The Andhra Agric. J 58(1):70-79, 2011

Water Budget Studies of College and Hostel Buildings of CAE Campus, Bapatla

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ABSTRACT

Water is essential for all forms of growth and development of human, animal and plants to sustaining basic need. The fresh water is just 0.26% of global water. The rainwater is pure and can be stored and used for required purpose. An attempt has been made to estimate the pure rainwater that can be harnessed from College of Agricultural Engineering (CAE), Bapatla. The total rooftop surface area of college building and boy's hostel building were measured to be 1061.9 m^2 and 608.74 m^2 respectively. The average annual rainfall of Bapatla for 10 years (i.e.1999-2008) is 998.33 mm. The average rainfall of CAE Campus at 50% probability is 806.05 mm and highest average weekly rainfall is 52.49 mm. In the College building, the total water that can be harvested, total water demand, total water supply and estate supply were 727562.10, 3503500.00, 3535562.10 and 2808000.00 litres per year respectively and a total of Rs. 25464.7 per year could be saved from the harvested water. In the boy's hostel, the total water harvested, total water demand, total water supply and estate supply were 417075.04, 2695680.00, 3112755.04 and 2839200.00 litres per year respectively and a total of Rs. 14597.63 per year could be saved.

Key Words: Probability, Rooftop surface area, Weekly rainfall, Water budget.

Water is essential for all forms of growth and development of human, animal and plants to sustaining basic need. The fresh water is just 0.26% of global water. The rainwater is pure and can be stored and used for required purpose. The fresh water lakes and rivers, are the main source of water, contain an average of 90,000 cubic kilometers of water or just (0.26%) of total global fresh water reserves. In India the average annual freshwater availability has been reduced from 5177 cubic meters from 1951 to 1820 cubic meters in 2001 and it is estimated to further come down to 1341 cubic meters in 2025 and 1140 cubic meters in 2050 (Ministry of Water Resources, GOI, 2003). The total average annual run-off of all rivers is estimated to be 1,674 billion cubic meter (BCM).

Farrar (1974) reported that the catchment area being both roof and ground, which was adoptable in a number of houses in Botswana and each house has two rainwater tanks. One stands on the ground and collects water directly from the roof to provide water for drinking and cooking. The other was an excavated tank filled by overflows from the first as well as runoff from hard ground near the house. This tank was used to provide small amount of water for the garden as well as some water for washing.

Ghosh (1999) observed that if all the water could be trapped and stored, all the people in Chennai could get 940 liters per head per day nearly fivefold the revised estimate of 200 liters suggested for domestic consumers by the Chennai Metro Water Board. Gopinath (2000) stated that to meet the demand, rainwater harvesting is a must for every home and reported that average requirement of water per person was 15 per cent for drinking and cooking, 30 per cent for flushing and 55 per cent for bathing and washing. He suggested that rainwater harvesting could be done in two ways either by collecting and storing artificial recharge. The collecting and storing method can be adopted by independent houses, flats as well as by industrial houses. Approximately 700 liters of water can be collected from ground in a day when there is normal rainfall. This collecting and storing method involves: diverting, filtering and finally storing. Vishwanath (2001) reported that the Bangalore is located at $12^0 58'$ N latitude and $77^0 35'$ E longitude and at an average altitude of 921 MSL, encompasses 1279 km^2 of comprehensive development area with a current population of nearly 6 million. The average annual rainfall is 970 mm from the last 10 years and also the average for 30 years from 19510 to 1980 rainfall occurs about 85% between 4.30 p.m. to 4.30 a.m. In an average year of rainfall, a 1000 m^2 roof area would theoretically generate 97,000 liters of water of which about 77600 liters could be harvested assuming 80% capture efficiency. With a consumption of 100 lpcd (litres per

Table 1 Average domestic water consumption in Indian city

Use	Consumption in litres/day/person
Drinking	5
Cooking	5
Bathing	55
Washing of clothes	20
Washing of Utensils	10
Washing and cleaning of hoses and residences	10
Flushing of latrines, etc.,	30
Total	135

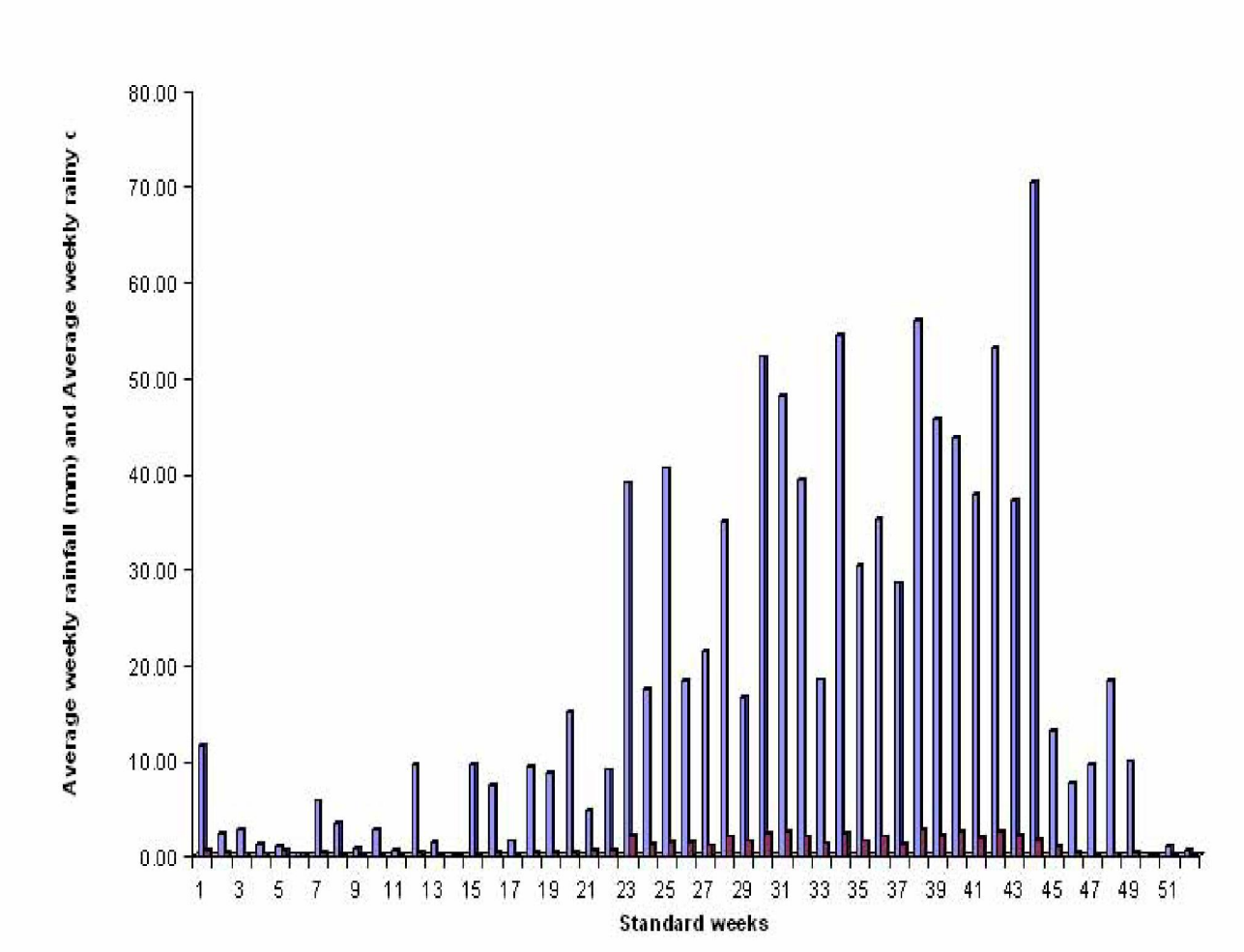


Fig 1. Average weekly rainfall (mm) and average weekly rainy days from 10 years (i.e 1999- 2008) rainfall data.

Table 2 Expected rainfall (mm) estimation at different probability levels by Gamble's probability distribution

Weekly rainfall	At 40% level	At 50% level	At 60% level	At 75% level	At 90% level
1	15.75	8.58	2.02	0.00	0.00
2	3.58	1.40	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00
4	1.94	0.92	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00
7	8.03	4.13	0.56	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00
10	4.24	1.61	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00
16	10.81	4.96	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00
18	11.63	7.74	4.18	0.00	0.00
19	10.95	7.03	3.45	0.00	0.00
20	20.02	11.46	3.63	0.00	0.00
21	6.11	3.93	1.93	0.00	0.00
22	12.14	6.79	1.91	0.00	0.00
23	44.52	35.08	26.46	13.64	0.00
24	20.67	15.17	10.15	2.68	0.00
25	57.43	28.33	1.74	0.00	0.00
26	22.84	15.10	8.03	0.00	0.00
27	28.76	16.09	4.52	0.00	0.00
28	41.61	30.23	19.83	4.37	0.00
29	18.93	14.80	11.03	5.41	0.00
30	56.70	48.89	41.75	31.14	18.16
31	54.85	43.37	32.88	17.27	0.00
32	46.70	34.13	22.64	5.55	0.00
33	22.11	15.78	10.01	1.42	0.00
34	66.16	45.99	27.57	0.16	0.00
35	36.39	25.91	16.34	2.10	0.00
36	39.98	31.83	24.39	13.31	0.00
37	33.03	25.28	18.20	7.67	0.00
38	64.14	49.99	37.07	17.84	0.00
39	52.15	41.20	31.20	16.31	0.00
40	54.85	35.51	17.85	0.00	0.00
41	45.99	31.83	18.89	0.00	0.00
42	61.89	46.74	32.90	12.30	0.00
43	42.65	33.28	24.71	11.98	0.00
44	95.04	52.49	13.62	0.00	0.00
45	15.40	11.30	7.55	1.97	0.00
46	10.83	5.16	0.00	0.00	0.00
47	13.13	7.04	1.49	0.00	0.00
48	0.00	0.00	0.00	0.00	0.00
49	14.92	6.28	0.00	0.00	0.00
50	0.00	0.00	0.00	0.00	0.00
51	1.46	0.72	0.04	0.00	0.00
52	0.00	0.00	0.00	0.00	0.00

Table 3. Water budget calculation at College building

Std week	Rain-fall (mm)	Water demand in(L)						Supply in (L)			Deficit/ Surplus (L)	Saving Rs.
		Effective rainfall (mm)	Drinking Water (L)	Washing of hands (L)	Cleaning of building(L)	Flushing of urinals, *etc*., (L)	Total water requirement (L)	Total harvested water (L)	Estate supply (L)	Total (L)		
1	8.58	7.29	6125	12250	12250	36750	67375	7740.19	54000	61740.19	-5634.81	270.9
2	1.4	1.29	6125	12250	12250	36750	67375	1263.04	54000	55263.04	-12111.96	44.2
3	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
4	0.92	0.78	6125	12250	12250	36750	67375	833.32	54000	54833.32	-12541.68	29.2
5	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
6	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
7	4.13	3.51	6125	12250	12250	36750	67375	3723.86	54000	57723.86	-9651.14	130.3
8	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
9	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
10	1.61	1.37	6125	12250	12250	36750	67375	1456.90	54000	55456.90	-11918.10	51.0
11	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
12	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
13	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
14	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
15	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
16	4.96	4.22	6125	12250	12250	36750	67375	4481.25	54000	58481.25	-8893.75	156.8
17	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
18	7.74	6.58	6125	12250	12250	36750	67375	6982.68	54000	60982.68	-6392.32	244.4
19	7.03	5.97	6125	12250	12250	36750	67375	6343.51	54000	60343.51	-7031.49	222.0
20	11.46	9.74	6125	12250	12250	36750	67375	10341.84	54000	64341.84	-3033.16	362.0
21	3.93	3.34	6125	12250	12250	36750	67375	3544.12	54000	57544.12	-9830.88	124.0
22	6.79	5.77	6125	12250	12250	36750	67375	6132.17	54000	60132.17	-7242.83	214.6
23	35.08	29.82	6125	12250	12250	36750	67375	31664.42	54000	85664.42	18289.42	1108.3
24	15.17	12.90	6125	12250	12250	36750	67375	13694.61	54000	67694.61	319.61	479.3
25	28.33	24.08	6125	12250	12250	36750	67375	25567.20	54000	79567.20	12192.20	894.9
26	15.10	12.83	6125	12250	12250	36750	67375	13626.21	54000	67626.21	251.21	476.9
27	16.09	13.68	6125	12250	12250	36750	67375	14521.90	54000	68521.90	1146.90	508.3

28	30.23	25.70	6125	12250	12250	36750	67375	27286.66	54000	81286.66	13911.66	955.0
29	14.80	12.58	6125	12250	12250	36750	67375	13357.06	54000	67357.06	-17.94	467.5
30	48.89	41.55	6125	12250	12250	36750	67375	44125.83	54000	98125.83	30750.83	1544.4
31	43.37	36.86	6125	12250	12250	36750	67375	39144.61	54000	93144.61	25769.61	1370.1
32	34.13	29.01	6125	12250	12250	36750	67375	30802.99	54000	84802.99	17427.99	1078.1
33	15.78	13.42	6125	12250	12250	36750	67375	14247.53	54000	68247.53	872.53	498.7
34	45.99	39.10	6125	12250	12250	36750	67375	41515.74	54000	95515.74	28140.74	1453.1
35	25.91	22.02	6125	12250	12250	36750	67375	23388.29	54000	77388.29	10013.29	818.6
36	31.83	27.06	6125	12250	12250	36750	67375	28732.43	54000	82732.43	15357.43	1005.6
37	25.28	21.49	6125	12250	12250	36750	67375	22819.75	54000	76819.75	9444.75	798.7
38	49.99	42.49	6125	12250	12250	36750	67375	45125.30	54000	99125.30	31750.30	1579.4
39	41.20	35.02	6125	12250	12250	36750	67375	37189.07	54000	91189.07	23814.07	1301.6
40	35.51	30.19	6125	12250	12250	36750	67375	32055.96	54000	86055.96	18680.96	1122.0
41	31.83	27.05	6125	12250	12250	36750	67375	28726.95	54000	82726.95	15351.95	1005.4
42	46.74	39.73	6125	12250	12250	36750	67375	42188.00	54000	96188.00	28813.00	1476.6
43	33.28	28.29	6125	12250	12250	36750	67375	30036.44	54000	84036.44	16661.44	1051.3
44	52.49	44.61	6125	12250	12250	36750	67375	47374.69	54000	101374.69	33999.69	1658.1
45	11.30	9.60	6125	12250	12250	36750	67375	10199.00	54000	64199.00	-3176.00	357.0
46	5.16	4.39	6125	12250	12250	36750	67375	4658.52	54000	58658.52	-8716.48	163.0
47	7.04	5.99	6125	12250	12250	36750	67375	6358.67	54000	60358.67	-7016.33	222.6
48	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
49	6.28	5.33	6125	12250	12250	36750	67375	5664.08	54000	59664.08	-7710.92	198.2
50	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0
51	0.72	0.61	6125	12250	12250	36750	67375	647.32	54000	54647.32	-12727.68	22.7
52	0.00	0.00	6125	12250	12250	36750	67375	0.00	54000	54000.00	-13375.00	0.0

Total Demand	3503500.00L
Total Supply	3535562.10L
Total Surplus	32062.10 L
Total Saving	Rs 25464.67
Total harvested water	727562.10 L

capita per day) and a family size of 4 members rainwater should theoretically suffice for 194 days in a year. Vishwanath (2005) stated that the conservation practices like rainwater harvesting, including rooftop rainwater harvesting, need to be practiced to further increase the utilizable water resources. The aim of rooftop rainwater harvesting especially in rural areas is to provide drinking water for both humans and animals. The Karnataka State Water Policy stated that the water requirement for urban people is 55 liters per person per day, for rural areas 70 liters per person per day, in towns 100 liters per person per day in the municipal council areas 135 liters per person per day.

MATERIAL AND METHODS

The present investigation on rooftop rainwater harvesting was carried out during 2008-2009 at CAE Campus, Bapatla. Bapatla is situated in Coastal Zone of Andhra Pradesh state at $15^0 54^1$ N latitude and $80^0 30^1$ E longitude with an altitude of 5.49 m above the mean sea level. The average annual rainfall of CAE is 998.329 mm.

Description of the Study Area

The College main building in the CAE Campus is the major roof top collecting surface, which is situated near to the main road [Bapatla to Karlapalem road] which is of three storied building with flat terrace roof surface. Water is supplied from a circular overhead tank, which is located on top of the building and about 175 members are working in this building. The roof top area of this building is 1061.91 m^2.

The boy's hostel building is two stored building with the flat terrace roof surface, which is located about 250 meters from the left side of the CAE College building. Water is supplied from two circular overhead tanks they are located on top of the building. Nearly 66 members are staying in this building. The roof top area of this building is 608.74 m^2.

Water budgeting studies

For the water budgeting analysis, the individual buildings of boy's hostel and college building were selected. The weekly demand and supplies for these buildings were arrived at during the study period.

Source of data

By conducting personal interview method with the help of comprehensive interview schedule, the data were collected from the selected college and boy's hostel buildings of CAE campus, Bapatla. The data collected from the respondents include total persons present in individual buildings, total water requirement and estate water supply.

Demand calculation

The total weekly drinking water demand was calculated by multiplying the water requirement for drinking per person per week and the number of persons present in the building. Similarly for cooking, bathing, washing clothes, cleaning dishes, cleaning houses and flushing toilets demands were calculated. By adding all these different demands, the total water demand was worked out for individual buildings.

Supply calculation

The total supply constitutes the rainfall collected from rooftop surface of individual buildings using established system components and water supply from the CAE campus. The daily rainfall data for the study area were collected from Meteorology Center, Bapatla for 10 years (1999 to 2008). By using this rainfall data, the weekly rainfall was estimated at 40, 50, 60, 75 and 90 probability levels, using Gumble distribution. The effective rainwater collected from the rooftop surface area was calculated by the following formula.

Where,

Er = Effective rainwater storage per week in liters (L)
Dr = Depth of rainfall received during the standard week (mm)
A = Area of the rooftop surface (m^2)
C = Effective rainfall proportion for storage

Surplus or Deficit water

The surplus or deficit water was worked out by the difference between the total supply and the total demand i.e. total water requirement. From this difference, the supply demand gap for various buildings was worked out. The cumulative supply and cumulative demand were calculated to know the supply and total demand of a calendar year for each building. The saving per week was worked out by multiplying the volume of water and with the cost of municipal office water supply per 1,000 litres i.e. Rs. 35 per 1,000 litres. The total cost of saving per year was worked out by adding weekly savings.

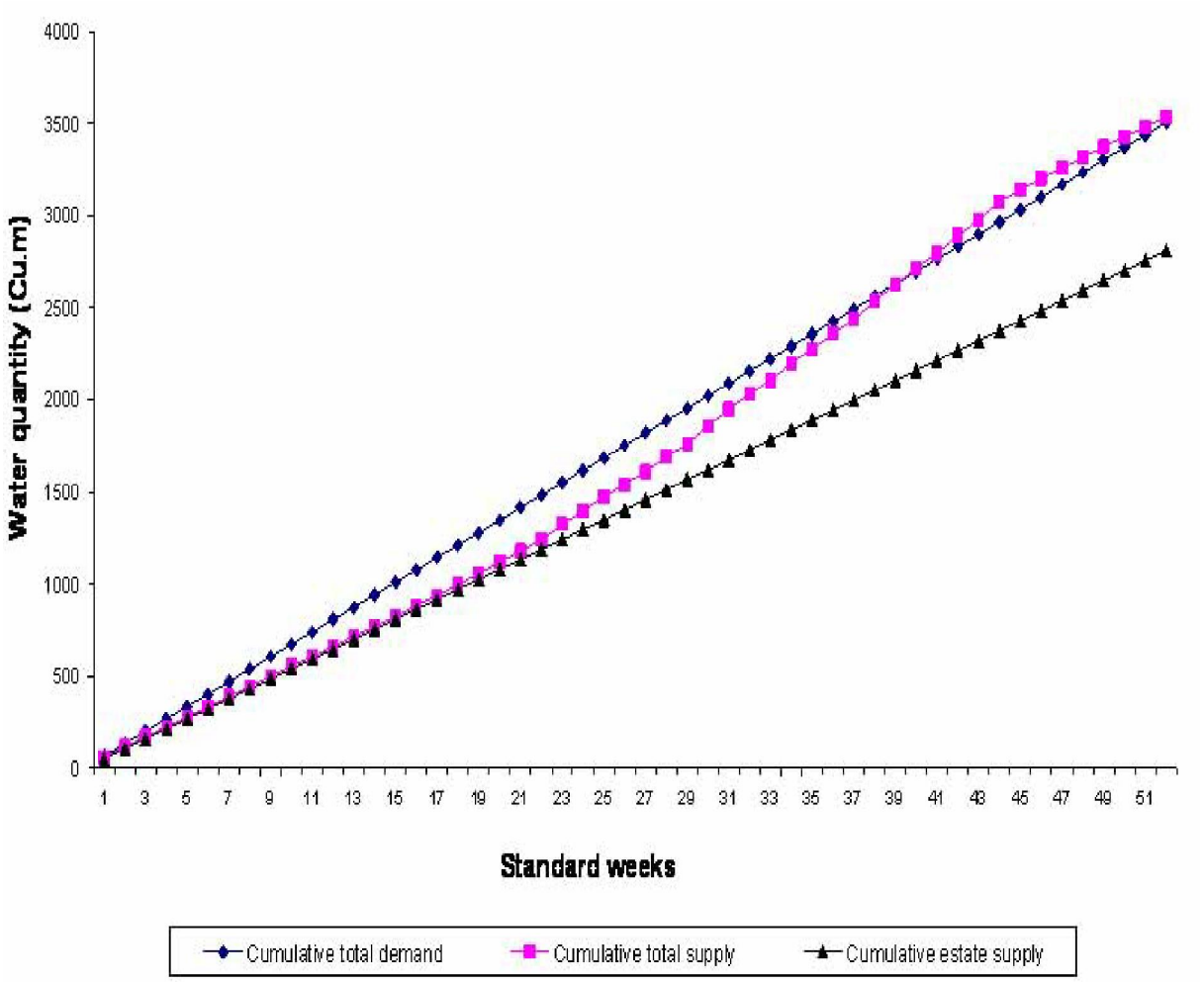
Table 4. Water budget caculation at UG boy's hostel building at CAE Campus Bapatla.

			Water demand in(L)								Supply in (L)				
Std week	Rain-fall (mm)	Effective rainfall (mm)	Drinking Water (L)	Cook-ing (L)	Bath-ing (L)	Washing of clothes (L)	Wash-ing of Uten-sils (L)	Wasing and cleaning of resi-dence (L)	Flushing of la-trines, *etc*., (L)	Total water require-ment (L)	Total harvested water (L)	Estate supply (L)	Total (L)	Deficit/ Surplus (L)	Saving Rs.
1	8.58	7.29	4200	4200	13860	9240	4620	4620	13860	54600	4437.06	51840	56277.06	1677.06	155.3
2	1.40	1.19	4200	4200	13860	9240	4620	4620	13860	54600	724.04	51840	52564.04	-2035.96	25.3
3	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
4	0.92	0.78	4200	4200	13860	9240	4620	4620	13860	54600	477.70	51840	52317.70	-2282.30	16.7
5	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
6	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
7	4.13	3.51	4200	4200	13860	9240	4620	4620	13860	54600	2134.70	51840	53974.70	-625.30	74.7
8	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
9	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
10	1.61	1.37	4200	4200	13860	9240	4620	4620	13860	54600	835.17	51840	52675.17	-1924.83	29.2
11	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
12	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
13	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
14	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
15	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
16	4.96	4.22	4200	4200	13860	9240	4620	4620	13860	54600	2568.88	51840	54408.88	-191.12	89.9
17	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
18	7.74	6.58	4200	4200	13860	9240	4620	4620	13860	54600	4002.82	51840	55842.82	1242.82	140.1
19	7.03	5.97	4200	4200	13860	9240	4620	4620	13860	54600	3636.42	51840	55476.42	876.42	127.3
20	11.46	9.74	4200	4200	13860	9240	4620	4620	13860	54600	5928.46	51840	57768.46	3168.46	207.5
21	3.93	3.34	4200	4200	13860	9240	4620	4620	13860	54600	2031.66	51840	53871.66	-728.34	71.1
22	6.79	5.77	4200	4200	13860	9240	4620	4620	13860	54600	3515.27	51840	55355.27	755.27	123.0
23	35.08	29.82	4200	4200	13860	9240	4620	4620	13860	54600	18151.63	51840	69991.63	15391.63	635.3
24	15.17	12.90	4200	4200	13860	9240	4620	4620	13860	54600	7850.44	51840	59690.44	5090.44	274.8
25	28.33	24.08	4200	4200	13860	9240	4620	4620	13860	54600	14656.40	51840	66496.40	11896.40	513.0
26	15.10	12.83	4200	4200	13860	9240	4620	4620	13860	54600	7811.23	51840	59651.23	5051.23	273.4
27	16.09	13.68	4200	4200	13860	9240	4620	4620	13860	54600	8324.68	51840	60164.68	5564.68	291.4
28	30.23	25.70	4200	4200	13860	9240	4620	4620	13860	54600	15642.08	51840	67482.08	12882.08	547.5

29	14.80	12.58	4200	4200	13860	9240	4620	4620	13860	54600	7656.94	51840	59496.94	4896.94	268.0
30	48.89	41.55	4200	4200	13860	9240	4620	4620	13860	54600	25295.14	51840	77135.14	22535.14	885.3
31	43.37	36.86	4200	4200	13860	9240	4620	4620	13860	54600	22439.65	51840	74279.65	19679.65	785.4
32	34.13	29.01	4200	4200	13860	9240	4620	4620	13860	54600	17657.82	51840	69497.82	14897.82	618.0
33	15.78	13.42	4200	4200	13860	9240	4620	4620	13860	54600	8167.40	51840	60007.40	5407.40	285.9
34	45.99	39.10	4200	4200	13860	9240	4620	4620	13860	54600	23798.90	51840	75638.90	21038.90	833.0
35	25.91	22.02	4200	4200	13860	9240	4620	4620	13860	54600	13407.34	51840	65247.34	10647.34	469.3
36	31.83	27.06	4200	4200	13860	9240	4620	4620	13860	54600	16470.87	51840	68310.87	13710.87	576.5
37	25.28	21.49	4200	4200	13860	9240	4620	4620	13860	54600	13081.42	51840	64921.42	10321.42	457.8
38	49.99	42.49	4200	4200	13860	9240	4620	4620	13860	54600	25868.08	51840	77708.08	23108.08	905.4
39	41.20	35.02	4200	4200	13860	9240	4620	4620	13860	54600	21318.64	51840	73158.64	18558.64	746.2
40	35.51	30.19	4200	4200	13860	9240	4620	4620	13860	54600	18376.08	51840	70216.08	15616.08	643.2
41	31.83	27.05	4200	4200	13860	9240	4620	4620	13860	54600	16467.72	51840	68307.72	13707.72	576.4
42	46.74	39.73	4200	4200	13860	9240	4620	4620	13860	54600	24184.27	51840	76024.27	21424.27	846.4
43	33.28	28.29	4200	4200	13860	9240	4620	4620	13860	54600	17218.39	51840	69058.39	14458.39	602.6
44	52.49	44.61	4200	4200	13860	9240	4620	4620	13860	54600	27157.55	51840	78997.55	24397.55	950.5
45	11.30	9.60	4200	4200	13860	9240	4620	4620	13860	54600	5846.58	51840	57686.58	3086.58	204.6
46	5.16	4.39	4200	4200	13860	9240	4620	4620	13860	54600	2670.50	51840	54510.50	-89.50	93.5
47	7.04	5.99	4200	4200	13860	9240	4620	4620	13860	54600	3645.11	51840	55485.11	885.11	127.6
48	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
49	6.28	5.33	4200	4200	13860	9240	4620	4620	13860	54600	3246.93	51840	55086.93	486.93	113.6
50	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0
51	0.72	0.61	4200	4200	13860	9240	4620	4620	13860	54600	371.08	51840	52211.08	-2388.92	13.0
52	0.00	0.00	4200	4200	13860	9240	4620	4620	13860	54600	0.00	51840	51840.00	-2760.00	0.0

Total Demand	2839200.00 L
Total Supply	*3112755.04 L*
Total Surplus	*2695680.04 L*
Total Saving	Rs.14597.63
Total harvested water	417075.04 L

Fig 2 Water budgeting of College Building



RESULT AND DISCUSSION

Supply – Demand analysis

This analysis was carried out to estimate the supply-demand gap for individual building before and after installation of the rooftop rainwater harvesting system.

Demand analysis

The domestic water demand includes the water required in individual building for drinking, cooking, bathing, washing of clothes, washing of utensils, washing and cleaning of houses and residences, flushing of latrines, *etc*. The total domestic consumption generally amounts to 55 to 60 percentage of the water consumption. On average, this domestic consumption under normal conditions in an Indian city is expected to be around 135 litres/day/person as per IS: 1172-1971. The breakup of 135 litres/day/person may be approximately taken as shown in Table 1. The total demand of water domestic purposes was estimated as 135 litres/person/day from all needs or 945 litres/person/week. The total demand of water for individual building was calculated by adding the water requirement per head per week.

Supply analysis

Graphical representation of average weekly rainfall and average weekly rainy days for 10 years (i.e. 1999-2008) is shown in Fig. 1. The weekly rainfall at different probability levels i.e. 40, 50, 60, 75 and 90 % were calculated using Gumble's distribution and represented in Table 2.

The effective rainfall was calculated by multiplying the weekly rainfall at 50 percentage probability level (chosen for this study keeping the risk factor) with runoff coefficient (0.85). The volume of harvested water for each building was calculated by multiplying the effective rainfall per week with the roof surface area of respective building. The total water supply was calculated by summation of the total harvesting water and of external supply from estate branch. Deficit/ Surplus and total savings were calculated per year for each building.

Water budgeting for college building at 50% probability level weekly rainfall

The values of total water harvested, demand and supply were estimated and presented in Table 3. and it is observed that the total water harvested, total water demand, total water supply and estate supply were 727562.10, 3503500.00, 3535562.10 and 2808000.00 litres per year respectively. Hence, the total water surplus of 32062.10 litres per year can be stored and used when there is deficit. It was also found that from harvested water, a total of Rs. 25464.7 per year could be saved. Graphical representation of cumulative total demand, cumulative total supply, and cumulative estate supply over period of 52 weeks (one year) is shown in Fig. 2 and it is observed that the cumulative supply line was moving just less than by cumulative demand line up to 39th week. After this week the cumulative supply line is almost equal to cumulative demand line.

Water budgeting for boys' hostel by using 50% probability level weekly rainfall

The values of total water harvested, demand and supply were estimated and presented in Table 4 and it was observed that the total water harvested, total water demand, total water supply and estate supply were 417075.04, 2695680.00, 3112755.04 and 2839200.00 litres per year respectively. Hence, the total water surplus of 273555.04 litres per year can be stored and used when there is deficit. It was also found that from harvested water, a total of Rs. 14597.63 per year could be saved. Graphical representation of cumulative total demand, cumulative total supply, and cumulative estate supply over period of 52 weeks (one year) is shown in Fig. 3. and it was observed that the cumulative supply line was moving just less than by cumulative demand line up to 25th week. After this week the cumulative supply line drastically increased due to South-West monsoon.

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(Received on 02.08.2010 and revised on 20.10.2010)