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Possibility Rainwater Harvesting at Western side of Al-Najaf Provence, Iraq

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Abstract

The research aims to highlight on the largest wades in the study area (wade Al-Khur and wade Haussab) which are located in the West of Al-Najaf province and study the possibility of investing in rainwater harvesting through establishment of several submersible dams. Building such of these dams their have many benefits for the region like the protection from floods, obstructing the waters to get more time to penetrate through the soil column, recharging of groundwater from aggregate of water behind the dam via injection of water directly in the groundwater aquifer by use the modern methods. On the other hand, existences of such water ponds which allow to provide the water to the local population (Bedouin) and watering their animals, also it can be used for irrigation. Drainage patterns of secondary valleys are drawn by using Digital Elevation Model (DEM) is applied to determine the typical locations of small dams or barriers of concrete or soil. Several of field traps were conducted in the study area, where the main course of both wades were tracked to determine the most appropriate location for constructions such of these submersible dams in the region.

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Introduction

The studied area is located within the Southern Desert, central Iraq in the western side of Al-Najaf province. It lies between the latitudes (31° 8'43.74" - 31°26'8.38") N, and the longitudes (44° 2'42.33"- 44°30'52.30") E, with an area of 9630 km², (Fig.1). Southern Desert is part of the Arabian platform, it's covered by the marine carbonate sedimentary deposits for Tertiary period as well as, its contents to a younger continental clastic deposits, (Ma,ala, 2008). The eastern and northeastern side of the study area are represented as a discharge zone for big basin that extended to extensive distances, regionally and locally to the West and southwest. Surface runoff that flows in many of wades towards the discharge zone that governed by the gravity force such as, wade Al-Khur, Haussab and AlRhimawi, (Al-Jiburi and Al-Basrawi, 2007). The region is characterized by a simple of low hills, (Al- Atia, 2006). The elevation of ground ranging of (10-281m) above the sea level and the gradient of lands is generally from the West and southwest to the North and northeast with low degrees of slope. The slope of wades are trend to the East and northeast direction which are working by transporting of rain water from the high regions in the western and southwestern side of the study area to the East and northeast, to the low lands forming the marshes, (Fig. 1).

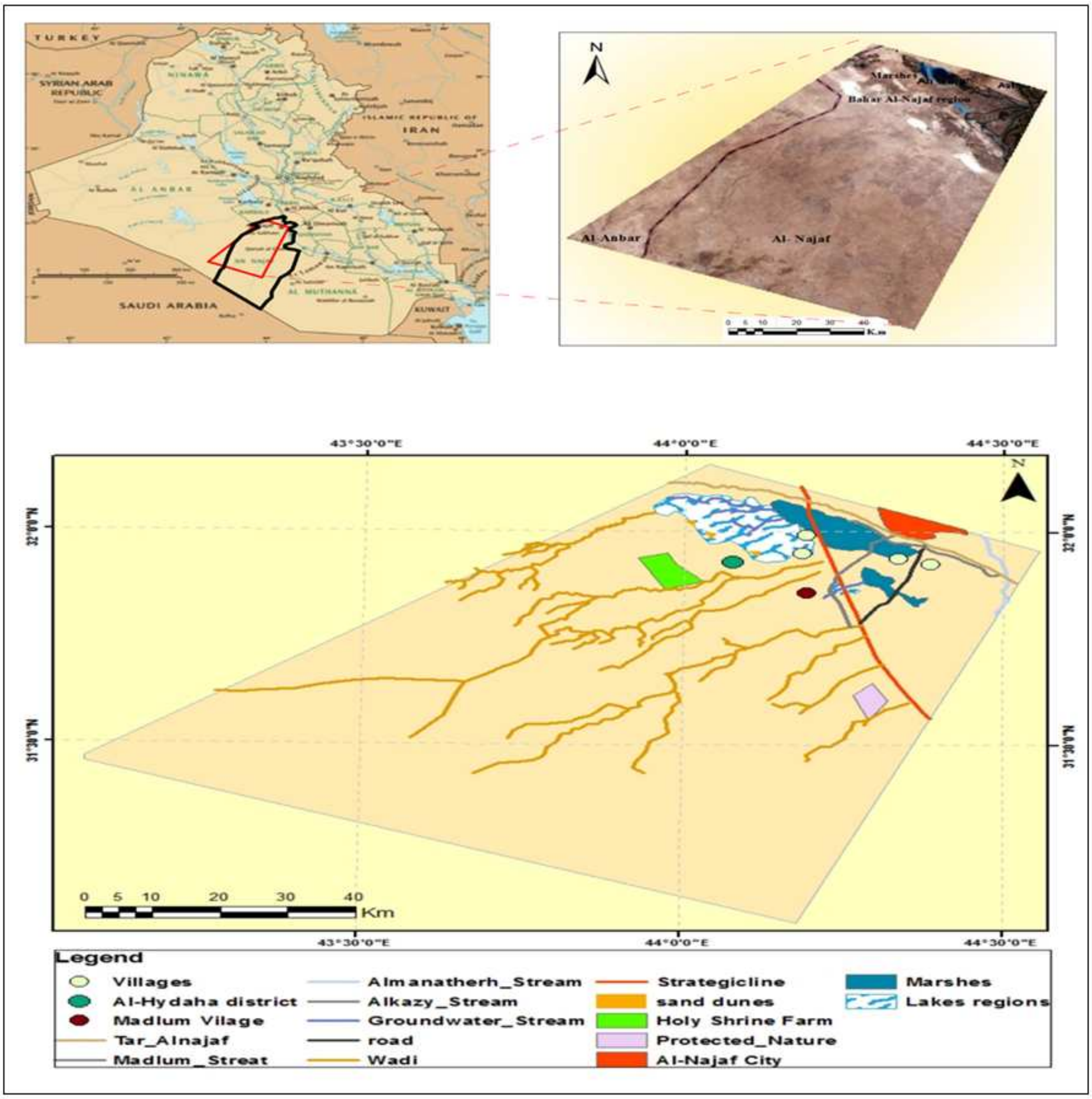


Fig. 1. Location map of study area.

Several 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. Routine Aster Global Digital Elevation Model (DEM) has a resolution of 30m is used to draw the secondary drainage basins including streams, watersheds, drainage network, slope, and flow direction for runoff routing through a network of the basin by using Arc Hydro tools version 10.3, in addition to determine the location of the dams or barriers on the maps after conducting the site preview in the field. In addition to, used the satellite data of ALOS (Advanced Land Observing Satellite) Global Digital Surface Model (DSM) "ALOS World 3D - 30m" (AW3D30) dataset with a horizontal resolution of approximately 30-meter mesh (1 arcsec) and Height accuracy 5 meters, which obtain from website of veloped by Japan Aerospace Exploration Agency (JAXA).

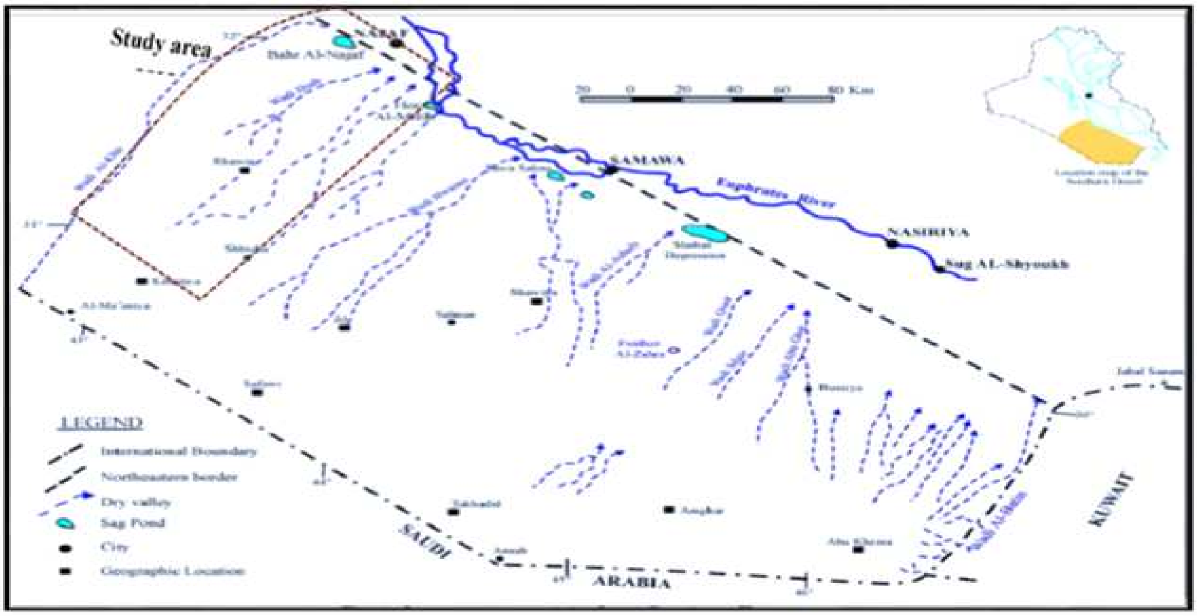


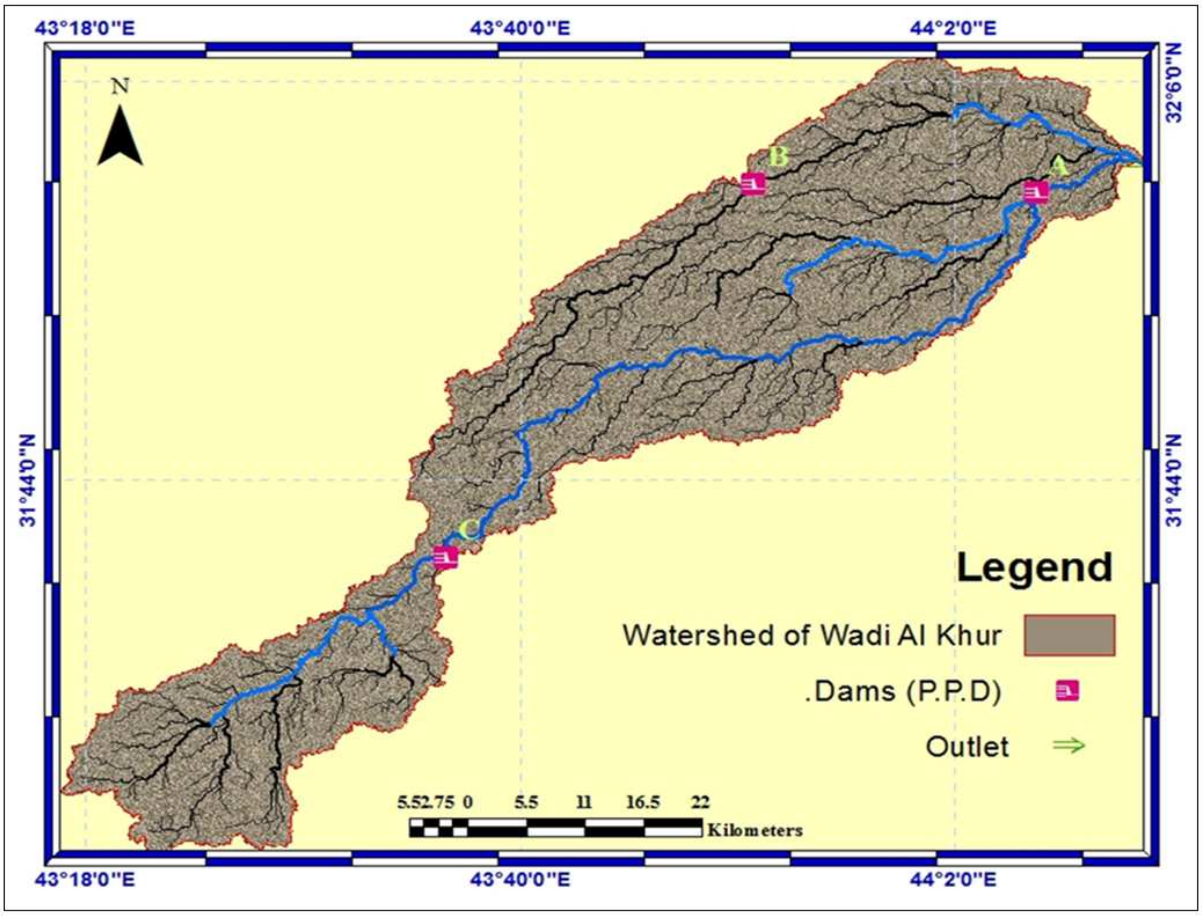
Fig. 2. Perennial wades and direction of surface water in the Southern Desert GEOSURV, 2009).

(http://www.eorc.jaxa.jp/ALOS/en/aw3d30/data/index.htm
).

Several of field trips were conducted in the study area, where the main course of both valleys was tracked to determine the most appropriate location for constructions of submersible dams.

Climate

The geographical location on the globe plays an important role by affecting on the climate, it is a set of weather conditions which dominates on a particular area and which affecting directly on the water resources for that region so, that climate is correlating with geology, environment and water resources instantly. Weather are represented by some factors like rainfall, temperature, evaporation, relative humidity sunshine hours and wind speed. The weather is the atmospheric conditions for a certain location at a particular time such as day to day or week to week, (Bello and Adejuwon, 2011). However, the studied area is characterized by a long hot dried desert summer and short cold winter with limited rainfall but in some of status it reach to the stage of flood which may occur every few years. The data of climate elements depends on determining the climate information that's recorded in Al-Najaf meteorological station during the period (1962-2017) by (Iraqi Meteorological Organization, 2018), and they are summarized in (Table-1). Temperature and precipitation are the commonest of climate elements on which the climate classification depends. Generally, the type of climate in the study area has classified as semi-arid to arid region, (Al-Kubaisi, 2004).



P.P.D: position of proposal dams.

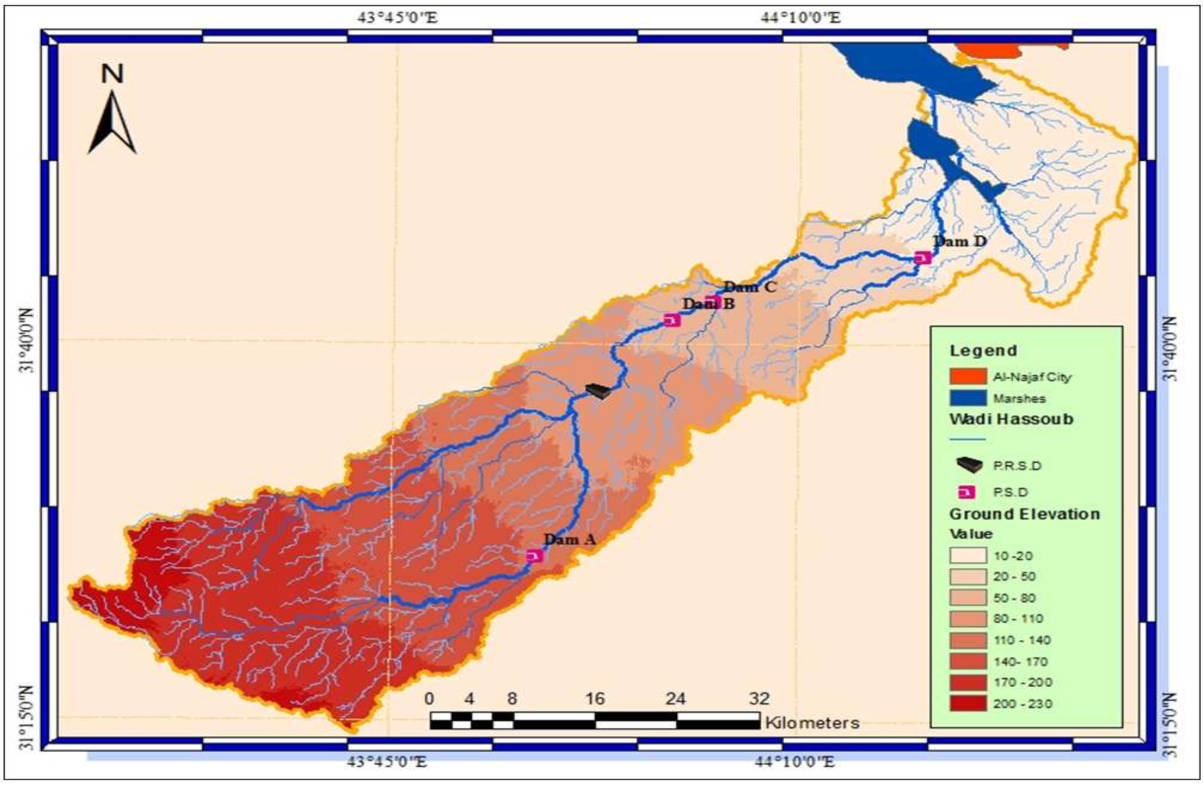
Fig. 3. Wade Al-Khur watershed and positions of proposal submersible dams.

Geological setting

The study area is conjunction with the Southern Desert with regard to the design of conceptual framework of hydrogeological units through the outlook of ground surface on the study region; it should deal with the geological setting criteria. The geomorphology districts the flow regime of (sub) - surface water (Wades) and (dis) -recharge areas depending on the gravity forces which inclines to the East and northeast down to the discharge zone. As well as, it is affected by the climate elements like distribution of precipitation.

Geomorphological, a few reliefs mark are existing in the study area like (Tar Al-Najaf), elevation of surface ground is ranging of (10-281m) approximately, above the sea level. The ground surface slopes gradually from the West and southwest towards the North and northeast with rises gradually 50m every 10-15 km, (Jassim, and Goff, 2006). Eastern side of the study area is seems as a closed topographic depressions, low lands relative to the surrounding and appear as marshes. Generally, the study area is characterized by several of wades, which can discharges the rainwater from the west and southwest to East and northeast directions (marshes), which be coincide with the decline direction of the regional topography, (Al-Jawad and et. Al, 2002). Such of these wades are wade Haussab and wade Al-Khur, Al-Rhimawi and Abo Kumssat which could participate in pooled of water and recharge the aquifers, (Hassan, 1973).

Stratigraphy, Numerous of formations belong to Tertiary period are exposed in the studied area, Al-Dammam and Euphrates are exposed in most of the area while the other formations like Nfayil, Injana, Zahra and Dibdibba are exposed as a narrow strip near Tar Al-Najaf. Rus and Umm Er Radhuma formations lie beneath the Al-Dammam formation, (Rafa'a and Al-Jiburi, 2009).



P.R.S.D: Position of real submersible dam.

P.S.D: Proposal of submersible dam.

Fig. 4. Wade Hassoub, including the real and proposal submersible dam in the study area.

Structurally, the study is area lay within the boundaries of Al-Salman subzone including the stable shelf that specialized in its simple structures. The structural features in this area are few for the reason of the weak effect of the Orogenies that reached this zone. The subsurface folds are mostly with prevailing axes of (N-S) and (NW-SE) trends, and their forms reflect as horst and graben structures, (Buday and et. Al, 1987).

Table 1. Average monthly and annual values of climate elements over period (1962-2017) at Al-Najaf station, (Iraqi Meteorological Organization, 2018).

Month	Rainfall	Temperature	Evaporation	Relative	Sunshine duration	Wind speed
October	5.21	27.7	239.84	41.00	8.6	1.39
November	27.17	17.8	114.18	64.77	7.4	1.33
December	14.41	12.5	77.88	66.73	6.1	1.32
January	17.15	10.8	81.19	68.31	6.6	1.53
February	12.70	13.5	111.08	57.08	7.4	1.87
March	10.74	18.2	186.98	47.24	7.9	2.01
April	8.05	24.6	260.46	38.98	8.6	2.11
May	4.04	30.8	354.46	30.52	9.5	2.25
Jun	0.00	35.1	456.28	24.69	11.7	2.62
July	0.00	37.5	499.88	23.10	11.8	2.63
August	0.00	36.9	435.78	23.83	11.4	2.14
September	0.00	32.5	329.27	28.39	10.3	1.58
Average	8.29	24.8	262.27	42.89	8.94	1.90
Total	99.47	-	3147.26	-	-	-

This secondary zone is marked by a North southwest-South southeast trending subsurface folds that reflect on the surface as a series of elongated convex linear features associated with the faults, (Al- Atia, 2006). A huge fault which extend in the far eastern side forms the limits of the stable boundary which is called the Euphrates fault, this fault and the rest of the faults in the area plays an important role for controlling with groundwater movement in study area, existing of the spring which considered as a good evidence of the presence of deep faults, (Jassim, and Goff, 2006).

Table 2. Proposals locations of the submersible dams within Wade Al-Khur basin.

Submersible dam	East	North	Depth of Valley (m)	Width of valley (m)	Elevation a.t.s.l (m)
Dam A	391105	3539660	6	200	78
Dam B	366087	3537677	4.5	100	171
Dam C	331370	3492507	4	250	279

It could be considered that this fault zone represents a transitional zone between the two shelves the stable and unstable zones (Mesopotamian plain), which marked by a shelf system known as (Heet-Abu Jir) that extends from Hadeetha in the North to Abu Jir and pass through Najaf in its way to Samawa in the south,(Benni, 2001. Abu Jir fault zone, including the Euphrates fault extends perpendicular to the other trending faults, which make a barrier that allow the water to pass through and circulate within this net of faults.

Table 3. The position of suitable place for construction of submersible dames on cross-section valley of wade Hassoub.

Submersible dam	East	North	Depth of Valley (m)	Width of valley (m)	Elevation a.t.s.l (m)
Dam A	395873	3478419	4	80	203
Dam B	397918	3480797	5	150	184
Dam C	412837	3508477	8	100	89
Dam D	430140	3514932	6	100	40

Hydrology

The studded area is characterized with a rolling and / or undulating terrain, most parts of the study area, it is a slightly rolling or flat, and decreasing in its height towards the East and northeast. Despite of the studied area has a dried climate, sometimes rainfall happens as heavy flushes that occur once every several years usually one or two times every four years causes a superficial flux for the rainwater which creating many of the ephemeral and temporarily rivers in the desert. Most of these rivers are flowing to the large wades, whereas the small valleys have gathers its water in a small spaces as form temporary ponds called "Al-fidah", its waters are infiltrating through the soil column and the other part is evaporate to the atmosphere over the time, (Fig.2). All wades in the study area are discharging its water towards the marshes, bordering to Tar Al-Najaf. Marshes have a water depth exceeds to 2 m in some regions and its elevation is 10 m at the sea level. The wades are collecting and transfer the rainwater to the marshes, which makes them to be one of the water sources for the marshes, (Fig. 5).

Most of wades are a tracer for the old faults which characterized by fractures and fissures therefore, wades are facilitates from infiltration process for the surface water to the groundwater, (Al- Jiburi and Al-

Basrawi, 2007).

Rainwater harvesting

Rainwater harvesting is collection and storage of any waters either from runoff or creek flow, or practice of collecting water from an area treated to increase runoff from rainfall or snowmelt, (Myers,1975). Moreover, Rainwater harvesting is broadly defined as the collection and concentration of runoff for productive purposes such as crop, fodder, pasture or tree production, livestock and domestic water supply in arid and semi-arid regions, (Gould,1999).

Fig. 5. Rainwater flow through wade Hassoub in November 2015.

The first use of such techniques was believed to have originated in Iraq over 5000 years ago by the Assyrian, Sumerian, and Babylonian civilizations, where the agriculture is started before 8000B.C, (HARDAN, 1975). However, there is an urgent need for more of efficient water capture in arid and semi-arid areas and an optimization in rainfall management through water harvesting in sustainable and integrated production systems which can contribute to improving of farmer's livelihood by upgrading of agriculture production and animal husbandry. The rainwater harvesting is usually practiced in arid and semi-arid regions where the surface runoff often has an intermittent character which is based on the utilization of runoff that requires a runoff producing area and a runoff receiving area; because of the intermittent nature of runoff events, water storage is an integral part of the system and it can be done directly in the in the small surface reservoirs or/and in the soil column or/and in the tanks or aquifers, (OWEIS, and KIJNE, 1999). Rainwater harvesting is applied through construction many of small dams which must be built on bedrock or highly compacted sub-soil. For the obvious reason of economy of materials and labor the stream must be reasonably narrow with well-defined and stable river banks and the bedrock or impermeable subsoil within a few meters of the stream bed. Typically, sand dams are built in the transitional zone between hills and plains where the gradient of the riverbed is between 0.2 - 4%. Sand dam is a reinforced concrete wall (or a similarly robust and impermeable weir), built up by (1- 4m), it can store a million of liters of water - refilling after each rainfall which characterize by the low cost, without operational costs and requires less maintenance, (Lasage, and Vries, 2008).

Characteristics of rainwater harvesting

Rainwater harvesting systems mast have the following characteristics, (Burdass, 1975; Myers, 1967).

The operation of rainwater harvesting is applied in arid and semi-arid regions where the runoff has an intermittent character and the surface runoff occurs as a discrete event and the subsurface water may flow in a part of the year and it stop during dry periods due to its ephemeral where its storage is an integral part of water harvesting.

Rainwater harvesting depends totally upon local water such as surface runoff, creek flow, springs, and soaks, therefore it does not include storing river water in large reservoirs or the mining of groundwater. Rainwater harvesting is representing as relatively small-scale operations in terms of catchment area, volume of storage, and capital investment, therefore this characteristic is a logical consequence of the other two characteristics.

Possibility rainwater harvesting in the study area

The success or failure of rainwater harvesting depends largely on the quantity of water that can be harvested from an area under given climatic conditions; as consequence, the threshold for any catchment area depends on various components such as quantity of precipitation which required to initiate runoff, surface storage, rainfall intensity and infiltration capacity, (Fink and Ehrler, 1979).

Generally, threshold of rainfall requires to 3-5 mm of moisture in the stony soils and shallow soils while, on the dry soils it requires 7-9 mm to gets upon surface runoff, (REIJ and BEGEMANN, 1988).

Fig. 6. Cross-section of wade Al-khur.

The dominant soil classification in the area is clayey loam (Sand fraction 39%, Silt fraction 37%, and Clay fraction 24%) soil textural classification, (HWSD-FAO, 2012). In the study area, wades that are dependable on the harvesting of rainwater are wade Al-khur and wade Hassoub due to the large area to aggregate of rainwater and their extension which may cross the Iraqi- Saudi border.

An exploration field trips were conducted for both the wades where some positions were determined which might be a suitable for the construction of submersible dams along both of wades.

Possibility rainwater harvesting from wade Al-Khur

Wade Al-Khur is located along contact line of the southern part from the western desert specifically, within the Salman zone (according to the Iraq tectonic divisions), which are monocline dipping towards Euphrates River and it represents as one of the oldest and the biggest basins within Iraqi Western Desert, (Jassim and Goff, 2006) . Wade Al-Khur has a watershed area about to 1710 km² inside borders of the study area and it has an extension out of the Iraqi-Saudi border.

The stream gradient is 2 to 5 m/km and mean slope is higher for the more turbid streams in addition to its streams are following the branching drainage pattern which called the dendritic pattern, (Fig.3).

However, the options for constructing of submersible dams on the main valley of wade Al-Khur are limited due to it has a wide width for the cross-section of the valley and edge walls of the valley is low height, (Fig. 6). The width of wade ranging of 100m to exceed more than 3km, while its depth does not exceed on 6m approximately. Some sites have been listed, which may be a suitable for building of submersible dams on the cross-section of wade Al-Khur, (Table -2).

Possibility rainwater harvesting from Wade Hasoub

Wade Hasoub is smaller than Wade Al-Khur in terms of its extension. The watershed area of wade Hasoub reaches to 2307 Km². The main valley that descends towards Bahr Al-Najaf regain (to the marshes), also it have many of turbid streams in case of flood that follows the dendritic drainage pattern, (Fig.4).

Although wade Hassoub is shorter than wade al-Khur in terms of extension, the first has a large area of watershed that sloping towards the main valley as a slight tendency which difficult distinguish it especially by the satellites. A submersible dam was established prior a year 2000 A.D on the main valley of wade Hassoub within the coordinate (E: 401402; N: 3497871), 134m (a.t.s.l), the dam was constructed along 70 m approximately of concrete, and about 100m was a soil dam reinforced with stone, (Fig. 7),

Fig. 7. Submersible dam that built on the wade Hasoub cross-section.

(Fig.4). The presence of this dam and in this remote site does not prevent the flood of rainwater from moving towards Bahar Al- Najaf (Marshes) due to the presences of many streams that pour its waters into the main valley behind of the constriction dam.

In addition to presence of wadie War, which pour its water into the ends of the wade Hassoub; an example of such this case, the flood which it happening in November 2015, (Fig. 5). (Table-3) lists some of suitable sites which includes the coordinate position installed by GPS, depth and width of the valley at that site and the elevation above the sea level. These positions may be a suitable place for building of submersible dams on the cross-section of wade Hassoub.

Conclusions

The climate of study area is classified as arid to semi-arid, the rain is fall from October to May months.

Rainfall represents the only source for groundwater recharging.

The short wades are Al-Rahimawi, Abu Khamesat and wade Wa'ar while the large and the important wades are wade Al-Khure and wade Hassoub.

Wades are the intermediary to transport the rainwater in the study area from an elevation (281 m a.t.s.l) in the West and southwest to the East and northeast which has an elevation (10m a.t.s.l).

Wade Al-Khur has a watershed 1710 km^2 and it extends out boarder of study area, its cross-section characterized by an extremely wide reach to thousands of meters in some regions and it has low depth, these features reduced the chances for constructions of submersible dams on the cross-section of wade Al-Khur.

Wade Hassoub has a watershed 2307 km^2; it's cross-section characterized by expanding and narrowing from one region to another, valley's depth reaches to 8m approximately.

Recommendation

Submersible dams are a kind of kinds of dams that builds on some temporary and permanent rivers which is characterized by low economic cost and lack of maintenance requirements in the near term. It is necessary and possible to build several submersible dams on the cross-section of wade Al-Khur and wade Hassoub, and can offer many of benefits to the study area which can summarized as follows:

Protections from the floods.

Obstructing flow of water and creating of water pools behind the dams, which gives the time for these waters to penetrate through the pores of the soil and cracks to recharge of groundwater.

It is possible to recharging of groundwater via injecting the waters from pools by using fast and modern ways.

Water ponds can remain several months, so they are a good source of drinking water for the desert population (Bedouin) and their animals.

Create a local environment by planting trees near the dam to produce the food and provides shadows that reduce the evaporation.

The dams create a natural buffer that reduces the threat posed by flooding and drought and builds the resilience of communities to cope with the impacts of climate change in semi-arid regions.

Reference

Al-Atia MJ. 2006. History of AL-Najaf Earth, Geological legacy and Natural Wealths. AL- Nbras Institution for advertising and Publishing, AL-Najaf - AL-Ashraf, Iraq, p 159.

Al Jiburi HK, Al-Basrawi NH. 2007. The Hydrogeology of Iraqi Western and Southern Desert. Western Iraqi Desert Journal Special Issue, p 77-91.

Al-Jawad SB, Al-Dabach RH, Mohsa MSJ, Abd-Al Hadi HA, Bashoo DY, Hana FHN, Al-Azawi HA. 2002. The comprehensive book national program to the best usage of water resources in Al-Furat.

Al-Kubaisi QY. 2004. Annual aridity index of type. 1 and type.2 mode options climate classification, Iraq, Journal Science **45(1),** p 32-40.

Bello NJ, Amori AA, Adejuwon. 2011. "Introduction to climatology and biogeography", Technical Seminar, Department of Water Resources Management and Agrometeorology, College of Environmental Resources Management, p 21.

Benni TJ. 2001. Sedimentlogical and palaeoclimatic record of Bahr Al-Najaf depression during late quaternary, M.Sc. Thesis, College of science, Baghdad University, Iraq. (unpub). (in Arabic), p 154

Buday T, Jassim SZ, Kassab II, Abbas MJ. 1987. The Regional Geology of Iraq, Tectonism, Magmatism, and Me-tamorphism, Baghdad, 445 p.

Iraqi Standard (IQS). 2009. Iraqi Standard of drinking water, NO. 417; modification No. 2.

Burdass WJ. 1975. Water harvesting for livestock in Western Australia. Proc. Water Harvesting Syrup., Phoenix, AZ, ARS W-22~ USDA, p 8-26.

Fink DH, Ehrler WL. 1979. Runoff farming for Jojoba. In: Arid Land Plant Resources, Proc. Int. Arid Lands Conf. Plant Resources, Int. Center for Arid and Semi-Arid.

Gould J. 1999. Contributions relating to rainwater harvesting. Contributing paper. Guntur District, Andhra Pradesh, India. Environmental Geology **49,** 413.

Hamill L, Bell FG. 1986. Groundwater resource development, Butter worth's, London, p 344.

Hardan A. 1975. Discussion: Session 1. In: Proceedings of the water harvesting harvesting and management (WCHM)–Kenyan experience. harvesting. Contributing paper. World Commission on Dams, Cape Town, South.

Hassan. 1973. Achieved to study the hydrogological and hydrochemical aspects of the study area. The study area showed that the area is of low topography and the groundwater bearing beds are existed in the Recent and the Miocene deposits.

HWSD-FAO. 2012. Food and Agriculture Organization of the United Nation, Irrigation and Drainage, Rome, Data bank software.

Jassim SZ, Goff J. 2006 Geology of Iraq. Doline, prague, p 341.

Lasage R, Aerts J, Mutiso G, Vries AD. 2008. Potential for community based adaptation to droughts: Sand dams in Kitui, Kenya. Physics and Chemistry of the Earth, Parts A/B/C **33(1-2),** 67-73. Retrieved February 1, 2016.

Ma·ala KA. 2008. Tectonic and structural evolution of the Iraqi Southern Desert. Iraqi Bull. Geol. And Min., Special, p 35-52.

Myers LE. 1967. Recent advances in water harvesting. Journal of Soil and Water Conserv, **22,** 95-97.

Myers LE. 1975. Water harvesting. 2000. B.C. to 1974 A.D. Proc. Water Harvesting Syrup., Phoenix, AZ, ARS W-22, USDA, p 1--7.

Mosical TDS, Bunn PM, Davies CJ, Marshall. 1999. Effects of shade and nutrient manipulation on periphyton growth in the subtropical stream, Aquatic Botany **64,** p 167-177.

Oweis T, Hachum A, Kijne J. 1999. Water harvesting and supplemental irrigation Practical Guide, 3rd edition, CRC Press, Taylor and Francis Group, Boca Prentic Hall, Inc., USA, 600 p.

Rafa'a Z, Jassim, Buthaina S, Al-Jiburi, Iraqi Bull. Geol. Min. Special Issue. 2009. Geology of Iraqi Southern Desert, p 53-76.

Reij C, Mulder P, Begemann L. 1988. Water harvesting for plant.