Estimation of Rooftop Rainwater Harvesting Potential using Applications of Google Earth Pro and GIS

Article · July 2019

1 author:

Durgasrilakshmi Hari
Vardhaman College of Engineering

Estimation of Rooftop Rainwater Harvesting Potential using Applications of Google Earth Pro and GIS

Durgasrilakshmi Hari

***Abstract:** In the present scenario of global warming, the availability of drinking water is the main concern. The problem of water shortage tackled in reliable scientific approaches. Rainwater harvesting is one of the best practices in collecting and storing rainwater. This method is cost-effective in the planning and development of rainwater harvesting facilities in water-scarce areas for future needs. In this paper, a case study of Vardhaman College of Engineering, Hyderabad, in Telangana state has taken to estimate the rooftop rainwater harvesting potential. In this study, In this study to digitize the various types of rooftops, Google Earth Pro is used. The overall potential quantity of rainwater harvestable at the institutional level can be assessed by using ArcGIS. Total water demand for the study area is calculated considering the existing population. Rainwater harvesting sites are identified and proposed according to the lowest elevation and drainage direction of the study area. The volume of the storage tank is designed based on daily discharge by assuming the length, breadth and height. The results of this study will demonstrate the Applications of Google Earth Pro and GIS in estimating rainwater harvesting potential to tackle the prevailing water shortage in the study area. Rainwater harvesting provides water at the point of demand, minimizes the stress on existing natural resources and also an eco-friendly solution.*

***Keywords:** Rainwater, Rooftop, Harvesting, Potential, Demand.*

I. INTRODUCTION

Water plays a very important role in accomplishing the essential needs of all living beings. The most important aim of rainwater harvesting is to supply water for future needs. Rainwater harvesting is mainly essential in arid, urban and water scarce areas. Generally, harvesting rainwater is two types one is Surface runoff harvesting and the other is Rooftop rainwater harvesting (RTRWH). In rooftop, rainwater harvesting rainwater runoff is collected from various roof surfaces which typically offer dirt free water that can be used for drinking. The harvested rainwater is used for different non-potable applications as flushing, cleaning, gardening, and laundry washing etc. Rainwater harvesting, besides being eco-friendly, is an economic practice as well. The collection of rainwater may reduce flooding in certain areas as well. It also reduces the demand for Groundwater and the Water Bills. Setting up rooftop rainwater harvesting facilities is an economical way of water conservation, especially in the educational and commercial sectors as consists of large building rooftops which serve as a catchment for rainwater runoff.

Hence estimation of Rooftop rainwater harvesting potential is necessary for planning and installation of water harvesting structures.

II. STUDY AREA DESCRIPTION

The study area considered was Vardhaman College of Engineering, located at 78.30708E longitude and 17.2550N latitude in Kacharam, the village of Shamshabad Mandal in Ranga Reddy district of Telangana state at an elevation of about 581 meters above mean sea level. Average Temperature in summer is 32.80 deg C and in winter is 23.12 deg C. the average amount of annual rainfall is 781.5mm. It covers an area of 14.56 acres, having a population around 5600. Figure 1 shows the Study area map.

Figure 1. Study Area

III. PURPOSE OF PROJECT

Groundwater is the major water source in the study area. There is a great demand for water in college mainly for drinking, in laboratories, washrooms, for use in cleaning the building floors, labs as well as classes, for use in gardening purpose etc. The hydrological balance would be disturbed with the uncontrolled extraction of groundwater therefore; it is essential to adopt eco-friendly and renewable water conservation methods. Rooftop Rainwater harvesting is one of the promising solutions to the existing water demand

Revised Manuscript Received on July 05, 2019.
Durgasrilakshmi Hari, Assistant Professor, Vardhaman College of Engineering, Hyderabad, India.

and to address the future water needs in the college.

IV. OBJECTIVES OF THE STUDY

- To estimate the Rooftop Rainwater Harvesting Potential using Google Earth and GIS applications.
- To propose rainwater harvesting sites.
- To calculate Daily discharge and storage tank Volume.

V. DATA AND METHODOLOGY

A. Data Collection

The data related to population were obtained from the college office. Google Earth Pro is free and open source software it offers premium high-resolution photos. Google Earth Pro was used to digitize the different types of roof catchments. ArcGIS software was used to compute the area of various types of roofs in the study area. The annual average rainfall considered for the study is 781.5mm.
Data on various water demands and the available water resources in the study area were acquired.

B. Methodology

The methodology involves the following steps to achieve the objectives of the study

Step-1: Digitization of rooftops using Google Earth Pro
Step-2: Calculation of the area of various types of roofs using ArcGIS
Step-3: Estimation of Rainwater Harvesting Potential , Water demand
Step-4: Identifying and proposing rainwater harvesting sites
Step-5: Daily discharge and storage tank volume calculation

VI. RESULTS & DISCUSSION

Step-1: Digitization of rooftops using Google Earth Pro

Different rooftops of the study area are digitized using the polygon tool available in Google Earth Pro. This process resulted in digitized buildings with of 6 concrete roofs, 2 Asbestos rooftops, and 3 GI roofs of the study area that have been saved as KMZ (Keyhole Markup language Zipped) and represented in Figure 2 respectively.

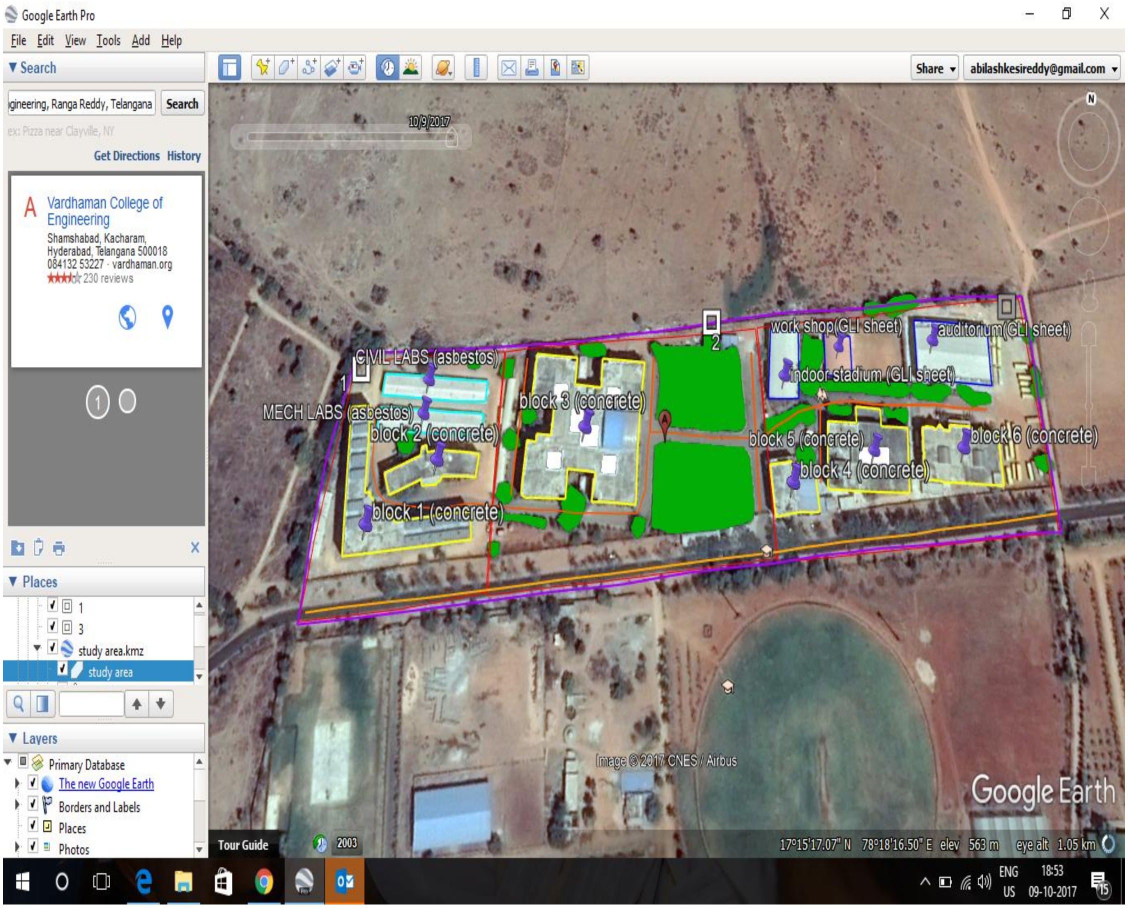

Figure 2. Different Types of Rooftops and Road Network digitized using Google Earth Pro

Published By:
Blue Eyes Intelligence Engineering & Sciences Publication

Step-2: Calculation of the area of various types of roofs using ArcGIS

Digitized different types of rooftops in the Google Earth Pro were imported to ArcGIS and the files were converted to Shapefile. Each shapefile coordinate system is changed to projected coordinate system i.e. EPSG: 32644 - WGS 84 / UTM zone 44N in order to calculate the areas of digitized rooftops by using geometry calculation tool available in Arctic. Figure 3 and Figure 4 shows the Digitized Rooftop catchments with Attribute Table containing rooftop areas in GIS.

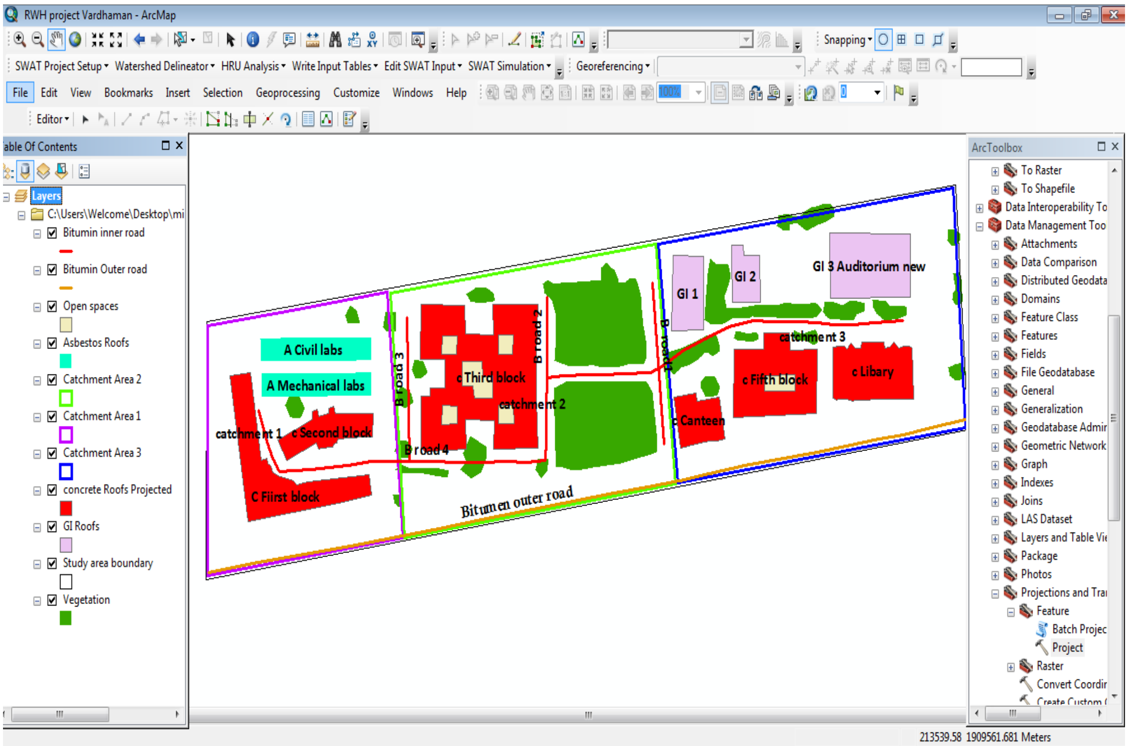

Figure 3. Shape files Projected in ArcGIS

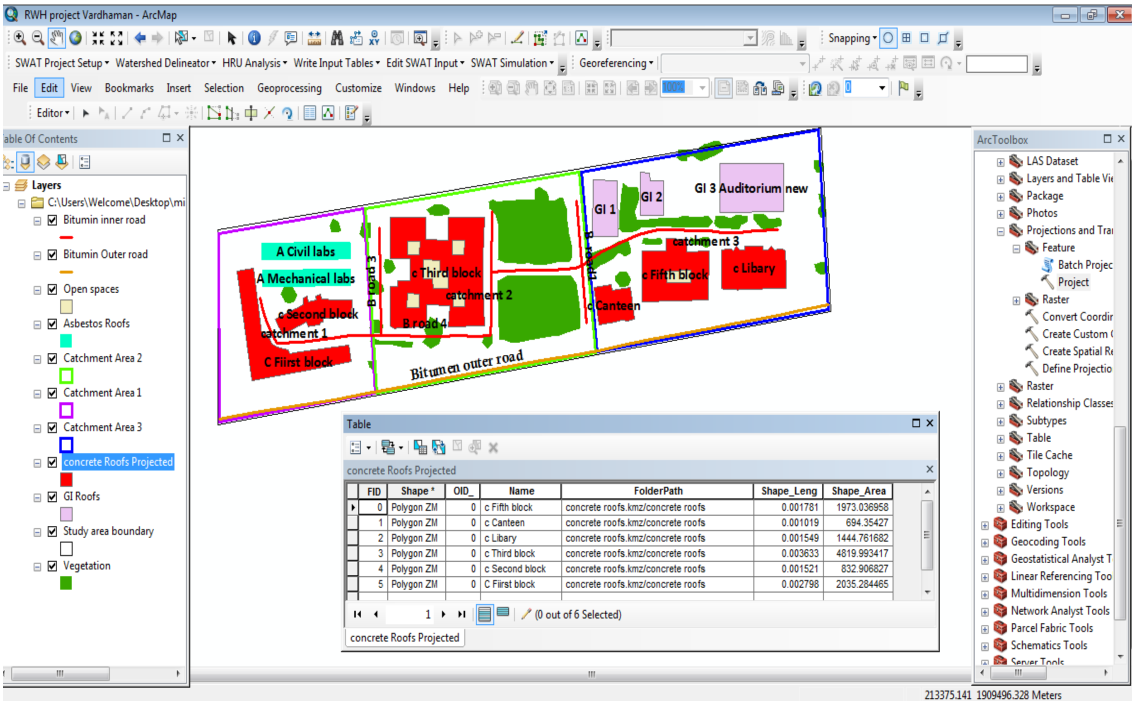

Figure 4. Digitized rooftop catchments with areas calculated in GIS

Step-3: Estimation of Rooftop Rainwater Harvesting Potential , Water demand of the study area
Rooftop rainwater harvesting Potential in the study area has estimated by using
Gould and Nissen Formula (1999): S = R*A*Cr
Where, S = Potential of roof rainwater harvesting (In cu. m.)
R = Average annual rain fall in m.
A = Roof area in Sq. m.
Cr = Coefficient of Runoff

Coefficient of rooftop (Cr) for any catchment is defined as “The ratios between volumes of water that runs of and that of the total volume of rain that falls on the Rooftop” [1]. Different types of Runoff coefficients considered to calculate the rooftop rainwater harvesting potential that depends on the surface type.

Table 1: Total Study Area Rooftop Rainwater Harvesting Potential

S.No	Roof Type	Area (m^2)	Runoff Coefficients	Annual Rainfall in (m)	(S =R*A*Cr) Runoff (cu. m)	(S = R*A*Cr) Runoff (liters)
1	Asbestos Roof	1721	0.85	0.78	1141.02	1141020
2	Concrete Roof	11137	0.95	0.78	8252.51	8252510
3	GI Roof	2957	0.98	0.78	2260.33	2260330
Total		**15815**			**11653.86**	**11653860**

The study area is divided into three catchments depending on the elevation, slope and drainage direction. Rainwater harvesting potential of each catchment is calculated and presented in Table 2.

Table 2: Catchment -wise Rainwater harvesting potential

S.No	Catchment 1	Catchment 2	Catchment 3
1	Concrete roof runoff = 2134.40m^3	Concrete roof runoff = 3181.11 m^3	Concrete roof runoff = 2941.02 m^3
2	Asbestos roof runoff = 1141.02m^3		GI roof runoff = 2260.33 m^3
Total Runoff	**3275.42m^3**	**3181.11m^3**	**5201.35m^3**

Table 1 shows that the major part of the study area covers the Concrete Roofs. Water collection capacity changes with roof type. Hence, maximum water that could be collected is obtained from the concrete roof (8252.51cu.m) followed by GI Roof (2260.33cu.m), Asbestos Roof (1141.02cu.m.) correspondingly. The Total Study Area Rooftop Rainwater Harvesting Potential is 11653.86 cu. m. From Table 2 statistics it is observed that runoff potential of catchment 3> catchment 1 > catchment 2.

A. Water Demand

As per the data obtained from vardhaman college departments the approximate Population in the college is 5600**.** If we consider the threshold water requirement of 15 liters/day/capita for drinking (3 liters) and Basic hygiene practices (12 liters) is sufficient for institutional purpose Thus from data,

Water demand = Per-Capita demand*population*number of days

Annual water demand for Drinking (@ 3Liters)

3*5600*365 = 6132000 liters (or) 6132 cu.m

Annual water demand for Basic hygiene practices (@ 12Liters)

12*5600*365 = 24528000 liters (or) 24528 cu.m

Total LPCPD Annual water demand (@ 15 Liters)

15*5600*365 =30660000 liters (or) 30660 cu.m

Table 3: Water Demand of the Study Area

Approximate Population in the college	Total Annual RRWH Potential (in Liters)	Total LPCPD Annual Demand of Water (@ 15 Liters)
5600	11653860	30660000

From the above calculations, it is observed that total drinking water demand is completely satisfied considering 3 lpcd and the remaining 47% water can

be used for Basic hygiene practices considering 15 lpcd for institutional purpose. Therefore the total calculated rooftop rainwater potential will satisfy the 38 % of total water demand of the study area. Table 3 shows the calculated Water Demand of the Study Area

Per person annual water available = 11653860/5572 = 2091.50 liters

Per person per day water available = 2091.50/365 = 5.73 ≈ 6 liters

Per person per day water availability during dry days = 2091.50/ 243 = 8.60 ≈ 9 liters
(8 months or 243 days)

It is evident from the above calculations that about 6 liters per person per day water is available and even in dry periods about 9 liters per day water available per person for various general uses.

Step-4: Identifying and proposing rainwater harvesting sites.

Considering the elevation, slope and drainage pattern and from the observed runoff of each catchment, rainwater harvesting sites/storage tank locations are identified, located and shown as S1, S2, and S3 at respective catchments in Figure 5.

Figure 5. Rainwater harvesting sites/storage tank locations

Step-5: Daily discharge and storage tank Volume calculation

- Size of storage tank is calculated based on daily discharge expected.
- Daily discharge is computed by using rooftop area and daily rain fall.
- Volume of storage tank is designed based of daily discharge by assuming the length, breadth, height. As a safety factor, the tank should be built larger than storage volume required. The results are presented in the Table 4.

For Catchment 1:

Daily discharge = Total area *2.14mm
= 3275.42*2.14
= 7.00 cu.m
Volume of 1st storage tank = 4*3*1

= 12 cu.m

For Catchment 2:

Daily discharge = Total area *2.14mm
= 3181.11*2.14 mm
= 6.80 cu.m ≈ 7.00 cu.m
Volume of 2nd storage tank = 4*3*1
= 12 cu.m.

For Catchment 3:

Daily discharge = Total area *2.14 mm
= 5201.35*2.14 mm
= 11.13 cu.m
Volume of 3rd storage tank = 4*4*1
=16 cu.m

Table 4: Storage Tank Design and Volume

Catchment	Daily discharge = Total area * 2.14 mm		Volume of storage tank = l*b*h per day	
	Obtained in cu.m	Obtained in liters	in cu.m	in liters
1	7.00	7009.39	4*3*1= 12	4*3*1= 12000
2	6.80	6807.57	4*3*1= 12	4*3*1= 12000
3	11.13	11130.889	4*4*1=16	4*4*1=16000

VII. CONCLUSION

In this study, analysis is made to estimate the potential of rooftop rainwater harvesting to meet the general demands of water in the study area. To achieve the objectives of the study the applications of Google Earth Pro was used for digitizing the available rooftops in the institution and ArcGIS was used to estimate the area of roofs. Rooftop rainwater harvesting Potential in the study area has estimated by using Gould and Nissen (1999) Formula. The geospatial applications like Google Earth Pro, Bing Maps and software's like ArcGIS are essentially helpful in the works wherever extensive field works are involved. The results showed that the volume of water can be harvested from various rooftops are observed as 11653860 liters to the total annual water demand 30660000 liters. Hence the total drinking water demand is completely satisfied considering 3 lpcd and the remaining 47% water can be used for Basic hygiene practices considering 15 lpcd for institutional purpose. Thus the mentioned work concludes emphasizing that, Rooftop Rainwater harvesting system is the suitable alternative available to meet the increasing water problems, in the study area. Rainwater Harvesting contributes to reduce the pressure on groundwater therefore; it should be promoted to the maximum possible extent. Planning Roof Water Harvesting is a very cost-effective solution for educational institutions as its buildings will have huge roof surface and the amount of water which can be stored will give a promising solution to the water demand.

ACKNOWLEDGMENT

The author expresses gratitude to the Vardhaman College of Engineering Hyderabad Management and administrative office staff, and the students K. Uday Kumar, K. Abhilash Reddy for their support.

REFERENCES

1. D. Hari, K. Reddy, K. Vikas, N. Srinivas, G. Vikas Assessment of rainwater harvesting potential using GIS IOP Conference Series: Materials Science and Engineering, 330 (1) (2018), pp. 1-9 https://doi.org/10.1088/1757-899X/330/1/012119
2. Singh, Omvir & Turkiya, Sushila. (2017). Assessing Potential for Rooftop Rainwater Harvesting:An Option for Sustainable Rural Domestic Water Supply in Arid Region of Haryana. Journal Of Rural Development. 36. 49-60. 10.25175/jrd/2017/v36/i1/112701.
3. Baby, Sultana & Arrowsmith, Colin & Al-Ansari, Nadhir. (2019). Application of GIS for Mapping Rainwater-Harvesting Potential: Case Study Wollert, Victoria. Engineering. 11. 14-21. 10.4236/eng.2019.111002.
4. Pawar-Patil V.S. and Mali Sagar P. 2013 Quest Journals Journal of Research in Humanities and Social Science 1 21-23 (Online):2321-9467
5. Jadhav Pranavr., Mane sharvari r., Ambi sheetal a., Vidulaa Dr. and Swami, miss. Vasundharah 2016 Lavangare a review of rooftop rainwater harvesting potential in ujlaiwadi region using geospatial approach IJATES 4 80-81 march.

AUTHORS PROFILE

Durgasrilakshmi Hari, Assistant Professor, Vardhaman College of Engineering, Hyderabad, India. Email: harisrilakshmi@gmail.com