Water harvesting estimation using GIS in Bani Na'im

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Abstract

This study aims to estimate the visibility of establishing an earth fill dam in semi-arid area by estimating the amount of the surface runoff. This estimation depends on analysing the rain fail records of 7 years period. Due to the fact that the rain fall is the only source of water in this watershed, the GIS used to determine the amount of the runoff depending on the curve number technique based on Antecedent Moisture condition with the combination of land use, land cover and hydrological soils group. Moreover, the results of this study shows that the amount of harvested runoff lie between (0.8442 -5.767) Million cubic meters depending on the frequently and the magnitude of the rainfall storms in winter season.

Keywords: the weighted curve number, GIS, Bani Na'im

1 Introduction

Fresh water sustains human life and is vital for human health. There is enough fresh water for everyone on Earth. However, due to bad economics or poor infrastructure, millions of people (most of them children) die from diseases associated with inadequate water supply, sanitation and hygiene. According to the united nation, water scarcity affects more than 40 per cent of the global population and is expected to rise. It is estimated that 783 million people do not have access to clean water and over 1.7 billion people are currently living in river basins where water use exceeds recharge.
Access to safe drinking water and adequate sanitation services is vital to human health, but also has other important benefits ranging from the easily identifiable and quantifiable (costs avoided, time saved) to the more intangible (convenience, well-being, dignity, privacy and safety)

According to the Israeli information centre for human rights in the occupied Palestinian territories B'Tselem , hundreds of thousands of Palestinians in the West Bank suffer a severe shortage of water for personal consumption, bathing, cleaning, livestock and irrigation. The severe shortage violates basic human rights, including the right to health, decent housing, equality, and the benefit of natural resources. Furthermore, according to the surveying done in 2014, the total water consumption in the West Bank was 102.8 million cubic meters, which gives each person a daily consumption around 79.1 litters per capita per day which is low figures if we comparing it with 340 litter per capita per day in the United States of America and we have 28.6 million cubic meter losses, which results in 27.8 percent of losses due to defective pipes and losses.

2 Methodology

The soil conservation Services-Curve Number used for the estimation of water runoff from in the watershed area. This method has been developed by U.S Bureau of Agriculture National Conservation Service. There are many advantages for using this method such as, accuracy and simplicity of the required inputs. The following steps are used to get Curve Number map.

2.1 Earth fill dam location

Earth fill dam location: according to the study and field visits, which are done by the ministry of Agriculture, the suitable place for establishing the dam is located in the following coordinates. This location has been chosen to harvest and to hold the maximum amount of water with little amount of sediments.

X	Y
172912	98149.82

Table (1) Earth Fill Dam coordinate.

2.2 Analysing rainfall records

Analysing and gathering rainfall data is provided by the ministry of water to three climatological stations from 2004 to 2014. These records were monthly rainfall records.

2.3 Soil analysis

Soil playing the first major role of controlling the runoff, soil type, depth, granular structure and soil texture. All of them are controlling the infiltration and runoff. The soil map is obtained for the study area by the ministry of Agriculture in Palestine. The Palestine 1923 _Grid is the coordinate system for this map

2.4 Landover analysis

Land cover playing the second major role for controlling the run off. Usually artificial surface runoff rainfall is more than agricultural fields' runoff. The map of land cover is obtained from the applied research institute Jerusalem.

2.5 Hydrological soil groups

According to the soil type, infiltration rate and runoff the soil divided to four groups. This classification is done according to the United States geological Survey land used and land cover classification system the following table shows the group notation and the main characteristics for each group.

2.6 Antecedent Soil Moisture

The Antecedent Soil Moisture used to describe the soil status before the rain event, and it is divided into three parts according to soil moisture.

2.7 Curve number calculation

Soil Conservation Service - Curve Number model: the Estimation of runoff depth is an important component for determining the suitable areas for rainwater harvesting. The runoff depth is used to assess the potential water supply during a runoff event (Melesse et al 2002). Soil Conservation Service and Curve Number modelling was used to estimate the runoff depth in the study area. Remote Sensing was used to derive the land cover map. ArcGIS 10.1 was used to interpolate the rainfall data and digitizing the soil map of the study area. The output of the Soil Conversation Service model has been used to extract the depth of the runoff from the rainfall for water harvesting planning (Gupta 1997). The equation of the Soil Conservation Service model can be expressed as below (Maidment 1993):

$$Q = \frac{(P - Ia)^2}{(P - Ia) + S}$$

Where:

- Q = runoff depth (mm)
- P = rainfall (mm)
- S = potential maximum retention after runoff starts (mm)
- I a = initial abstraction (mm)

Initial abstraction includes all losses before runoff starts, infiltration, evaporation and water intercepted by vegetation. (Melesse et al 2002), for small watersheds the value of Ia = 0.2*S; therefore, the above equation can be simplified to:

$$Q = \frac{(P - 0.2S)^2}{(P - 0.8S)}$$

3 Results

The final calculation for 9 years period showed the watershed can be harvested between 0.84 to 5.7 million cubic meter (Mm3) of water according to the rainfall season and the average amount of water is equal to 2.8 Mm^3. the following table shows the amount of rain fall, runoff and the total volume in Mm^3.

Years	Total Rainfall (mm)	Total Runoff (mm)	Runoff Percentage	Volume (Mm3) Runoff × Area
2004/20005	469	95.14	20.28	3.06554685
2006/2007	421.5	44.9	10.65	1.446742207
2009/2010	398	31.9	8	1.027863617
2010/2011	242	26.2	10	0.844201466
2011/2012	497	88	17.7	2.83548584
2012/2013	391	145.8	40.4	4.697884494
2013/2014	445	179	40.22	5.76763597
Average	409.071429	87.2771429	21.03571	2.81219435

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The Palestine Ministry of local Government portal for spatial information in Palestine (www.geomolg.ps).

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