1994).
   3. **pH :** estimated using the method (Jackson, 1958).
   4. **Electrical Conductivity (EC):** Using the electrical conductivity device the electrical conductivity device type EC 300 Eco Sence .
   5. **Sodium:** Estimated by flame retardant meter as reported in (Jackson, 1958).
   6. **Gypsum:** was measured by the method of precipitation using acetone, and then the electrical conductivity of the formed precipitate was measured, as mentioned in (Richards, 1954).
   7. **Calcium carbonate CaCO3:** was determined by Calcimmeter according to (Hesse ,1972).

5- Desktop Part: This stage included: Analyzing satellite visual data., Processing and interpretation of satellite visuals And Statistical application of water harvesting:
This method was adopted within the GIS environment using the program (ARC GIS 10.6) and using remote sensing data RS in order to identify areas with high surface runoff in order to choose the optimal location for water harvesting (suggesting the location of the dam), as the cell units are dealt with (pixels) with dimensions (10×10) meters, which allows obtaining accurate results covering the study area. The application of the (SCS-CN) method requires many stages, equations and procedures to obtain accurate high surface runoff estimates to complete the selection processes of the water harvesting area, and to adopt the following mathematical equations to measure the flow curve according to (USDA,1986) (Alshammari, 2019) :
- Classification of the land cover in the study area: The Sentinel 2 B satellite imagery with a resolution of 10 meters was used to classify the land cover .

- Hydrological Classification of Soils : Hydrological soils are classified into four groups according to the CN-SCS model, and the study area was classified into two groups only based on soil texture (USDA,1986).

- Extracting the value of CN : The value of CN is extracted by performing several steps, including identifying the land cover through the hydrological soil map, and the land uses of the study area are combined, and secondly the map obtained from the classification of land uses with the soil hydrological map through the (Combine) function and determining the values of Data for (CN) using ARC GIS10.6.

- Calculation of the coefficient (S) of the maximum water retention: S is calculated using the following mathematical formula: **S=** $\frac{25400}{CN} - 254$ **…. …. …. (3)**

was found that Ia is equal to one-fifth of the value of S, and Ia is calculated as follows:

$Ia = 0.2\,S$ …. …. …. (4)

By applying the equations using the ARC GIS 10.6 program.

- Estimation of runoff depth (Q) : The depth of runoff expresses the amount of water running on the surface during rainfall, and through numerical analysis of the natural data of the basins and the results of measuring LA, S, CN values and by calculating the annual average for each cell based on annual rainfall data **:** $Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$ **………(5)**

Q : Depth Of Direct Runoff (Mm) Ia : Initial Abstraction

P : Runoff (Mm) S :The Potential Maximum Retention Storage

- Estimated Surface Runoff Volume (QV): After the runoff depth (Q) was obtained, the annual Runoff Volume was calculated using the Arc Gis 10.6 program.

QV=Q * BASIN AREA/1000 …. …. …. (6)

Results and discussion :

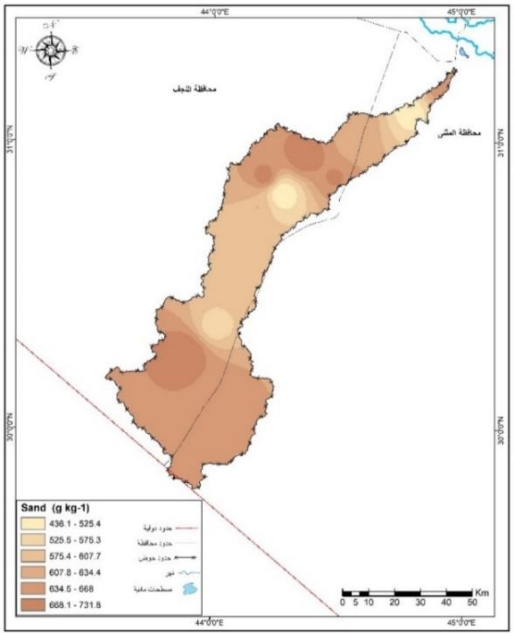
1. **Physical characteristics of the soil of the study area: Soil texture:** It includes 13 sites for surface and subsurface samples, and the texture in it was between sandy clay loam, sandy loam and loam, and the proportion of sand ranged from 428-732 g. kg^{-1}. The lowest value was in the sample 40 for the subsurface layer and the highest value for the sample 34 for the surface layer (Table 2) and (Fig. 2). The proportion of silt ranged from 100-380 g. kg^{-1}, and the lowest value for sample 41 was for the subsurface layer and the highest value for sample 39 was for the surface layer as shown in (Table 2) and (Fig. 3). As for the amount of clay, it ranged between 72 - 264 g. kg^{-1}. The lowest value was for sample 39 and 41 for the surface layer and the highest value for sample 30 and 36 for the surface layer and 33 for the subsurface layer (Table 2) and (Fig. 4). In the Abu maris basin, when matching the spatial variability of the clay (Figure 4) with the topographical shape (Figure 5), it appears that clay gathers in low areas and that the movement of water in the area is responsible for this variability, apparently according to the map of clay variability in the valley basin, and that The places where water collects in the valley stream shows a high percentage of clay, which affects the process of transferring this component due to the movement of rain water and the resulting torrents, which sometimes occur with strong runoff during high average rainfall due to the nature of the variation in ground levels and the steepness of the soil surface in the region.

Table 2. The physical characteristics of the basin.

point	0 surface 1 sub-surface	Depth (cm)	Bulk Density	Particle Density	Porosity %	Sand	Silt	clay	Texture	HC cm min^{-1}
			Mg M^{-3}			g kg^{-1}				
29	0	0-15	1.25	2.63	52.50	652	172	176	Sandy Loam	0.16
	1	15-30	1.28	2.67	51.92	568	200	232	Sandy clay Loam	0.28
30	0	0-15	1.28	2.52	49.21	476	260	264	Loam	0.04
	1	15-30	1.39	2.53	45.06	616	260	124	Sandy Loam	0.02
31	0	0-15	1.39	2.53	45.14	632	212	156	Sandy Loam	0.04
	1	15-30	1.16	2.53	54.07	488	260	252	Sandy clay Loam	0.36
32	0	0-15	1.09	2.46	55.69	616	240	144	Sandy Loam	0.11
	1	15-30	1.25	2.57	51.36	496	340	164	Loam	0.13
33	0	0-15	1.16	2.54	54.33	676	180	144	Sandy Loam	0.49
	1	15-30	1.39	2.54	45.28	496	240	264	Sandy Clay Loam	0.05
34	0	0-15	1.16	2.50	53.49	732	92	176	Sandy Loam	0.37
	1	15-30	1.28	2.59	50.51	568	108	252	Sandy clay Loam	0.21
35	0	0-15	1.16	2.51	53.78	696	160	144	Sandy Loam	0.24
	1	15-30	1.25	2.51	50.20	576	200	224	Sandy Clay Loam	0.18
36	0	0-15	1.25	2.55	50.98	436	300	264	Loam	0.19
	1	15-30	1.35	2.56	47.27	616	200	184	Sandy Loam	0.05
37	0	0-15	1.25	2.60	51.88	608	280	112	Sandy Loam	0.22
	1	15-30	1.35	2.60	48.11	608	180	212	Sandy clay Loam	0.03
38	0	0-15	1.16	2.54	54.30	588	280	132	Sandy Loam	0.30
	1	15-30	1.43	2.58	44.57	508	240	252	Sandy clay Loam	0.03
39	0	0-15	1.11	2.54	56.33	548	380	72	Sandy Loam	0.67
	1	15-30	1.39	2.46	43.47	528	280	192	Sandy Loam	0.01
40	0	0-15	1.35	2.58	47.70	728	180	92	Sandy Loam	0.34
	1	15-30	1.47	2.58	43.09	428	340	232	clay Loam	0.06
41	0	0-15	1.16	2.60	55.23	648	280	72	Sandy Loam	0.41
	1	15-30	1.04	2.60	59.90	688	100	212	Sandy clay Loam	0.06

Figure 2. Spatial variability of sand in the Abu maris basin

Figure 3. The spatial variability of the silt in the Abu maris Basin.



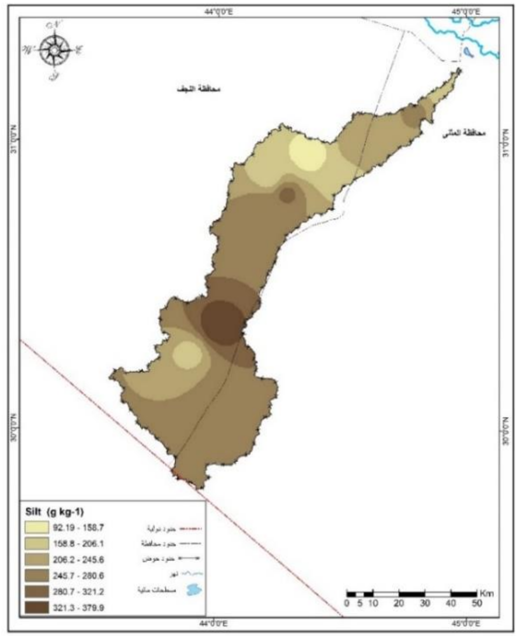
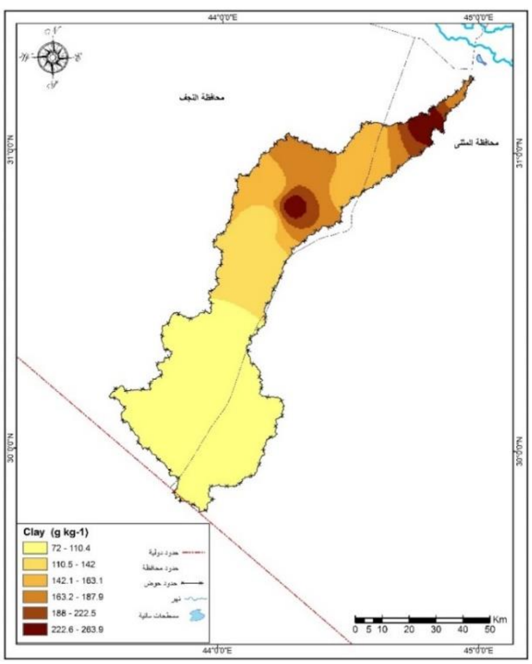
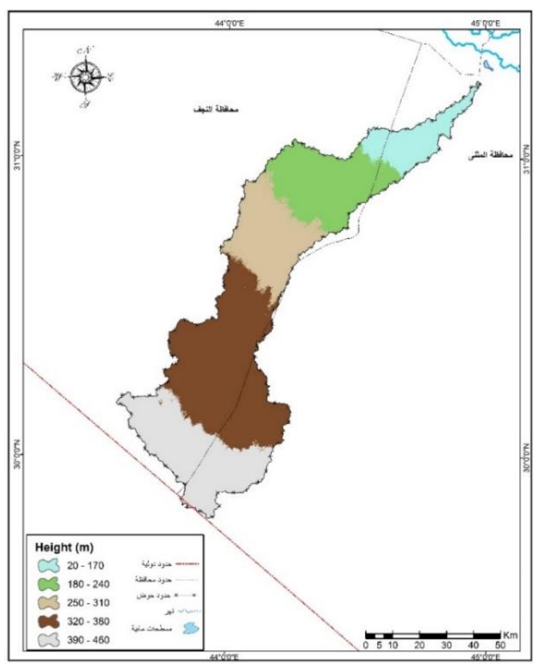


Figure 4. The spatial variability of clay in the Basin. **Figure 5. The height of the surface in the basin.**



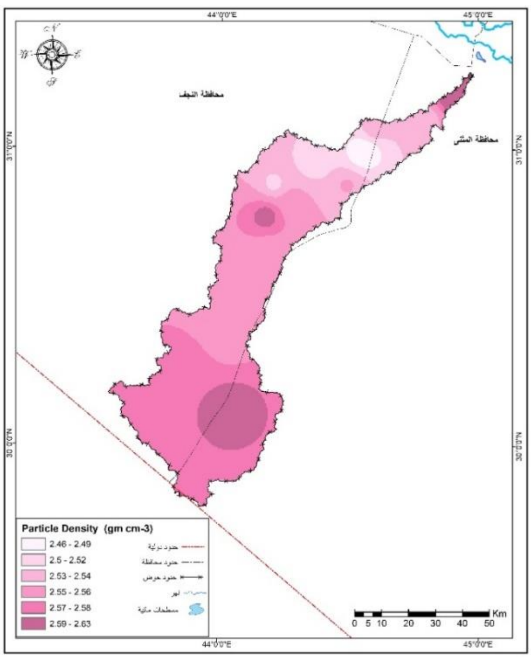


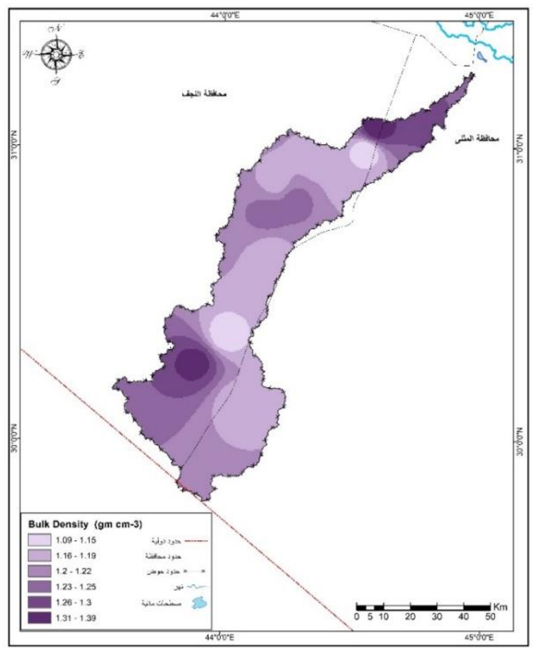
Source: From the researcher's work based on laboratory results and using the program (Arc GIS 10.6).

Particle density: the Particle density in it ranged between 2.67-2.46 Mg M^{-3}. (Table 2) The decrease in the Particle density in the north of the Basin is offset by a rise in the organic matter, and all the Particle density values were within the normal range of the Particle density values of the soil (Figure 6), and the nature of minerals affected the values of Particle Density (Katea and Majeed, 2013).

Bulk Densitythe spatial variability of the bulk density is observed in the southwest of Abu maris. The bulk density increased as a result of an increase in the separation of the clay in the northern and central parts of the basin (Fig. 7 and 4). Also, there is an inverse correlation between the spatial variability of the bulk density and the organic matter for the same sites, especially the south and center of the basin. This agrees With (Amer Et Al,2021) **.**

Figure 6. Spatial variability of the particle density in the basin. **Figure 7. Spatial variability of bulk density in the basin**

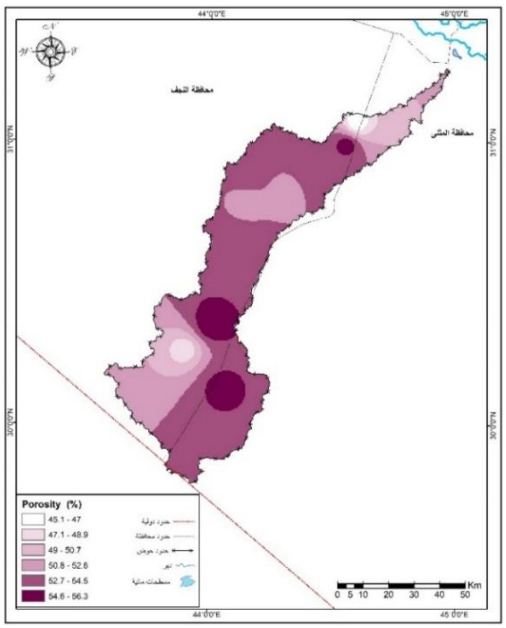


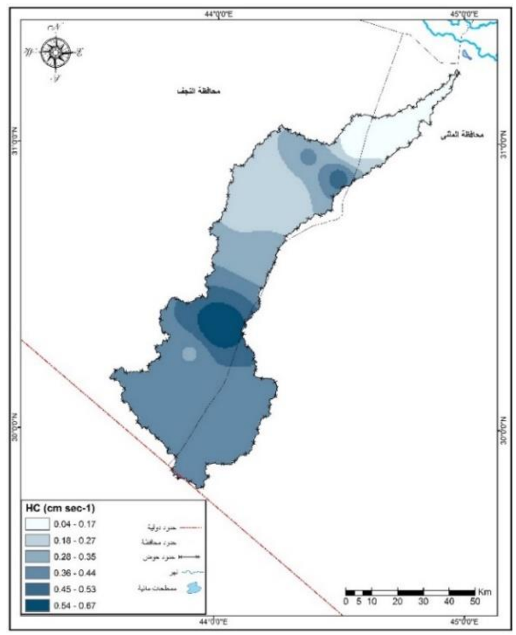


Porosity: The percentage of porosity ranged between 43.47-59.90%, and through the spatial variability of the porosity and the bulk density of the basin (Fig. 8 and 7), we find an inverse relationship, as the values were high in the south and center of the Basin, offset by a decrease in the value of the bulk density, and the porosity was also related to a relationship Reverse with calcium carbonate .

water conductivity: The water conductivity ranged between 0.02-0.67 cm min^{-1}, and the values for surface samples were higher than for subsurface samples in general. The conductivity was correlated with tissue as it was high in the middle and southern soils of the basin, because the tissue was of type B in the largest percentage of the basin and was few in The northernmost part of the basin, because the soil was of type C, which was characterized by an increase in separated clay (Fig. 9 and 4), which represents the spatial variability of conductivity and soil type in the basin, respectively. The saturated water conductivity is greatly affected by the geometry of the pores, the total porosity and the pore size variability in the soil.

Figure 8. Spatial variability of porosity in the Basin. **Figure 9. Spatial variability of water conductivity in th basin.**





2. **Chemical characteristics of the soil of the study area:**

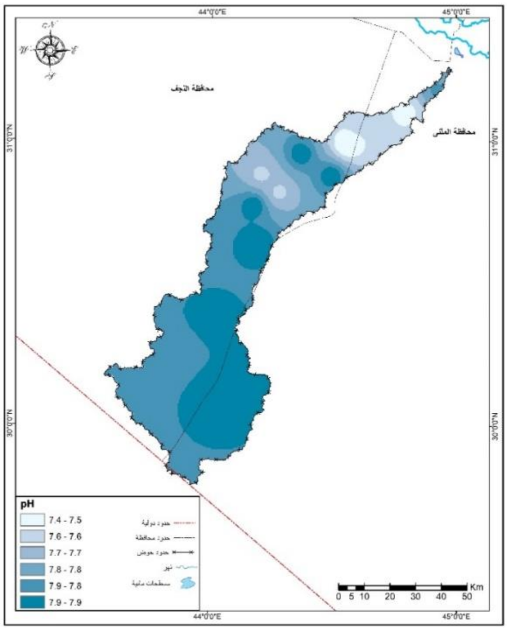
   Soil pH: The values of the degree of interaction ranged from 7.3-8.0 (Table 3) and (Fig.10) despite the high sodium content in these soils, they are not considered basic because the interaction degree values are less than 8.5 (Al-Mayahi, 2015), and the high content of calcium carbonate in the soil determines Evaluate the degree of soil reaction within these limits (Al-Kawaz, 2015). The values of the degree of interaction between moderate and close to alkaline are in agreement with the results of researchers who studied the soils of this region (Ali, 2013 and Al-Ghanmi, 2015). These values reflect the nature of the Iraqi soil, which is characterized by the alkaline feature.

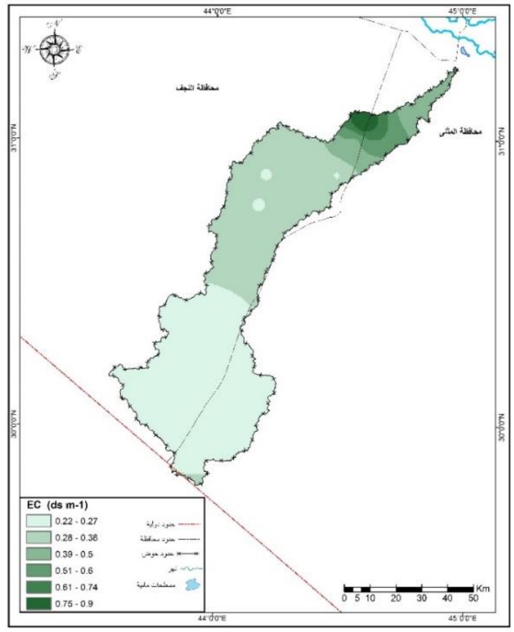
Electrical Conductivity: The salinity ranged between 0.21 - 1.63 dS.m^{-1} (Table 3). The soils of the basin are considered low salinity according to the classification of the US Department of Agriculture. Figure 11 shows the spatial variability of salinity in the basin using IDW. The slightly higher electrical conductivity in the northern parts of the basin is due to the high gypsum in this location and also to the fact that the soil type is C in this soil, which is characterized as low infiltration and thus reduces the leaching of salts. It is noted from the above that salinity is very low in most of the sites of the basins, due to the continuous washing due to torrential rains, and the soil texture plays a role in the washing process, especially the tissue in which the area is characterized by a sandy texture. Because of the low salinity of these soils, they are suitable for growing most agricultural crops, and they can be invested agriculturally in various fields. Maintaining an increase in the vegetation cover that covers the soil protects the soil from degradation factors. The soil cover is a function of a number of natural, social and economic factors that improve the physical properties of the soil. (Al-Waeli,2020)

Table 3. The chemical characteristics of the Abu maris **basin.**

point	**0 surface 1 sub-surface**	**Depth (cm)**	**pH**	**EC Ds m^{-1}**	**Na mg kg-1**	**Carbonates Gm kg-1**	**Gypsum %**	**CEC Cmol kg^{-1}**	**O.M %**
29	0	0-15	7.8	0.46	23.7	27.56	0.49	2.98	0.38
	1	15-30	7.5	1.63	24.8	30.78	3.97	5.24	0.39
30	0	0-15	7.5	0.46	1.0	28.91	0.39	9.80	0.43
	1	15-30	7.6	0.31	1.5	33.73	0.29	3.24	0.23
31	0	0-15	7.6	0.90	12.3	28.86	0.85	4.78	0.52
	1	15-30	7.9	0.40	23.8	21.35	0.49	6.19	0.57
32	0	0-15	7.4	0.48	0.8	23.83	0.49	4.59	0.45
	1	15-30	7.3	0.24	0.8	30.05	0.29	2.46	0.33
33	0	0-15	7.9	0.27	0.9	27.56	0.29	5.02	0.42
	1	15-30	7.7	0.38	1.9	31.81	0.39	9.02	0.46
34	0	0-15	7.9	0.29	28.4	24.66	0.29	7.59	0.38
	1	15-30	8.0	0.27	28.9	25.13	0.29	2.36	0.36
35	0	0-15	7.6	0.27	0.6	29.64	0.39	9.80	0.33
	1	15-30	8.0	0.25	0.8	33.68	0.29	6.85	0.49
36	0	0-15	7.6	0.28	1.0	28.50	0.39	8.24	0.36
	1	15-30	7.7	0.24	0.8	33.47	0.29	10.50	0.44
37	0	0-15	7.9	0.27	24.0	20.88	0.39	6.58	0.35
	1	15-30	7.9	0.33	23.7	25.54	0.39	3.68	0.52
38	0	0-15	7.9	0.30	25.5	23.89	0.49	4.57	0.41
	1	15-30	7.8	0.31	24.6	26.42	0.29	5.24	0.48
39	0	0-15	7.9	0.25	1.6	41.14	0.29	2.78	0.53
	1	15-30	8.0	0.26	1.7	36.48	0.29	4.57	0.24
40	0	0-15	7.8	0.22	1.6	18.55	0.29	8.47	0.34
	1	15-30	7.9	0.21	1.6	28.24	0.29	3.67	0.37
41	0	0-15	7.9	0.25	1.6	17.36	0.39	3.69	0.38
	1	15-30	7.8	0.30	1.7	21.35	0.19	4.57	0.59

Figure 10. The spatial variability of pH in the Abu maris Basin. **Figure 11. Spatial variability of EC in the Abu maris Basin.**



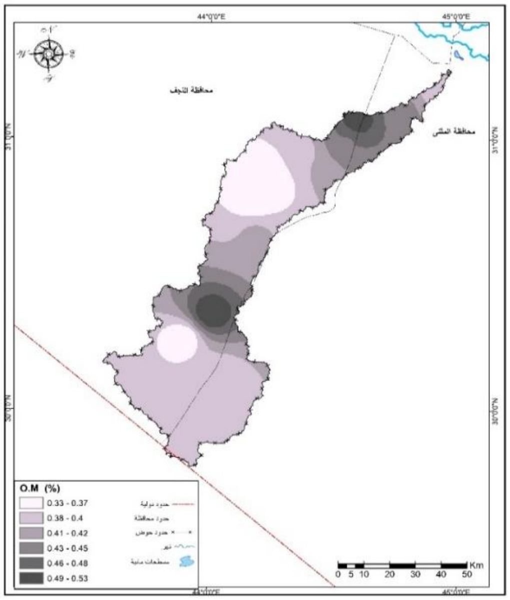


Organic matter: (Tab.3) shows a decrease in the value of organic matter in soil samples. The reason may be attributed to shallow soil, drought conditions in the region, and lack of vegetation cover, as this decrease in organic matter reflects the region's conditions of weak vegetation cover and high temperatures, which lead to decomposition and oxidation of the substance. Membership (Al-Hayaliyyin, 2017) (Abu Kahilah, 2020). In the Basin, there is a discrepancy in the organic matter if it is high in the areas of vegetation cover and areas of valley bottoms or water swamps, (Fig.12) Spatial variability of o.m in the Basin USING GIS. (Mahmood et al,2020) mentioned spatial forecasting of ArcGIS , it is an effective guidance tool to avoid the degradation of soil .

Cation Exchange Capacity CEC: (Table 3) Its values decrease as a result of the decrease in organic matter in the area. The decrease in CEC values due to the high proportion of coarse particles represented by sand at the expense of separated Other soils: Clay and silt, or the high content of calcium carbonate minerals in the study soils, which has an inverse relationship with the exchange capacity of positive ions. (Al-Ghanimi, 2015) (Al-Sarrajati, 2020).The CEC rises from 5.87 - 9.8 in the north and center of the basin as a result of the decrease in pH in these locations (Fig.13).

Sodium: It ranged 0.6 - 41.14 mg kg^{-1} for the surface sample 35 and sample 39 surface. Figure 14 .

Figure 12. Spatial variability of o.m in the Basin. **Figure 13. Spatial variability of CEC in the Basin.**



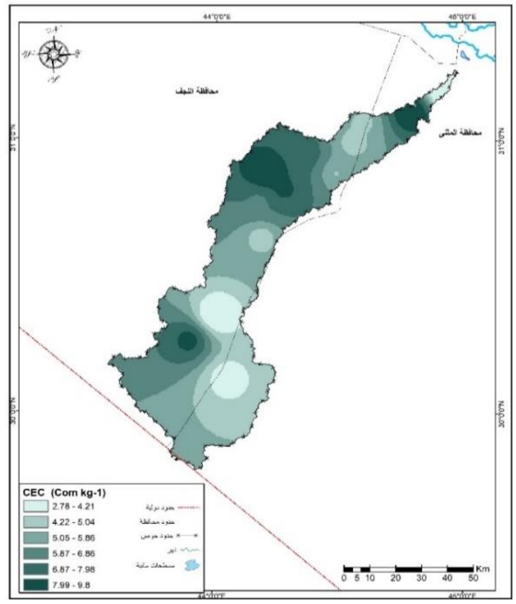
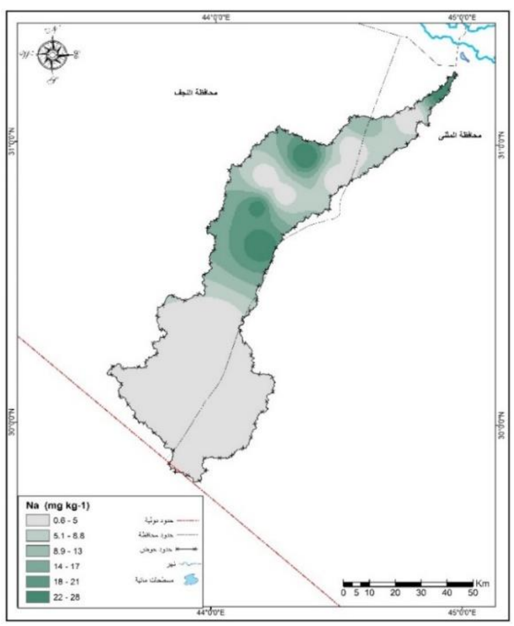


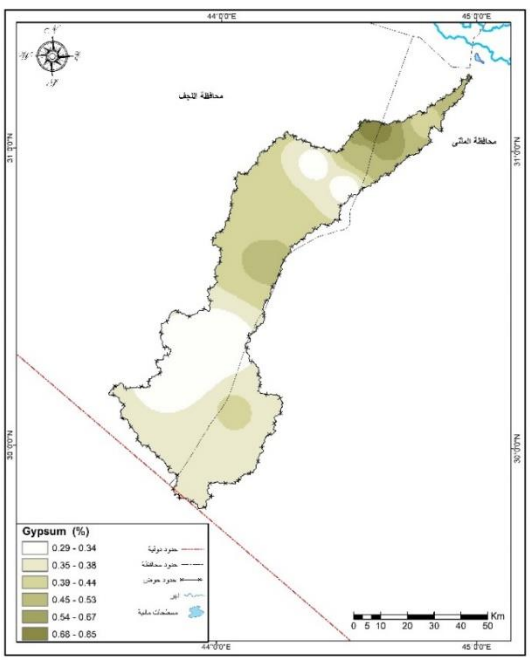
Figure 14. Spatial variability of sodium in the Basin.

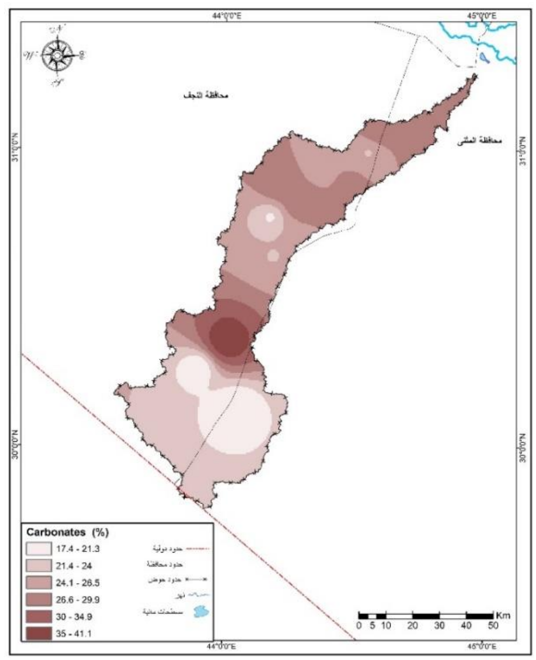


Calcium sulfate: In general, a decrease in gypsum is observed in the study area, depending on the nature of the soil, in addition to the accumulation of calcium carbonate at the expense of gypsum, as the carbonate and sulfate ions compete for the calcium ion to form either gypsum or lime according to the dominance of carbonate or sulfate ions (Al-Ghanimi, 2015) and secondary gypsum deposits are the result Mainly from the erosion processes of rocks dating back to the Triassic period and before (Al-Hamdani et al., 2018). Through the spatial variability of gypsum, we notice an increase in the values of gypsum in the northeast of the basin from 0.45-0.85%, due to the increase in the electrical conductivity in this location (Figure 15).

Calcium Carbonate: The high percentage of calcium carbonate in the area is evident due to the alkalinity of the soil, as rock formations of sedimentary origin are revealed in the study area, which consist of sandy and calcareous rocks, chalky limestones and sandy limestones (Hassan, 2018). The variability of lime in the basin varied due to the nature of the origin material. We note through the spatial variability an increase of lime, especially in the middle of the Abu Maris Basin, 26.6–41.1%, offset by a decrease in gypsum in this location (Fig. 16) as a result of the competition of carbonate and sulfate ions for the calcium ion.

Figure 15. Spatial variability of gypsum in the Basin. **Figure 16. Spatial variability of lime in the Basin.**



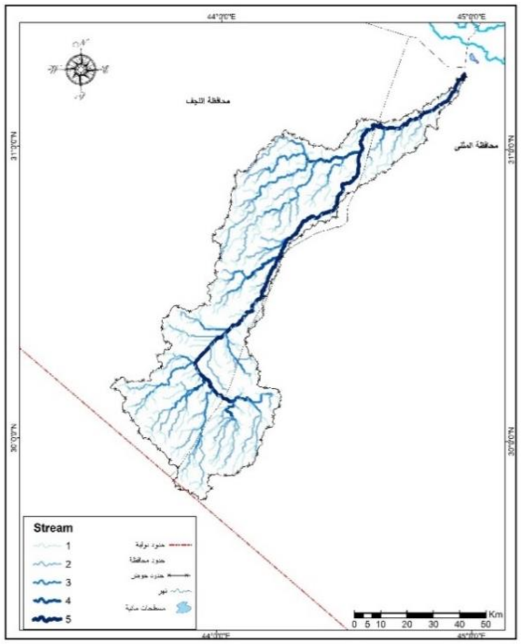


3. Hydrological Characteristics:

Basin area: means the area of the area that supplies water to the tributaries, which is reflected in the volume of water drainage inside the basin. The variation in the area of the basins is due to the difference in the erosion and weathering factors of the rocks, as well as the variation in the slope of the region, which increased the speed of water movement, which increased the process of water erosion, as well as the structural and tectonic nature and its trends that affected the variation in the basin area in addition to the prevailing climatic conditions.

Flow curves or river beds: The process of coding the river tributaries of which the water network is composed according to their stream are linked by the Streller method (1958), which considered that each tributary does not connect to another tributary takes the number 1. In the case of the connection of two tributaries of rank 1, a tributary of rank 2 is formed, and when two tributaries are connected of rank 2, it forms a tributary of rank 3. Thus, in the event that a tributary of a lower rank contacts a tributary of a higher rank, it does not affect it (Stahler, 1954). According to this classification, the river stream in the basins were classified into 6 riverine stream (Figures 17), which represent the riverine stream in the Abu Mrais Basin, respectively. These stream derived from the satellite visualizations of the study area give a function of the water drainage system in this area.

Figure 17. River stream in the Abu maris Basin.



Source: From the researcher's work based on laboratory results and using the program (Arc GIS 10.6).

Runoff : Rain is the only source of surface water in the basin area. It is known that these basins are among the dry valley basins that are exposed to seasonal rain showers that result in fast-moving torrents that cause a change in the features of the earth's surface. The study of surface runoff is not limited to providing drinking water, irrigation or ground nutrition, but also goes beyond environmental sustainability and the control of floods and their cause of soil erosion. The surface runoff was measured in the study area based on the ARC GIS program using the SCS method, which is the most widely used method for estimating the depth of runoff, which deals with many variables, including vegetation cover, soil quality and the amount of rainfall, as follows:

HSG classification for the studied basins: Soils are classified into four groups of soils according to the SCS method, which depends on the texture of the soil and its separations of green, sand and clay, and determining the extent of its water permeability. The laboratory results were relied on the physical analyzes of the study area, and based on this classification, the Abu maris Basin was classified and represented in Figure (18) that shows the soil The hydrological rate of the basin was very low in type C soil and in the upper parts, and type B soil (SL, L) prevailed in the rest of the basin area (Table 4), with a percentage of 96.620% and an area of (5221.460) km^2.

Table 4. Hydrological soils and their area in Abu Mrais Basin.

HSG	Ratio %	Area Km^2
B	96.620	5221.460
C	3.380	182.672

As for class C (SI.L, SI, S.C.L), it follows class B, but with a small percentage, it occupied (3.380)% of the basin area and an area of (182.672) km^2. The dominance of class B may be attributed to the dominance of sand separated over silt and clay for most of the samples. It is noted that the clay was the least separated in most of the basin sites, and this is due to the formation of the soil of the region and the origin material of the soil of this region. the clay is concentrated in the north of the basin. Soils of type C and B allow the emergence of surface runoff, and soil of type B is characterized by the infiltration of part of the water due to medium and high permeability, which leads to an increase in the possibility of vertical runoff as well, reaching the saturated area of groundwater in the study area and its nutrition. As for the places where class C prevails It allows the soil to achieve medium and high runoff in its areas due to the low infiltration rate below the medium due to the fine atoms of its different components due to the presence of a layer of clay and silt according to the SCS classification table.

Classification of land use LULC for the studied basins: LULC is also an important criterion for the generation of runoff (Kumar, et al. 2008), as the LULC categories have different effects on the generation of runoff depth, so the land uses of the region were classified from the SENTINAL satellite image on March 17, 2020 with a discriminatory accuracy of 10 m by integrating the beams Spectral (4, 6 and 7) using the ERDAS program, and through the unguided and directed classification and using the Arc Map 10.6 program and using the topographic maps of the area and the high-resolution visuals of up to 60 cm in GOOGLE EARTH In addition to the field visits to the study area, the study area was classified into four areas: Soils with vegetative cover, soils of valleys, mixed desert soils and barren soils of shape (19), and their proportions in the table (5) which determine the classification of land uses for the Abu maris basin, respectively, according to that.

Table 5. Classification of lands, their area and percentage in the Abu Mrais Basin.

LULC	Ratio%	Area KM^2
VEGETABLE COVER	16.593	896.718
VALLEY SEDIMENTS	18.186	982.780
BARE SOIL	30.860	1667.721
MIXED DESERT SOIL	34.361	1856.913

Figure 18. HSG classification in Abu maris **Basin.**

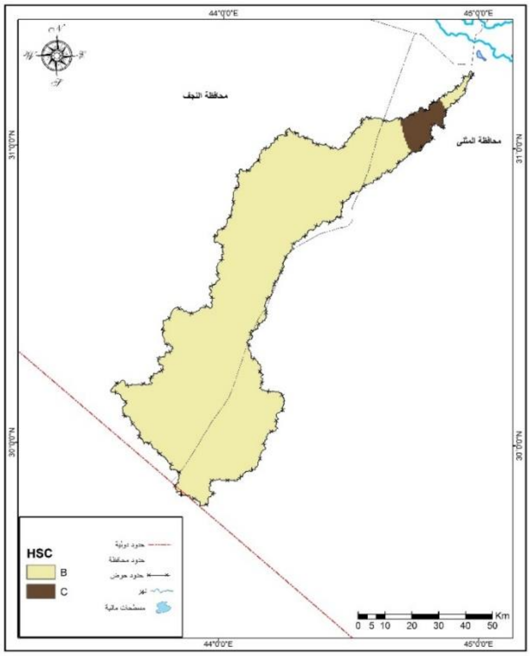
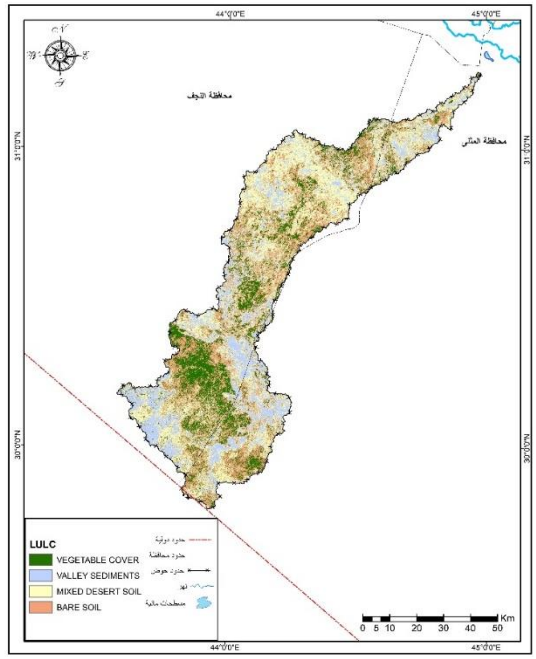


Figure 19. LULC classification of the Basin.



Extracting the CN for the study area: Curved values are determined on the basis of the type of land cover and soil hydrology, HSG This model was formulated by the Soil Conservation Department in the US Department of Agriculture (USDA), as reliable values were reached after thousands of measurements made on drainage basins in different types of natural and urban environments, and express The values of CN are about the amount of soil permeability, and the values should range from (1-100) as the values approach 100, the surface is more silent and less permeable, while the surface permeability increases if the values approach zero, so the surface of the basin is highly permeable to water, and the value 50 expresses The average value so that the rate of water infiltration into the soil is equal to what is happening on its surface. The value of CN is extracted by performing several steps, including identifying the land cover and land uses of the study area and by classifying the hydrological soil. According to the tables prepared from SCS to derive those values.

In the Abu maris Basin (Fig. 20), the CN values of the soil are divided into four classes (Table 6). The first category is from 77 to 79, with an area of 2696.6 km^2, which is the highest area in the basin that allows surface run-off and little water intrusion, and the second category is from 80 to 85, with an area of 1017.5 km^2 that allows Surface runoff with the possibility of less leakage. As for the third category, from 86 to 88, and the fourth category, 89-91, which has an area of 43.63 km^2, these two categories allow high surface run-off with very little water leakage.

CN	Ratio%	Area KM^2
77 - 79	49.899	2696.652
79 - 85	18.829	1017.532
85 - 88	30.463	1646.285
88 - 91	0.808	43.663

Table 6. CN values and area in the Abu maris Basin.

It is clear from these results that the CN values in all basins recorded values higher than 50, and this indicates their ability to form surface runoff more than the vertical runoff to groundwater, and all values are greater than the median value in the area, so it is possible to generate surface runoff with less infiltration because the values of The CN is close to 100, and its permeability is low. Therefore, it is suitable for applying methods of water harvesting and storing it in the paths of this water. The chance of groundwater enhancement in the area is weak because the CN values of the study area tend to have more horizontal flow than vertical flow. Therefore, the idea of surface sequestration is reinforced. This water is used to benefit from it instead of wasting it with the continuous flow and its loss in the flats of evaporation.

Calculation of the coefficient of the maximum potential for soil to retain water after the start of the surface runoff S: The coefficient S refers to the state of the soil completely saturated with water after the cessation of the infiltration process and the start of the runoff, that is, the maximum probability of the soil retaining water after the start of the surface runoff. The soil's ability to retain water corresponds to the degree of permeability, porosity and depth of the soil. The vegetation cover also affects the ability of the soil to retain water, as plants work to impede the flow of water and increase the seepage into the soil, and the slope has an effect on the soil and its ability to retain water, and a value (S) close to zero indicates the low ability of the soil to retain water, which affects On the speed and quantity of surface runoff, and that a higher (S) value means an increase in the soil's ability to retain water and affects the amount of surface runoff and leads to its decrease, and the water retention rate of the soil is equal to the amount of water running on the surface if the value of S reaches the median value of (10 inches) Which is equal to 254 mm when converted to the metric system (USDA, 2010), while the possibility of soil water retention increases when the value exceeds the median value, which leads to a decrease in surface runoff (USDA, 2010). The coefficient (S) is calculated by the following relationship:

$$\frac{25400}{CN} - 254$$

As for the values of (S) in the Abu maris basin (Table 7) and (Fig. 21) they were also distributed into four categories, the first category of 25.12 and an area of 43.66 km^2, and the second category of 25-41 with an area of 1646,285 km^2, which is the second highest area in the basin, while the third category is from 41- 48 with an area of 1017.53 km^2 and the fourth category 48-75 with an area of 2,696,625 km^2, which is the highest values and gives an indication of the ability of the soil to conserve water more than other categories and thus reduce the chance of surface runoff in this area, which indicates the possibility of seizing running water in the valley stream before this area to benefit from it To recharge groundwater, the vertical movement of water is higher than the horizontal movement.

S	Ratio %	Area KM^2
25.12	0.808	43.663
25.13 - 41.35	30.463	1646.285
41.36 - 48.38	18.829	1017.532

48.39 - 75.87	49.899	2696.652

Table 7. Classification of the Maximum probability coefficient and its area in the Basin.

It is noted that all the values (S) calculated for the basins are less than the median value of this parameter, which is 254 mm, which indicates the rapid response of the basins to the surface runoff in general. Harvest rainwater in this area accordingly.

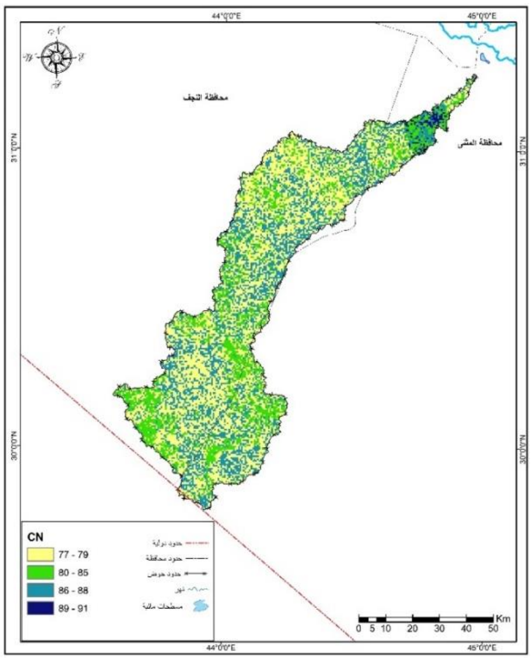


Figure 20. CN values in Abu maris **Basin.**

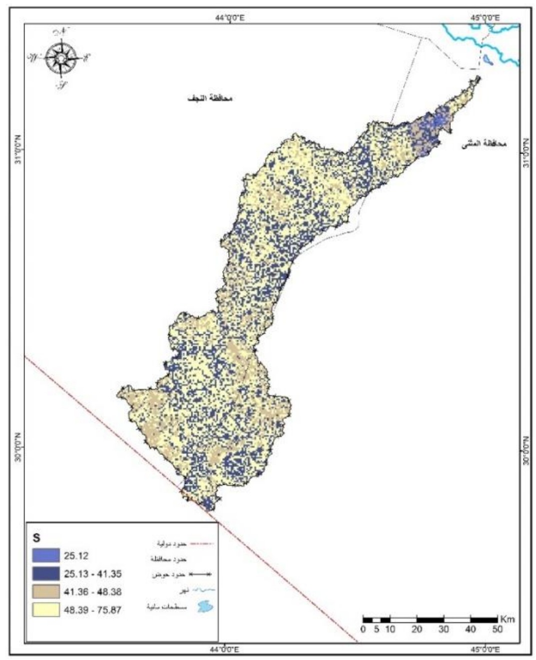


Figure 21. Maximum probability coefficient in the Basin.

Calculation of the initial extraction coefficient for the study basins: The initial extraction coefficient LA indicates the amount of rainwater lost by evaporation and seepage and intercepted by the plant before it is converted into surface runoff. La is calculated using equation:

LA = 0.2 S

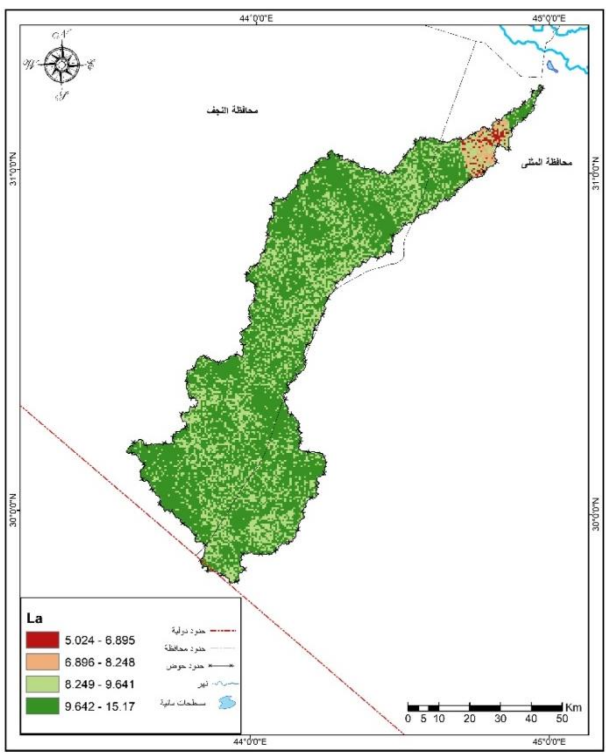
It represents 20% of the values of S, and the coefficient of extraction LA is closely related to the coefficient (S) for its relationship to land use, its cover and hydrological soils. The value of this coefficient, which is close to zero, indicates the lack of rainwater losses before the start of surface runoff, which leads to an increase in the amount of The running water on the surface, while the extraction rate LA becomes equal to the rate of running water if the median value is 50.8, and if the value of LA is higher than that, it indicates a higher amount of loss from rain water and this is reflected in the amount of surface running water.

The results showed that the LA values in the study area, table (8) were distributed into four categories, the first category is 5.02 and these values are close to zero, which indicates the low amount of rainwater lost before the start of the runoff, which leads to the generation of high surface runoff and it is compatible With equation S, the second category is from 5.02-8.24, which also indicates the lack of rainwater losses, but slightly less than the first category, the third category from 8.24 - 9.64, and the fourth category from 9.64-15.17 (Fig. 22). It is evident from the initial extraction values that the area or basins help surface run-off, which helps in harvesting water and the possibility of investing it in many aspects, whether agriculture or other services.

Table 8. The primary extraction factor and its area in the Abu maris Basin.

LA	Ratio %	Area KM^2
5.024 - 6.895	0.808	43.663
6.896 - 8.248	0.834	45.061
8.249 - 9.641	31.110	1681.216
9.642- 15.17	67.248	3634.192

Figure 22. Primary extraction factor in the Abu maris Basin.



Estimation of the depth of runoff of the basins: The depth of runoff was estimated by using the values of S and LA and the use of weather data obtained from satellites provided by the Center for Meteorology and Remote Sensing at the University of California (CHRS) (Center for Hydrometeorology

And Remote Sensing) and took the highest annual rate for 20 years. From (2000-2020) for 3 stations in each basin, rainfall is characterized by fluctuations from year to year, in addition to falling in the form of strong and volatile drops that form strong torrents sometimes. Abu maris Figures (23). The results showed the variation of the values of the depth of the runoff calculated from equation (10) with the variation of the values of CN, where the highest values of the depth of runoff were recorded for the highest CN values, while the lowest values of the depth of the runoff corresponded to the lowest values of CN as well. The table (9) and the figure (24) show the depth of the surface runoff of the Abu maris, respectively.

Figure 23. Rainfall distribution in the basin.

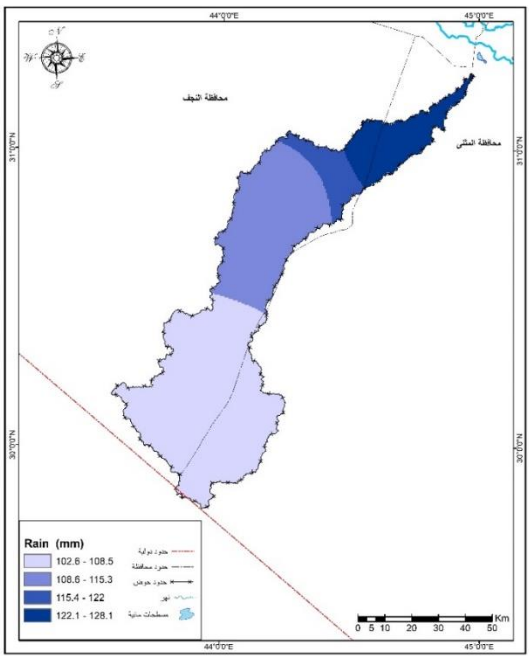
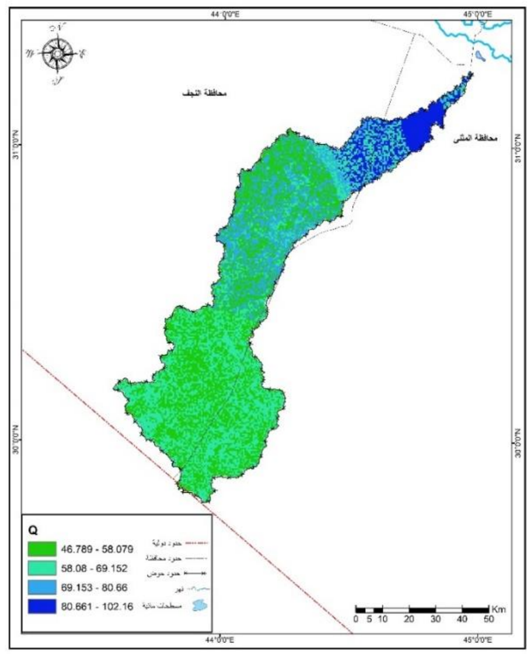


Figure 24. Depth of runoff in the Basin.



Source: From the researcher's work based on laboratory results and using the program (Arc GIS 10.6).

Table 9. values for the depth of runoff of the Abu Marys Basin (mm) Q.

Q	Ratio%	Area KM^2
46.789 - 58.079	40.606	2194.375
58.08 - 69.152	34.6998	1875.225
69.153 - 80.66	16.509	892.1452
80.661 - 102.16	8.186	442.386

Estimation of the volume of surface runoff of the basins: Due to the absence of stations that deal with hydrological measurements of the basin, including surface runoff, it was calculated according to the following relationship:

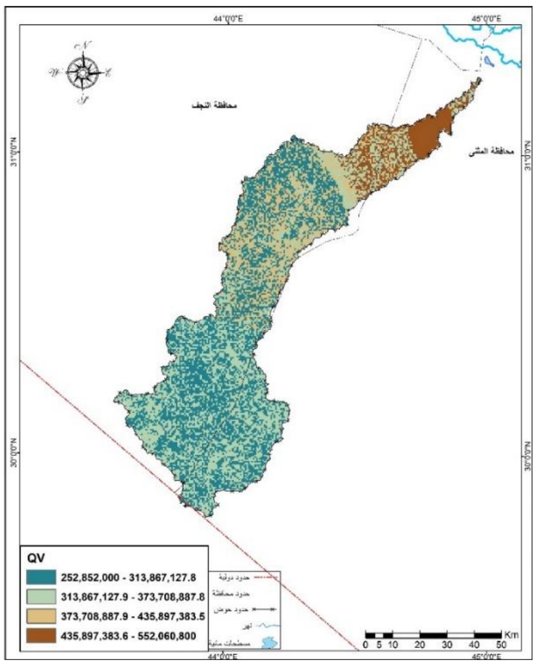
$QV=(Q*A/1000)$ …. …. ….

The Abu maris Basin had the highest area for the volume of high surface runoff, which falls within the third category, which ranges between 435897383.5-373708887.9 m3, as it recorded an area of 1975.64 km^2 of the basin area (Table 10) and (Figure 25).

Table 10. The volume and area of surface runoff in the Abu maris Basin.

QV (m^3)	Ratio%	Area KM^2
313867127.8-252852000	25.4613	1375.961
373708887.8-313867127.9	20.153	1089.112
435897383.5-373708887.9	36.558	1975.640
552060800-435897383.6	17.827	963.4185

Figure 25. Volume of runoff in the Abu maris Basin.



The results indicated the occurrence of surface run-off in a large proportion, and therefore the possibility of harvesting large water in these basins for the purposes of recharge of groundwater. It can be proposed to establish aggregate dams in areas with high water conductivity to ensure a high movement of water within the soil and to enhance the aquifer water storage instead of its horizontal movement and its loss in the end flats of valleys. and vaporize it.

Estimation of the depth of runoff of the basins at the highest intensity of rain in 2005 and 2018: The depth of runoff was estimated by using the same values of S and LA and using the rain data obtained from satellites provided by the Center for Hydrometeorology and Remote Sensing at the University of California (CHRS) for the highest rainfall intensity during the past 20 years. Which occurred in 2005 and ranged in Abu maris stations 22.73 - 27.74 mm. In 2018, the highest rainfall intensity ranged from 12.86-16.99 mm **.**

The results show for the year 2005 in Abu Maris Basin, the depth of the runoff ranged between 0.68-10.78 for a rain storm that occurred for one day only. (Table11) (Figure26). In 2018, the depth of runoff in the basin ranged from 0-3.854 mm. (Table12) (Figure27) These values can indicate the amount of surface water running for the purposes of water harvesting and its use for various agricultural and service purposes in these areas, which are subject to rapid evaporation and loss otherwise, although the depth of this surface runoff includes the entire area of the basin and not necessarily all of it reaches Wadi the purpose of Promote the concept of water harvesting in those areas.

Runoff volume of the highest daily rainstorm for 2005 and 2018: After applying the equation and multiplying the depth of the surface runoff by the area of each basin on one side, it was found that the volume of the surface runoff for a daily rain storm for the year 2005 for the Abu maris Basin was 26809192.06 - 58262776 m3 (table13) (Figure28), but in 2018 the volume of surface runoff was 12168951.63 - 20826058 m3. (Table14) (Figure29)

This depth and the volume of surface runoff was for a single rainstorm that occurred for one day. When this storm is repeated in a month or months, it leads to a high possibility of saturation of the soil with water, and with its accumulation, it leads to an increase in the groundwater recharge in order to enhance the ground recharge in these locations. It is more important than harvesting water for irrigation purposes because its quantity is small.

Table 11. Depth of rainfall for the highest rainstorm in 2005 in the Basin.

Q2005	Ratio %	Area KM2
0.6847 - 1.991	47.746	2580.234
1.992 - 3.417	13.182	712.382
3.418 - 4.961	23.057	1246.054
4.962 - 10.78	16.015	865.462

Q2018 (mm)	Ratio %	Area KM2
0- 0.3778	53.411	2886.393
0.3779 - 1.013	24.981	1349.980
1.014 - 2.252	20.712	1119.307
2.253 - 3.854	0.897	48.452

Table 12. Depth of rainfall for the highest rainstorm in 2018 in Basin

QV2005 (m3)	Ratio %	Area KM2
3700436.5 - 10761445.14	47.746	2580.234
10761445.15 - 18464363.66	13.182	712.382
18464363.67 - 26809192.05	23.057	1246.054
26809192.06 - 58262776	16.015	865.462

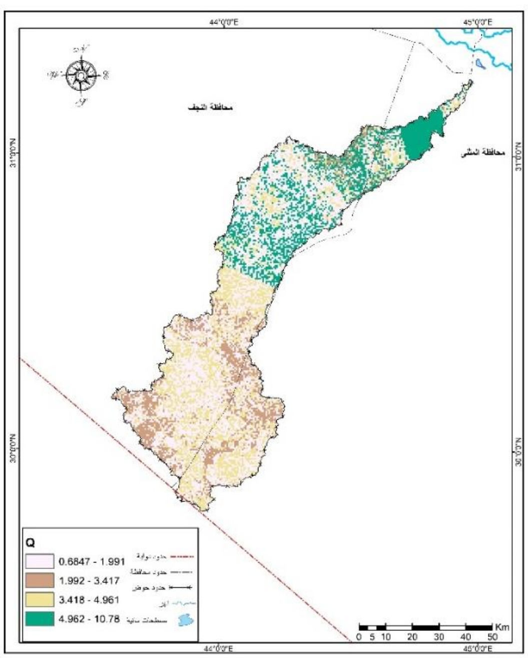
Table 13. The volume of surface runoff for the highest rainstorm in the Basin for the year 2005.

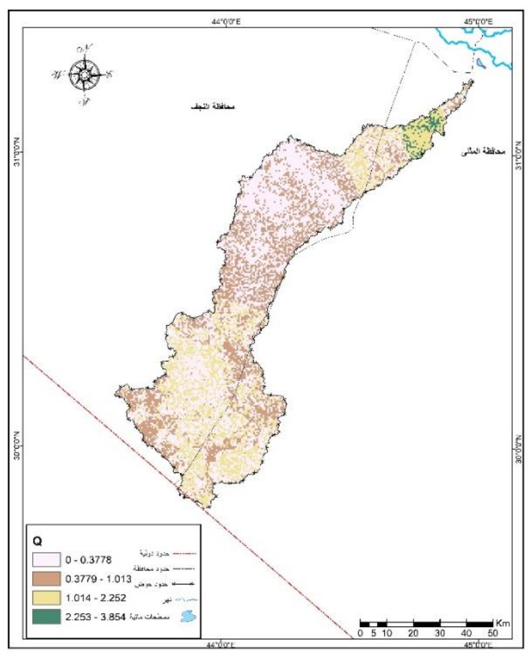
QV2018 (m3)	Ratio %	Area KM2
0.19120194 - 2041770.565	53.411	2886.393
2041770.566 - 5471944.792	24.981	1349.980
5471944.793 - 12168951.62	20.712	1119.307
12168951.63 - 20826058	0.897	48.452

Table 14. The volume of surface runoff for the highest rainstorm in the Basin for the year 2018.

the highest volume of surface runoff ranged for Abu Maris Basin Tarawah 12168951.63 - 20826058 m3 This depth and the volume of surface runoff were for one rain storm that occurred for one day.

Fig 26.





Depth of runoff in the Basin.2005

Fig 27. Depth of runoff in the Basin2018.

Fig 28. QV in the Basin2005.

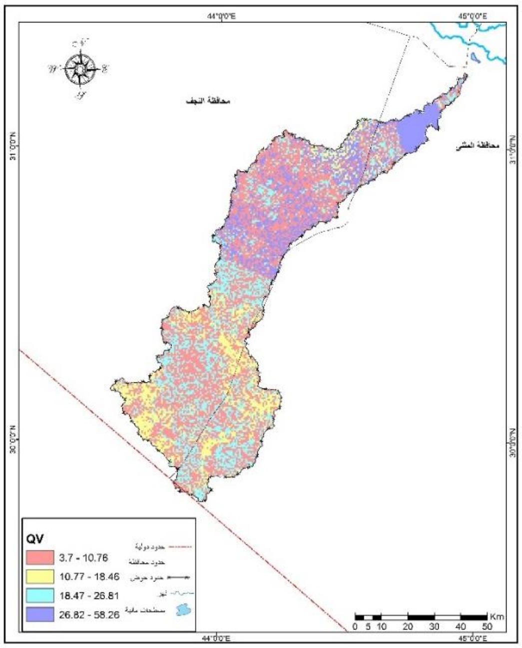
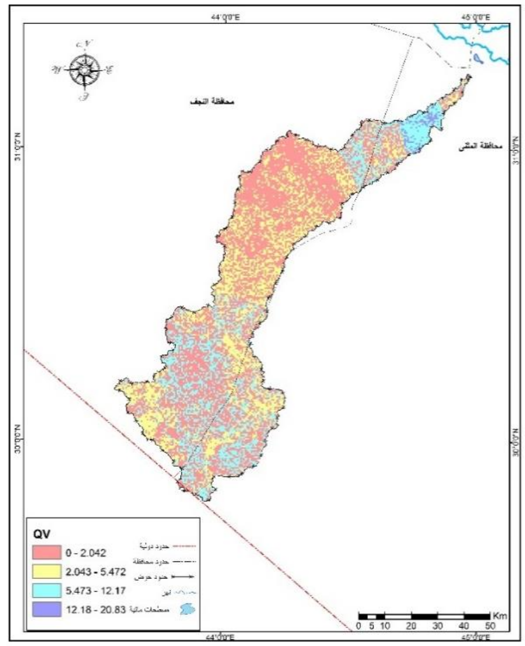


Fig 29. QV in the Basin2018.



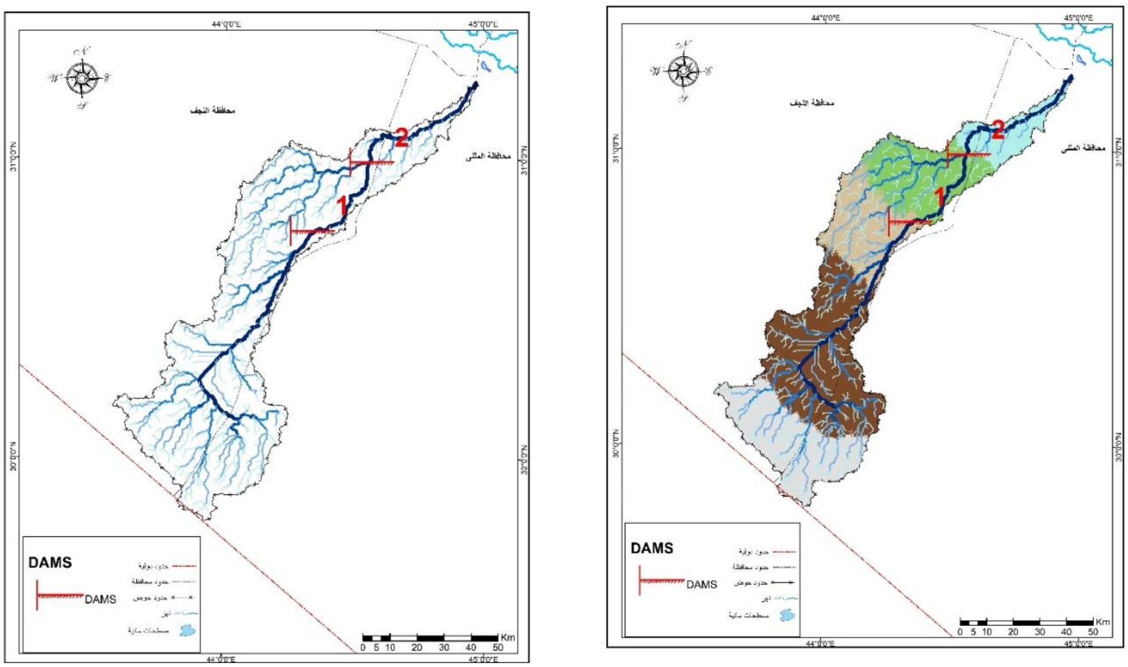
Water harvesting in the Abu maris Basin: The Abu maris Basin is divided into three areas: the water collection area, which is in the south of the basin, the middle of the basin water storage area, and the central and northern water storage area,The places of gathering valleys or the beginning of the watercourses are considered to reach the middle area in which the watercourse is of the fifth rank, which can collect water in the middle area and store it Depressions or transferring them to Lake Sawa by a watercourse or to agricultural areas close to them by constructing a dam or an earthen barrier to retain water in these locations.

In the south and middle of the B-type texture, which allows high infiltration, water storage is important to enhance the groundwater, especially since the water conductivity is high in the south and center of the basin and thus achieves a higher possibility of water storage and groundwater recharge, and this corresponds to the depth of the surface runoff, which decreased in these areas against an increase Infiltration and an increase in the depth of the surface runoff in the north, because the soil is of type C. Therefore, the northern region can be used to store water and transfer it to depressions or surrounding agricultural areas or to establish agricultural areas around it, because the surface runoff is higher in it at the expense of less infiltration.

Also, based on what was mentioned, the water harvesting places in the basin were divided into two locations (Fig.30):

Site No. 1: (30.762626 N, 44.339186E), which is located in the storage area in the middle of the basin, which can be used to store water and enhance groundwater according to the characteristics of the soil and topography. And Site No. 2: (30.992141 N, 44.568297 E), which is located in the north of the basin and is used to store water and transfer it to depressions or surrounding agricultural areas or to establish agricultural areas to benefit from the water that collects of high precipitation.

Fig 30. Water harvesting sites in the Basi



Conclusions and Recommendations:

Conclusions:

1-It is possible to use remote sensing data and geographic information systems to prepare maps that help in water resource management processes by determining the hydrological and soil properties and determining the best sites for water harvesting in the study area.

2- The amount of water calculated for three basin (Abu maris) out of 13 basins was good, although these basins are permeated by a large group of valleys and water courses, in addition to the spread of depressions and floods that have a role in contributing to the increase of underground storage and high evaporation conditions in Region .

-3 The heights varied between 15-455 m, and the slope of the land was from southwest to northeast in the study area using DEM visuals.

-4 The predominant separator in the soil is sand and the texture variety varies between S.CL.L, S.L and L. The water conductivity is moderate to high in most of the basins, which contributes and encourages water harvesting in the area for the purposes of underground nutrition.

5- Pond soils were dominated by alkaline character to the degree of soil interaction and were relatively low salinity, their water conductivity was moderate to fast and their organic matter was low.

-6 The predominance of hydrologic soils of type B in most of the basins, followed by a small percentage of soil of type C, which allows achieving medium and high flow in the basin areas for the purposes of following up the movement of water and the possibility of organizing its courses to ensure maximum benefit from it.
-7 The land uses of basins, according to the Sentinai 2 satellite visuals, are classified into four types: vegetation cover, valley bellies, mixed desert soils, and barren soils.
8- The values of the depth and volume of the surface runoff increased with the increase in the values of CN in the basins. This means that these basins have a high production capacity for surface runoff and water collection in a good quantity, and that the idea of water harvesting in this area can be of great economic feasibility.
-9 Suggest sites for the construction of dams or earthen barriers for each basin, depending on the depth and volume of the surface runoff of the basin and the characteristics of the soil, and based on the topography of the area, in order to benefit from it in the development of the area on the one hand, and in the recharge of groundwater on the other hand.
10- The suitability of some of these soils for agricultural investment through the study of the chemical and physical properties of the soil and this encourages interest in the subject of water harvesting in the research area and its exploitation for agriculture.

Recommendations:

-1 Establishing a hydrological monitoring station or a network of measuring stations on the main seasonal drains of the basins to measure the surface water running during the rainy season in order to assess the surface runoff for various purposes.
-2 Develop a plan to benefit from the waters of floods and torrential rains in agricultural and pastoral projects by constructing dams in places where the volume of surface run-off and water storage increases.
-3 Studying the economic cost of building structural barriers for water harvesting in the region.
-4 Studying groundwater nutrition, movement and quality in the region.
5- Establishing several meteorological stations for the purpose of calculating the amount of rain water falling during the water year and the possibility of benefiting from it.
-6 Benefiting from GIS in studies of torrents and floods because of the capabilities they offer that will contribute to the early prediction of their risks, support proper planning and help reach the best decisions.
-7 Conducting field studies on the management of these water resources and the possibility of increasing the agricultural area therein.
8- Conducting detailed studies for the drainage of water resulting from torrential rains in the water drainage basins.

Reference

- **Abdel Ghani, Imad Tafah. Ibrahim, Muthanna Khalil. Abdel Hamid, Essam Mohamed (2017).** Morphometric analysis of Wadi Houran using remote sensing and geographic information systems, Anbar Journal of Agricultural Sciences, Vol. 15, No. 1.

- **Abu Kahilah, Ola Saad Rasoul Fadel Hussein, (2020)** Spatial Variations of Desert Soil Characteristics in Najaf Governorate Using Different Statistical Methods - PhD Thesis - College of Agricultural Engineering Sciences - University of Baghdad.
- **Al-Ghanimi, Ahmed Kazem Fazza (2015).** Characterization and classification of some selected soils for Al-Rehab area in Al-Muthanna Governorate / Master's thesis. College of Agriculture/University of Al-Muthanna.
- **Al-Hamdani, Hussain Musa Hussain and Dakhl Radi Nadwi and Hussain Musa Hussain Al-Shamri. (2018).** Characterization and classification of soil map units in Bahr al-Najaf region using remote sensing technologies, geographic information systems and prediction by defining the boundaries separating the map units. 2- Digital classification of soils in Bahr al-Najaf region - Iraq, Kufa Journal of Agricultural Sciences 10(1):198-224.
- **Al-Hayaliyn, Osama Samir Aziz Majeed (2017).** Study of dust phenomena affecting the city of Al-Amarah for the period from 2005-2015 - High Diploma - College of Agriculture / University of Baghdad.
- **Ali, Khalil and Husseini, Iyad Kazem (2013).** Classification and characterization of the soils of Lake Sawa site in Muthanna Governorate, Iraqi Journal of Agricultural Sciences 44 (5).
- **Al-Jubouri, Sabar Rahi Jassem (2012).** Origin and inheritance of gypsum mineral in some gypsum soils from Iraq. PhD thesis / Faculty of Agriculture. Baghdad University.
- **Al-Kawaz, Mona Abdel-Karim Hamad. (2015).** Monitoring the variation of the ground cover of the Hammar marsh in southern Iraq using remote sensing and geographic information systems - Master's thesis - College of Agriculture/University of Baghdad.
- **Al-Mayahi, Mustafa Saleh Ali. (2015).** Classification and evaluation of some lands in Basra Governorate for the purposes of agriculture - Higher Diploma - College of Agriculture / University of Baghdad.
- **Al-Sargati, Hussein Abd Ali Issa (2020).** The relationship between reflectivity and desert soil characteristics using geospatial technologies and spectrophotometry in Najaf Governorate, Ph.D. thesis, College of Agriculture / University of Baghdad.
- **AL-Shammari, Muthanna Mahmuod Ali. (2019)** Delineation of Suitable Sites for Water Harvesting and Artificial Groundwater Recharge in Down Stream of Ubaydh Watershed, West of Karbala, Iraq , A Dissertation- The College Of Science University Of Baghdad. Science In Geology .
- **Al-Waeli, Aurass Muhi Taha,(2020).** ASSESSMENT OF SOIL SENSITIVITY FOR PHYSICAL DEGRADATION IN ABI-GARAQ BY GEOMATICS TECHNIQUES, Int. J. Agricult. Stat. Sci. Vol. 16, Supplement 1, pp. 1865-1873, 2020
- **Amer. K.Z, K.H. Swain1 and Hussein Abbas jebur (2021),** THE IMPACT OF PLOWING DEPTH AND SOIL MOISTURE ON SOME TECHNICAL INDICATORS AT USING DISK PLOW, Int. J. Agricult. Stat. Sci. Vol. 17, No. 1, pp. 177-180, 2021.
- **Bashour, Essam & Antoine Al-Sayegh (2007).** Soil analysis methods for arid and semi-arid regions, American University of Beirut - Lebanon. ISBN 978-92-5-6056611-0 .
- **Bilal, Adel Ali. Abdel-Baqi, Yusra Taha. Al-Shakarji, Bashar Munir (2019).** Rainwater harvesting in Wadi Al-Murr / Nineveh Governorate / Northern Iraq. The Iraqi Journal of Desert Studies (1) 9.
- **Black, C. A., D .D Evans. J.L.Whit., L E. Ensminger and F.E Clark.)1965**(. Methods of soils analysis. Part I.Soc.of Agro. Inc.USA.

- **Buraihi, F. H., (2016).** Selection of rainwater harvesting sites for groundwater augmentation by using remote sensing and GIS techniques, M.Sc. Thesis, School of Graduate Studies, University of Putra, Malaysia, 115p.p.
- **Hassan, Ibtihal Taqi. (2018).** Application of some remote sensing techniques to detect mineral deposits in the Bahr al-Najaf region using Landsat data - (OLI) 8, Kufa Journal of Physics 10(1): 17-28.
- **Hesse, P. R.)1972(.** A Textbook of Soil Chemical Analysis. Chemical Publishing Co., Inc. New York.
- **Jackson , M.L. (1958) .** Soil chemical analysis . univ. of wisconsin madison.
- **Katea, Hassan Hamid and Khalil Ibrahim Majeed. (2013).** Soil survey and hydrological investigations project for Fadak farm (the upper holy shrine) Najaf, Ministry of Water Resources - National Center for Water Resources Management - Environmental Studies Department.
- **Kumar, M. G., Agarwal, A. K., & Bali, R. (2008).** Delineation of potential sites for water harvesting structures using remote sensing and GIS. Journal of the Indian Society of Remote Sensing.
- **Mahmood, Saad Shakir . Taha ,Samer Muhi . Aurass Muhi Taha Al Waeli and Duraid K. A. AL-Taey1*(2020)** INTEGRATED AGRICULTURAL MANAGEMENT OF SALINE SOILS OF SOWAIRA, WASIT GOVERNORATE, Int. J. Agricult. Stat. Sci. Vol. 16, No. 1, pp. 113-119, 2020
- **Page, A. L.; R. H. Miller and D. R. Keeney,)1982(.** Methods of Soil Analysis Part 2, 2nd ed. Agronomy 9, Madison, Wisc. USA.
- **Richards, L.A., (1954).** Diagnosis and Improvement of Saline and Alkali Soils, Agric. Hand book 60, U.S. Dept of Agric, Wishing ton, D.C.
- **Stahler A,N,(1954)** ,Quantitive geomorphology of erosional landscape ,Qeal,Cong,(Algiers) c.R fare ,V.15,P341-345.
- **USDA (2010).** Natural Resourses Conservation Servise ,Hydrology National Engineering Handbook,2010,P12.
- **USDA-TR55, (1986).** Urban Hydrology for Small Watersheds, Department of Agriculture, USA, P213.