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HYDROLOGICAL MODELING OF SURFACE WATER HARVESTING IN THE VALLEY AL- MANAI BASIN USING REMOTE SENSING TECHNIQUES AND GEOGRAPHIC INFORMATION SYSTEMS

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ABSTRACT

The study deals with an applied hydrological study of surface water harvesting in the Valley al-Manai basin in the western plateau of Iraq using remote sensing techniques and geographic information systems in order to determine suitable locations for collecting water for human use, in the field of agriculture .

Spatial analysis, based on the USSA system, resulted in the presence of five types of soil cover and two types of hydroponic soils. The volume of surface runoff was calculated based on the hypothesis of SCS-CN so that the surface runoff in Valley Al-Manai basin was 84.96 million cubic meters, Three sites for the construction of dams and a reservoir card amounted to (10055051.44) million cubic meters.

INTRODUCTION

Rainfall in a few months of the year in arid and semi-arid regions is of major importance in wetlands. This is particularly important in the absence or lack of surface and groundwater sources, making rainwater investment the most viable means of human and other human activities, In this sense, the use of water harvesting technologies has become necessary to provide surface water by assembling it in geologically appropriate places for the construction of dams, as well as by supporting groundwater reserves by leaking part of the ground water underground .

PROBLEM OF THE STUDY

The study area suffers from a severe shortage in the abundance of surface water as a result of the lack of rain and its fluctuation, which adversely affected the investment of promising lands for agricultural production as well as other human uses , which required the use of water harvesting techniques for the construction of dams in the study area.

THE HYPOTHESIS OF THE STUDY

The study area is characterized by natural properties of dams that contribute to the storage of runoff resulting from the storm, which helps the investment of land and improve the economy of the region.

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OBJECTIVE OF STUDY

1-analysis of spatial characteristics and knowledge hydrological of their implication for the selection suitable location for construction of dams.

2- estimate the annual runoff access to the possibility of investment harvesting water.

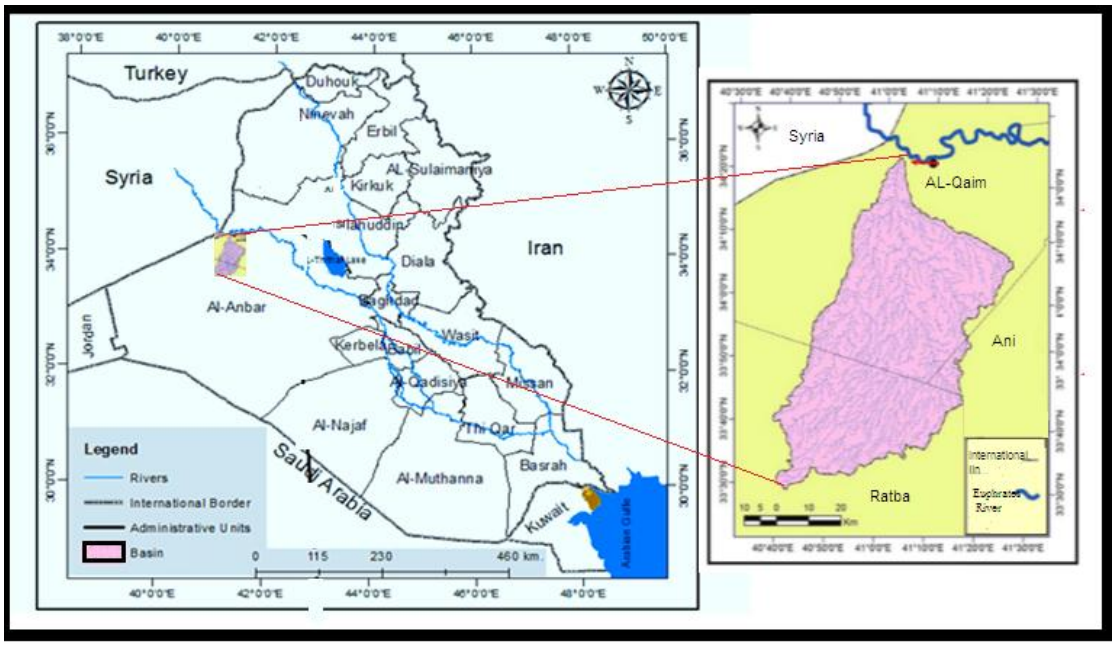
3- Intending to settle humans by desert agriculture of improving promising lands by agricultural investment.

SPATIAL ANALYSIS

LOCATION OF THE SEARCH AREA

The research area (Valley Al-Mani Basin) is located in the western plateau of Iraq within Anbar province, and the valley ends at the Euphrates River at the city of Qaim between two latitudes (33°-40'-34°-20') North and longitude (40°-40'-41°-20') East,map (1)

Map (1) Location of the research area within Irap



Source: Ministry of Water Resources, General Survey Authority, Anbar Topographic Map, Scale 500000: 1, for the year 2010.

GEOLOGY RESEARCH AREA

The different physical, chemical and structural properties of rocks are of great importance in selecting the appropriate locations for the construction of dams in water basins, and assessing the validity of the retained water for human activities. And the importance of geological studies in the

interpretation of the course and direction of surface water runoff and its variation from one region to another, will highlight rock formations in the study area .

It is through the map (2) shows multiple geological formations in the study area, revealing the formation of the aperture in the form of sedimentary cycles. Each cycle consists of the green shale, limestone and gypsum[1] .

The composition of the waste consists of anhydrite, gypsum and salt overlap with layers of calcareous rocks, marl and phytic deposits of clay rocks, sand and sand, whereas the presence of clay stone contributes to impeding surface water infiltration into subterranean layers[2]. The composition of the Euphrates is made up of gravel and limestone, dolmite, and the solubility of these components is calcareous and clay, in the form of thin, well-applied layers[3] .

Rectangular rocks consist of sand and gravel with a small amount of anhydrite, clay and sandstone, and are characterized by the presence of dolmite sand, with gray-yellow colored clay deposits, sandstone limestone and limestone[4]. The composition of the controversy consists of dolomite limestone, flint stone, phosphate deposits and in some cases it is a chalk limestone in limestone limestone[5]. The composition of a limestone is composed of limestone, which turns into dolmite containing marl and limestone. The highest is characterized by the presence of marlene limestone[6].

The material is composed of silica and calcareous material. This layer is followed by a sandstone stone composed of limestone and on top composed of very solid calcareous rocks[7]. The slopes of the river are composed of gravel and limestone. The size of the gravel ranges from fine to rough and sometimes very rough gravel (semi-rounded), often composed of limestone with a few flints and characterized by high permeability and quick filtration. Subsurface layers.

Water flow in the study area is closely related to the nature of the climate. The climatic data of Al-Qaim station were used to determine the climatic conditions in the study area. The average temperature at Al-Qaim station was (20.8 m for the period 1995-2015), Annual rainfall (146.4 mm).

ESTIMATION OF RUNOFF MODEL

Estimating the volume of runoff for water harvesting contributes to making appropriate decisions in determining appropriate locations for the construction of dams, in order to collect and store water for supplementary irrigation in areas promising investment or other human uses.

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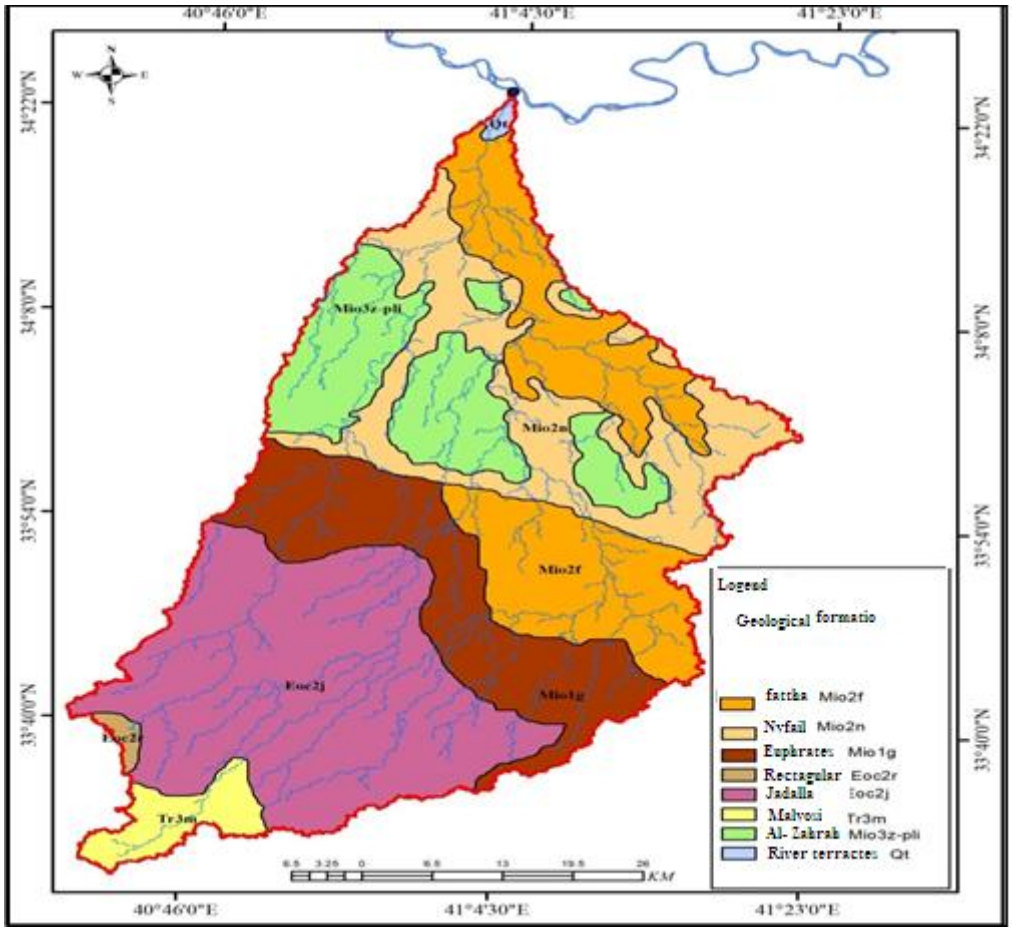
Map (2) Geology of the search area



Source: From the work of the researcher based on the Ministry of Industry and Minerals, Geological Survey and mineral investigation, Iraq geological map, the scale of 1000000: 1, 2000.

ESTIMATION OF RUNOFF MODEL

The volume of surface runoff is subject to the effect of the surface, morphological and surface characteristics of the feeding basin and the intensity and continuity of the rainstorm in the area, as well as the soil's ability to leak and leak, While in soils with high permeability such as sand[8]. The process of identifying and estimating the most suitable areas for water harvesting requires accurate

estimates of the size of runoff. There are many methods used to arrive at these estimates. However, the US Soil Conservation Service, known as SCS-CN, Used to calculate the volume of runoff[9].

This mathematical model was adopted using remote sensing data and processed with ArcGis 10.2.1 within the geographic information systems environment, in order to obtain accuracy in determining the most areas of their surface run-off in order to select suitable locations for water harvesting. The mathematical relationship of the runoff curve model is expressed in the following equation[10] :

$$Q = \frac{(^2P - 0.2S)}{(P + 0.8S)}$$

Where:

=Q depth of runoff (inch)

p = falling rain (inches)

=s Maximum storage capacity or surface assembly after the start of the flow and extracted as follows S=(1000/cn)-10:

It is noted that the inputs of the model data were in inches, which required the rewording of the equation to conform to the metric measures. The fixed numbers were set at 254 to convert from inch to millimeter. The equation became as follows :

$$S = \frac{25400}{Cn} - 254$$

Extract the value of Cn

CN values represent the state of soil cover and soil hydrology in terms of their surface water permeability, reflecting the response of the river basin to the concentration of runoff. (0-100). High values indicate that the surfaces are very strong and are capable of generating the flow, whereas the low values indicate the non-solid surfaces[11].

The CN values of the Valley Al-Manai basin were obtained by merging the soil layers and soil hydrological groups using the Combine function in the Arc GIS program. Which we will discuss in detail below:

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1- Hydrological soils

US soil maintenance has identified four groups of soil, depending on the rate at which water is transferred through the soil tissue and the infiltration rate, as shown in Table (1)

Based on the Bjornk classification and analysis of soil samples for the study area, it was found that it contains two types of hydroponic soils as follow:

Hydrological Group (B)

This group consists of sandy soil with coarse texture that predominates in the upper beds of the basin, where the rate of runoff is low due to the speed of water penetration inside the soil. It occupies an area of 2169.25 km² with 67.85% of the basin area. Water leakage rates range between (3.81-7.62 mm / h)[12].

Hydrological Group (C)

This group consists of clay soils with a mixture of gravel and rock deposits with a lower depth than the group (B), which predominates in the desert depressions (flocks and cisterns) in the basin, and occupies an area of 1027.75 km² (32.15) of the basin area. Water leakage rates range between (3.81-7.62 mm / h)[13].

2-**Classification of land cover**

The classification of the land cover of the region was based on satellite imagery and ArcGis10.2 was used to reach the best results. Several land uses were identified within the area occupied by the basin based on the equation of the US Soil Conservation Service (SCS-CN) as shown in Table 2) And a map (3).

Table (1) Hydrological groups of soil by method (SCS)

Soil class	Flow depth	Soil type
A	few deep	sand layer with very little amount of clay and silt
B	Average	sand layer less depth than Class A with average infiltration rate
C	above average	A shallow mud layer with an average infiltration rate or a rocky layer covered with a layer of soil
D	High	A thick clay layer covered with a shallow layer of soft clay or a bare rock layer

Source:Soil Conservation Service.Urban Hydrology for Small Watershed. Technical releases55,2nd, U.S.Dept of Agriculture, Washington D.C.(1986).

Table (2) The ground cover of Al-Manai basin

Type of ground cover	Area	Area%
Agricultural Land	189.0	%5.9
Open land	823.3	%25.8
Terrestrial dry terrain	215.1	%6.7
Arid land is abandoned	1712.5	%53.6
	3197	%8

Source: From the work of the researcher based on the digital height model and the output of Arc Gis 10.2

1-Agricultural Land:

Agricultural lands predominate in different areas, most of which are concentrated in the lower part of the basin. They occupy an area of 189.0 km² and 5.9% of the total area of the basin. The presence of vegetation contributes to the obstruction of water flow on the surface, which increases its penetration into the ground.

2- Open Lands:

The open lands represent all the lands promising investment and occupy large parts of the study area, especially in the western part of the highest basin. This cover covers an area of 823.3 km² and 25.8% of the total area of the basin. Which increases the chances of leaking as much water into the soil..

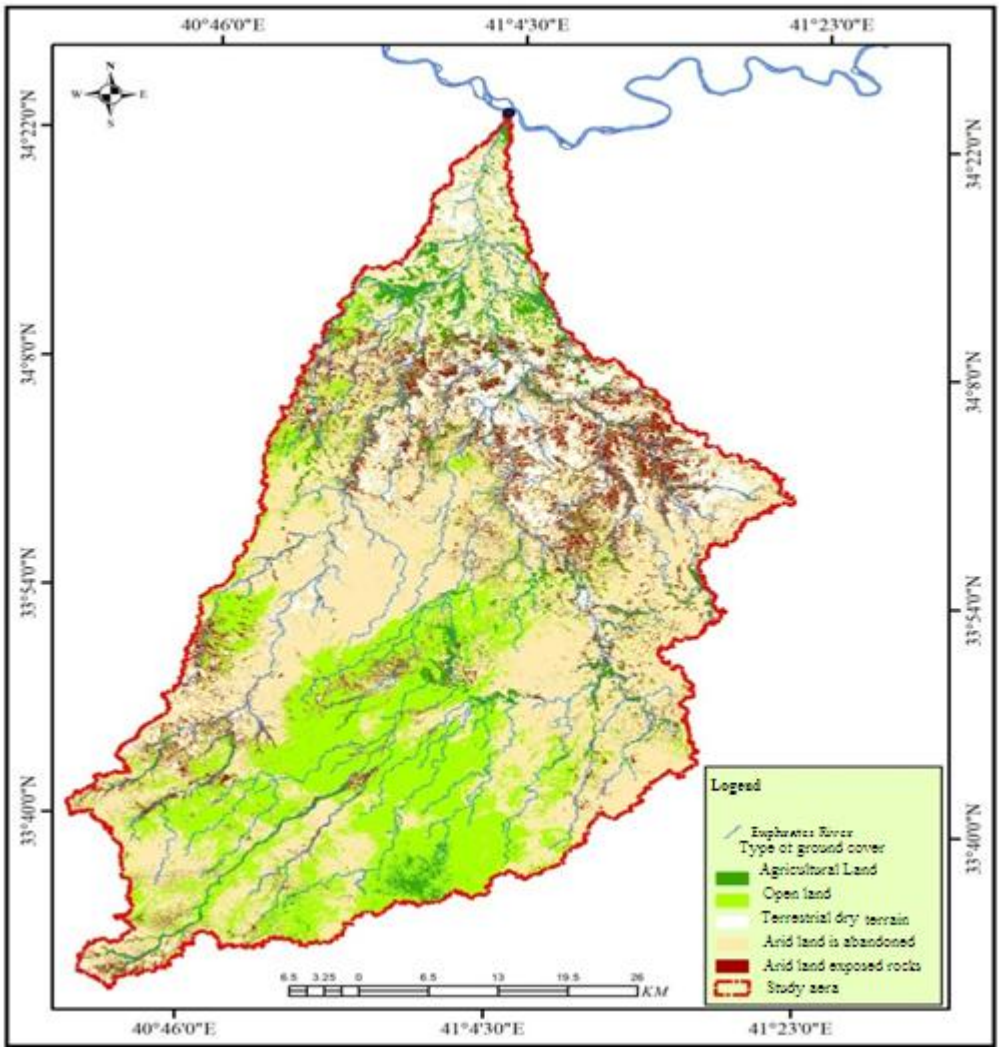
3-Arboreal drylands:

This cover is in different parts, but it is concentrated in the western part of the lowest basin, the area occupied by this cover (215.1) km² and by (6.7%) consists of deposits of geological and fossil free from the vegetation to some extent.

4- Arid land left:

This cover covers large parts of the basin, representing an area of 1712.5 km² (53.6%). It has few desert year-old plants scattered in a scattered manner and few trees scattered on the slopes of the slopes, which contribute poorly to the runoff.

Map (3) Classification of the land cover of Valley Al-Manai basin



.Source: From the work of the researcher based on the satellite satellite (Landsat) type (DEM) for 2010, and processing using the program (Arc MAP GIS10.2).

5-Arid land exposed rocks:

This cover covers most of the lower part of the basin, consisting of coarse and decomposed deposits due to continuous water erosion, which contributes to the removal of soft sediments from the plains and mud, increasing the chances of water leakage. The area covered by this cover is 257.1 km², 6.7% .

The value of (CN) of the Valley Al-Manai basin was obtained by combining the two soil layers of the area and the hydrological groups of the soil and considering that the pre-condition of soil moisture is the AMS-II moderate state. After the values of both variables were determined, the value of (CN) (CN) is (88) with an estimated area of (242.28) km² and 7.58% of the total area of the basin, The most common value is (93) with an area of (1138.4) km² and (35.61%). It represents the open arid lands of the rocks. In general, it is clear that all the values of CN are high, Basin in generating runoff for the establishment of an appropriate water harvesting projects.

Table (3) cn values and hydrological categories of soil

Type of ground cover	A	B	C	D
Agricultural Land	63	77	81	86
Open land	77	89	91	-
Terrestrial dry terrain	62	85	88	-
Arid land is abandoned	76	80	87	92
	-	-	-	93

Source:USDA-SCS,Urban hydrology for small watershed,department of agriculture,USA,1986,p5

Table (4) cn values extracted for ValleyAl -Manai basin

CN values	Area	Percentage
63	724.65	22.67
89	465.46	14.56
88	242.28	7.58
92	625.68	19.58
93	1138.4	35.61
63	3197	100

Source: From the work of the researcher based on the digital height model and the output of Arc Gis 10.2.

Estimation of runoff depth:

The depth of surface runoff is expressed as rain precipitation, which exceeds the absorptive capacity of the soil. Several levels are taken according to the soil and the nature of the formation. It is determined by a period of time that begins with the fall of rain on the surface and ends at the estuary in the watercourse[14]. The highest rainfall during the one year at Al-Qaim station, as it showed fluctuation in rainfall rates. The highest value of the surface runoff depth (1995 - 2015) was recorded in 1997 (47 mm), and the lowest record depth in 2011 was recorded by (4,234) mm for the total basin.

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Estimation of the surface runoff of Valley Al-Manai basin:

For the preparation of the layers (S, Ia, Q), the cellular calculus was used within the functions of the spatial shop to calculate the volume of runoff according to the following mathematical relationship[15]:

Qv=(Q*A/1000)
Whereas:
Qv = volume of runoff
Q = Depth of runoff / mm
A = basin area km²
1000 = conversion factor

The annual flow rate of the Valley Al-Manai basin was calculated by applying the equation and using the results of the depth of the extracted surface runoff and the total basin area. The results showed that the annual surface runoff values of the basin were high at 84.96 million cubic meters, Rock formations and large area of the basin, which helps to receive the largest amount of rain precipitation, which contributes to increase the volume of runoff, which will lead us to choose the best areas for harvesting water for investment in the development of promising lands.

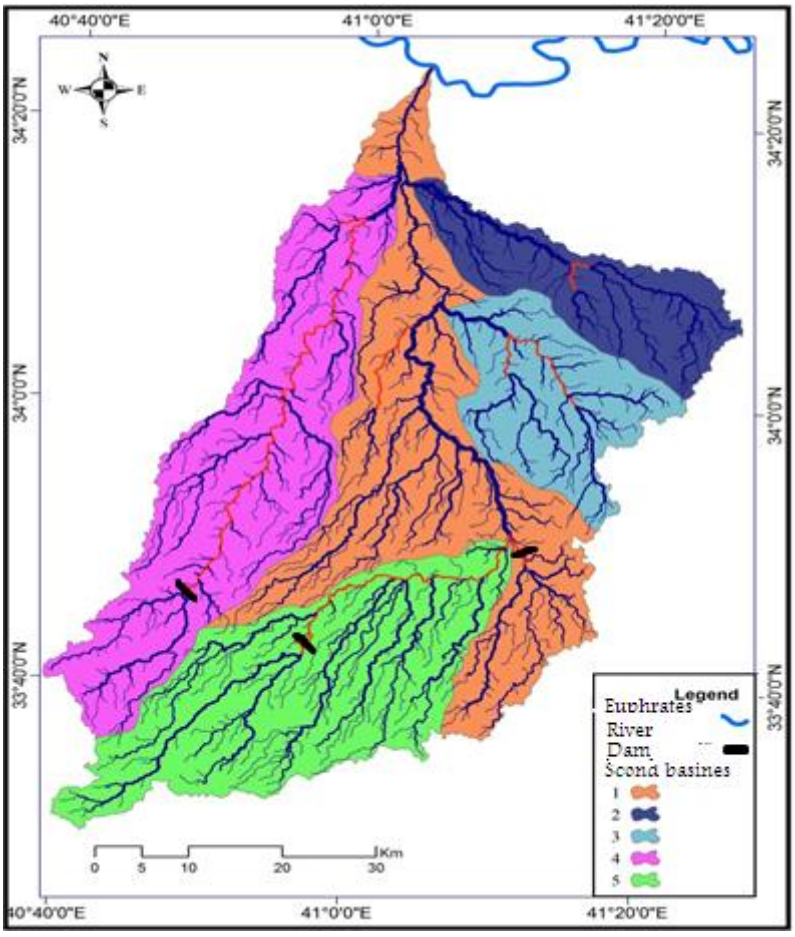
AREAS SUITABLE FOR HARVESTING WATER:

The identification of suitable sites for the construction of small dams on the seasonal streams of the valleys requires a detailed study of the geological, hydrological and surface factors, as well as the human factors represented by the economic feasibility of dam construction. Three sites were chosen for the construction of small dams, as shown below:

1-The location of the proposed dam No. (1): Located in the western part of the basin within the geological formations suitable for the construction of dams, especially the composition of the Euphrates, which is characterized by its hardness, and the maximum level of water storage collected from rainwater harvesting in the proposed dam lake at the high (440) Meters above sea level to (5015308.23) m 3.

2-The location of the proposed dam No. 2: Located at the top of the center of the basin and characterized by the existence of geological formations solid, especially the composition of the controversy, which is one of the most appropriate formations for the construction of dams small aggregate, and the maximum level of water storage collected from the torrent of rain water in the lake proposed dam at The elevation line (460) meters above sea level to (2014325.73) m 3.

Map (4) locations suitable dams in the valley al-manai basin.



Source: From: the work of the researcher based on the satellite satellite (Landsat)

Type (DEM) for 2010, and processed using the program (Arc MAP GIS10.2).

3-location of the proposed dam No. (3): Located in the south - east of the basin within the configurations of the opening and Ijana characterized by its hardness and resistance to water erosion factors, resulting in the emergence of rocky edges of steep slope on both sides of the stream, which contributes to the possibility of increasing the height of the proposed level of the lake, Level of water storage collected from the harvesting of rain water in the lake Sadaand line height (440) meters above sea level to (3025417.48) m 3.

CONCLUSIONS:

1-Hydrological modeling using modern geographic techniques has contributed to determining the most suitable sites for the construction of dams on the valleys and the collection of runoff water in lakes that can be used in the dry season.

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2-The annual surface runoff of 84.96 million cubic meters was obtained using the US Soil Conservation Method (SCS), which is more suitable for accurate results and contributes to the selection of dam sites proposed for collecting rainwater in the ponds.

3-The study found three suitable sites for harvesting rainwater through simulations of the natural characteristics of the research area. The total capacity of the proposed lakes within the Valley Al-Manai basin was about (10055051.44) million cubic meters.

RECOMMENDATIONS:

1-Establishing a hydrologic station on the main valley to determine the volume of water discharge from rain storm in order to determine the possibility of investing in the development of the area..

2-Expanding the use of modern geological techniques in the hydrological modeling of the unexplored areas in order to establish the payment of the obstruction of the runoff water and its accumulation or dispersal to the largest possible area for investment in the agriculture of demography..

3-Work on the establishment of the payment proposed in the study in order to benefit from the water collected in the development of land promising agricultural investment on both sides of the course and other human uses to achieve economic development across the region.

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