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Water Management Through Rainwater Harvesting In Urban Areas

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Abstract

The total water available on the earth remains constant but its distribution with respect to time and space is highly variable leading to hydrologic extremes. Demand for water is increasing as the worlds population increasing rapidly. Rainfall on a general note is considered to be the starting point of hydrologic cycle. Large quantum of water evaporates from surface water bodies and precipitate over the landmass through rainfall. Rainfall is highly variable in time and space. It is essential to store and utilize the rainfall in an effective and efficient way. Surface and groundwater resources declining both in terms of quantity and quality. This study presents water management through rainwater harvesting. Rainwater harvesting is a practice that is in use in many regions to meet the growing water demand. Rooftop rainwater if harvested effectively can be utilized as potable water for our regular domestic as well as industrial activities. In Chennai city, where annual rainfall is high, rainwater if harvested properly could meet a significant amount of total demand. This study ensures a sustainable water management system through rain water harvesting mechanism in a residential apartment. Ben Foundation, Maple Orchid, a residential apartment located at Mogappair, Chennai is selected for the current study. The total premises area accounts to 5683 m2 which includes four separate 7-storey building and a park at the front. The apartment consists of a population of 476. 27 years of rainfall data has been collected and rainfall analysis has been carried out for the study area in order to understand the rainfall pattern. Demand and harvest storage analysis was carried out for 75% dependability and 50% dependability. This method illustrates the water savings and reliability of rainwater harvesting system.

Keywords: Rainfall data, dependability analysis, rainwater harvesting, GIS

Introduction

Water distinguishes our planet compared to all the other planets we know about. The global supply of available freshwater is more than adequate to meet current water demand but its spatial and temporal distributions are not equally distributed to all the regions (Cosgrove, W. J., and D. P. Loucks 2015). Freshwater resources are inadequate in many regions to meet domestic, economic and environmental needs. The total volume of freshwater on Earth far outweighs the human demands. Out of the overall water resources on Earth, about 97% can be found in the oceans while the remaining 3% remains available for direct exploitation. Out of this 3%, the quantity of water that is available for use by humans is estimated at one-hundredth. Water resources are being intensively exploited and polluted. Due to rapid urbanization, industrialization, intensive agriculture growth, population growth, higher standard of living and climate change etc it is estimated that, the level of water stress will be high worldwide.

As the world population increases, the demand increases for quality drinking water. Surface and groundwater resources are being utilized faster than they can be recharged (J.R.Julius, Dr.R.Angeline Prabhavathy and Dr. G.Ravikumar 2013). Rainwater harvesting is a practice that is in use in many regions to meet the growing water demand. Rainwater harvesting (RWH) is the collection and storage of rain, rather than allowing it to run off. It is one of the simplest methods of self-supply of water for residential, household, small-scale projects and groundwater recharge. Depending on precipitation intensity, rainwater constitutes potential source of drinking water also (Rawia Marwan Dabdoob and Puterishireen Jahn Kassim 2019). G Arvind et al. (2017) performed a case study on statistical analysis of 30 years rainfall data. This analysis provides useful information for water resources planner, farmers and urban engineers to assess the availability of water and create the storage accordingly.

Methodology

The methodology adopted for the current study is given in the flowchart as shown in Figure 1.

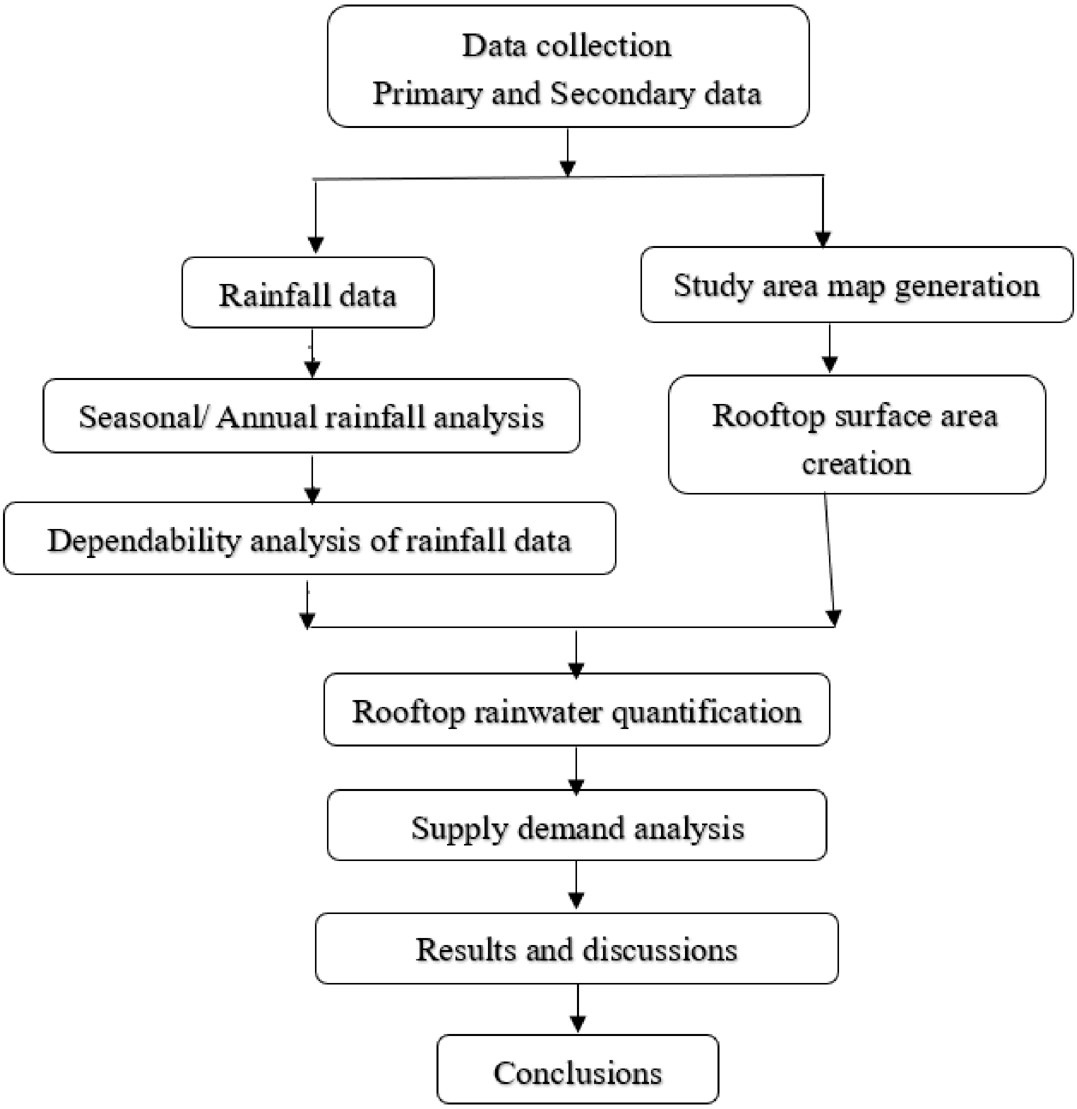

Figure 1 Methodology Flowchart

Study Area

The study area of the project is Ben Foundation, Maple Orchid, a residential apartment located at Mogappair, Chennai. The total premises area accounts to 5683m^2 which includes four separate 7-storey buildings and a park at the front. The apartment consists of a population of 476. Each block has a sufficient rooftop area which is to be used for harvesting rain water. Satellite image of the Ben Foundation, Maple Orchid is shown in Figure 2.

Figure 2 Satellite Image of Study Area

Study area map generated with the help of ArcGIS software is shown in Figure 3.

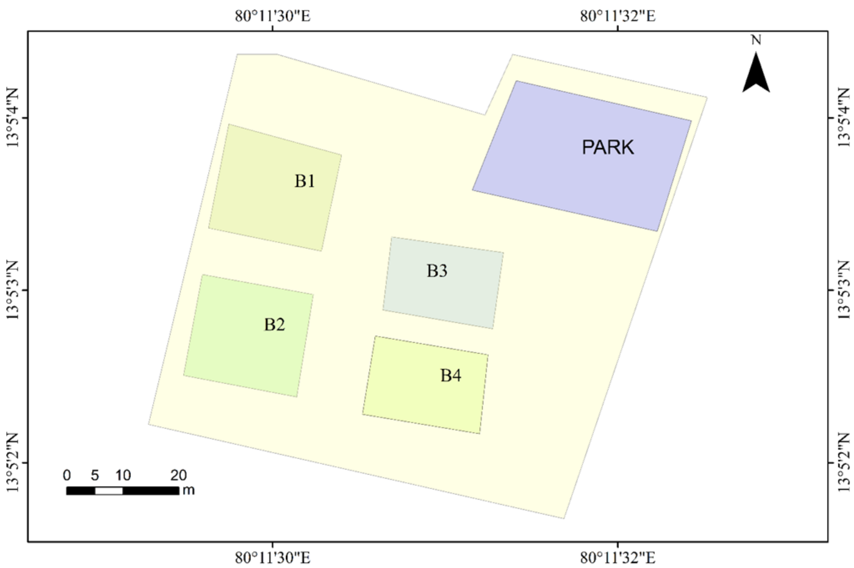

Figure 3 Study Area Map Generation

B1 – Cedar A, B2 – Cedar B, B3 – Oak A, B4 – Oak B

Rooftop Area Calculation

S. NO.	BLOCK NAME	ROOF AREA (m2)
1.	B1 (OAK A)	352
2.	B2 (OAK B)	367
3.	B3 (CEDAR A)	263

4.	B4 (CEDAR B)	289
Total		**1271**

Total Rooftop Area = 1271m^2

Total area of the Premises = 5683m^2

Results and Discussion

Rainfall Analysis

The year can be declared as normal or excess or deficit based on the following conditions (T. Murali Krishna. G. Ravikumar. M. Krishnaveni 2009).

Normal year - ±18% of the annual average rainfall

Excess year - >+18% of the annual average rainfall

Deficit year - <-18% of the annual average rainfall

Rainfall analysis was carried out for the period from 1192 to 2018. Annual rainfall values were calculated for Redhills raingauge station, which are presented in Table 1. The Average Annual Rainfall (AAR) in the study area was estimated as 1387.91mm. Out of 27 years, 13 years were falling under Normal, 04 years were under Excess and 10 years were under Deficit conditions. Rainfall analysis gives an idea of rainfall pattern in the study area. Classification of years based on annual rainfall is given in Table 1.

Table 1 Classification of Years based on Rainfall

S. No.	Year	Total Rainfall (mm)	Category
1	1992	1041	DEFICIT
2	1993	1581	NORMAL
3	1994	1547	NORMAL
4	1995	1525	NORMAL
5	1996	2354	EXCESS
6	1997	3007	EXCESS
7	1998	1377.4	NORMAL
8	1999	974	DEFICIT
9	2000	1078.3	DEFICIT
10	2001	1368	NORMAL
11	2002	1175	NORMAL
12	2003	601.1	DEFICIT
13	2004	1101.4	DEFICIT
14	2005	2431.5	EXCESS
15	2006	1326	NORMAL
16	2007	1537.4	NORMAL
17	2008	1468	NORMAL
18	2009	1175	NORMAL
19	2010	1609.6	NORMAL
20	2011	1513.6	NORMAL
21	2012	945.5	DEFICIT
22	2013	497	DEFICIT
23	2014	739.8	DEFICIT

24	2015	2285	EXCESS
25	2016	868.7	DEFICIT
26	2017	1627.5	NORMAL
27	2018	718.9	DEFICIT

Quantification of Possible Water Harvest

The total amount of rainfall that could be harvested is found by using the formula given below.

Rain water that could be harvested = Roof area x Dependable rainfall x 0.9

The coefficient 0.9 is multiplied to take care of losses. 0.9 is used as the coefficient assuming 90% efficiency in harvesting (Krishnaveni M and Vignesh Rajkumar 2016). Dependability analysis of rainfall has been carried out for the years from 1992 to 2018 for the months from June to December. The 75% dependable value and 50% dependable value for each month are found out and that value was used in the calculation of rainfall that could be harvested. Demand and harvest storage analysis was carried out for 75% dependability and 50% dependability for both Rooftop area as well as Total area of the premises.

Table 2 Total Quantity of Rainwater Harvested for 75% Dependability

(Rooftop Area)

Month	75% Dependable Rainfall (mm)	Rainwater Harvested (m^3)
June	32.5	37.17
July	45.25	51.76
August	67.83	77.59
September	71.393	81.66
October	158	180.73
November	176	201.32
December	45.57	52.12
TOTAL		**682.35**

Table 3 Total Quantity of Rainwater Harvested for 75% Dependability

(Area of premises)

Month	75% Dependable Rainfall (mm)	Rainwater Harvested (m^3)
June	32.5	166.22
July	45.25	231.435
August	67.83	346.923
September	71.393	365.148
October	158	781.11

November	176	900.18
December	45.57	233.07
TOTAL		**3024.08**

Table 4 Total Quantity of Rainwater Harvested for 50% Dependability

(Rooftop Area)

Month	50% Dependable Rainfall (mm)	Rainwater Harvested (m³)
June	45	51.47
July	72.1	82.47
August	130.5	149.27
September	137	156.71
October	307.6	351.86
November	343	392.35
December	145.85	166.83
TOTAL		**1350.96**

Table 5 Total Quantity of Rainwater Harvested for 50% Dependability

(Total premise Area)

Month	50% Dependable Rainfall (mm)	Rainwater Harvested (m³)
June	45	230.16
July	72.1	368.76
August	130.5	667.46
September	137	700.71
October	307.6	1573.28
November	343	1754.34
December	145.85	745.978
	TOTAL	**6040.68**

Estimation of Water Demand

The per capita demand of water is 135 liters per person per day which includes every domestic use like bathing, washing clothes, brushing, cleaning utensils, cooking food etc. For a population of about 476 in the study area, the amount of water that is demanded in a day has to be calculated. Total volume of water or demand per day in the study area is calculated and presented in the Table 6.

Table 6 Estimation of Water Demand

S. No.	Blocks	Population	Percapita Demand (Litres)	Volume of Water Required (m^3)
1	Oak A	127	135	17.14
2	Oak B	116	135	15.66
3	Cedar A	111	135	14.98
4	Cedar B	122	135	16.47
Total		**476**		**64.25**

Water demand for a month = 64.25*30 = 1927.5 m^3

Water demand for a year = 1927.5 *12= 23130 m^3

Conclusions

Annual Rainfall analysis has been carried out to understand the rainfall pattern in the study area. The study area map has been generated in GIS environment. From the annual rainfall data analysis, it has been observed that out of 27 years, 4 years are falling under excess rainfall category, 13 years are falling under normal rainfall category, 10 years are falling under deficit rainfall category. Dependability analysis of rainfall has been carried out for the years from 1992 to 2018 for the months from June to December. Demand and harvest storage analysis was carried out for 75% dependability and 50% dependability. Water demand for a month is estimated as 1927.5m^3. For 75% dependability, the total rain water harvested is 3024.08m^3, which can be used for 1.6 months without depending on any other source of water. For 50% dependability, the total rain water harvested is 6040.68m^3, which can be used for 3 months without depending on any other source of water. The results of this study provide useful information for further development of the rainwater harvesting practice in urban areas.

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