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Rainwater Harvesting of Hauran Valley, West of Iraq

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Abstract

The aim of this paper is to study the rainwater harvesting of Hauran valley in Iraqi Western Desert by using remote sensing techniques. Drainage patterns of secondary valleys are drawn. Digital Elevation Model (DEM) is applied to determine the typical locations of small dams or barriers of concrete or soil. Small lakes along Hauran valley will do to increase urban activities and can be useful for agriculture, irrigation and development of artificial forests to decrease the desertification phenomenon.

Keywords: harvesting, elevation model, barrier, irrigation, desertification.

حصاد مياه الامطار لوادي حوران، غرب العراق

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الخلاصة

يهدف البحث لمعرفة حصاد مياه الامطار لوادي حوران الواقع في الصحراء الغربية العراقية باستخدام تقنيات التحسس النائي. رسمت أنظمة تصريف المياه لبعض الوديان الثانوية التي تصب في وادي حوران. استخدم موديل الارتفاعات الرقمي لتحديد واختيار مواقع السدود الصغيرة أو الحواجز (خرسانية أو ترابية) وذلك لعمل بحيرات على امتداد مجرى الوادي والاستفادة منها في عمل وحدات سكنية مدنية وكذلك الاستفادة من مياهها في الري والزراعة وعمل الغابات الاصطناعية لزيادة الغطاء النباتي والتقليل من ظاهرة التصحر المنتشرة في تلك المنطقة.

Introduction

Hauran valley is ephemeral valley. It lies in Iraqi Western Desert. It runs northeastward from Iraqi, Jordan and Saudi Arabia borders. The valley drains into Euphrates River between Haditha and Al-Baghdadi cities at coordinate UTM (E828522.53 N3765627.86 meters). Its mouth locates approximate 200 km west of Baghdad Figure-1.

Two scenes of Landsat-8 LDCM (Landsat Data Continuity Mission) images 170-37 and 171-37 at date 12/June/2015 and 3/June/2015 respectively are used to cover the study area. Spatial resolution of Landsat-8 LDCM is 30 m for all bands except panchromatic (band 8) has special resolution 15m and thermal bands (10 and 11) have spatial resolution 100m. Layer stack for all bands which have spatial resolution 30m (bands 1, 2, 3, 4, 5, 6, 7 and 9) are applied to produce multispectral band. Merging bands are done by ERDAS software between panchromatic band and multispectral band to increase the spatial resolution of the bands from 30 m to 15 m. Mosaic of two scenes and image subset are done.

Routine Aster Global Digital Elevation Model (DEM) has resolution of 30m is used to draw secondary drainage basins of Hauran valley and determine the location of the dams or barriers. Several

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software's such as ERDAS IMAGING version 2014 and ArcGIS version 10.3 are used to get data about the maps of the selected area. Several enhancement processes e.g. histogram equalization, color composite and high pass filter are applied to the scenes. High resolution enhanced satellite imagery allows the linear features and geomorphological units to appear clearly.

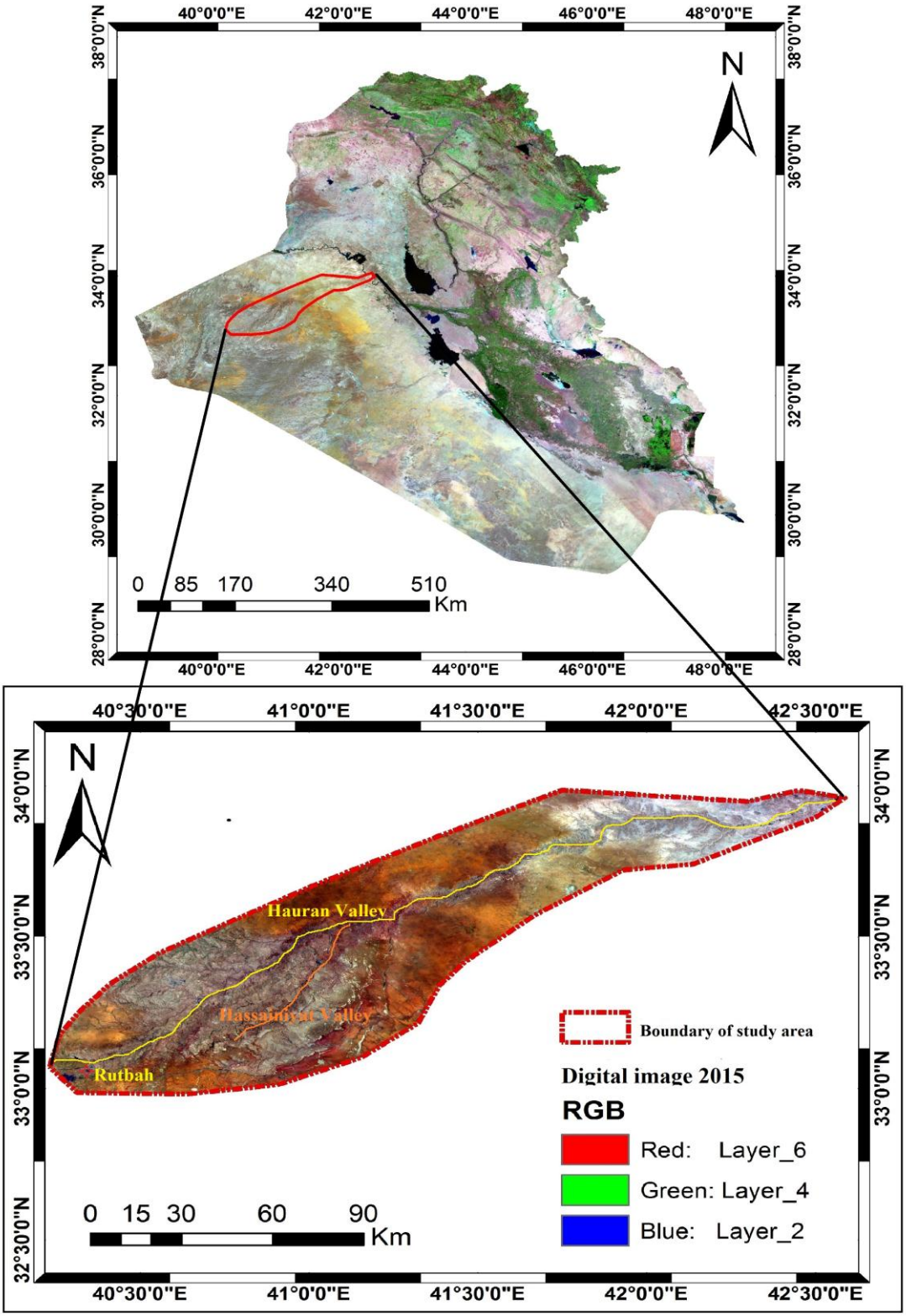

Figure 1- Location map of study area

The Climate:

The climate factors obtained from Haditha station for the period (1971-2010) and Rutbah station for the period (1971-2010) are summarized in Tables-1 and 2 respectively [1].

Table 1- Average climatic factors from Haditha Station for the period (1971 – 2010)

Parameter	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Aver.
Rainfall (mm)	20.8	26.7	21.1	19.2	6.2	0.2	0.0	0.0	0.3	5.7	17.0	24.5	11.8
Evaporation (mm)	46.9	75.8	121.3	204.1	311.2	418.1	496.0	446.4	370.9	240.6	117.1	53.4	239.5
Deficit (mm)	26.1	49.1	100.2	184.9	305	418.1	496.0	446.3	370.9	234.9	100.1	28.9	227.7
T(C°)Max	13.9	16.7	21.4	28.0	34.6	39.6	42.3	42.2	38.4	31.5	22.0	15.3	28.8
T(C°)Min.	2.7	4.3	7.8	13.3	18.4	22.9	25.5	24.9	21.1	15.5	8.0	4.1	14
Wind speed (m/s)	2.4	2.8	3.3	3.4	3.6	4.8	5.4	4.6	3.2	2.5	2.2	2.4	3.5

Table 2- Average climatic factors from Rutbah Station for the period (1971 – 2010)

Parameter	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Aver.
Rainfall (mm)	22.7	21.2	24.6	23.9	7.2	0.01	0.0	0.0	0.01	6.7	13.0	24.0	11.95
Evaporation (mm)	55.6	81.6	121.6	202.1	295.5	377.5	420.7	402.0	353.5	233.5	115.9	61.3	226.7
Deficit (mm)	32.9	60.4	97.0	178.2	288.3	377.5	420.7	402.0	353.5	226.8	102.9	37.3	214.8
T(C°)Max	13.2	15.3	19.4	25.9	31.6	35.7	38.3	38.1	35.8	29.4	20.7	14.6	26.5
T(C°)Min.	1.9	3.1	6.5	11.8	16.6	20.2	22.8	22.4	19.2	14.1	7.6	3.6	12.5
Wind speed (m/s)	3.0	3.7	4.0	3.9	3.6	3.9	4.1	3.5	2.7	2.6	2.5	2.8	3.5

According to climate classification the study area is located in arid climate, hot and arid summer and cold and rare rainfall winter. Knowledge of average rainfall, evaporation and deficit reflects the importance of this research and how can use the surface runoff to store its water either as lakes above earth's surface or subsurface aquifers.

Surface runoff represents the rainfall subtracts the amount of evaporation and infiltration. The evaporation influences by temperature, humidity and wind speed whereas the infiltration influences by geological sitting, topography, type of soil, land cover and land use. Rainwater harvesting is the ideal technique of fresh water supply for this area because of not only the climate factors (low rainfall and high evaporation and temperature) but also deep of the groundwater levels eventually deep of the water wells. Finally most of wells have salty water except area of Rutba city therefore the research concentrates to area between Rutba and Euphrates.

The geological sitting:

The Iraqi Western Desert, where Hauran valley is located, is a part of stable shelf of Arabian platform. Structurally, the area of Hauran valley is almost flat terrain. The strata are approximate horizontality which has gentle dip northward or northeastward. Significant surface structures are absent except NW-WE trending faults are developed in the central part of Iraqi Western Desert that pass through Hauran valley. [2, 3] described these faults as a vertical horst and graben forming normal faults that are partly associated with horizontal displacement. [4] Named these faults Hauran Fault System and characterized them as left strike slip faults with straight trace extending between few to 120 km. The displacement varies considerably along the faults ranging from few to 6 km. Hauran Fault System well be considered when determine the location of the small dams.

Stratigraphy, the age of exposed rocks in Hauran valley are ranged from Upper Triassic to Quaternary deposits. The oldest formation is Zor Horauran Fn. (Upper Triassic). It exposes in Rutbah city and extends along Hauran valley for about 56 Km Figure-2. The formation consists of yellow and green gypsiferous marl and shale, interbedded with yellow marly limestone, limestone and dolostone

[5]. The Jurassic Formations are exposed as strips along right bank of Hauran valley then exposes along the valley in small area Figure-2. They represent Ubaid Fn. (L. Jurassic), Hussainiyat Fn. (M. Jurassic), Amij Fn. (M. Jurassic), Muhaiwir Fn. (M. Jurassic) and Najmah Fn. (U. Jurassic). Five sedimentary cycles represent Jurassic period, each cycle consists of clastics overlain by carbonates, with some exceptions [6].

Nahr Umr Formation (Early Cretaceous) exposes along Hauran valley northeastward. It divides into two parts. A lower part consists of yellow, greenish grey, pink and brown sandstone. An upper part consists of yellow and pale green, fossiliferous marl interbedded with (2-3) horizon of fossiliferous, yellow and brown limestone [2]. Sheikh Alas Formation (Early Oligocene) exposes in Hauran valley and extends downstream for about 35 Km. It consists of creamy, yellowish white, porous limestone [7]. Euphrates Fn. (M. Miocene) exposes along of Hauran valley in area near the Euphrates River. [8] divided it into three members:

1. Lower Member consists of basal conglomerate, followed by dolostone and dolomitic limestone.
2. Middle Member consists of white, fossiliferous limestone, alternated with pseudoolitic chalky like limestone.
3. Upper Member consists of alternation of grey limestone with green marl. Nfayil Fn (Middle Miocene) is exposed as patches in Hauran vicinity. It consist of two members, lower member consists of three cycles, each one consists of green marl and grey fossiliferous limestone, and upper member consists of cycle deposits, each one consists of reddish brown claystone, siltstone and sandstone with thin limestone [9].

Finally, Hauran gravels (Pleistocene) expose in both bank of Hauran valley Figure-2. They compose of loose rounded pebbles of different sedimentary rocks. The size of the pebbles is ranged from 1-10 cm.

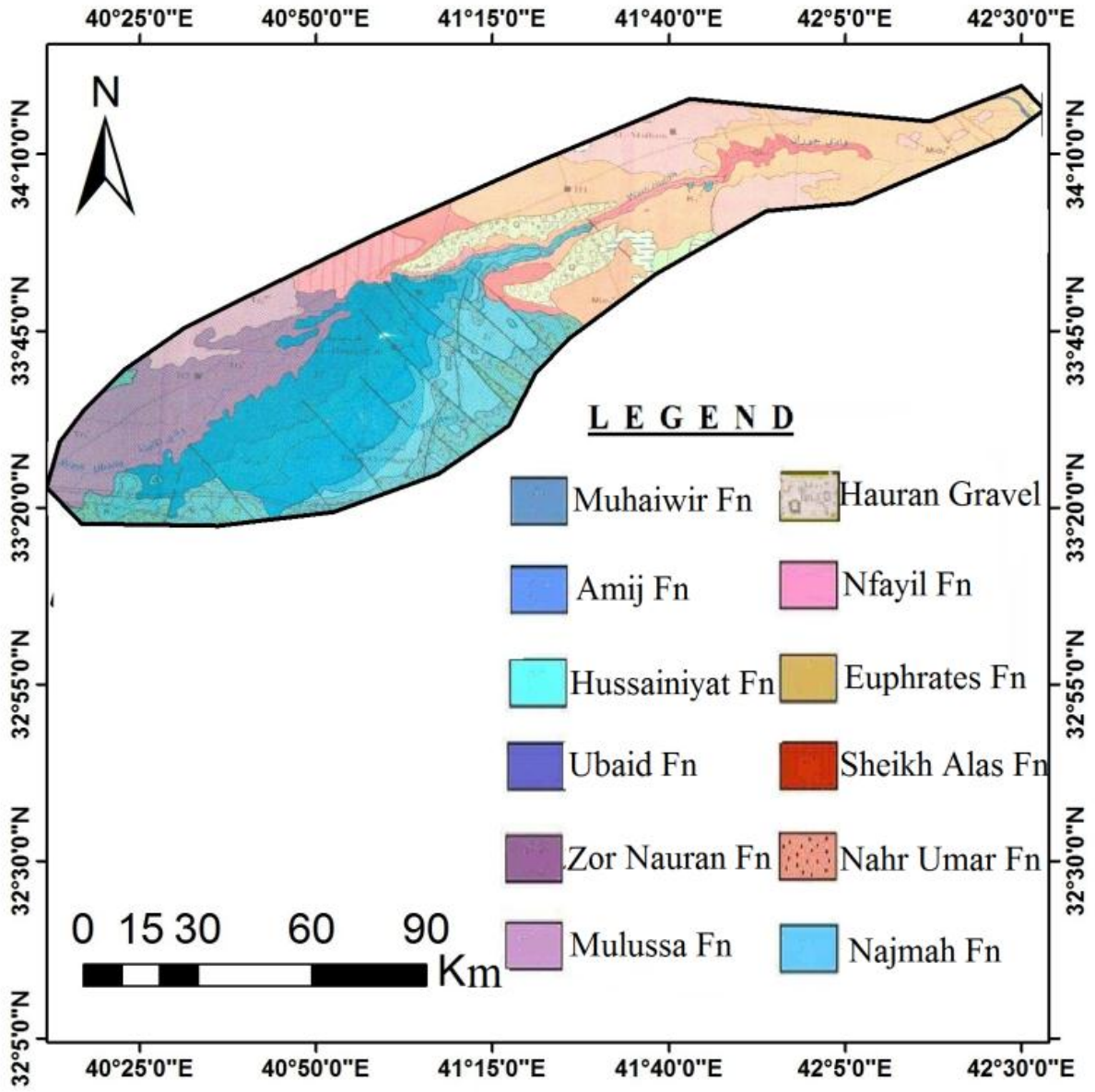

Figure 2- Geological map of study area, modify from geological map of Iraq [10]

Locations of the dams or barriers

Although Iraqi western desert locates in stable shelf but geological map of Iraq shows some strike slip faults cross the channel of Hauran valley in limited area Figure-2. These faults are inactive during last decades. The faults and some factors are considered when determine the location of the dam or barrier. Generally most of exposed rocks in the valley are hard limestone. They are good base for dam or barrier site and can be used them for investiture of the front side of the barrier. The site of dam is chosen in hard, narrow and has high shoulders section of secondary valley to decrease the cost of dam construction. Size of secondary drainage basin and open area in front of the dam to store water are considered too.

Five secondary drainage basins along Hauran valley are chosen between Rutbah City and Euphrates River by determining the water divide of them within drainage basin of Hauran Figure-3. Stream orders of the secondary drainage basins and morphometric studies of them are done by using software ArcGIS 10.3 Tables-3, 4 and 5 and Figures (4 - 13).

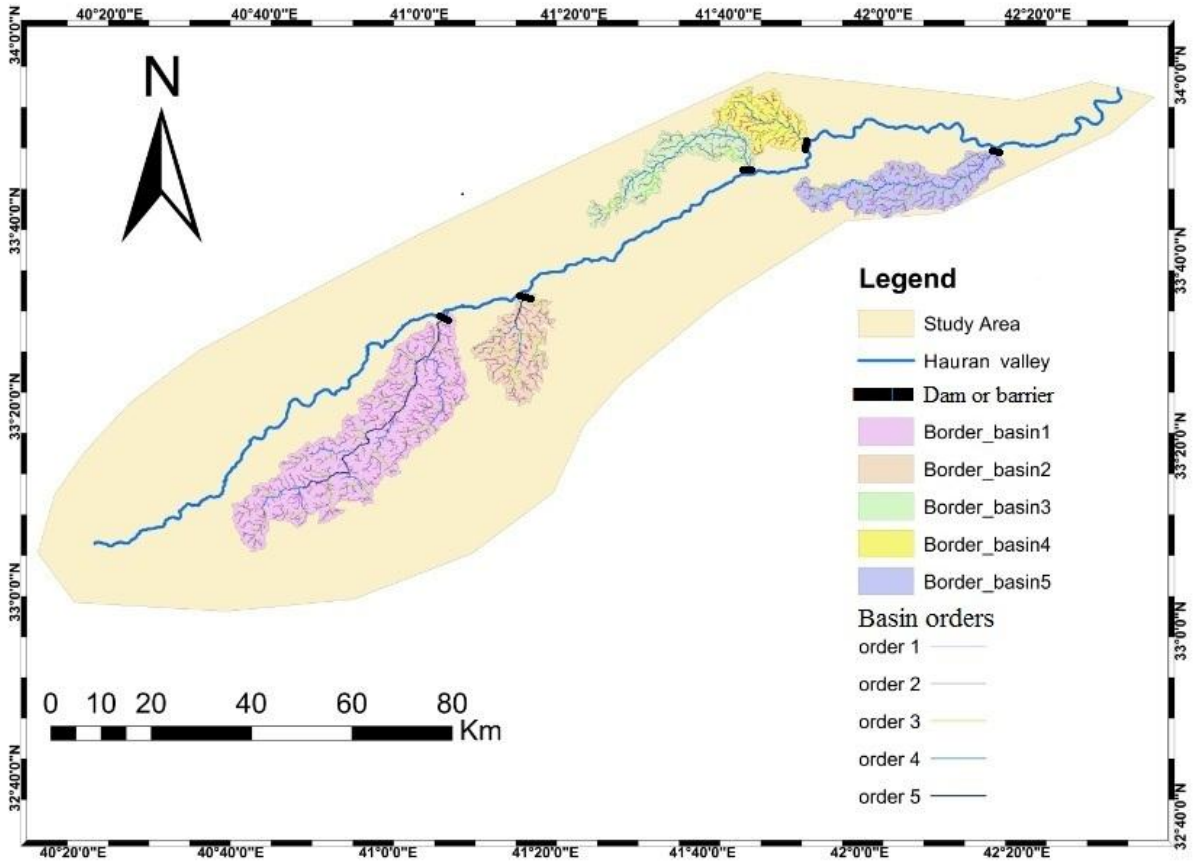

Figure 3- Five secondary drainage basins that drain in Hauran valley are chosen in study area

First secondary drainage basin, Wadi Al-Hassainiyat, is typical sample of the water harvesting and dam construction. It has a large area, 762.751 Km^2, five stream orders and the length of the basin is 61.335 Km. The cross section profile of the dam located at the end of the order five therefore the basin utilizes all water that runoff at the basin. It has good shoulders. Maximum height of the dam is 26 m depend on left shoulder. Width of the dam at the top of the dam is 440 m Figure-5. The location of the dam is in area of no dam or lake available.

Second secondary drainage basin has five stream orders. Good area but small in comparison with the first basin. It has good cross section profile; the two shoulders have same height. Maximum height of the dam is 26 m and the width at the top of the dam is 550 m Figure-7. Third and fifth secondary drainage basins are elongate. They have four stream orders and good area especially the later Table-5. They have good cross section profiles and shoulders. Maximum heights of the dams are 29 m and 11 m respectively. Width of the third dam at the top of it is 490 m whereas the width of the fifth is 290 m. Forth secondary drainage basin is the smallest in area. It has four stream orders and good cross section profile. Maximum height of the dam is 14 m and the width at the top of it is 305m. Finally all the cross section profiles are chosen not only depend on the best location of the dam but also the best volume of the lake beyond the dam or the barrier.

Table 3- Morphometric analysis depends on numbers of stream orders of secondary drainage basins.

Basins	Order one	Order two	Order three	Order four	Order five
1st basin	546	153	68	8	1
2nd basin	137	31	9	2	1
3rd basin	132	27	3	1	--
4th basin	123	26	6	1	--
5th basin	212	48	8	1	--

Table 4- Morphometric analysis depends on lengths (in Km) of stream orders of secondary drainage basins

Basins	Order one	Order two	Order three	Order four	Order five
1st basin	483.743	226.997	121.285	61.842	58.881
2nd basin	123.730	70.825	40.659	14.513	8.088
3rd basin	106.960	64.294	28.832	44.096	--
4th basin	93.453	47.451	30.884	23.714	--
5th basin	170.644	103.162	34.435	52.291	--

Table 5- Morphometric analysis of secondary drainage basins

Basins	1st basin	2nd basin	3rd basin	4th basin	5th basin
Area of basin $(Km)^2$	762.751	201.811	188.32	151.335	282.
Perimeter of basin(Km)	240.851	115.329	154.919	84.546	146
Sum of order lengths (Km)	952.762	257.812	244.185	195.503	360.533
Length of basin (Km)	61.335	23.68	45.22	20.60	42.65
Width of basin (Km)	12.437	8.522	4.164	7.346	6.612
Bifurcation ratio	5.58	3.59	5.629	5.05	6.139
Shape index	0.203	0.36	0.092	0.357	0.155
Relief ratio	3.456	6.326	4.312	6.99	4.807
Area cohere nce ratio	0.167	0,192	0.1	0.232	0.166
Perimeter coherence ratio	2.447	2.282	3.162	2.076	2.454
Drainage density Km/Km^2	1,25	1.28	1.3	1.29	1.28

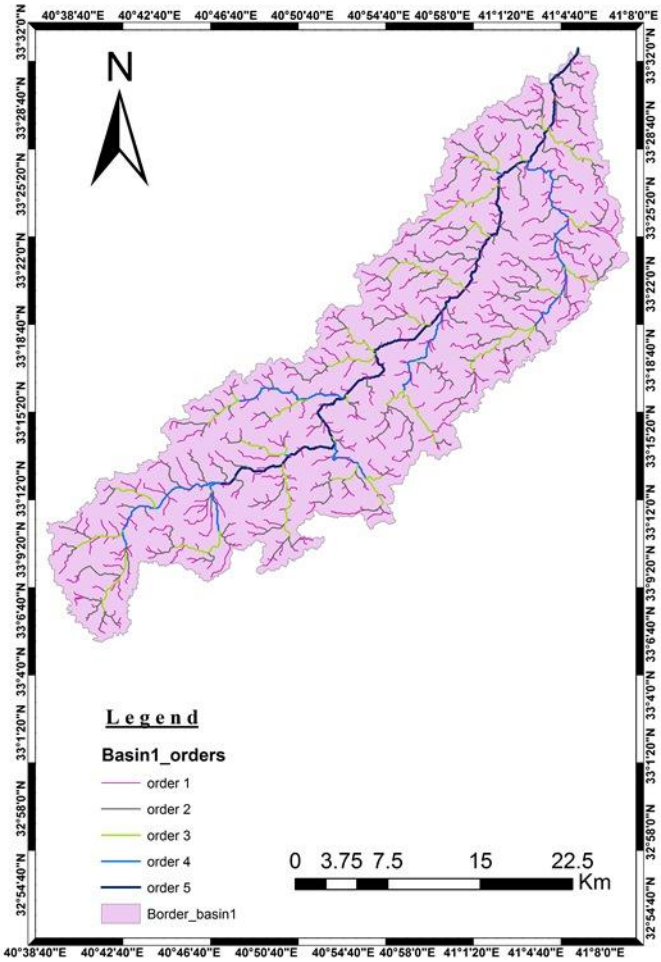

Figure 4- Secondary drainage basin No. 1

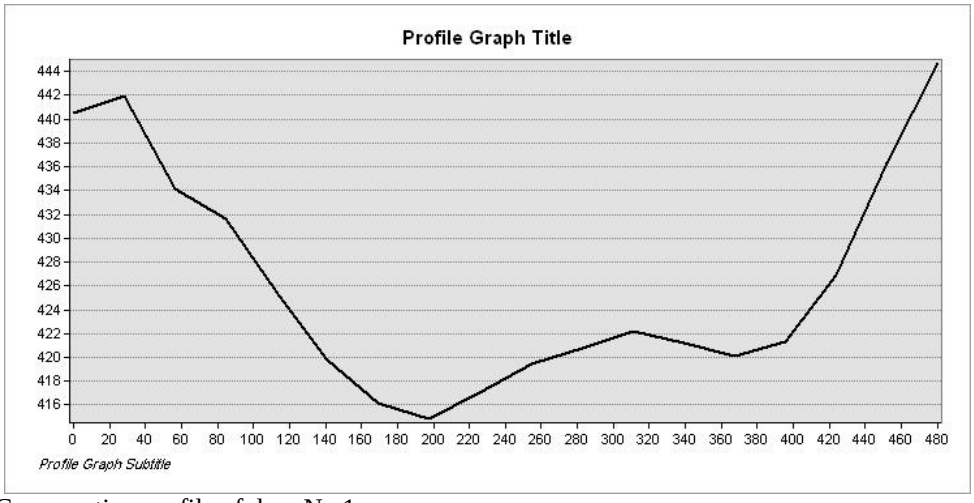

Figure 5- Cross section profile of dam No 1
Location: Long. 41.0842E – Lat. 33.5318N
Max. dam height: 442 - 415= 26M
Dam length: 440M

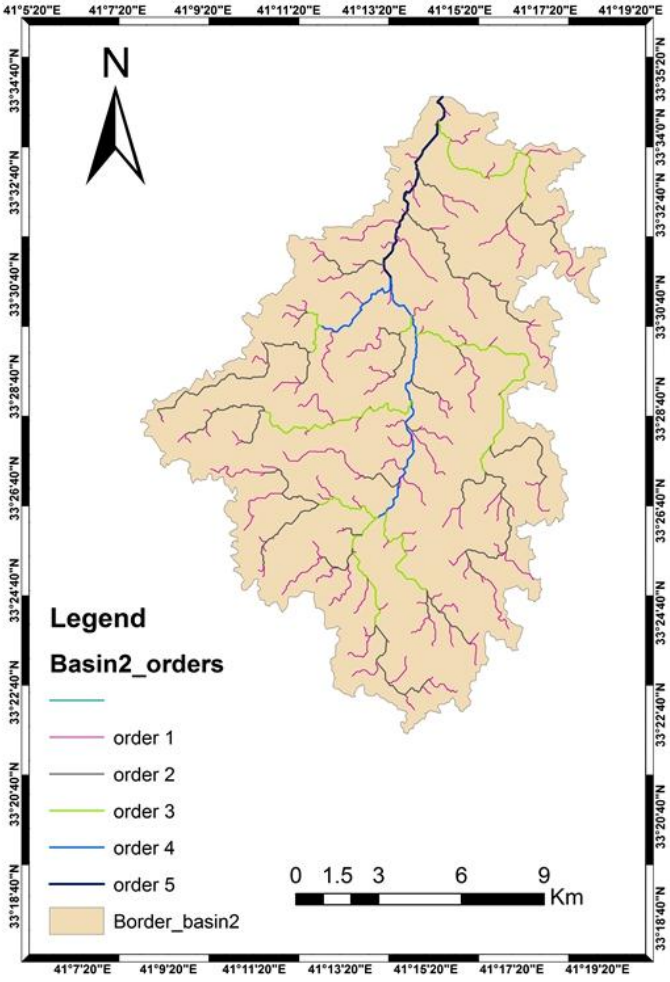

Figure 6- Secondary drainage basin No. 2

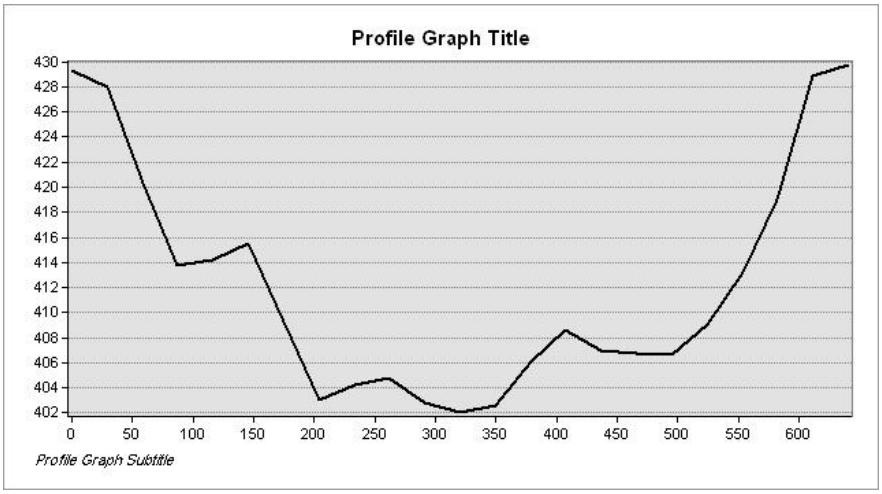

Figure 7- Cross section profile of dam No 2
Location: Long. 41.2513E – Lat. 33.5732N
Max. dam height: 428 – 402 = 26M
Dam length: 550 M

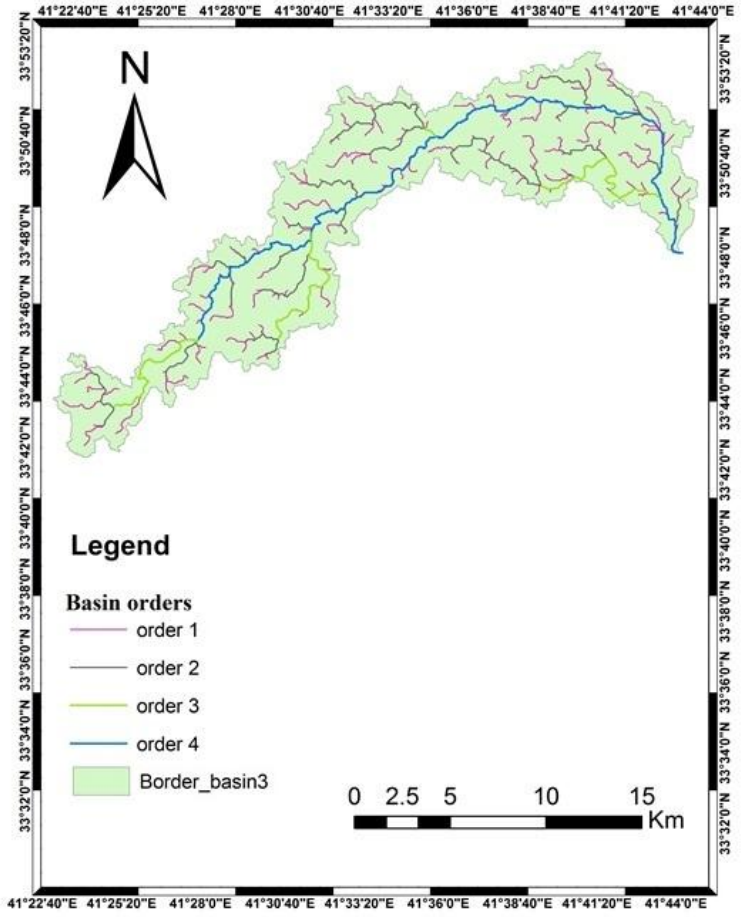

Figure 8- Secondary drainage basin No. 3

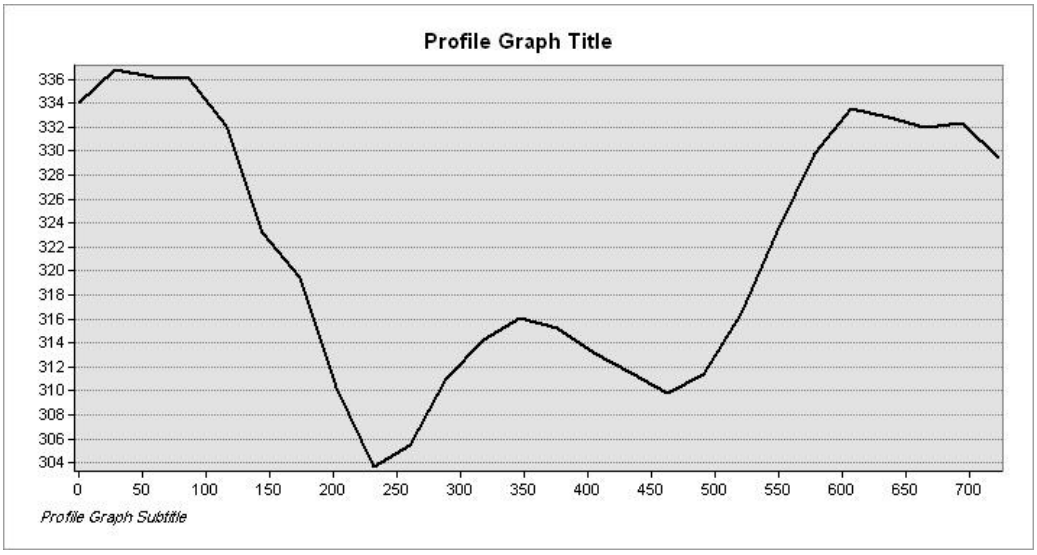

Figure 9- Cross section profile of dam No 3
Location: Long. 41.721E – Lat. 33.8035N
Max. dam height: 333 – 304 = 29M
Dam length: 490M

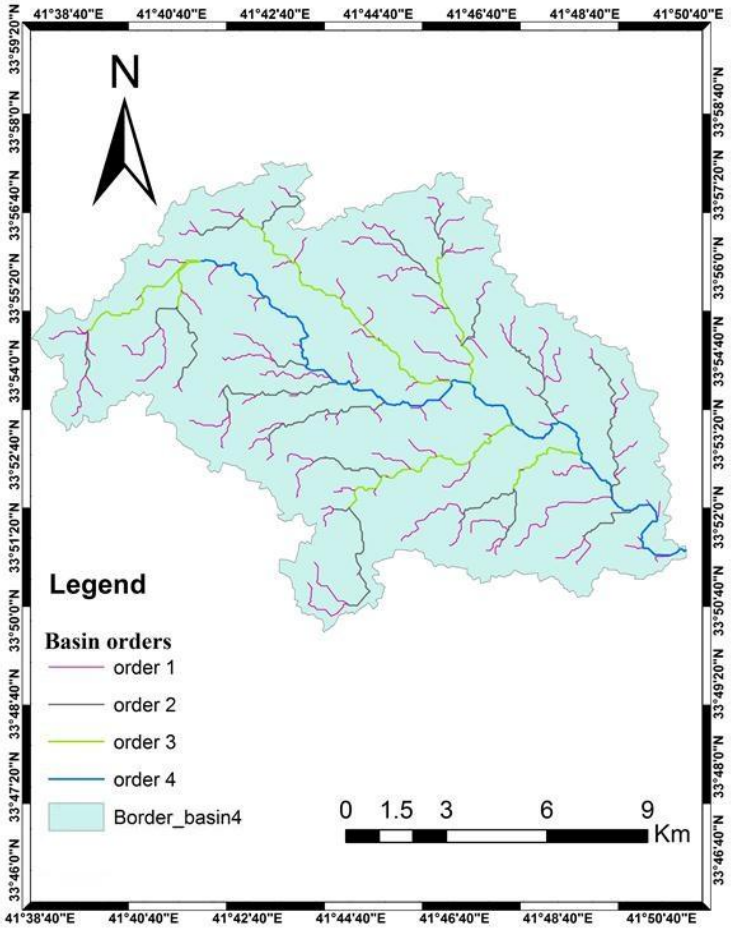

Figure 10- Secondary drainage basin No. 4

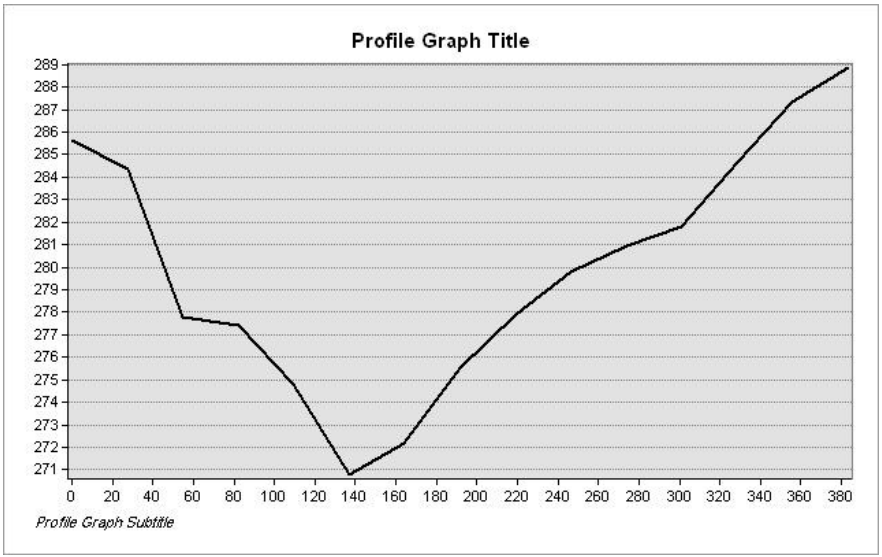

Figure 11- Cross section profile of dam No 4
Location: Long. 41.8438E – Lat. 33.857N
Max. dam height: 285 – 271 = 14M
Dam length: 305M

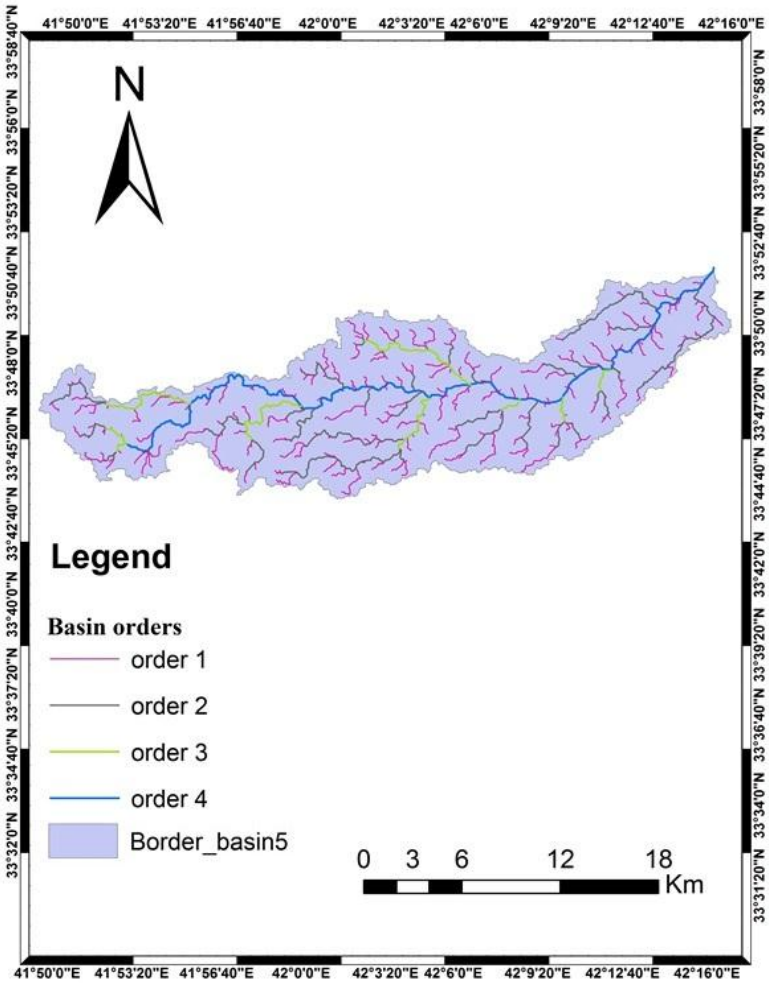

Figure 12- Secondary drainage basin No. 5

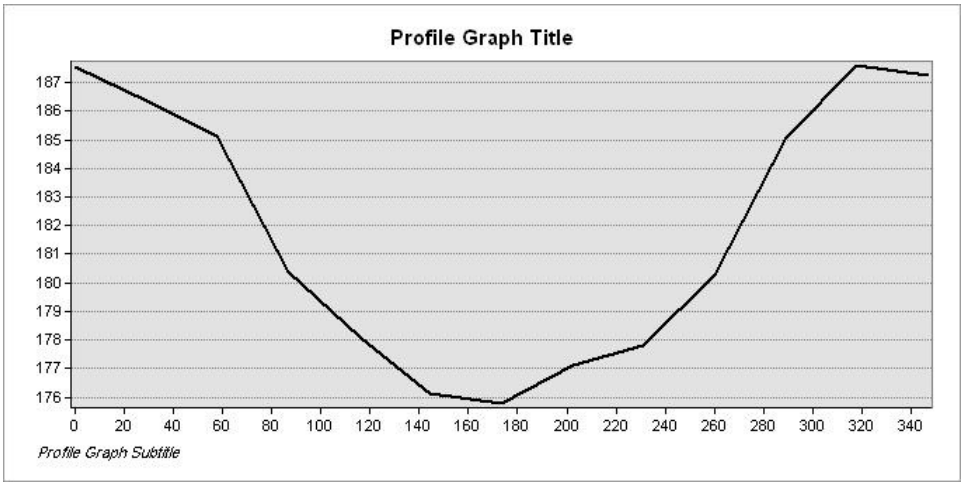

Figure 13- Cross section profile of dam No 5
Location: Long. 42.2578E – Lat. 33.8607N
Max. dam height: 187 -176 = 11M
Dam length: 290M

Discussion

This research focuses along Hauran Valley from Rutbah City downward to Euphrates River because of Rutbah City has a shallow fresh water aquifer and there are some barriers along Hauran Valley upward, whereas no dam or barrier through study area is available, but some deep wells of salty water.

Desertification phenomenon increased in Iraqi Western Desert during last three decades, therefor typical useful of seasonal rainwater must be done. Small lakes will develop on some secondary valleys that drain in Hauran valley by construct small dams or barriers of concrete or soil. The lakes can be useful for urban activities, irrigation, agriculture and development of artificial forests. It's important to mention that the soil of the Iraqi western desert is immature calcareous, clayey and very fertile when water is available [11]. All above activities can be monitored by using remote sensing techniques.

Materials of dam or barrier construction such as soil, silt, sand, gravels and rocks are available in area of Hauran valley. One problem perhaps agonist of this project is the materials (sand and gravels) or suspensions (clay and silt) that the surface runoff water is bring and deposit them on floor of the lake. Two factors are considered to decrease the depositional materials, the size of the secondary drainage basin is small and the slope of valley channel is low. Finally can be develop this research in whole Iraqi western desert particularly there is net of main and secondary valleys, some of them drain in Euphrates such as Al-Walaj, Swab, Akash, Ratga, Mana`i, Halgum, Chabbab, Khazga, Qasir, Fhaimi, Akhdhar, Haqlan, Asadi and Mohammadi, other drain in Razazzah lake such asHzaimi, Ghadaf, Abu Mindhar, Meela, Tabbal, Ubayidh, Hamir, Saffawiyat Al-Shaikh, and Saffawiyat Al-Ubaidat, that play major roll to increase the vegetation cover in try to decrease the desertification phenomenon and the bulletin by sand storm.

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