

ROOF WATER HARVESTING QUANTITY ESTIMATION USING GIS

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ABSTRACT

The study was undertaken to estimate roof water harvesting quantity for Junagadh Agricultural University Campus using GIS. Monthly roof water harvesting potential for four each rainy month (June to September) was calculated by using average annual rainfall based on rainfall depth records from year 1961 – 2015. As most of the rooftop areas of JAU campus are of cement concrete and runoff coefficient was taken as 0.85 for this study. Roof top area of each building of campus was calculated using Google Earth and Quantum GIS (QGIS). Average monthly rainfall was found as 190 mm, 342 mm, 210 mm and 139 mm for June, July, August and September month, respectively. Monthly roof water harvesting potential of all 81 buildings of JAU campus with the total rooftop area as 1,04,012 square meter considering design rainfall average monthly rainfall, it was found to be 16797.94, 30236.29, 18566.14 and 12289.02 kilo liter for the month of June, July, August and September, respectively with total of 77889.39 kilo liter.

KEY WORDS: QGIS, roof water harvesting

INTRODUCTION

Increasing population of India as well as its all-round development has resulted in increase of water demand. Rooftop water harvesting is a process of collecting of runoff during rains from impermeable surfaces on houses or close to houses, its storage in water proof vessels and its subsequent use for the inhabitants of the houses. Zhu *et al.* (2004) stated that the capture and utilization of rainwater is an ancient tradition which dates back to similar techniques used in today's Iraq around 5000 years ago. Jankar and Bhanuse (2013) envisaged that the roof water harvesting systems would enable poor households in the community to supplement their water supply needs. Patel *et al.* (2014) stated that implementation of rainwater harvesting project to the campus will be the best approach to fight with present scenario of water scarcity in all aspects. Rande's

coefficient of runoff index for various types of roof and Gould and Nissen-Petersen formula (1999) have been utilized for calculation of potential of roof rain water harvesting. Patil and Mali (2013) used Rande's coefficient efficiency index of runoff for different types of house roofs. Selvarani (2006) carried out roof water harvesting case study based on average annual rainfall and runoff coefficient 0.85 for cement concrete rooftops. Keeping in view all the facts mentioned above, a study was undertaken with an objective to estimate quantity water can be harvested by roof water harvesting for Junagadh Agricultural University (JAU) campus using GIS.

MATERIALS AND METHODS

Junagadh Agricultural University, Junagadh is located in South Saurashtra Agro-Climatic Zone-VII of Gujarat state. Geographically, Junagadh is situated at 21.5⁰ latitude and 70.5⁰ E longitude with

an elevation of 60 meters above the mean sea level. The major part of the Saurashtra region, falls under semi arid and arid types with varying climatic as well as soil conditions. More than 95 per cent of the total annual rainfall is being received during June-September in most parts of the region. Roof top area of each building of campus was calculated using Quantum GIS (QGIS) and Google Earth. Rooftops of all buildings of campus were digitized in Google Earth and kmz file was prepared. This file was imported in QGIS and area of each polygon was calculated using field calculator function.

Following are the steps to calculate the roof top area from the .kmz file exported from Google Earth.

1. Open the QGIS Tool.
2. Importing.kmz file to QGIS

Go to Layer

- > Add Layer
- > Add vector layer
- > source type as File
- > browse the .kmz file.

By this process we can see that raster file of google earth converted into vector file in QGIS which gives vector map of the polygons which were created in Google earth.

3. Area Calculation

Go to layer >

Open attribute table >

Open field calculator or CTRL + I.

> select the new column and type the following expression

Output Field name: Roofarea,
Output Field type: Decimal Number (Real), Output field width: 10, Precision: 4
In function > Geometry > Select \$area for find area of any polygon .

When you click ok, you will have a new area field added to your table.

The area is in square units.

Go to Vector > Geometry tools > Export/Add geometry columns > Run.

Go to Vector > XY tools > save attribute table as Excel File so that the each Polygon area will be exported in Excel. This option is not available in

standard download so plugin is to be added in standard QGIS.

Potential of roof rainwater harvesting refers to the capacity of an individual roof to harness the water falls on that roof in a particular year covering all rainy days. Monthly roof water harvesting potential for four each rainy month (June to September) was calculated for each building from the following formula given by Gould and Nissen-Petersen formula (1999)

$$Q = C \times A \times I$$

Where,

Q=Monthly Rainwater Harvesting Potential, litre

A = Area of roof top Catchment, (m²)

I= Average Monthly Rainfall (mm)

C= Runoff coefficient

Based on the study of Patil and Mali (2013), coefficient of runoff for Cement Concrete was taken as 0.85

RESULTS AND DISCUSSION

Average monthly rainfall was calculated based on rainfall data from 1961-2015 available from Meteorology Station, JAU, Junagadh. It was found that average monthly rainfall of Junagadh for June, July, August and September month is 190 mm, 342 mm, 210 mm and 139 mm, respectively. The roof top areas of all buildings of JAU campus were digitized in Google Earth, the file was saved in .kmz with total 169 number of polygons which will serve as an input for QGIS.

The vector map of digitized polygons of building's roof tops were created from .kmz of Google Earth. The output was obtained from QGIS as excel file stating two columns i.e. name of polygon R₁, R₂, etc. in first column and area in square meter in second column. Based on combination of polygons, each building was identified using Google Earth and transect walk. the area of total in JAU campus and the total roof top area of 81 JAU campus buildings containing 169 polygons is 1,04,012 sq. which has been shown in Table 1.

Based on the area calculated for each building of campus, the quantity of water which can be harvested from each building was calculated considering the roof top as cement concrete. The rainfall amount was multiplied by roof top area of a building and runoff coefficient which has been given in Table 1.

For Example, the quantity of roof water that can be harvested from College of Agricultural Engineering and Technology building for June month by considering design rainfall as average monthly rainfall

$$= 14844(\text{m}^2) \times 190(\text{mm}) \times 0.85$$

$$= 2397306 \text{ liters} = 2397.31 \text{ kilo liter}$$

Likewise, roof water harvesting potential for each building was calculated for various rainy months.

Monthly roof water harvesting potential of all 81 buildings of JAU campus with the total rooftop area as 1,04,012 square meter was found to be 16797.94, 30236.29, 18566.14 and 12289.02 kilo liter for the month of June, July, August and September, respectively.

Hence, total estimated roof water harvesting quantity of JAU campus calculated by adding the potential of all four rainy months is found to be 77889.39 kilo liter for design rainfall as monthly average rainfall. The roof top size of various buildings ranges from minimum 88 m² to maximum 14844 m². From this size of catchment, total amount of water can be harvested per year ranges from 65.90 to 11115.93 kilo liter.

CONCLUSION

The study reveals that the quantity of water available from roof water harvesting highly depends on design rainfall. In areas with significant variations in the annual rainfall pattern, the matching of water supply and water demand may be difficult. For long periods of drought, it is necessary to store excessively large

volumes of water. The economics of roof water harvesting depends on method by which it is to be used. Storing the water in storage tank is efficient method for utilizing water harvested from rooftops and cost of storage tank has big share in total cost of roof water harvesting. The choice of utilizing and storing depends on local ground situations, rainfall as well as purpose of its use etc.

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Table 1: Estimated roof water harvesting quantity of JAU campus

Sr. No	Name of Building	Area (m ²)	Water Harvesting Potential, Kilo Liter				
			June	July	August	September	Total
1	College of Agricultural Engg. & Tech.	14844	2397.31	4315.15	2649.65	1753.82	11115.93
2	College of Veterinary Science & Animal Husbandry	13127	2120.01	3816.02	2343.17	1550.96	9830.15
3	Library & Examination Hall	3349	540.86	973.55	597.80	395.68	2507.90
4	Dept. of Agronomy, Entomology, Meteorology	3125	504.69	908.44	557.81	369.22	2340.16
5	UG Girls Hostels	2298	371.13	668.03	410.19	271.51	1720.86
6	Oilseed Research Station	2288	369.51	665.12	408.41	270.33	1713.37
7	Indoor Complex Sports Stadium	2219	358.37	645.06	396.09	262.17	1661.70
8	Dept. of Chem. & Soil Science	2194	354.33	637.80	391.63	259.22	1642.98
9	Auditorium & Community Hall	1964	317.19	570.93	350.57	232.05	1470.74
10	P.G. Institute of Agri Business Management	1813	292.80	527.04	323.62	214.21	1357.67
11	Polytechnic in Horticulture(NEW)	1749	282.46	508.43	312.20	206.64	1309.74
12	Dept. Of Economics, Statistics, Plant Pathology	1722	278.10	500.59	307.38	203.45	1289.52
13	College of Agriculture Building	1663	268.57	483.43	296.85	196.48	1245.34
14	Vivekanand Hostel	1619	261.47	470.64	288.99	191.28	1212.39
15	Plant Breeding Department	1582	255.49	459.89	282.39	186.91	1184.68
16	Bio Chemistry, DSW	1549	250.16	450.29	276.50	183.01	1159.97
17	College of Horticulture	1532	247.42	445.35	273.46	181.01	1147.24
18	Bio Control Lab	1479	238.86	429.95	264.00	174.74	1107.55
19	Vikas Boy's Hostel	1302	210.27	378.49	232.41	153.83	975.00
20	Vivek Boy's Hostel	1281	206.88	372.39	228.66	151.35	959.28
21	Food Testing Lab & Dept of Bio-Tech.	1280	206.72	372.10	228.48	151.23	958.53
22	Vidhya Boy's Hostel	1214	196.06	352.91	216.70	143.43	909.10
23	Vinay Boy's Hostel	1213	195.90	352.62	216.52	143.32	908.36
24	SC/ST CELL	1184	191.22	344.19	211.34	139.89	886.64
25	Vijay Boys Hostel	1176	189.92	341.86	209.92	138.94	880.65
26	P.G (new) Hostel	1149	185.56	334.01	205.10	135.75	860.43
27	Department of Horticulture	1141	184.27	331.69	203.67	134.81	854.44
28	Sardar Patel Hostel	1110	179.27	322.68	198.14	131.15	831.22
29	Staff Quarter	1057	170.71	307.27	188.67	124.88	791.53
30	Goverdhan Hostel	1049	169.41	304.94	187.25	123.94	785.54
31	Gokulesh Hostel	1047	169.09	304.36	186.89	123.70	784.05
32	University Bhavan	1036	167.31	301.17	184.93	122.40	775.81
33	Class 4 Quarter	1014	163.76	294.77	181.00	119.80	759.33
34	Educational Museum	1009	162.95	293.32	180.11	119.21	755.59
35	Viswkarma Hostel	992	160.21	288.37	177.07	117.20	742.86
36	Chankya Hostel	960	155.04	279.07	171.36	113.42	718.90
37	Wheat Research Center	957	154.56	278.20	170.82	113.07	716.65
38	PG Girl's Hostel	950	153.43	276.17	169.58	112.24	711.41
39	Krishikar Atithi Bhavan	949	153.26	275.87	169.40	112.12	710.66
40	Riddhi Girls Hostel	923	149.06	268.32	164.76	109.05	691.19
41	RTTC	867	140.02	252.04	154.76	102.44	649.25
42	Polytechnic in Horticulture Hostel	842	135.98	244.77	150.30	99.48	630.53

Table 1 Conti.....

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43	Virat Hostel	829	133.88	240.99	147.98	97.95	620.80
44	Biotechnology Girl's Hostel	817	131.95	237.50	145.83	96.53	611.81
45	Mahatma Gandhi Hostel	801	129.36	232.85	142.98	94.64	599.83
46	Javerbhai Patel Hostel	793	128.07	230.53	141.55	93.69	593.84
47	GTC Quarter-C to I	773	124.84	224.71	137.98	91.33	578.86
48	Vegetable Research center	754	121.77	219.19	134.59	89.09	564.63
49	SBI Bank	700	113.05	203.49	124.95	82.71	524.20
50	Pulse Research Station	699	112.89	203.20	124.77	82.59	523.45
51	Staff Quarters block-B	699	112.89	203.20	124.77	82.59	523.45
52	Polytechnic in horticulture(OLD)	692	111.76	201.16	123.52	81.76	518.20
53	GTC Quarter-J to R	624	100.78	181.40	111.38	73.73	467.28
54	Seed Processing & Storage Unit	618	99.81	179.65	110.31	73.02	462.79
55	Staff Quarters block-A	600	96.90	174.42	107.10	70.89	449.31
56	Bakery School	570	92.06	165.70	101.75	67.35	426.84
57	International Hostel	558	90.12	162.21	99.60	65.93	417.86
58	Class 1 Quarters	547	88.34	159.01	97.64	64.63	409.62
59	Lab. For Bio Agents mass production	534	86.24	155.23	95.32	63.09	399.89
60	RKVY Testing Centre	513	82.85	149.13	91.57	60.61	384.16
61	Teacher's & Academic quarters	494	79.78	143.61	88.18	58.37	369.93
62	SBI Bank Outside	491	79.30	142.73	87.64	58.01	367.69
63	IT Cell	481	77.68	139.83	85.86	56.83	360.20
64	AGRISNET Studio	403	65.08	117.15	71.94	47.61	301.79
65	Quarters Op H 1	370	59.76	107.56	66.05	43.72	277.07
66	Canning Plant	365	58.95	106.11	65.15	43.12	273.33
67	Staff Quarters block-D	346	55.88	100.58	61.76	40.88	259.10
68	GTC Quarter-B	345	55.72	100.29	61.58	40.76	258.35
69	Staff Quarters block-K	343	55.39	99.71	61.23	40.53	256.86
70	Panchvati Quarter 2	400	64.60	116.28	71.40	47.26	299.54
71	Practical Class of Agronomy	311	50.23	90.41	55.51	36.74	232.89
72	Panchvati Quarter 1	294	47.48	85.47	52.48	34.74	220.16
73	Vice Chancellor Bungalow	252	40.70	73.26	44.98	29.77	188.71
74	Panchvati Quarter 2	209	33.75	60.76	37.31	24.69	156.51
75	GTC Quarter-A	182	29.39	52.91	32.49	21.50	136.29
76	Quarters Op H 3	167	26.97	48.55	29.81	19.73	125.06
77	Quaters Op H 2	161	26.00	46.80	28.74	19.02	120.56
78	Staff Welfare Activity Building	143	23.09	41.57	25.53	16.90	107.09
79	GTC Quarter-1	126	20.35	36.63	22.49	14.89	94.36
80	Pathology Farmhouse	102	16.47	29.65	18.21	12.05	76.38
81	Sardar Smriti Kendra	88	14.21	25.58	15.71	10.40	65.90
Total		104012	16797.94	30236.29	18566.14	12289.02	77889.39