

Full Length Research Paper

Rainwater harvesting of Wadi Al-Kassab catchment's area by weir construction, West of Mosul City, North of Iraq

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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, much of these are lost as surface runoff, and as a result, there is a scarcity of water which results to risk for human beings. 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. Four sites of special hydrological and geomorphologic characteristics have been chosen and pointed in 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 study and understand 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 m³. 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 m³/s.

Key words: Rain water harvesting, storage structures, reservoir, surface runoff, drainage system.

INTRODUCTION

The increasing demands of using both surface and ground water becomes an obsession which limit the developmental plans and programs that were carried out, and at the same time, they are considered as a dangerous economical and political challenge in the present time. Moreover, they will form an obstacle in the way of civilized and social precedence in the nearest future, if we do not find the suitable solution for this problem. Water shortages in many areas of the world can be alleviated by harvesting surface runoff water (Pachpute et al., 2009). 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; 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 to 37° 47 N. and longitude 42° 42 to 43° 18 E. It covers an area of about (1293) km² and represent a region of fertile land with high precipitation during rainy season appropriate for agricultural production such as barley and wheat (Pachpute, 2010). The main channel is of 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 to 300 mm during rainy season from (November to April). Rainfall is the main sources of recharging the ground water of the studied area and different factors affect recharge

precipitation, among these are, elevation, time, type and intensity of rainfall, (Frasier and Lloyd, 1983).

SCOPE OF THE STUDY

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

1. The harvested water can be used for various purposes such as domestic consumption and irrigation the crops during the scarcely rainy months.
2. Treatment the traces of desert-made land caused by the unbalanced environment due to bad investment of natural resources.
3. Recharging the ground water, which is formed, is the principle resources of water in the studied area.
4. A forestation the areas around the surface water storage to create a suitable environmental weather.
5. Development and growth of the agricultural crops such as vegetables and fruits together with the wheat and barley.
6. 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 (Buday and Jassim, 1984).

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. This kind of rocks is of high percentage of surface runoff of the catchments area.

Al-Fatha formation

This formation is of Middle Miocene age consisting of variable lithological units such as gypsum, marls, clay and limestone (Buday and Jassim, 1984; Mohi addin et al., 1977). 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 by 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 drains 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 geographical distribution and the confined aquifer within Al-Fatha formation. Both aquifers are formed from the main sources of ground water in the studied area (Parsons, 1955). The depth to the ground water level of deep wells in the studied area range between 5 to 12 m during rainy season, while in dry season, range between 8 to 14 m (Taha, 2005).

People in the studied area fetched 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 (Buday, 1980).

Rainwater harvesting is used to provide drinking water and to refill aquifers in processes 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 (Frasier and Lloyd, 1983). 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 (Figure 1). The area is characterized by well developed dendritic type of drainage system. Dendritic type of drainage system is found in homogeneous rocks such as soft sedimentary. Structure and lithology seems to be dominant factors in the development of the drainage system (Al-Taee, 2002). The output mean surface runoff of wadi al-kassab basin, for a rainfall storm of 3.22 mm/h of period 14.5 h, has been calculated and is found to be $8.87\text{m}^3/\text{s}$.

Aim of the study

Rainwater harvesting is convenient in the sense that, it

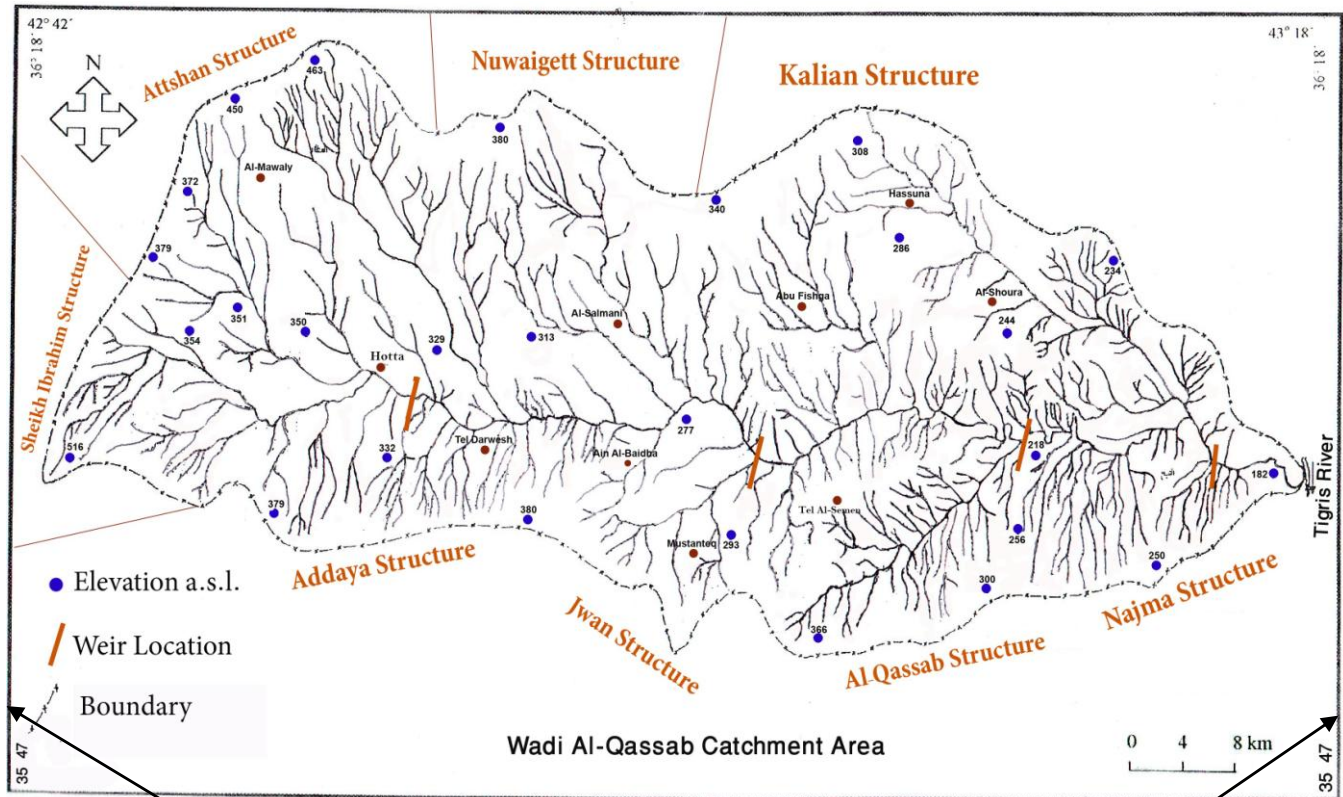


Figure 1. Location of the study area.

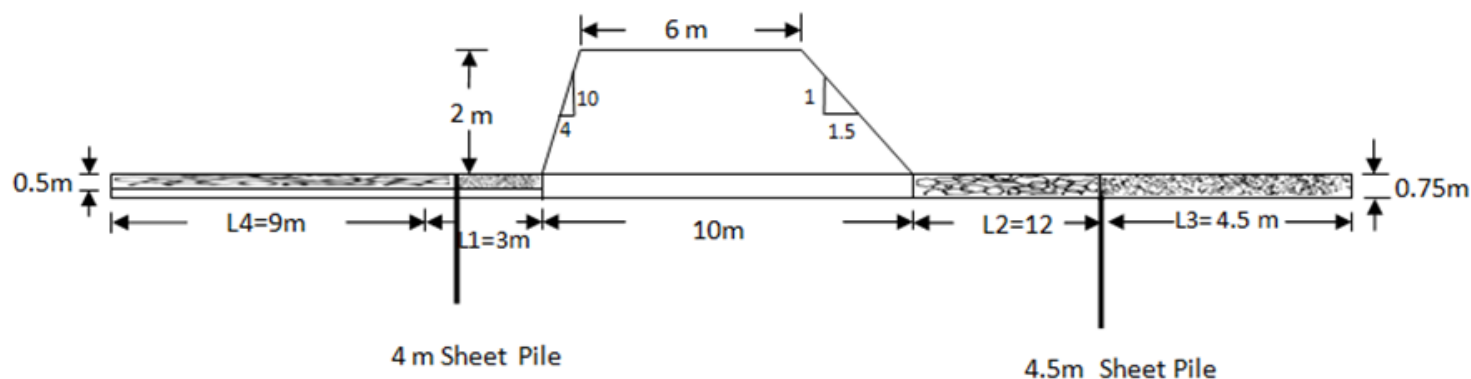


Figure 2. Schematic Diagram of the weir.

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).

MATERIALS 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 width of the watercourse (rivers, valleys and 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 (Schiller and Latham, 1987; Wall and McCown, 1989).

It is based on construction structures that the collection and storage of surface water runoff is allowed in order for it to be used in places where it is 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; 6) social factors such as, land tenure and traditional water use practices.

Four sites (1, 2, 3 and 4) of special hydrological and geomorphologic characteristics have been chosen and pointed in the drainage map of the studied area as shown in Figure 1, for the construction of storage structures on the main channel to impound and harvested 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 impounded water could be used for different purposes during scarce rainy months. Part of the impounded water infiltrate into the soil and recharge the ground water 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 study and understanding 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.

A model of a vertical drop weir based on Bligh theory (1979) and (Varshney et al., 1979) has been designed (Figure 2) and could be of different shapes 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

there is a concrete wall, or where it is filled with impervious soil, penetrating through the surface layer of the channel (Pacey and Cullis, 1989). The foundation must extend to a depth that is sufficient enough to ensure that 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 (Nissen-Petersen, 1982). To determine the drainage basin or watershed area, the location of line water divide must be determined (Hurvtiz, 2008). In the current study where 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 River Tool Grid (Rtg) formulae by the program to outline the boundary and the outlet of the basin and all the tributaries order is as shown in Figures 3 and 4. 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 (Strahler, 1975) (Table 2). It is found that wadi Al-Qassa basin is of 10th order and this demonstrates 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 in the face of increasing water scarcity and escalating demand. The results of the detailed geological, geomorphologic and hydrological investigation undertaken have been used to



Plate 1. Sinking weir.



Plate 2. Stadium weir.

Table 1. Measurements of channel dimensions and volume of water.

Sites	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

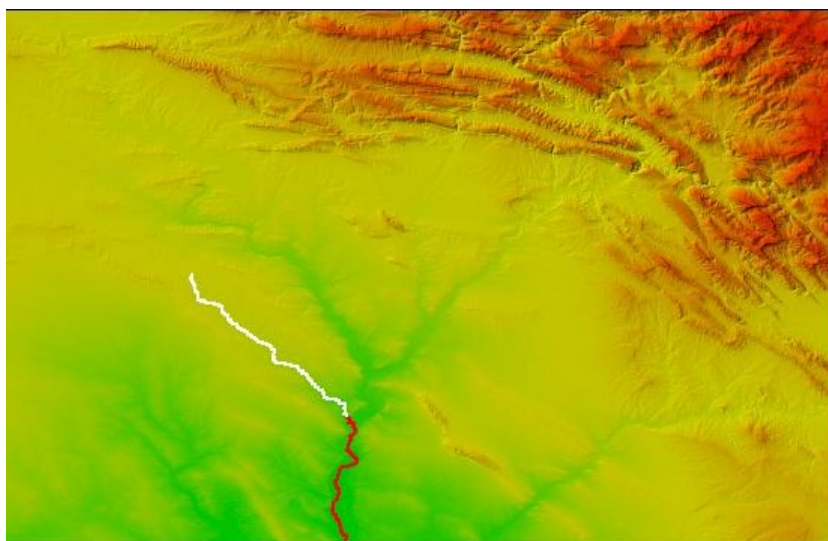


Figure 3. DEM of the study area.

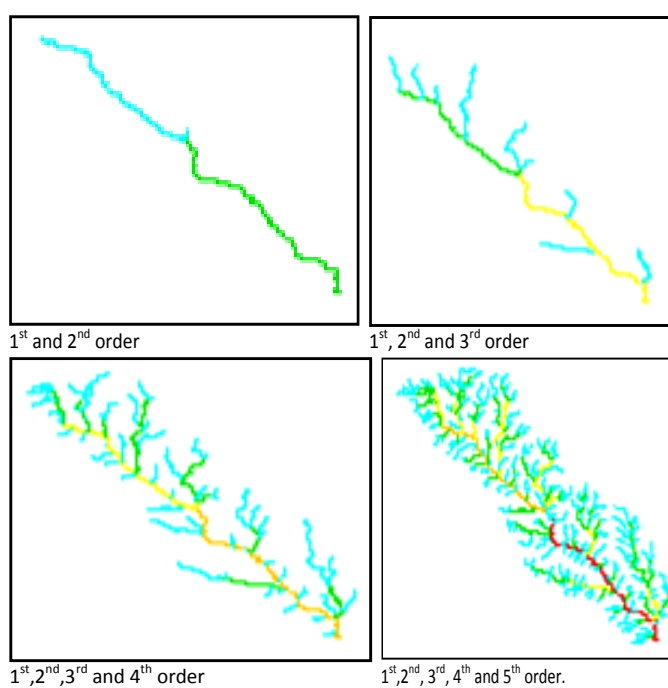


Figure 4. River tool software output of the main channel and tributaries order of the basin.

Table 2. Attribute and morphometric features of Al-Kassab basin calculated by river tool software.

Attribute of Al-Kassab Basin	Calculated Parameter
Outlet elevation	180 m
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

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 ground water for future demand. The author prediction of this kind of research partakes, in better land use policy and increased agricultural products in the semi-arid region. A considerable attention should be paid in future to recreational uses of water for such purposes as swimming, fishing and for simple aesthetical enjoyment. The author hopes that the reported results will give at least a part spur to the required research and provide some information that meets the aim of the study, also, it can be considered as a feed back to future study.

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