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Using Landscape analysis techniques to prevent silt accumulation in the reservoir of the Dwerige weir project and developing River basin, Missan, South Eastern IRAQ

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Abstract
Water harvesting techniques developed globally during the last decades with highly increasing water crisis and climate changes. The Yeoman keyline method was spread widely with increased use for sustainable permaculture development. The main aim of the current study is to analyze and solve the siltation problem in Dwerige weir and to develop water resources in the basin area. The remote sensing data, field surveying, and hydrology are used together to build a new geotechnical approach. The results show that a huge siltation quantity was not considered in the weir design studies, which were represented by sand sheet materials and eroded soils washed by flooding and entering the weir reservoir through four main channels. The topography and hydrology of the study area are analysed, and the key points-keylines principle used by selecting the suitable contour lines to dig trenches along them to control soil erosion by decreasing flow velocity and holding part of floodwater to increase soil water content and recharge groundwater. The floodwater quantities are estimated in normal and storm cases, finally, the extra drain water is evaluated.

Keywords: *Keyline, Key points, Trench, Main ridge, Primary ridge, Primary valley, Water divide line*

استخدام تحليل التضاريس الطبيعية لمنع تجمع السلت في خزان سد الدويريج وتطوير منطقة حوض النهر الخاصة به. محافظة ميسان جنوب شرق العراق

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الخلاصة
شهدت الطرق المستعملة في حصاد مياه الامطار تطورا كبيرا في السنوات الأخيرة بسبب تفاقم ازمة المياه والتغيرات المناخية العالمية. وطريقة وايمان الخاصة باستخدام الخنادق على طول بعض خطوط الكنتور من الطرق التي انتشرت مع انتشار طرق الزراعة المستدامة. يعاني خزان سد الدويريج من مشكلة ارتفاع منسوب السلت والذي سبب توقف السد عن العمل. ولدى دراسة المشكلة من صور الأقمار الصناعية والمسح الموقعي تبين بان السبب الرئيسي هو كمية المواد الناعمة المنقولة من جبل الفكه الواقع الى الشمال من خزان السد والتي لم تؤخذ بالحسبان عند اعداد التصميم حيث تم احتساب المواد القادمة من النهر من إيران فقط. ومصدر

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هذه المواد الإضافية هي الرمال التي تتجمع على سفوح الجبال خلال فترة الصيف والمواد التي تنتج من تعرية التربة السطحية بالمياه حيث تنقل كل هذه المواد بواسطة السيول وتدخل الى خزان السد من خلال أربع قنوات او وديان رئيسية. لحل هذه المشكلة تم اعتماد تحليل طوبوغرافية المنطقة باستخدام مبادئ النقاط الدالة وهي النقاط التي يتغير عندها انحدار المنطقة والخطوط الدالة التي تصل بين هذه النقاط. حسبت الكميات المتوقعة للمياه الجارية من خلال معرفة كمية الامطار المتساقطة خلال الفترات الاعتيادية والمواسم الممطرة بشدة. تم دراسة الكميات الترابية للقنوات التي سوف يتم حفرها على طول الخطوط الدالة وكمية المياه التي سوف تخزن على طول هذه الخطوط. ان وظيفة الخطوط الدالة هي تقليل سرعة جريان المياه وتقليل التعرية والسماح لتسرب المياه الى داخل التربة و الى خزانات المياه الجوفية في اسفلها. تم أيضا تقدير كميات المياه التي سوف تزيد عن سعة خنادق النقاط الدالة وتقديم المقترحات حول كيفية الاستفادة منها. استنتجت الدراسة بان مشكلة الترسبات في خزان السد لايمكن حلها دون ان يتم معالجة مشكلة السيول القادمة من وديان جبل الفكة كما ان معالجة هذه السيول سوف يساعد في تطوير حوض النهر مستقبلا من خلال الاستفادة من مياه الفيضان القادمة من هذه الوديان.

Introduction

This paper covered part.2 of developing studies of Dwerige weir project (southeastern Iraq), which includes landscape analysis, hydrological analysis, and completing the geotechnical design of water harvesting systems. In this part, a practical approach was developed to study topography and analyse landscape parameters of the weir surrounding areas. The problem of silt accumulation in Dwerige weir reservoir was studied in detail by Al Siaede [1] .Dwerige weir is a small weir has (512 m) long and (3.5 m) Height above ground level. The weir storage capacity is about 1,870,000 Cubic meters of water in the upstream reservoir, Ministry of water resources [2], Missan consultant engineering bureau [3], Rasol, Z [4]. The construction works were completed, and the weir operated during 2016. The weir reservoir was filled with silt in 2019, causing problems for the river course by increasing flooding risks and decreasing the water supply for the surrounding areas [5].

Rainwater harvesting techniques depend on the principles of collecting precipitated from the catchment in the application (target) area during drying seasons. These techniques or systems comprise mainly catchment, storage, and application areas. The shape and size of the catchment area are used to classify water harvesting systems to the following [6];

A. Micro catchment systems
a. Rooftop and courtyards systems.
b. On-farm systems.
B. Macro catchment systems
a. Long slope systems
b. Flood systems.

Ground natural landscape analysis before the design of any hydraulic project like water harvesting structures and dams is a significant factor in reducing disadvantages like siltation and increasing the operating life of these projects, Oweis, et al [7], and Rahemi et al [8]. The landscape includes three water lines: contour, water divide, and drainage streamlines. These lines divided the landscape into three main shapes: main ridge, primary ridge, and primary valley [9]. The key point is the point on the hillside when it changes from convex to concave, and the line reached between different key points in the landscaped area has been named the keyline (Figure1), Yeomans [10], Molison [11] and Powers [12] . The objective of this study is to compute water runoff for these valleys to suggest a suitable keyline design to control flooding and soil erosion.

1. Location of the study area:

Dewerige weir is located at coordinates (741989E and 3551916N) on the southern limb of Faqi anticline. Faqi anticline is a NW-SE axis anticline located Southeast of Missan, adjacent Iraqi – Iranian international borderline. The anticline length is about (14 kM), and the width is about (3.5 kM), with low elevation (highest point about 80 m above sea level and (50 m) above ground level (Figure 2).

Figure 1-The keyline keypoint method details [12].

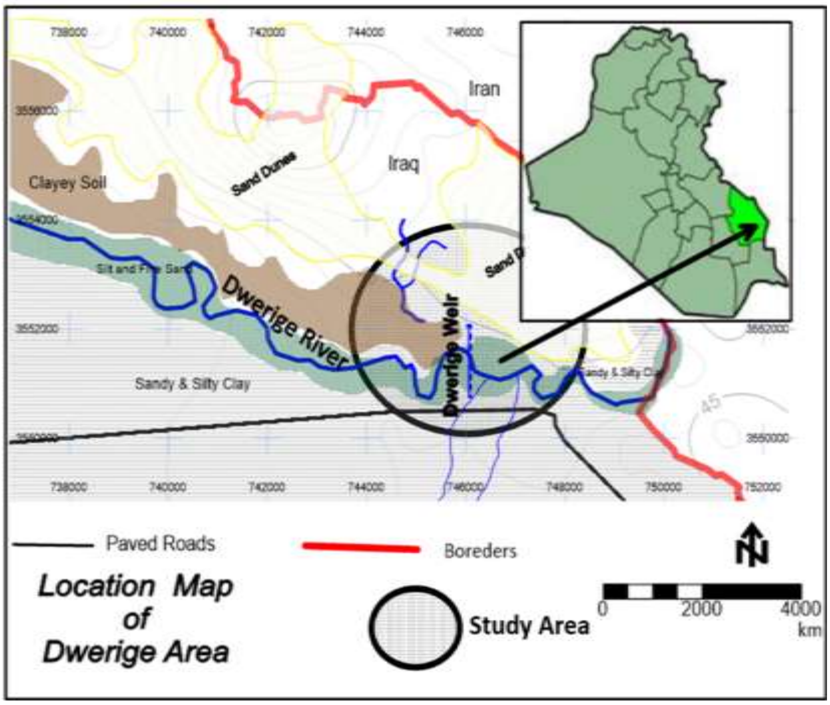

Figure 2-The location map of the study area.

2. The problem of the study

The main problem of the recent study is to analyse the silt accumulation problem in the weir reservoir. Satellite images and field works showed an extra huge amount of silts supplied from the Faqi anticline located to the north side of the weir. The main silt source is the eroded soil and torrents washed away sand sheets, which are transported during flood season and deposited finally in the reservoir. Four valleys have been observed studying which are believed to be the result of erosion of the area (Figure 3).

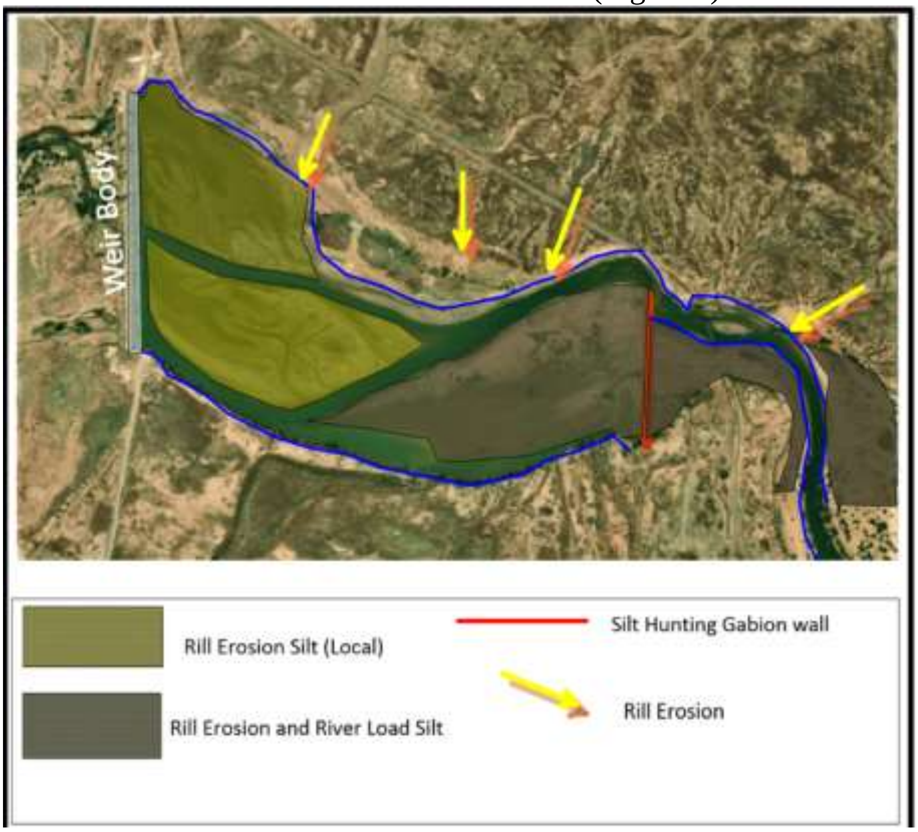

Figure 3- Satellite image shows silt distribution and rill erosion in Dwerige weir area.

3. Geology and hydrology of the area

The eastern Missan area is undulating terrain and represents a part of the Zagros foothill zone. The Recent alluvial fans and aeolian deposits covered the area with outcrops of alluvial Quaternary and Tertiary deposits Jassim and Goft [13]. The geological map of the study area was drawn using satellite images and field works, Figure (4). Dewerige river originates from the Zagros Mountains and enters Iraq from southeastern parts at an elevation of about 35 m flowing northwest direction to Hor Al-Sinaf. About 90% of the river lies within Iran's borders. The river is about (202 km) in, and width of about (800 m). The catchment area is 3270 km^2. The average length of the river in Iraq is about (35 Km) [14].

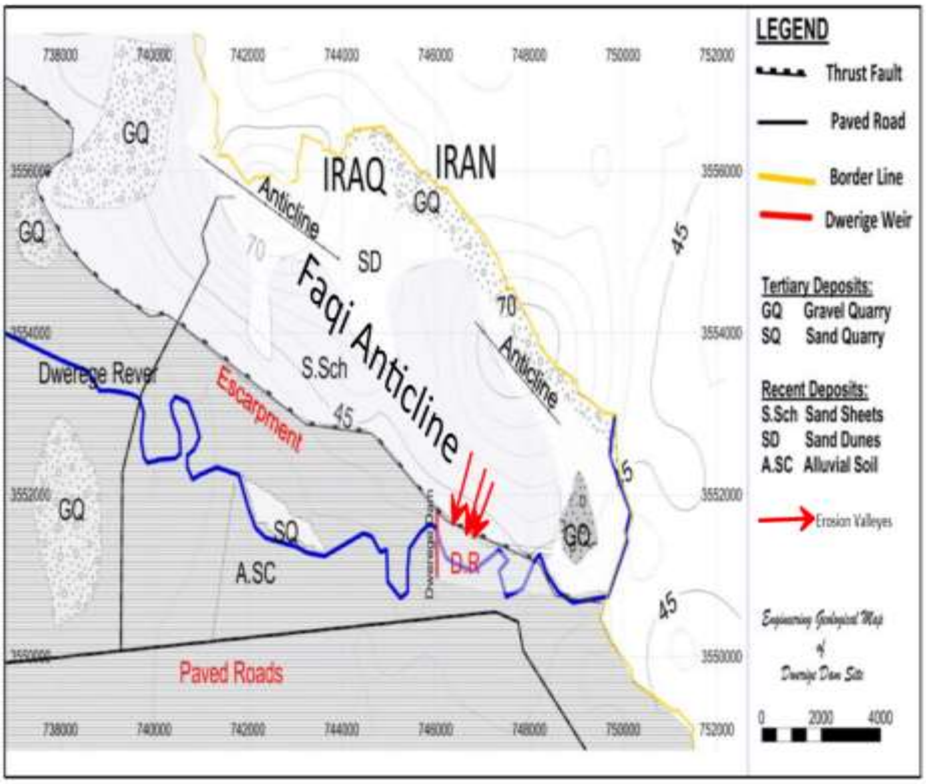

Figure 4-Geological map of the study area.

4. Climate conditions

Dwereige Weir area is arid to semi-arid, characterized by high temperature and increased evaporation during summer. The precipitation average is about 248 mm and the maximum value of (809.8 mm) Table 1, Rahi [15] The stormy precipitation due to global climate changes causes flooding risks. Two precipitation values are taken (200 and 810 mm) to estimate the limits of runoff quantity and for adequate keyline trench design (the precipitation of average and stormy are used).

Table 1- Precipitation (mm) on Dwerige Basin [14]

Year	Precipitation (mm)
2009	191.9
2010	262.5
2011	270.3
2012	206
2013	284.3
2014	260.8
2015	71
2016	95.4
2017	159.4
2018	121.2
2019	809.8
Average	248.4

5. Methodology

The study approach has been developed based on the topography, hydrology, water harvesting and permaculture techniques to find the best system for reducing siltation, soil erosion and desertification problems. The study techniques include the following steps;

1. The topography is studied carefully by satellite images and field investigation.

2. The digital elevation models, topographic and watershed maps, sun and wind direction plans, and soil properties are studied. The landscape was analyzed according to keyline procedure principles, Figure (5).
3. Measuring The surface area above each contour line on the topographic map automatically represents the catchment, while the surface area below each contour line represents the application area Table 2.
4. The key points are selected on the profile section drawing from contour data (Figure 6 A, B). the contours 35, 45 and 65 are selected as keylines to dig a trench along with them to collect water and increase water filtration to recharge groundwater aquifers in the area.
5. The rainfall volume in each catchment is computed as follows:

Total rainfall (m^3) = catchment area (m^2) x Average Annual Precipitation (m)…… (1)

6. Estimating the runoff of catchment above each contour line (runoff coefficient taken equal to (0.4) For the surface soil cover) as follows:

Runoff (m^3) = rainfall(m^3) x runoff coefficient…. (2)

7. The volume of earthworks per meter for the keylines trench (Figure 6 C) is computed according to the following equation:

$$E = d\,(b + z \times d) \quad \ldots\ldots (3)$$

Where E: earthworks volume per meter (m3/m).
b: the base width of the trench (m).
d: the trench depth (m).
z: the slope of the trench side

Typical value of b is 0.1 to 0.4m, d: 0.15 to 0.6m and: 1:1 to 4:1, the values for the three variables were taken (b=0.4m, d=0.6m, and z=4:1).

8. The volume of earthworks for each unit area (donum), (Iraqi donum=2500 m^2) is computed as follows:

$$V = E \times (2500/s) \quad \ldots. (4)$$

Where **S** is the distance between contour lines

6. The Result and Discussions

The area above and below contours are computed by topographic maps and the results are shown in Table 2. Runoff is calculated in each area by using equations 1 and 2 for normal and storm precipitation quantities (200 and 810 mm) respectively (Table.3)

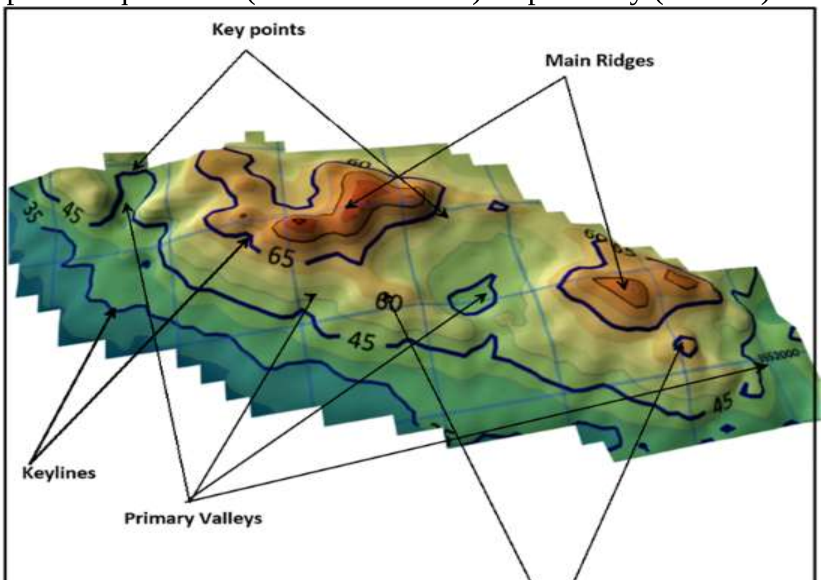

Figure 5-Landscape analysis of Faqi anticline.

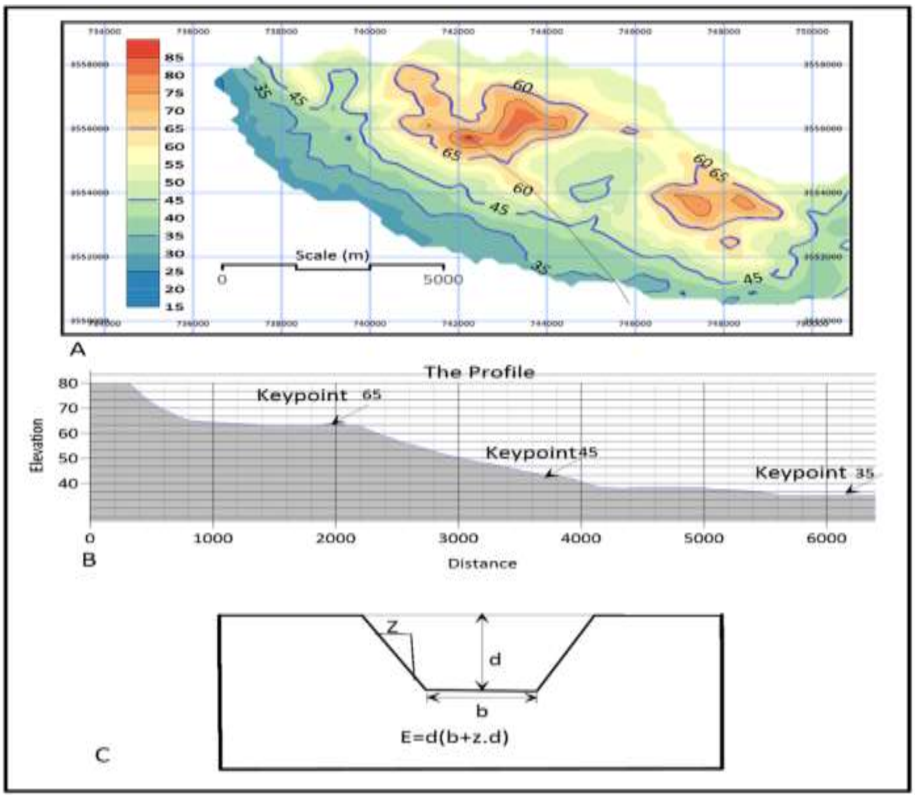

Figure 6-A-Selected 35, 45 and 65 contours as keylines, B-Keypoint profile, C- The main parameters of equation 3.

Table 2- The surface areas between the contour lines of Figure 6-A

Contour Value	Surface Area Above Contour(m^2)	Surface Area Below Contour(m^2)	Surface Area Between Contours(m^2)
10	66313063.66	0	3075042.512
15	63238021.15	3075042.512	11760254.43
20	51477766.72	14835296.94	11013693.68
25	40464073.04	25848990.62	10622881.92
30	29841191.12	36471872.54	6934868.813
35	22906322.31	43406741.35	6600894.378
40	16305427.93	50007635.73	5114186.585
45	11191241.35	55121822.31	3645425.829
50	7545815.517	58767248.14	3298027.447
55	4247788.071	62065275.59	2440689.094
60	1807098.976	64505964.69	1243828.938
65	563270.0379	65749793.62	416503.2833
70	146766.7546	66166296.91	122416.9197
75	24349.83493	66288713.83	24349.83493
80	0	66313063.66	n/a

Table 3-rainfall and runoff quantities in normal and stormy conditions above contour lines

Contour Value	Surface Area Above Contour	Av. rainfall (m3)	runoff (m3)	St. rainfall (m3)	runoff(m3)
10	66313063.66	13262612.73	6631306.366	53713581.56	26856790.8
15	63238021.15	51222797.13	25611398.57	51222797.13	25611398.6
20	51477766.72	10295.55334	5147.776672	41696991.04	20848495.5
25	40464073.04	8092814.608	4046407.304	32775899.16	16387949.6
30	29841191.12	24171364.81	12085682.4	24171364.81	12085682.4
35	22906322.31	4581264.462	2290632.231	18554121.07	9277060.54
40	16305427.93	3261085.586	1630542.793	13207396.62	6603698.31
45	11191241.35	2238248.27	1119124.135	9064905.494	4532452.75
50	7545815.517	1509163.103	754581.5517	6112110.569	3056055.28
55	4247788.071	849557.6142	424778.8071	3440708.338	1720354.17
60	1807098.976	361419.7952	180709.8976	1463750.171	731875.085
65	563270.0379	112654.0076	56327.00379	456248.7307	228124.365
70	146766.7546	29353.35092	14676.67546	118881.0712	59440.5356
75	24349.83493	4869.966986	2434.983493	19723.36629	9861.68315

Equations 3 and 4 were used to estimate the required removed soil volume to construct the keyline trenches. The results of computations are:
$E=1.68m^3/m$, $v=4.2m^3/donum$
The total area is about $46.1km^2$ (about 18440 donum).
The total soil volume that must be removed is about ($77,448m^3$). The holding water in the keylines trench can be estimated as equal to the total trench capacity ($77,448\ m^3$). The excess amount of runoff can be computed by subtracting the runoff above contour 35m from the trench capacity as below;
Excess water (Normal runoff) =2290632.231-77448=2213184.231 m^3
Excess water (Stormy runoff) = 9277060.540-77448=9199612.54 m^3
The results show that the best outlines of the main trenches are 35, 45 and 65 m as in the topographic map of the study area. These Trenches are collects the runoff water from the catchment area. Water running through these lines will decrease running velocity and reduces soil erosion and silt volume in the reservoir. This will excess water drained to the swamps (Marshes) through the Dwerige weir by a chanal or stored in a small earthen dam to be built later. The foundation problems of any hydraulic structure in this matter must be studied in detail before a decision is made to construct a dam.

References

[1] R. A. Siaede, "Geotechnical approach to calculate silt Voleum in Dwerige weir reservoir by direct surveying methods.," The Iraqi geological journal, vol. 1, no. 2, pp. 53-60, 2019.
[2] M. o. w. resources, "Dwerige weir design," unpuplished report, Amara, 2009.
[3] M. c. e. bureau, "geotechnical investigation report for Dwerige dam site," unplished, Amara, 2009.
[4] Z. Rasol, Geotechnical study for the Dwerige weir problems, Basra: unpuplished Msc. Thesis , 2018.
[5] Z. R. Riaed Al siaede, "Geotechnical study to assess the weir stability on heigh eroded soils," periodical of engineering and natural sciences PEN, vol. 1, no. 2, pp. 1412-1419, 2019.
[6] B. Lancaster, Rainwater harvesting for drylands and byound volume 1, london: Rainsource press, 2019.

[7] D. P. A. Y. Theib Y. Oweis, Rainwater hravesting for agriculturein the dry areas, CRC press, 2012.
[8] R. A. a. A. Yadollahi, "Raifed almond orchards in Iran, ancient and new methods and the value of water harvesting," in IV international symposium on pistachios and almonds , 2005.
[9] Yeomans, the challenge of landscape: the development and practice of keyline, keyline puplisher, 1958.
[10] Yeomans, water for every farm, keyline press, 2002.
[11] B. Mollison, Permaculture: A designer's manual, permaculture press, 1988.
[12] M. Powers, the permaculture student 2, pwerspermaculture, 2017.
[13] J. C. G. Saad Z. Jassim, Geology of Iraq, London: DOLIN, 2006.
[14] R. A. Siaede, "A practical geotechnical analysis of insitue stress variationsand hydraulic stability of small weirs using SEEP/W and SIGMA/W Simulation.," Iraqi Journal of science , vol. 3, no. 2, pp. 2457-2467, 2019.
[15] A. S. T. A. m. a. S. N. A. h. Khayyun A. Rahi., "Assessment of surface water resources of Eastern Iraq," Hydrology, vol. 6, no. 3, p. 57, 2019.