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Research Article **Open Access**

Water Harvesting in the Jimin Basin by Using Remote Sensing Techniques and Geographical Information Systems

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ABSTRACT

What is meant by water harvesting is the process of collecting and storing surface runoff water resulting from precipitation to benefit from it for agricultural purposes, feeding underground storage, and providing drinking water for humans and animals. For the basin, especially evaporation, where the number of hours of the solar surface was recorded in two Kirkuk stations (11) hours/day, respectively, and it was recorded in Chamchamal station at about (12) hours/day, while it decreases during the winter months, as it reaches about (5) in Chamchamal station, respectively, while in Kirkuk station reached (6) hours/day, respectively. The highest monthly rates were recorded during the winter months (December) by (66.4, and 66.7%) for both stations (Chemchamal-Kirkuk), respectively. While its lowest monthly rates were recorded during the summer months (July and August), when it reached (24.2%), which can predict the presence of saturated soil, which reduces filtration and leakage after rain falls and generates surface runoff, which can be harvested and utilized from the water. For both stations, they are spatially and temporally dissimilar, as the highest average of their monthly totals was recorded during the winter seasons in Chamchamal station in January and February to (92.9 mm) respectively, then it decreased relatively during December as recorded (90.1 mm). The annual rainfall was recorded in both stations (Chemchamal-Kirkuk) (502.3, 337.7 mm). It is clear from the foregoing that the plant has an important role in the presence of organic matter in the soil, which increases the seepage of falling rainwater and does not generate surface runoff. Therefore, the areas that are characterized by the presence of vegetation can be exploited by applying the harvesting methods designated for such areas that are characterized by water leakage into the ground, and therefore the soil is radiant with moisture, which can be cultivated directly, especially by applying the technology of mountain terraces that works to impede water and increase its seepage into the soil layer, especially These areas are characterized by their height and exposure to soil erosion after heavy rains.

KEYWORDS: GIS, water harvesting, hydrology, Jimen basin.

الخلاصة

يقصد بحصاد المياه هي عملية تجميع وتخزين مياه الجريان السطحي الناتجة عن هطول الامطار للاستفادة منها في اغراض الزراعة وتغذية الخزين الجوفي وتوفير مياه الشرب للإنسان والحيوان ومن اهم النتائج التي توصلت اليها الدراسة تبين ان ارتفاع عدد ساعات السطوع الشمسي وزيادة كمية الاشعاع الشمسي يؤثر على خصائص الجريان السطحي للحوض، لا سيما التبخر حيث سجلت عدد ساعات السطوح الشمسي في محطتين كركوك (١١) ساعة/اليوم على التوالي وسجلت في محطة جمجمال حوالي (١٢) ساعة/اليوم بينما تنخفض خلال اشهر الشتاء حيث تبلغ في محطة جمجمال حوالي (٥) على التوالي بينما في محطة كركوك بلغت (٦) ساعة / اليوم على التوالي . ان اعلى المعدلات الشهرية سجلت خلال أشهر الشتاء (كانون الاول) بمقدار (٦٦,٤، ٦٦,٧٪) لكلا المحطتين (جمجمال–كركوك) وعلى التوالي. بينما سجلت ادنى معدلاتها الشهرية خلال اشهر الصيف (تموز وآب) اذ وصلت الى (٢٤,٢ %) الامر الذي يمكن التنبؤ بوجود تربة مشبعة مما يقلل عمليات الترشيح والتسرب عقب تساقط الامطار وتولد جريان سطحي والتي يمكن حصادها والاستفادة من المياه ان معدل المجاميع الشهرية للأمطار لكلا المحطتين تكون متباينة زمانياً ومكانياً، اذ سجلت اعلى معدل لمجاميعها الشهرية خلال فصل الشتاء في محطة جمجمال في شهر(كانون الثاني) وشباط الى (٩٢,٩ ملم) على التوالي، ثم انخفضت نسبياً خلال شهر كانون الأول اذ سجلت (٩٠,١ مم) ان معدل المجموع السنوي للأمطار سجل في كلا المحطتين(جمجمال–كركوك) (٥٠٢,٣، ٣٣٧,٧ ملم) ويتضح مما سبق ان للنبات دور مهم في تواجد المادة العضوية في التربة والتي تزيد من عمليات التسرب لمياه الامطار المتساقطة وعدم تولد الجريان السطحي. لذا يمكن استغلال المناطق التي تمتاز بتواجد الغطاء النباتي بتطبيق طرائق الحصاد المخصصة لمثل هذه المناطق التي تمتاز بتسرب مياه الى باطن الارض وبالتالي فان التربة تكون مشعة بالرطوبة والتي يمكن زراعتها

مباشرة لاسيما تطبيق تقنية المدرجات الجبلية التي تعمل على اعاقة المياه وزيادة تسربها الى طبقة التربة، لاسيما ان هذه المناطق تمتاز بارتفاعها وتعرضها الى عملية انجراف التربة عقب الشدة المطرية.

INTRODUCTION

The scarcity of water resources constitutes a real problem facing man on an ongoing basis, especially with the exacerbation of environmental degradation and drought that affected large parts of the globe. In arid and semi-arid environments, including Iraq [1], the problem of providing potable water and agriculture arises, which is offset by the lack or lack of permanent flowing surface water and total dependence on rain water and groundwater storage. By operations, water is collected and stored, and dams are built on rivers and torrents, in order to supply water to meet the needs of the population. The study of water harvesting in the advantages of the economy and the environment lied in the effect on increasing and improving the productivity of agricultural crops by providing additional water at a low cost that uses supplementary irrigation, and this water may be the main source for many population groups in some arid regions that are characterized by drought for long periods of the year to meet human and animal needs from the water. There are some research and studies on this subject, including Al-Obeidi (2018). The study of water harvesting in the advantages of the economy and the environment lied in the effect on increasing and improving the productivity of agricultural crops by providing additional water at a low cost that uses supplementary irrigation, and this water may be the main source for many population groups in some arid regions that are characterized by drought for long periods of the year to meet human and animal needs from the water. There are some research and studies on this subject, including Al-Obeidi (2018). It shows that the research basin is of great hydrological importance because it enjoys hydrological conditions. Al-Jawari (2015) Water harvesting in the Aidan basin in northwestern Iraq. The research and analysis dealt with the possibility of water harvesting in the Wadi Aidan basin in northwestern Iraq. Ali Murad (2018) [3]. Hydrogeometric indications for modeling water harvesting methods in the Wadi Al-Ghanam basin. The study dealt with hydrological assessment and the production of a map showing the harvesting locations in Wadi Al-Ghanam Basin. Al-Diwani (2019) The possibility of water harvesting in the Khwaisa Valley, east of Maysan Governorate. Ghilan (2019) Hydro geomorphology of the Wadi Jada basin the study dealt with the Wadi Jada basin and its economic investment using geographical technologies. Awais (2013) Water harvesting, traditional techniques for developing drier environments. Al-Akkam (2014) The relationship between surface runoff and geomorphological variables in the valleys of eastern Iraq. Salman (2014) Flood risks in the Jazan region, southwest of the Kingdom of Saudi Arabia. Dagestani. (2004) Study of the hydrological systems and rainwater harvesting within the spate vents at the northern end of Mount Sinjar. Elaly (2010) Application of geographic information systems in building a database of morphometric characteristics and their hydrological implications in Wadi Yalamlam basin.

MATERIALS AND METHODS

The special data, special data and information represented in geological and climatic information, information on water resources, soil, natural vegetation, the nature of human activity, and the relationship of nature available in the region were collected through several tools:

The Topographical maps that play an important role in tracing the path of the valley and identifying surface features was used [4]. The satellite image was based on a satellite view of the Jimen basin from satellite data, and the earthly (digital) three-dimensional body software (10.8 GIS AVC), and the program (Global mapper r.16.). The soil samples were collected and analyzed by using Excel program.

Study Area

The study area is located in the northern part of Iraq [5], with an area of (440) km² within the provinces of Kirkuk and Sulaymaniyah in the district of Chamchamal and Kirkuk [6]. as shown in Figure 1. Because the region is characterized by abundant rainfall and has a large number of secondary basins with a low economic cost, as the benefit pervades the region in terms of animal grazing and human settlements.

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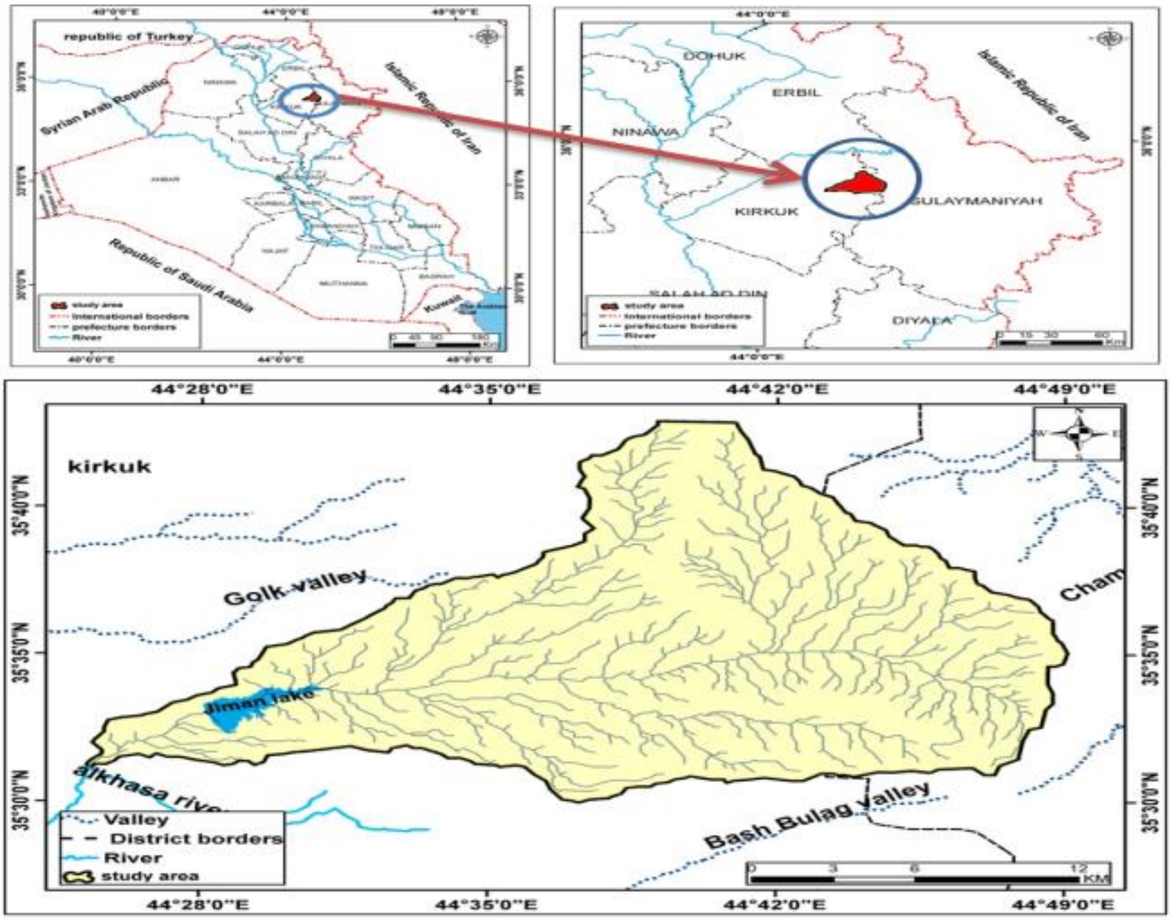

Figure 1. The location of the study area of Iraqi and the provinces.

RESULTS AND DISCUSSION

The climatic elements have a major role in the direct and indirect impact on the human and natural aspects in the study area, where the climatic elements affecting the Jimin Basin as follows:

1. Solar radiation

The intensity of the actual solar radiation is controlled by many factors, including the clearness of the sky from clouds, dust and fog. Then the duration of the actual solar radiation extends for hours and long, while the opposite happens when the sky is cloudy. The higher the number of hours of the solar surface and the increase in the amount of solar radiation affects the characteristics of the surface runoff of the basin [7]. Figure 2 represents the monthly average of the actual solar radiation over the Chamchamal region for the period (1989-2021) .The figure shows that the region has long periods of solar radiation with in the months the area is exposed for long periods within months(June-July-August) and both stations Kirkuk / Chamchamal recorded (11.11/11.1/11.2) hours per day for Kirkuk station and recorded for the same months about (12.2/12.1/10.5) for Chamchamal station from this, it is clear to us that the increase in the number of hours of solar surface and the increase in the amount of solar radiation affect the characteristics of the surface runoff of the basin of the study area. As shown in Table 1.

Table 1. Monthly average temperatures in Celsius (C°).

Station / Months	Chamchamal	Kirkuk	Seasons
September	10.4	10.3	Autumn season
October	7.5	8.1	
November	7.2	7.2	
Semester Average	8.4	8.5	
December	4.5	5.4	Winter season
January	4.1	5.4	
February	5.1	6.3	
Semester Average	4.6	5.7	
March	6.3	7.1	Spring season
April	7.2	8.2	
Mays	8.4	9.5	
Semester	7.3	8.3	

Average			
June	10.5	11.2	Summer season
July	12.1	11.1	
August	12.2	11	
Semester Average	11.6	11.1	
The Annual Rate	8	8.4	

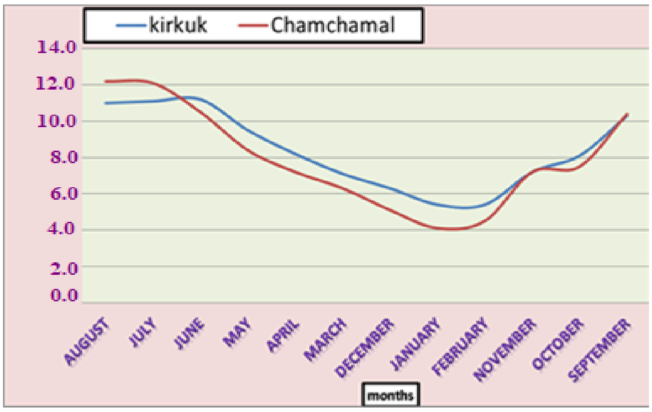

Figure 2. The monthly average actual solar brightness hour/day for the period (1989-2021).

2. Relative humidity

To study the humidity, their role in determining the extent of humidity and dryness of the region, then it turns out that the highest monthly rates were recorded During the winter in month of December with value 66.7/66.4% for both stations (Kirkuk/Chamchamal), respectively, while the lowest monthly rates were recorded during the summer in months of August and July with value for both stations, recorded during the summer in months of August and July with value for both stations but during the two transitional seasons (autumn and spring),the monthly rates of relative humidity differ for both stations, as it reached during The autumn to) 57.2/62.4 Km, While in springer in month of March the relative humidity reached to the highest rates for both stations with value 56.2-54.1. Through the above, it is clear that the decrease and increase in relative humidity is due to the characteristics of air masses, wind movement, and the nature of the terrain, which can be predicted by the presence of saturated soil, which reduces filtration processes and the survival of water for long periods. After the rains fall, they can be exploited by following water harvesting methods for grazing livestock and watering crops, as shown in Figure 3.

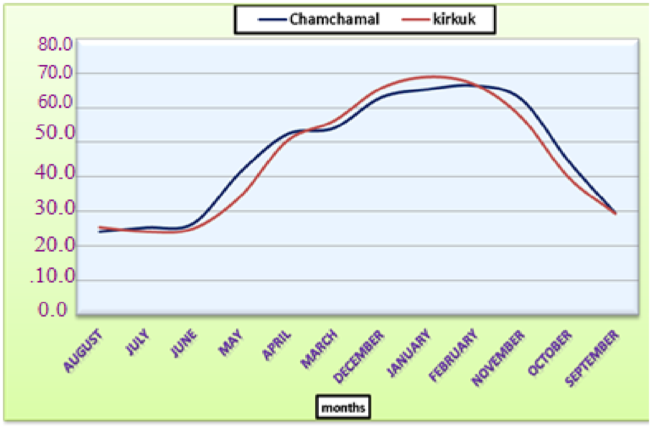

Figure 3. The monthly average relative humidity at the stations of the study area for the period (1989-2021).

3- Rain

The rainy season begins in the study area at the beginning of the autumn season and continues until the winter and spring season, and ends at the end of May, which is the beginning of the summer season, as the precipitation is initially in relatively small quantities, especially in the Autumn season, while it increases in the winter season and reaches its maximum quantities, then it decreases gradually in the spring until it stops in the summer. On this basis, knowing the seasons of rainfall and in large quantities contributes to proper planning in choosing suitable water harvesting methods that can be applied in the study area. It becomes clear that the winter season increases in rainfall, which coincides with the arrival of the Mediterranean depressions [8]. Causing rain that leads to saturation of the dry soil, all of which are factors that help store quantities of water during the summer season in order to apply a harvest that is beneficial to the region and the population, as shown in Figure .4.

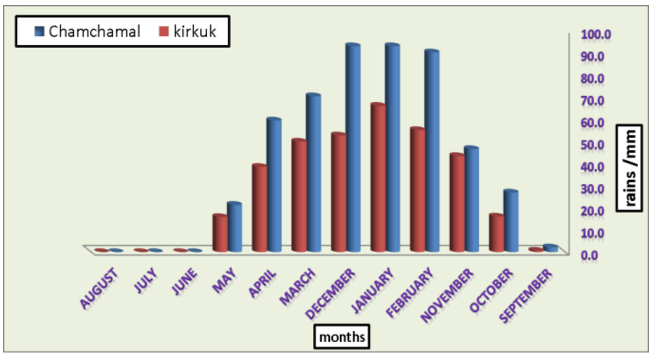

Figure 4. The average monthly total rainfall (km) for the study stations for the period (1989-2021).

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4. Natural Plants

The natural vegetation is of great importance in the hydrological studies through its density, quality, nature and distribution. Its effect appears in preserving soil stabilization and cohesion and protecting it from erosion, water and wind erosion. It also shows its role in obstructing the water surface runoff and allowing the rain water to leak into the ground. In order to detect the density and distribution of the vegetation cover, the vegetation index (NDVI) was relied upon, which was retrieved based on a satellite image (land sat 8) on 2020/4/28, which consists of (11) different spectral bands. The fourth spectral band indicates the reflection of red rays. (R). The fifth spectral band refers to the reflection of infrared radiation (IR) from plant leaves. Note map (1-2) and table (16-3). The vegetation cover index (Normalized Difference Vegetation-index (NDVI)) was calculated and analyzed according to the following equation (John, 2007) [9].

$$\text{NDVI}= \frac{\text{IR}-\text{R}}{\text{NIR}+\text{R}} \quad (1)$$

The value was close to (+1), indicating the density of the vegetation cover, which is in a good health condition and adapted to the prevailing environmental conditions. If the opposite occurred, or the values approached zero, then it indicates a low density of the vegetation cover and it has lost its vitality and is considered less dense and more scattered. It should be noted that any increase in the value of the index (NDVI) indicates an increase in the value of vegetation cover and vice versa. Thus, the relationship between them is positive. According to these space plants, the vegetation cover was classified into three zones, and they were verified in the field, and some types of plants were identified in each zone, As shown in Figure 5 and Table 1 as follows:

1-Low Density Plants

The low-density plants covered the area about 73.9 km (73.9 km) with a rate of (16.8%), and it thus constitutes an aerial spread in the study area, but it is the least dense in vegetation cover and is concentrated in the southeastern and central parts and scattered in the northwestern parts of the study area. Among the types of plants that indicate in this range It is (willow, tamarisk, warbler). As shown in Figure 5 and Table 2.

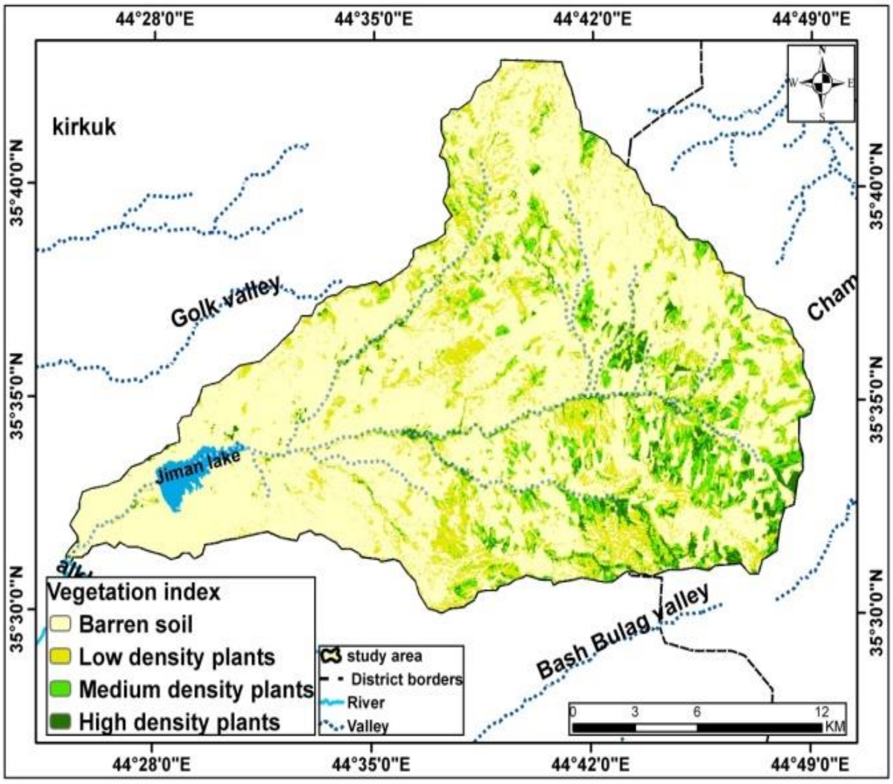

Figure 5. Vegetation index (NDVI).

Table 2. Plant coverage index i (DVIN), study area.

Vegetation density	The area (km^2)	Percentage%
1. Low Density	73.9	16.8
2. Medium Density	34.5	7.8
3. High Density	13.2	3.0

2-Medium Density Plants

The medium density plants covered the area bout is (34.5 km) and is (7.8%) of the total area of the study area. It is spread scattered in the eastern and northern parts. It is represented by the range of plants in the stomachs of deep valleys (Shalim, babonk, licorice, hawthorn wild, carrot wild).

3-High Density Plants

The high-density plants covered the area about is (2.13 km) and is (3%) of the total area of the study area. It is spread small, intermittent and scattered, especially in the northern and eastern parts of Chamchamal district, and this area is the densest, but the least area in the study area (Oak, Cranberries, Almonds, Cypress, pines, Walnut). It is clear from what has been studied the study area and how to choose the best and most suitable sites for the application of water harvesting through the selection of multiple methods such as earth dams and semicircular bodies because of their potential for successful water harvesting after studying the area from all the natural ingredients of formations and the nature of slope and analysis of soil samples and water in more than one location in the study area [10].

CONCLUSIONS

The main problem is characterized by the scarcity of water in the study area, so the best means for carrying out water harvesting projects will be addressed through the best appropriate methods for collecting rain water without losing it and benefiting from it for various human activities as well as agricultural and pastoral activity according to the environmental conditions that characterize the basin. The study shows that the increase in the number of hours of solar brightness and the increase in the amount of solar radiation affects the characteristics of the surface runoff of the basin, especially evaporation, as the number of hours of solar surface was recorded in two Kirkuk stations (11) hours / day, respectively, and it was recorded in the Chamchamal station about (12) hours / day. While it decreases during the winter months, reaching about (5) in Chamchamal station, respectively, while in Kirkuk station, it reached (6) hours / day, respectively. The highest monthly rates were recorded during the winter months (December) by (66.4, 66.7%) for both stations (Chemchamal-Kirkuk), respectively. While its lowest monthly rates were recorded during the summer months (August and July), when it reached (24.2% 24.2%), which can predict the presence of saturated soil, which reduces filtration and leakage after rain falls and generates surface runoff, which can be harvested and utilized from the water. For both stations, they are spatially and temporally dissimilar, as the highest average of their monthly totals was recorded during the winter season in Chamchamal station in January and February to (92.9 mm) respectively, then it decreased relatively during December as it recorded (90.1 mm). The annual rainfall was recorded in both stations (Chemchamal-Kirkuk) (502.3, 337.7 mm). It is clear from the foregoing that the plant has an important role in the presence of organic matter in the soil, which increases the seepage of falling rainwater and does not generate surface runoff. Therefore, the areas that are characterized by the presence of vegetation can be exploited by applying the harvesting methods designated for such areas that are characterized by water leakage into the ground, and therefore the soil is radiant with moisture, which can be cultivated directly, especially by applying the technology of mountain terraces that works to impede water and increase its seepage into the soil layer, especially These areas are characterized by their height and exposure to soil erosion after heavy rains.

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Disclosure and Conflict of Interest: The authors declare that they have no conflicts of interest.

REFERENCES

[1] I. A. Alwan, N. A. Aziz, and M. N. Hamoodi, "Potential water harvesting sites identification using spatial multi-criteria evaluation in Maysan Province, Iraq," ISPRS Int. J. Geo-Information, vol. 9, no. 4, p. 235, 2020. https://doi.org/10.3390/ijgi9040235

[2] M. ABDEL-FATTAH, S. KANTOUSH, and T. SUMI, "Integrated management of flash flood in wadi system

of Egypt: disaster prevention and water harvesting," B, vol. 58, no. B, pp. 485-496, 2015.

[3] S. Z. Jassim, A. S. Jibril, and N. M. S. Numan, "Gypsum karstification in the middle Miocene Fatha Formation, Mosul area, northern Iraq," Geomorphology, vol. 18, no. 2, pp. 137-149, 1997. https://doi.org/10.1016/S0169-555X(96)00018-9

[4] A. N. Strahler, "Quantitative analysis of watershed geomorphology," Eos, Trans. Am. Geophys. Union, vol. 38, no. 6, pp. 913-920, 1957. https://doi.org/10.1029/TR038i006p00913

[5] V. Kastelic, M. Vrabec, D. Cunningham, and A. Gosar, "Neo-Alpine structural evolution and present-day tectonic activity of the eastern Southern Alps: the case of the Ravne Fault, NW Slovenia," J. Struct. Geol., vol. 30, no. 8, pp. 963-975, 2008. https://doi.org/10.1016/j.jsg.2008.03.009

[6] A. Yazar and A. Ali, "Water harvesting in dry environments," Innov. Dryl. Agric., pp. 49-98, 2016. https://doi.org/10.1007/978-3-319-47928-6_3

[7] H. Allafta and C. Opp, "Spatio-temporal variability and pollution sources identification of the surface sediments of Shatt Al-Arab River, Southern Iraq," Sci. Rep., vol. 10, no. 1, pp. 1-16, 2020. https://doi.org/10.1038/s41598-020-63893-w

[8] Q. Shi, "Flood hazard assessment along the Western regions of Saudi Arabia using GIS-based morphometry and remote sensing techniques." 2014.

[9] A. P. H. S. Al-Daghastani, "Water harvesting search in Ninevah governorate using remote sensing data," Iraqi J. Desert Stud. Vol, vol. 2, no. 1, 2010. https://doi.org/10.36531/ijds.2010.51719

[10] N. Koshak and G. Dawod, "A GIS morphometric analysis of hydrological catchments within Makkah Metropolitan area, Saudi Arabia," Int. J. Geomatics Geosci., vol. 2, no. 2, p. 544, 2011.

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