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Rainwater Harvesting of Wadi Al-Kassab Catchment's Area by Weir Construction, West of Mosul City/North of Iraq

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Abstract: Surface and ground waters are scarce in semi-arid and arid regions. Therefore attempts are made in these regions to collect and preserve rainwater to the maximum possible extent. In arid and semi-arid areas where rainfall pattern is irregular and much of these are lost as surface runoff and as a result there is a scarce of water resulted into the risk of human being. Under such conditions the water harvesting is a substitute and is most important. Water harvesting is a collection of rain and runoff water by using different types of storage structures such as weirs or small dams, primarily for humans, irrigation and livestock consumption, conserve soil moisture for crop production, reduce soil erosion and enhanced groundwater recharge. Rain water harvesting contributed in recharging groundwater resources in the studied area through infiltration and this will help to solve water shortage during the dry period of the year (between May-September). Four sites of special hydrological and geomorphologic characteristics have been chosen and pointed on the drainage map of the studied area for the construction of storage structures on the main channel to impound and harvested rain and runoff water, forming surface storage reservoir and a model of the weir has been designed based on Bligh Theory. Geometrical survey has been done for the four sites of the recommended weirs construction, to determine the probable size of the reservoir, formed by harvested water. The geometrical dimension of each reservoir and bulk volume of water stored behind the weir of the four sites had been measured and calculated. The total volume of storage water behind the dams of the four sites could reach 150000000 m^3. The mean output surface runoff of wadi al-kassab basin, for a rainfall storm of 3.22 mm/h intensity of 14.65 h period, has been calculated and is found to be 8.87 m^3/sec.

Key words: Water harvesting, Semi-arid areas, Groundwater resources, Conserving soil moisture, Crop production

INTRODUCTION

The increasing demand of using both surface and ground water becomes an obsession to limit and carrying out the developmental plans and programs. It is also considered as critical economical and political challenge in the present time and moreover formed obstacle in the way of civilized and social precedence in the nearest future if a suitable solution for this problem could not be found.

Water shortages in many areas of the world can be alleviated by harvesting surface runoff water [1]. Criteria used to determine an appropriate harvesting method for a given location include: 1) the purpose for which the water will be harvested; 2) land slope; 3) soil properties; 4) construction costs; 5) amount, intensity and seasonal distribution of rainfall; and 6) social factors such as land tenure and traditional water use practices.

The studied area is located to the west of Mosul City, north of Iraq, approximately between latitude 36° 18'-37° 47' N and longitude 42° 42'-43° 18' E. It covers an area of about 1293 km^2 and represent a region of fertile land with high precipitation during rainy season, appropriate for agricultural production such as barley and wheat, [2]. The main channel has a length of about 92 km draining water towards Tigris River. The climate is considered to be semi-arid and the annual precipitation being approximately 260-300 mm during rainy season from Nov. to April Rainfall is the main source of recharging the groundwater of the studied area however, different factors are affecting recharge, such as elevation, time, type and intensity of rainfall, [3].

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Scope of the study: Water harvesting plays a major role in the development of the studied area and suffices the following purposes:

- The harvested water can be used for various purposes such as domestic consumption and irrigation the cops during the scarcely rainy months.
- Treatment the traces of desert-made land caused by the unbalanced environment due to bad investment of natural resources.
- Recharging the groundwater, which is formed the principle resource of water in the studied area.
- A forestation the areas around the surface water storage to create a suitable environmental weather.
- Development and growth of the agricultural crops such as vegetables and fruits together with the wheat and barley.
- Consequently rainwater would stand on the surface of the earth and were not to be lost in any manner.

Geology Setting: Stratigraphically, the area under study is dominated by the following geological formations ranging from Lower Miocene to Quaternary, [4]:

Jeribi Formation: This formation is of lower Miocene age cropped out at the core of Attshan, Shaikh Ibrahim and Nuegett anticlines and formed the upland recharge areas of wadi Al-Kassab basin. It is composed of crystallized and dolomitic limestone. These kinds of rocks are participating of high percentage of surface runoff of the catchments area.

Al-Fatha Formation: This formation is of Middle Miocene age consists of variable lithological units such as gypsum, marls, clay and limestone [4, 5]. This formation is cropped out at the outer boundaries of most anticlines in the studied area.

Quaternary Sediments: The Quaternary sediments are mostly covering the studied area and consist of residual soil, flood plain deposits and slope deposits.

Wadi Al-Kassab catchment area is a structurally controlled folded topography and from geomorphology point of view, wadi al-kassab is formed a major synclinal depression bounded by three anticlinal folds (Attshan, Nuegett and Eklayan) from the north of the main channel, one anticline fold (Shaikh Ibrahim) from the west and four anticlines (Addaya, Jwan, Al-Kassab and Najma) from the south. The folded anticlines are dissected by several tributaries which are draining water to the main channel during rainy season.

Hydrogeology Setting: Two major types of aquifer have been identified in the studied area; the unconfined aquifer in the Quaternary sediments which has wide geographicaldistribution and the confined aquifer within Al-Fatha Formation. Both aquifers are formed the main sources of ground water in the studied area [6].

The depth to the ground water level of deep wells in the studied area range between 5-12 meter during rainy season, while in dry season range between 8-14 meter [7].

People in the studied area pumped water from deep wells to meet their needs and domestic purposes. The quality of ground water is not uniform and differs from season to another due to the difference in rainfall quantity, recharge, fluctuation change of water level and variation of lithological units of Al-Fatha Formation, [8].

Rainwater harvesting is used to provide drinking water and to refill aquifers in process called groundwater recharge.

Drainage System: The catchment of a water harvesting system is the surface which directly receives the rainfall and provides water to the system [3]. A watershed is an area from which runoff resulting from precipitation flows past a single point into a large stream, river and lake. Each watershed is an independent hydrological unit. It has become an acceptable unit of planning for optimum use and conservation of soil and water resources.

A map of the drainage system for the studied area has been prepared Fig. (1). The area is characterized by well developed dendritic type of drainage system. Dendritic type is found in homogeneous rocks such as soft sedimentary. Structure and lithology seem to be dominant factors in the development of the drainage system [9].

The output mean surface runoff of Wadi Al-Kassab Basin, for a rainfall storm of 3.22 mm/hour of period 14.5 h, has been calculated to 8.87m^3/sec.

Aim of Study: Rainwater harvesting is convenient in the sense that it provides water at the point of consumption and people can use it for irrigation and various purposes during non rainy months (April and May of the year) such as conserving soil moisture for crop production, reduce soil erosion and enhanced groundwater recharge.

MATERIAL AND METHODS

Surface structures for runoff water harvesting are small weirs consisting of earth fill, aggregate or concrete. They are typically constructed across the entire

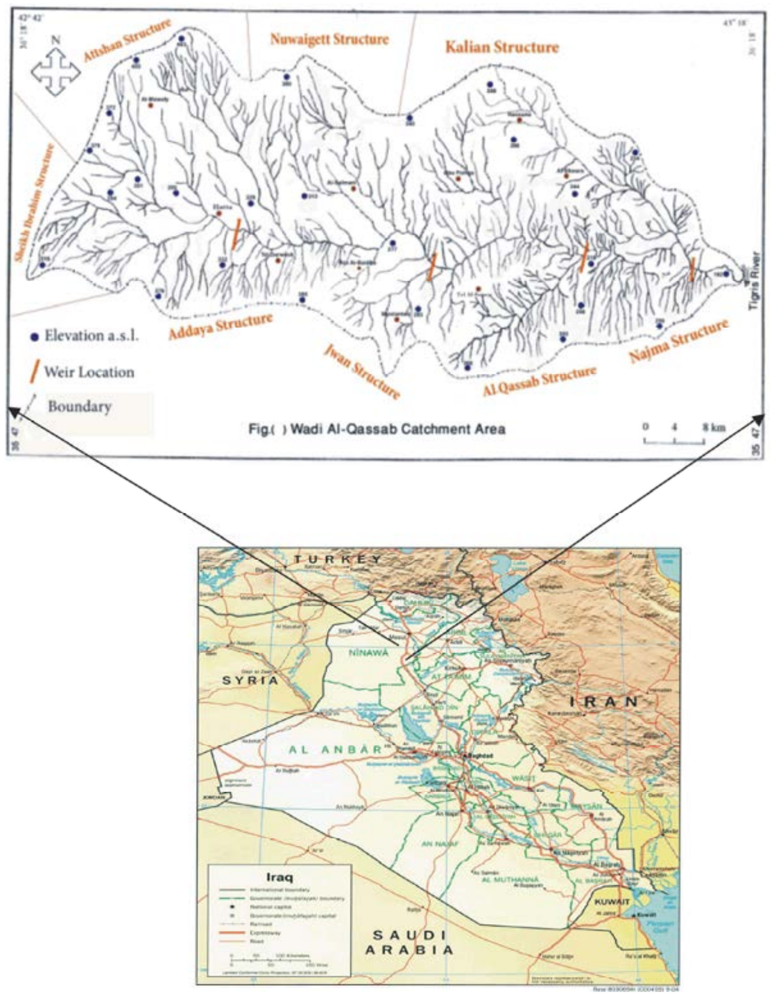

Fig. 1: Location of the Study Area

width of the watercourse (rivers, valleys, flood relief channels) so that a small lake is formed behind them. The storage volume of the lake is proportional to the height of the weir, with the weir height not exceeding few meters in most cases, [10, 11].

It is based on constructing structures that allow for collecting and storing of surface water runoff, to be used where needed throughout the dry season and in different locations.

Water shortages in many areas of the world can be alleviated by harvesting surface runoff water. Criteria used to determine an appropriate harvesting method for a given location include: 1) the purpose for which the water will be harvested; 2) land slope;

3) soil properties; 4) construction costs; 5) amount, intensity and seasonal distribution of rainfall; and 6) social factors such as land tenure and traditional water use practices.

Four sites (1, 2, 3, 4) of special hydrological and geomorphologic characteristics have been chosen and pointed on the drainage map of the studied area (Fig. 1) for the construction of storage structures on the main channel to impound and harvest rain and runoff water, forming surface storage reservoir and the excess water in the channel is allowed to flow over the weir for another site of storage. The impound water could be used for different purposes during scarce rainy months. Part of the impound water infiltrate into the soil and recharge the groundwater aquifer, which could be harvested by digging wells very near to the infiltration zone.

Geometrical survey has been done for the four sites of the recommended weirs construction, to determine the probable size of the reservoir formed by harvested water, taking into consideration several requirements such as location, foundation, stable banks, slope and sufficient discharge.

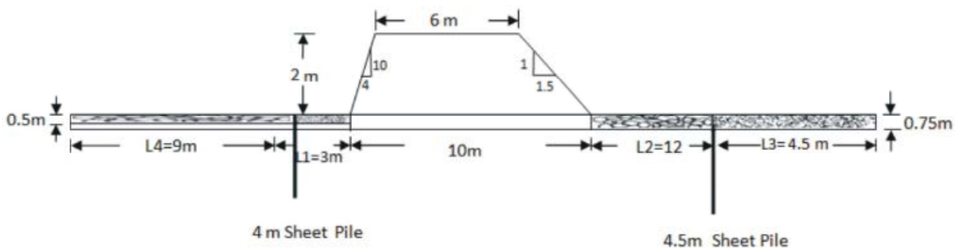

Fig. 2: Schematic Diagram of the Weir.

Table 1: Measurements of Channel Dimensions and Volume of Water

Site	Mean Length (m)	Mean Width (m)	Area of Reservoir (m^2)	Mean Height of Water(m)	Volume of Water(m^3)
1	8000	4000	32000000	1.0	32000000
2	12000	4000	48000000	1.0	48000000
3	10000	4300	43000000	1.0	43000000
4	8000	4200	33100000	1.0	33100000

Plate 1: Sinking Weir.

Plate 2: Stadium Weir.

A model of a vertical drop weir based on Bligh Theory (1979), [13], has been designed (Fig. 2) and could be of different shape such as sinking weir, stadium weir and thunderous weir as shown in plates (1 and 2). The geometrical dimension of each reservoir and bulk volume of water stored behind the weir of the four sites had been measured and calculated as shown in Table (1).

The weir foundation is usually built, where either a concrete wall, or filled with impervious soil penetrating through the surface layer of the channel [13]. The foundation must extend to a depth sufficient to ensure the weir is safe from failure due to water seepage through the dam structure when the lake is filled.

RESULTS AND DISCUSSION

Watershed development and management implies an integration of technologies within the natural boundary of a drainage area for optimum development of land, water and plant resources, to meet the people's basic needs in a sustained manner [14].

To determine the drainage basin or watershed area, the location of water line divide must be determined [15]. In the current study DEM file is used to draw a line of water divide of Wadi Al-Qassab basin by River Tool Software V 3.0. This program is designed to analyze hydrological and morphological features of drainage system of river basin. The DEM converted to Rtg (River Tool Grid) formulae by the program to outline the boundary and the outlet of the basin, then all the tributaries order (Figs. 3 and 4).

Table 2: Attribute and morphometric features of Al-Kassab Basin calculated by River Tool Software

Attribute of Al-Kassab Basin	Calculated Paramers
Outlet elevation	180m
Basin Area	1314.1027 km^2
Basin relief	0.227 km
Strahler order	10
Network magnitude	494319
Network diameter	2907
Longest channel length	110.461 km
Total channel length	54713.160 km
Drainage density	41.635 km^{-1}
Source density	376.164 km^{-2}

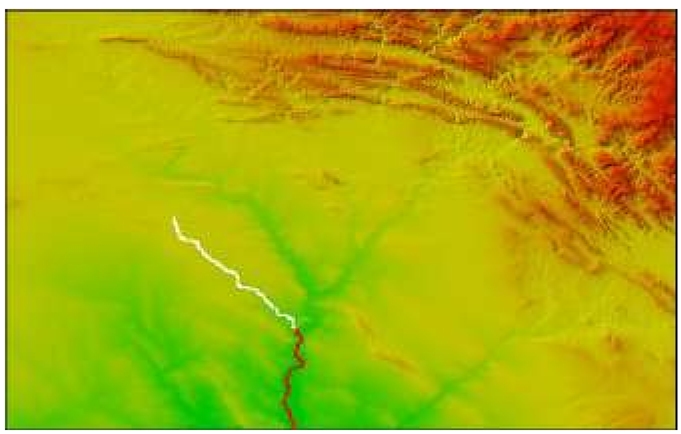

Fig. 3: DEM of the Study Area.

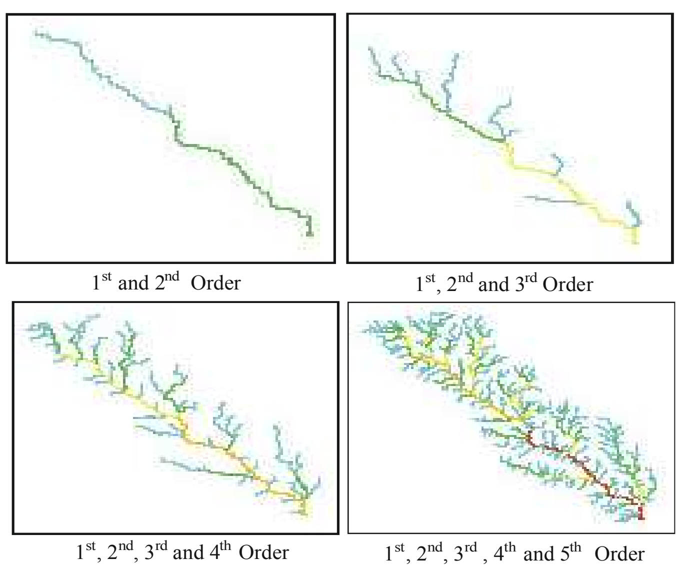

Fig. 4: River Tool Software output of the Main Channel and Tributaries Order of The Basin

The importance of the morphometric analysis is to know the relation between hydrological and basin shape features with, structural geology, nature of rocks, climate and land cover. The morphometric analysis features are calculating depending on Strahler classification [16] see table (2). It is found that Wadi Al-Qassa Basin was of 10th order and this demonstrated how much water this basin draining to the main channel.

CONCLUSION

Rainwater harvesting appears to be one of the most promising alternatives for supplying freshwater to face increasing water scarcity and escalating demand.

The results of the detailed geological, geomorphologic and hydrological investigations have been used to choose the sites to construct the weirs on the main channel of the studied area.

Water harvesting is a proven technology to increase food security in drought prone areas and helps to erosion control and recharge of groundwater for future demand.

The research results may help in establishing a better land use policy and increasing the agricultural product in the semi arid regions.

A considerable attention should be paid, in future, to recreational uses of water for such purposes as swimming, fishing and for simple esthetical enjoyment.

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