# Rainwater Harvesting - A Case Study at Pimpri Chinchwad College of Engineering and Research, Ravet

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**ABSTRACT**

*At the rate in which India population is increasing, it is said that India will surely replace China from its number 1 position of most densely populated country of the world after 20-30. These will lead to high rate of consumption of most valuable natural resource "Water" resulting in augmentation of pressures on the permitted freshwater resources. Ancient method of damming river and transporting water to urban area has its own issues of eternal troubles of social and political. In order to conserve and meet our daily demand of water requirement, we need to think for alternative cost effective and relatively easier technological methods of conserving water. Rainwater harvesting is one of the best methods fulfilling those requirements. The technical aspects of this paper are rainwater harvesting collected from rooftop which is catchment areas from Institute building at P.C.C.O.E.R. Ravet campus. First, required data are collected i.e. catchment areas & hydrological rainfall data. Water harvesting potential for the college building was calculated, and the tank capacity with suitable design is being considered. Volume of tank has been calculated with most appropriate method of estimation. Optimum location of tank based on hydrological analysis and GIS analysis was done in the campus. Finally, Gutter design, its analysis, gravity chamber and filtration mechanism are also dealt with in detail. The result shows that the RWH system which will be applying in future will be of storage capacity 1521 cubic metre per year and the construction cost will be 3,90,840/-. The developed system satisfies the social requirements and can be implemented in rural areas by considering almost all the technical aspect.*

***Keyword:*** *Rainwater harvesting, Roof water system, pipeline conveyance, Underground RCC tank.*

## 1. INTRODUCTION

Water is essential to sustain human life, economic development and the functioning of eco-system. The water level in most part of the world in general and in India is going down considerably very low. Most of the towns and cities find water shortage during summer. People roam here and there for want of water. If this scarcity of water is not taken into consideration days may not be off when there will be war for water, Deforestation, development of concrete jungles tremendous increase in population poor water management etc. are various reasons for water shortage.

Globally about 2.3% of total rain is received on land and rest in the ocean. Of this only 2.5% of total rainwater available is fresh water. Out of this 69% water is present in non-potable forms like glaciers, icecaps, moisture in air and soil etc. Thus, ground water alone constitutes a major water source for human activities on the earth is the only source to sustain this water balance. Rapid urbanisation and industrialization in India have increased the water demand many folds. This is severely depleted ground water. Other sources like rivers and lakes have been exploited injudiciously and as a result, these sources have been contaminated with wastewater discharge into the them. Under such conditions, rainwater harvesting alone can receive the hope of recharging of ground water to maintain the water level and its availability.

As land pressure rises, cities are growing vertical and in countryside more forest areas are encroached and being used for agriculture. In India the small farmers depend on Monsoon where rainfall is from June to October and much of the precious water is soon lost as surface runoff. While irrigation may be the most obvious response to drought, it has proved costly and can only benefit a fortunate few. There is now increasing interest in the low-cost alternative-generally referred to as 'Rainwater Harvesting' (RWH).

According to Kim et al. (2005), rainwater harvesting may be one of the best methods available to recovering the natural hydrologic cycle and enabling urban development to become sustainable. The harvesting of rainwater has the potential to assist in alleviating pressures on current water supplies and storm water drainage systems. Rainwater collection has the potential to impact many people in the world.

As water harvesting is an ancient tradition and has been used for millennia in most dry lands of the world, many different techniques have been developed. However, the same techniques sometimes have different names in different regions and others have similar names but, in practice, are completely different (Oweis 2004). Consequently, there are a dozen of different definitions and classifications of water harvesting techniques and the terminology used at the regional and international levels has not yet been standardized (Nasr 1999).

Today, only 2.5 per cent of the entire world's water is fresh, which is fit for human consumption, agriculture and industry. In several parts of the world, however, water is being used at a much faster rate than can be refilled by rainfall. In 2025, the per capita water availability in India will be reduced to 1500 cubic meters from 5000 in 1950. The United Nations warns that this shortage of freshwater could be the most serious obstacle to producing enough food for a growing world population, reducing poverty and protecting the environment.

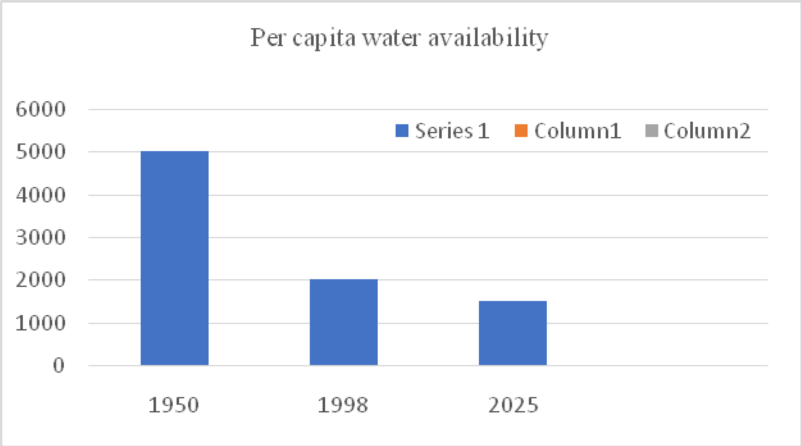


**FIGURE 1: PER CAPITA WATER AVAILABILITY**

### 1.1 PROBLEM STATEMENT

Design of rainwater harvesting system of PCCOER campus using Geographic Information System (GIS). For this taking catchment area of campus from parking area and roof top area. Demarcate and calculate area by using GIS. The slope of the catchment shall be checked by auto level. Analyse the potential of runoff from the rainfall from the catchment and suggest suitable recharge pit locations and volume of rainwater to be recharge in the ground. What will be the approximate expenditure for these recharge pits? If the institute wants to construct underground storage tank, what will be the approximate expenditure.

## 2. LITURATURE REVIEW

2.1 **Reitano, Raffaella. "Water harvesting and water collection systems in Mediterranean area. The case of Malta."** ***Procedia Engineering*** **21 (2011): 81-88.** systems of water collection and water harvesting, developing appropriate solutions to meet the specific needs of their ancient and present-day inhabitants by using traditional knowledge, building skills, and local resources, leading to solutions that to different extents, fit into the existing environment. This research helps to understand the different approaches in each country, resulting from climatic, geographical, socio-economic, and cultural conditions, as well as those related to spatial planning and urban development. Malta's case can be seen as a particular approach to this problem, which has led to a new source of water harvesting for common use. Malta has always been characterized by underground and rainwater shortages due to the intense but short rainfalls

2.2 **Julius, J. R., R. Angeline Prabhavathy, and G. Ravikumar. "Rainwater Harvesting (RWH)-A Review."** ***International journal of Innovative research and Development*** **2, no. 5 (2013).**This paper reviews the methods, design of rainwater harvesting systems, and its impacts adopted in all parts of the world. As water harvesting is an ancient tradition and has been used for millennia in most dry lands of the world, many different techniques have been developed. Gitte and Pendke (2002) conducted a study on the water conservation practices, water table fluctuations and ground water recharge in watershed areas.

**2.3 Yadav, Manisha, and Baldev Setia. "Conceptualization and Design of an Efficient Groundwater Recharge System for NIT Kurukshetra."** ***Procedia Technology*** **25 (2016): 138-145.** NIT Kurukshetra is a large campus institute, Due to lack of an efficient drainage system, the campus turns into a system of pools at important locations. This accumulation of water for long durations creates an unhealthy environment for the inhabitants besides damaging the roads, pavement and foundation of buildings. Hence, keeping in view all the above problems and status of the campus, rainwater harvesting can be considered as one of the solutions for addressing the problem of accumulated rainwater in the NIT Kurukshetra. In this paper the have done detailed design of the components of rainwater harvesting through artificial recharge i.e. filter gallery, recharge well, recharge pit, inspection pit etc are provided. It is expected that the result of the study if implemented will certainly fulfill the dual objective of addressing the menace of water logging in the campus besides enriching the groundwater aquifer.

**2.4 Mwamila, Tulinave Burton, Zacharia Katambara, and Moo Young Han. "Strategies for household water supply improvement with rainwater harvesting."** ***Journal of Geoscience and Environment Protection*** **4, no. 09 (2016): 146.**There are significant household water supply challenges including quantity sufficiency and quality, which have economic and social implications. The challenges have remained despite the efforts of government establishing centralized or groundwater systems, and/or having individual crude systems. A Tanzanian rural household case study was considered by assessing the performance of a currently relied surface runoff collecting pond system for domestic purposes. A daily water balance model was applied with performance parameters, no water days (NWD) and rainwater usage (RUR). Rooftop runoff harvesting system was proposed as a water supply source in addition to the current one. In this paper The RWH technology strategies presented in this study.

**2.5 Raimondi, A., and G. Becciu. "Probabilistic design of multi-use rainwater tanks."** ***Procedia Engineering*** **70 (2014): 1391-1400.** In last decades the interest for the use of multi-use rainwater tanks is increased due to the great flexibility of operation modes they allow. They can have different configurations; often they are composed of different compartments each of them with a specific function. The coupling of a rainwater use tank with an infiltration basin allows to meet both the need of water saving and of local control of runoffs which would otherwise be handled by the urban drainage system. Rainwater collected from roof is generally not much polluted and can be used for different purposes representing, especially during dry periods, a precious source for water supply. A multi-use rainwater tank can satisfy these different requirements. On small scale, as in the case of multi-use rainwater tanks for buildings, the stochastic process of rainfall events should be closely considered, to make a reliable design of the facility. Although in literature several methods are proposed to take into account this process, mainly based on simulation techniques, the temporal interconnection among events is often disregarded when direct approaches are considered. The use of analytical probabilistic approaches for the design of both infiltration basins and storage units in green buildings has been applied with good results by some authors (J.C.Y. Guo, 2001; Y. Guo, 2007). In this paper an analytical probabilistic approach to size multi-use rainwater tanks is proposed, aimed to find an optimal trade-off between the risk of water shortage and the risk of overflow.

**2.6 Badarnah, Lidia. "Water management lessons from nature for applications to buildings."** ***Procedia Engineering*** **145 (2016): 1432-1439**.Water management and regulation in buildings have been facing real challenges with the increasing environmental awareness during the last decades. Current concerns of shortage in water resources increase the demands to enhance water management strategies. In this respect, buildings should be able to gain, conserve, transport, and lose water adequately. Efficient water management solutions can be extracted from strategies found in nature. In this paper they classify a basic array of strategies for water management; discuss morphological features and active means; and list corresponding examples from nature, to facilitate the search for and the selection of strategies from the large database of nature, and inspire new design solutions. This literature review was carried out to source water management strategies found in nature. Special attention was given to organisms that live in deserts and employ unique strategies for adapting to extreme conditions, where they can obtain and conserve water, and prevent dehydration, among others. We find these organisms worth studying because of their extraordinary ability to manage water under water-scarce environments. This section classifies water management into four main functions: gain, transportation, conservation, and loss. One main objective of this paper is the systematic representation of the biophysical information for water management promoting the search for mechanisms to inspire new solutions for buildings. The relatively small amount of studies on biomimetic water management solutions for building applications has left a significant territory awaiting its grounds to be broken, and further research is required to test and validate the potential applications at the building scale.

**2.7 Campisano, A., D. Di Liberto, C. Modica, and S. Reitano. "Potential for peak flow reduction by rainwater harvesting tanks."** ***Procedia Engineering*** **89 (2014): 1507-1514.** The objective of the paper is to evaluate the potential of tank-based rainwater harvesting systems as source control methods to mitigate runoff flow peaks in urban areas. In the recent years, rainwater harvesting (RWH) is gaining increasing attention as a complementary supply source to save fresh water in urban areas. RWH systems normally make use of relatively small-size tanks to store rainwater collected over the building rooftop. Subject to basic treatment (normally filtration and/or chlorination), stored rainwater are locally used for both internal and external non-potable consumption (i.e. toilet flushing, garden irrigation, terrace cleaning, etc.). Rainwater tanks have been recognized also as a method to mitigate environmental impacts of urbanization on storm water drainage systems and receiving water bodies. It is then expected that very high time resolutions (in the order of the minute) are mandatory if the tank effect on the reduction of the storm water flow peak is explored. In that case, extended rainfall data sets have to be treated and specific methods to disaggregate the household water demand data are to be used. Water balance simulations of rainwater tanks were carried out in this paper to explore the potential benefits of tank-based rainwater harvesting systems to reduce runoff flow peaks at the household scale. A specific procedure from the literature was also adopted to disaggregate available data from the daily time scale and to generate a synthetic series of toilet water demands for the one-year water balance simulation of the rainwater tank.

**2.8 Shaheed, Riffat, Wan Hanna Melini Wan Mohtar, and Ahmed El-Shafie. "Ensuring water security by utilizing roof-harvested rainwater and lake water treated with a low-cost integrated adsorption-filtration system."** ***Water Science and Engineering*****10, no. 2 (2017): 115-124.** Drinking water is supplied through a centralized water supply system and may not be accessed by communities in rural areas of Malaysia. This study investigated the performance of a low-cost, self-prepared combined activated carbon and sand filtration (CACSF) system for roof harvested rainwater and lake water for potable use. The most common sources of water used for drinking water supply and irrigation are surface water and ground water. Between the two only a small amount is accessible to humans, since most of the surface water is locked in glaciers, snow caps, and ice (Gleick and Palaniappan, 2010). The ecosystem is experiencing increasing pressure due to anthropogenic activities, such as urbanization, agriculture, industry, and infrastructure development. In general, this system performed satisfactorily and offers an attractive option to rural communities, or, during water crisis, a way of providing an alternative water source through the treatment of harvested rainwater (for short ADIs) and lake water. However, longer ADIs and abstraction of lake water require a greater height of activated carbon and sand layers (in the chambers) to ensure a higher quality of effluent.

## 3. METHODOLOGY

Rainwater Harvesting is a simple technique of catching and holding rainwater where its falls. Either, we can store it in tanks, or we can use it to recharge groundwater depending upon the situation.

### 3.1 STUDY AREAS

As discussed earlier in the section of introduction – importance of rainwater harvesting at PCCOER Ravet, we clearly came to know the all the advantages which we can draw out by implementing this small but highly efficient technique in the campus. Thus, to increase the potential, benefits of this system and draw maximum advantages from it, we need to have large rooftop areas which will be going to act as catchment areas. More the catchment areas more will be the surface runoff, and thus more will be the amount of harvested water.

The campus of Pimpri-Chinchwad College of Engineering and Research, Ravet (PCCOE&R) is situated at $18^0$ 38' 00'' N latitudes and 73 $^0$44'41'' E longitudes and is located in the Paschim Maharashtra region of Maharashtra.

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The campus of this institute is situated at the corner area of Pimpri-Chinchwad city. The institute surrounded by agriculture and residential area. The total strength of campus including students and staff peoples is more 1200. Thus, with this present strength and with the expansion, campus should also increase its facilities and maintenance requirements. Thus, water is most natural resource being always in high demands by human beings and is indispensable part of the life. Hence, keeping in view all the above problems and status of campus PCCOER, Ravet, administrative body focussed on water scarcity problem. Therefore, in this situation, rainwater harvesting system can be considered as a best solution for fighting against water scarcity in campus. [2]

## 3.2 DATA COLLECTION

The rooftop surface area is nothing but the catchment area which receives rainfall. Catchment areas of the educational building are measured. This measurement was done manually with the help of "measuring tape" which is the simplest technique known as, "tape survey". Before using the tape, tape was checked for any zero error and also length of the tape was also carefully checked for its accuracy. The total catchment area of the educational building is about 1946.54 square metre.

**FIGURE 2: CATCHMENT AREA**

## 3.3 MEASUREMENT OF CONSUMPTION OF RAINWATER:

Finally, we need to store the water which is obtained from the rooftop area of the buildings. The volume of tank which stores the harvested water will be directly proportional to the total volume of water harvested.

The consumption of water depends upon the number of consumers and their per head consumption of water.

For educational building the per head consumption of water is about 10 To 30 litre/head/day.

And the number consumers of water in PCCOER campus are about 1500 including students of all branches, all technical and non-technical staff.

So, let us assume consumption of water per head is 10 litre/day.

Therefore, consumption of water of PCCOER campus = 1,500 X 10 = 15,000 litre/day

= 15 $m^3$/day

Total water collected by RWH = 1951.19 $m^3$

Number of days harvested water can be use = 1951.19/15 = 130.07 days

= 4 months and 10 days

So, the water collected by RWH can full fill the 4 months and 10 days water requirement of campus.

### 3.4 COMPUTATION OF VOLUME OF RUNOFF PER YEAR

PCCOER campus has two buildings one for engineering and another for S. B. PATIL (11 & 12th). The total rooftop area of the PCCOER available for the rainwater harvesting is 1946.54$m^2$. The cumulative runoff that can be captured from the roof slab is calculated using tape survey. The cumulative rainfall runoff at the end of the year is calculated to be 1950.43$m^3$. The tank capacity can be estimated to be a lower value accounting for the continuous consumption going on during period of rainfall.

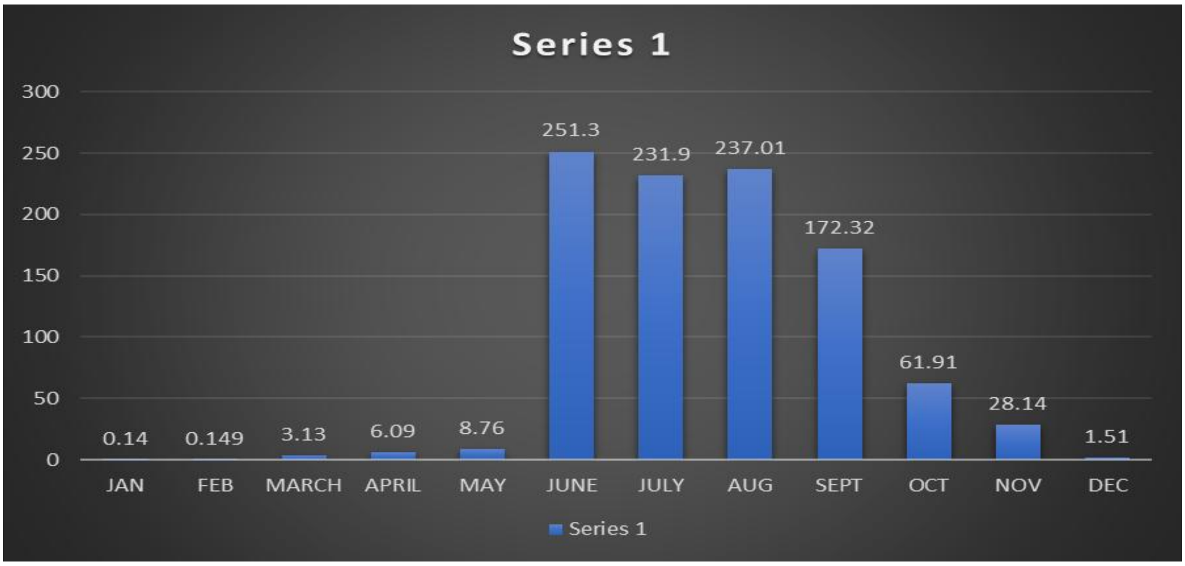


**FIGURE 3: AMOUNT OF RAINFALL COLLECTED IN THROUGHOUT THE YEAR**

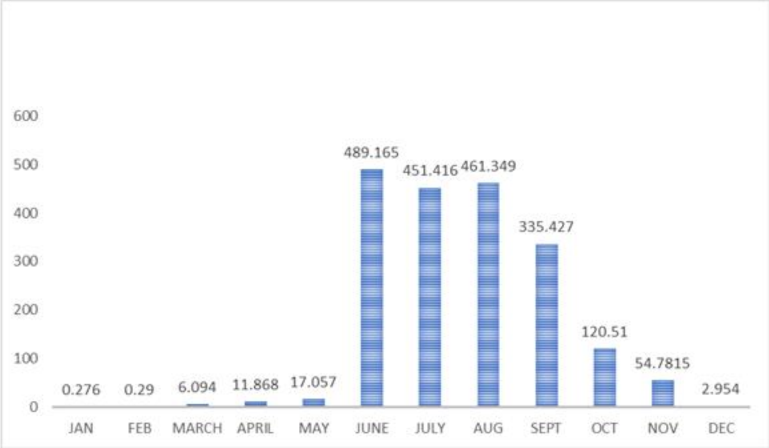


**Figure 4: Volume of water Collected from Rainfall throughout the year ($m^3$)**

### 3.5 TYPES OF TANK

Two types of tank can be used for storing of rainwater discharged from the roof - Lined Storage Tank and Unlined Natural Storage Tank

In lined storage tank, earth work excavation is done and underground RCC water storage tank is constructed which is completely covered from the top. The land above the tank can be used for serving as playground or parking slot, etc. In unlined natural storage tank, earth excavation is done, and all the water being allowed to fall directly in that pit and store it. In this method, we get two advantages. Firstly, our natural water gets recharged leads to augmentation of water level and ground condition, increasing prospects for better future cultivation and plantation. Secondly, underground water can be extracted anywhere within some limited areas from that pit and can be used to satisfy daily water demand.

Design of all the components of rainwater harvesting of tank size is 5 m x 2m x 2m is done.

### 3.6 ESTIMATION

Finally cost of entire project play a crucial role in any type of project. Before implementing the project, it is highly necessary for the engineers to check project, whether it is economical or not. Hence, the detail cost estimation should be done.

The tank shall be of R.C.C of 1:2:4 cement concrete with standard water proofing compound. Thickness of long wall and short wall of tank is about 170 mm. Roof covering slab shall be of thickness 150 mm and bottom slab should be of 300 mm. Quantity of steel required in water tank is about 2% of total volume of concrete.

Table 1 given below shows the detail cost estimation of constructing an underground tank of dimensions (5 x 2 x 2 m) at PCCOER campus:

**Table 1**

| Sr. No. | Particular | Quantity | Rate | Cost (Rs.) |
|---|---|---|---|---|
| 1 | Earth work in excavation | 25.33 $m^3$ | 130 Rs/$m^3$ | 3292.9 |
| 2 | Water proofing | 38 $m^2$ | 575 Rs/$m^2$ | 21,850 |
| 3 | Cement concrete | 9.52 $m^3$ | 2800 Rs/$m^3$ | 26,656 |
| 4 | R.C.C. work | 1494.64 kg | 48 Rs/kg | 71,742.72 |
| | | | **Total** = | 1,23,541.62 |
| 5 | Contingency + work charge establishment | (3%+2% = 5%) | - - | 6,177.08 |
| 6 | Contractor profit | (10%) | - - | 12,354.16 |
| | | | **Grand Total =** | **1,42,072.86** |

Total cost of piping material = Rs. 113724.

Therefore, total cost of rainwater harvesting system for our college is 255796.86 Rs.

## 4. CONCLUSION

This project dealt with all aspect of improving the water scarcity problem in PPCOER campus by implementing ancient old technique of rainwater Harvesting. Two alternatives have been suggested for tank design, which takes separate approaches towards the Storage of harvested rainwater. These results are given clearly in project. Hence from this result, we can draw out a conclusion that a huge amount of water got collected from the rooftop surface of all the entire building. And if, this project is being done seriously and implemented to the campus then it has a huge harvesting potential. This collection tank should have to build for the storage of 20 $m^3$ of water. Hence this project has huge capacity of getting rainwater and on proper storage, this tank can supply water for almost 4 months and 10 days to 1500 consumers having a consuming rate of 10liter/day as calculated previously. It is concluded that RCC tank which is to be constructed should be an underground one, so that upper surface of the tank can be utilized economically for any land purpose such as parking space or cycle stands or any such small structure. Cost analysis has been done for the tank. And it was concluded that cost of construction was not so high, if it is compared with problems which will be faced by the students and staffs inside the campus due to water scarcity. The other component of the harvesting systems such as pipping, chlorination and slow sand Filtration have also been reviewed and designed for PCCOER campus building in details. Hence it was finally concluded that implementation of RAINWATER HARVESTING PROJECT to the campus of PCCOER, Ravet will be the best approach to fight with future scenario of water scarcity in all aspects, whether it is from financial point of view or from optimum utilization of land surface. Therefore, water is highly a precious natural resource which is always in high demand and thus, RAINWATER HARVESTING AT PCCOER campus is highly recommended.

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