Rooftop Rain Water Harvesting Potential: A Case Study of Dahivadi College Building and Campus in Man Tahsil of Satara District

C. J. Khilare[1], S. N. Pawar[2], D. D. Namdas[3] and V. P. Gaikwad[4]

[1,2,3] Dahiwadi College Dahiwadi, Dist. Satara (M.S.), India.

[4]Shri. R. R. Patil College, Savlaj, Dist. Sangli (M.S.), India.

Cjk_principal@rediffmail.com, sachinjipawar@gmail.com, ddnamdas@yahoo.co.in, gaikwadvp@gmail.com

Abstract

In the present study attempt has been made to examine the present status of water requirement and proposed rooftop RWH potential in the College campus. Building and campus of Dahiwadi College Dahiwadi located in Man tahsil of Satara district has been undertaken for the present investigation. Dahiwadi College is located in drought prone area; the average annual rainfall in the study area is hardly 500 mm. The proposed study is entirely based on primary and secondary data. Primary data collected form field work and secondary data collected from Socio – Economic Review and District Statistical Abstract of Satara, District Gazetteer and also data have been collected from various published and unpublished thesis, articles, books, etc. Rooftop rainwater harvesting method is used in the present study. The per capita daily water requirement is calculated as number of persons **x** 2 liters. The annual, daily and dry day's water requirement has been calculated in liters. Runoff Coefficient and Annual rainwater harvesting potential (ARHP) of the study region is estimated by using formula given by (Pecey,et.al;1989).

Dahiwadi College comprised with 6 acres of campus and 4410.6 m^2 area of roof surface. Population of college is about 3209 including students, teaching and non-teaching staff and daily visitors. Analysis revealed that 6418 l/d water required for drinking. At present college has already 2 water storage tanks having 88000 liters capacity and excess demand of water meet with recharge of bore well. Rooftop rainwater harvesting estimated potential is about 1649094 liters and it can be mitigating about 70.39 per cent annually drinking water demand and 43.86 per cent domestic water demand. Thus, the Rooftop RWH would be a solution for drinking and domestic water sustainability of the college in some extent. Results obtained from the present study suggested that Rooftop RWH method is more applicable in college campus located in drought prone zones of Maharashtra which would enable to solve the problem of water scarcity up to certain extent.

Key Words: Watershed, Rainwater Harvesting, Rooftop RWH, Runoff Coefficient, Sustainability

Introduction

Water is a one of the most important resources for survival of human being as much as food, air etc, but very few attentions are paid for its economical use and conservation of this precious resource. Due to over pumping of ground water, the water table is going down abnormally and if the problem is not given a serious look, then the future generations may have to face severe scarcity of water. Rainfall is the prime source of water and if rain water is harvested, the scarcity of water can be eliminated altogether. This is an ideal solution to overcome water problem where surface water sources are insufficient and inadequate groundwater supply quantitatively and qualitatively. RWH is the process of collecting and storing water for future productive use. Rooftop RWH is the technique through which rain water is captured from the roof catchments and stored in reservoirs. Rooftop RWH is essential for making water available for future use. This method is particularly important in drought prone, hilly, urban and coastal areas.

In fact, India and Maharashtra is blessed with adequate rainfall as a whole, yet there are large swathes of dry and drought prone area. In many places the quality of groundwater is not good. Some areas having quite even rainfall but there is also problem of a severe scarcity of drinking water. This is because we have rainfall in short spells of high intensity. Due to this intensity and short duration of heavy rain, most of the rain falling on surface tends to flow away rapidly and leaving very little for the recharge of ground. Therefore, it is necessary for users to collect and store rainwater. Rainwater harvesting through rooftops is an optimistic method of water conservation and Indian government has mounted this as a part of watershed management programme. Surface water is inadequate to meet our requirements hence we have to make use of ground water. Due to overuse of ground water, underground water level has been declining in such areas RWH is an ideal solution in near future. Therefore, attempt has been made here to examine the present status of water requirement and proposed rooftop RWH potential at micro level.

The study region :-

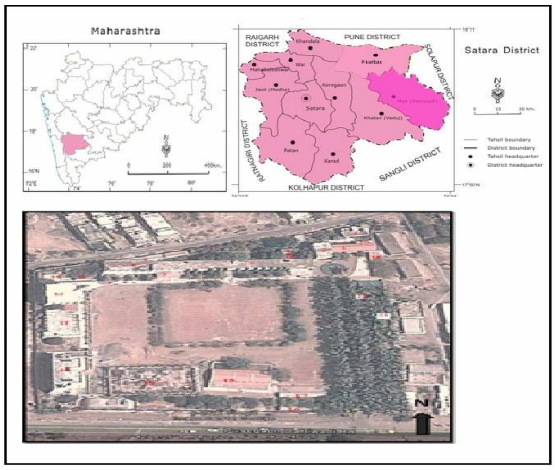

Fig. No.1 Location Map of Dahiwadi College Dahiwadi

Building and campus of Dahiwadi College Dahiwadi located in Man tahsil of Satara district of Maharashtra has been undertaken for the present investigation. It lies between 17° 40'54" north latitude and 74°37'47" east longitude. Dahiwadi College is located in drought prone area; the average annual rainfall in the study area is 500 mm.

Dahiwadi College comprised with 6 acres of campus with 4811.14 m^2 built up area and 4410.6 m^2 area of roof surface. Population of college is about 3209 including students, teaching and non-teaching staff and daily visitors. College has 712 m^2 area of fruit garden and 1550 m^2 area of botanical garden. At present, college has already 2 water storage tanks having 88000 liters capacity.

Objectives

1. To examine the present status of water requirement and supply gap.
2. To analyse the proposed rooftop rain water harvesting potential in the College campus.

Database and Methodology

The proposed study is entirely based on primary and secondary data. Primary data collected from field survey and secondary data collected from college records, Socio – Economic Review and District Statistical Abstract of Satara, District Gazetteer and also data has been collected from various published thesis, articles, books, etc. Rooftop rainwater harvesting method is used in the present study. The per capita daily water requirement is calculated as number of persons x 2 liters. The daily, annual and dry day's water requirement has been calculated in liters. Runoff Coefficient and Annual rainwater harvesting potential (ARHP) of the study region is estimated by using formula given by (Pecey, et.al; 1989).

$$\textit{Annual Rainwater Harvesting Potential (ARHP)} = R \times AC \times RC$$

Where, R - Rainfall (in metre)
AC - Area of catchment (in square metre)
RC - Runoff coefficient

Results and Discussion

Water Demand And Supply Gap: There are several estimates in the world regarding total water requirement for human being and also for drinking purpose. According to United States, it is estimated that 50 l/p/d drinking and domestic water is essential for rural communities in the developing country (Bansil, 1998). According to World Health Organization, it is estimated that average 2.5 liter daily water intakes per capita per day is required. According to U.S. Environmental Protection Agency, average daily water intake 2.0 l/p/d is required. National Academy of Sciences also estimated daily 2.0 liters water requirement for per person. For present investigation, it is assumed that average water requirement is 2.0 l/p/d.

The total population of the college is about 3209 including all students, all teaching and non-teaching staff and daily visitors. Analysis revealed that 6418 liters water is required for daily and 2342570 liters for drinking purpose per annum. Estimated daily domestic water demand of the college is about 10300 liters and annual demand is about 3759500 liters. Estimated daily drinking and domestic water requirement is 16718 liters and 6102070 liters annually. From July to February 12000 liters and from March to June 8000 liters ground water is extracted from 3 bore wells in the college campus. It is investigated that average 10,000 liters daily and 3650000 liters annually ground water is extracted from 3 bore wells in the college campus for the purpose of drinking and domestic use.

Drinking water demand is totally fulfilled through ground water extraction but; for domestic water demand and supply gap is about -109500 liters per annum. Present investigation shows the total demand and supply gap is -6718 liters daily and -2452070 liters annually (Table 2). It has been also increased from 8000 to 12000 liters per day in every summer season that leads to severe problem of water scarcity during the summer season. College has fulfilled total water demand and especially domestic water demand through providing water tankers during every summer season.

Population of the College (Students + Staff + Guests)		Estimated water requirement in liters (Drinking + Domestic)		Estimated ground water extracted in liters (through 3 bore wells)		Estimated water demand and supply gap in liters	
Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual
1	2	3	4	5	6	5 - 3	6 - 4
3209	1171285	16718	6102070	10000	3650000	-6718	-2452070

Table – 1 Estimated Water Demand and Supply Gap of Dahivadi College (2012)
Source: Field Survey, 2012

Rooftop RWH Potential In College Campus: Water Demand And Rooftop RWH Potential

Dahiwadi college campus has huge potential of RWH (Fig. No. 2). It is estimated that, 1649094 liters water is made available throughout the year. Annual drinking water demand of the college is about 2342570 liters. In this way, annually, 70.39 per cent requirement of drinking water can be fulfilled from Rooftop RWH in the entire college campus. In dry days (243 days) drinking water demand is about 155957 liters which is totally completed through Rooftop RWH, its potential is about 105.74 per cent, it means, dry day's drinking water demand is fulfilled 100 per cent by using harvested water. Annual domestic water demand of the college is about 3759500 liters. Annually 43.86 per cent requirement of domestic water can fulfilled from Rooftop RWH. In dry days (243 days), domestic water demand is about 2502900 liters out of which 65.88 per cent is completed through rooftop RWH, it means, in dry days, domestic water demand is also extensively fulfilled by using harvested water.

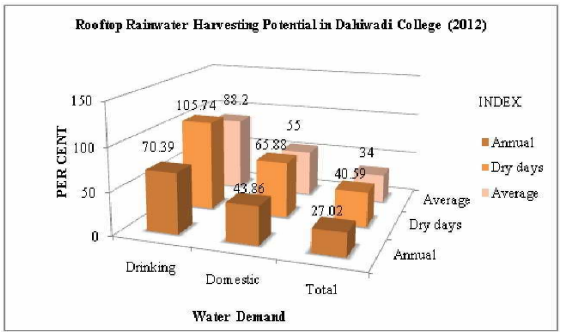

Fig. No. 2 Water Demand and Rooftop RWH Potential

Total drinking and domestic water demand of the college is 6102070 liters out of which 27.02 per cent total water demand is fulfilled annually. Dry day's water demand is less than annual demand i.e. 4062474 liters out of which estimated that 40.59 per cent water demand are completed through RWH. Thus, it is proved that by using rooftop rainwater harvesting method, water scarcity in the college campus can be minimized up to certain extent and water collected can be used for drinking and domestic purpose.

Buildingwise Details of Rooftop Area and Annual Potential:

Very High Potential (Roof Area 500 m^2 & above):

There is positive correlation between roof surface area and RWH potential. At present, Class room building is having highest potential of rooftop RWH in the college campus. Analysis reveals that this building has near about 700.3 m^2 rooftop surface areas which is highest compared to other buildings because of concrete roof surface, its collection efficiency is more than 70% per cent. Hence its estimated rooftop rainwater harvesting potential is 245105 liters per year.

At present, Indoor Sports Hall construction is in progress, its roof surface area and proposed rain water potential is highest in the college campus in next year. Its area would be about 864 m^2 and estimated annual rooftop rain water potential is 345600 liters. Roof surface of Indoor Sports Hall is of metal sheets having collection efficiency of more than 80 per cent which leads to a very high RWH potential in the college campus. Two building's total annual estimated rooftop rainwater harvesting potential is 35.6% out of overall potential of the college.

High Potential (Roof Area 300 – 500 m^2) :MCVC and Canteen building in the college campus shows 425 m^2 area of metal sheet roof surface having 80 per cent collection ability, because of this, estimated RWH potential will be 170000 liters. Auditorium building shows 350.9 m^2 area of roof surface having concrete surface so, its water collection capacity 70 per cent. Auditorium building shows high potential of rooftop RWH i.e. 122815 liters per year. Another important building is Ladies hostel. It shows 322.5 m^2 area of concrete roof surface and annual potential is about 112875 liters. All these buildings are included in high potential and suitable for rooftop RWH.

Medium Potential (Roof Area 100 – 300 m^2): Library & Class room building shows medium potential of RWH. This building is comprised with 284.09 m^2 area of roof surface and its estimated annual potential is 113636 liters. Secondly, Chemistry and Zoology Laboratory acquired 296.96 m^2 areas having 118784 liters annual potential. Humanities department covering 117.9 m^2 area of roof surface has proposed potential of 47160 liters per year. Roof surface of all these buildings made by metal sheets contains 80 per cent rain water collection potential. Office of the college has acquired 190.96 m^2 and Gents and Ladies Toilet building 166.44 m^2 roof areas having 66836 liters, 58254 liters annual potential capacity respectively.

Low Potential (Roof Area below 100 m^2): Remaining 12 buildings show less RWH potential due to below 100 m^2. roof surface area of all buildings. Buildings such as Principal's Cabin, Principal's Quarter, Botany Research Laboratory, Staff Toilet, Boys Common Room, Chemistry Apart Stores, Ladies Common Room, Car Parking, Motor Cycle Parking, Office Store, Vermiculture, Generator etc. are not much useful for RWH. All these buildings are comprised with 691.01 m^2 area of roof and their estimated annual potential is about 258596 liters. It shows low potential not utilized for harvesting of 10 buildings potential which is about 1401065 liters.

Conclusion

Present study shows the total water demand and supply gap is -6718 liters daily and -2452070 liters annually. It has been also increased from 8000 to 12000 liters per day in every summer season that leads to severe problem of water scarcity in the college campus. Both concrete and metal sheets types of roof surfaces in the college are more suitable for rainwater harvesting because its collection efficiency is more than 70 per cent. Estimated annual rooftop rain water potential of these roof surfaces is about 42.27 per cent and 56.97 per cent, respectively. Rooftop rainwater harvesting estimated potential is about 16, 59,650 liters and it can be mitigate about 70.39 per cent requirement of drinking water and 43.86 per cent domestic water demand annually. If college uses harvested water during dry days only then either 100 per cent drinking water demand or 65.88 Per cent domestic water demand can be fulfilled. Total water demand of the college is about 6102070 liters out of which annually 27.02 per cent and during dry days (243 days) 40.59 per cent can be completed through Rooftop RWH method. Highest rooftop RWH potential is existing in Class room and Indoor hall buildings. High and medium potential exist in buildings such as MCVC & Canteen, Auditorium and Ladies hostel but good potential is found at Chemistry & Zoology Laboratory, Library & Class rooms, Office, Gents & Ladies toilet and Humanities department buildings in the college campus. All these buildings are suitable for Rooftop RWH purpose.

Analysis reveals that the quantity of water available depends on intensity of rainfall and the surface of the roof, and additional sources of water are always needed. For long periods of drought, it is necessary to store excessively large volumes of water. In areas with significant variations in the annual rainfall pattern, the matching of water supply and water demand may be difficult. However, institution has a crucial role to play. Rainwater in many cases is the easiest way to access, most reliable, and least polluted source, especially in drought prone areas or where the groundwater is saline. Rooftop RWH is the only sustainable alternative for ensuring continued access to safe drinking water. Thus, the Rooftop RWH would be a solution for drinking and domestic water sustainability of the college to some extent. Results obtained from the present study suggested that Rooftop RWH method is more applicable in college campus which is located in drought prone zones of Maharashtra that would enable to solve the problem of water scarcity to certain extent.

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Building No.	Building Name	Rooftop Area in m^2	Coefficients	Annual Rooftop RWH Potential	
				Cu. m.	liters
1	Office	190.96	0.7	66.836	66836
2	Principal Cabin	93.65	0.7	32.7775	32777.5
3	Principal's Quarter	99.31	0.7	34.7585	34758.5
4	Botany Research Laboratory	42.5	0.7	14.875	14875
5	Class Rooms	700.3	0.7	245.105	245105
6	Staff Toilet	38.08	0.7	13.328	13328
7	Boy's Common Room	73.2	0.8	29.28	29280
8	Chemistry and Zoology	296.96	0.8	118.784	118784
9	Chemistry Apart Stores	44.2	0.8	17.68	17680
10	Ladies Common Room	32.64	0.8	13.056	13056
11	Gents and Ladies Toilet	166.44	0.7	58.254	58254
12	Library and Class Rooms	284.09	0.8	113.636	113636
13	Auditorium	350.9	0.7	122.815	122815
14	Ladies Hostel	322.5	0.7	112.875	112875
15	MCVC Building And Canteen	425	0.8	170	170000
16	Car Parking	93.06	0.8	37.224	37224
17	Motor Cycle Parking	93.06	0.8	37.224	37224
18	Humanities Departments	117.9	0.8	47.16	47160
19	Indoor Sports Hall	864	0.8	345.6	345600
20	Office Store	30.4	0.8	12.16	12160
21	Vermiculture	41.31	0.6	12.393	12393
22	Generator	9.6	0.8	3.84	3840
	Total	4410.06	7.5	1659.661	1659661

Table : 2 Building wise Annual Rooftop Rainwater Harvesting Potential Source: field Survery. 2012