STUDY OF RAIN WATER HARVESTING IN BENGALURU URBAN REGIONS

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Abstract

The scarcity of water is the basic problem faced in many parts of the world. The water sources like well, river and reservoirs are not adequate to fulfil the water demand of people. In urban areas of Bengaluru due to urbanisation, increase in the number of industries and also reduction in water availability in the Cauvery River basin mainly due to variation in precipitation levels, shortage of water has become a major problem faced by the people. Rainwater harvesting is the simple process or technology used to conserve rainwater by collecting, storing, conveying and purifying of rainwater that runs off from rooftops of buildings, parks, roads, open grounds, etc. for later use. This paper discusses about the opinion of people about the methods of rain water harvesting along with the expenditure, advantages and limitations of the usage of harvested water and also the effectiveness of rain water harvesting as a domestic water supply in urban areas of Bengaluru, with the help of sample data collected from a sample survey.

Key words: Rain water harvesting, storing and purifying, rooftops, harvested water.

Introduction

Bengaluru, a city housing more than 1.3 crore citizens, covering almost 750sq km and
1.5 crore households is the Silicon Valley of India. Known for its plush greenery and pleasing weather, nature has endowed the city with all the resources to make it a place comfortable and pleasant to live in. However, in the recent years, Bengaluru has been facing a water shortage crisis because of reduction in water availability in the Cauvery River basin mainly due to variation in precipitation levels. A city blessed with an annual average rainfall of 787 mm even without a record year, could have avoided the perennial struggle to meet its yearly water demand of 18 TMC ft (Thousand Million Cubic feet).

There is a very effective solution to make sure the people of Bengaluru never run out of water- RAIN WATER HARVESTING (RWH). Rainwater harvesting is the simple process or technology used to conserve rainwater by collecting, storing, conveying and purifying of rainwater that runs off from rooftops, parks, roads, open grounds, etc. for later use. The process of rainwater harvesting involves the collection and the storage of rainwater with the help of artificially designed systems that run off naturally or man-made catchment areas. Rain Water Harvesting has numerous benefits for the community and the environment reduces cost, decreases the demand for water, promotes both water and energy conservation, improves the quality and quantity of groundwater, reduces soil erosion, storm water runoff, flooding and pollution of surface water with fertilizers, pesticides, metals and other sediments, a source of water for landscape irrigation with no chemicals and dissolved salts and free from all minerals.

In addition to the great advantages, rainwater harvesting system has a few disadvantages like unpredictable rainfall, unavailability of the proper storage system, regular maintenance is required, limitation on storage capacity.

Rain water harvesting is considered by many researchers as a sustainable water management system. Boers & Ben-Asher(1982), Worm(2006), Helmreich & Horn(2009), Che-Ani et al.(2009), Ward et al. (2012), Umamani &Manasi(2013), Patel et al.(2014), Keskar et al.(2016), Campisano et al.(2017), Sheikh(2020), Anchan & Prasad(2021),. Deng(2021), have studied and presented the advantages, limitations and usage of rain water harvesting as an important source of water to fulfil the growing demand of water in different places, situations and contexts.

Studies have established that about 73% of Bengaluru's water demand can be met by efficient harvesting. Of the city's four valleys, the Vrishabhavathi valley has an estimated catchment yield of 7.32 TMCft of water, K C Valley (5.2 TMCft) and Hebbal (4.2 TMCft). The city's total annual rainwater yield stands at about 14.80 TMCft. Treating 18 TMCft of wastewater generated in the city could yield another 16 TMCft. This means Bengaluru can end up with 31 TMCft, which is a surplus situation. It can be self- sufficient and also give the excess water to the neighbouring districts.

However, there is a problem of implementation for RWH. In a city with an estimated 35 lakh properties, the Bangalore Water Supply and Sewerage Board (BWSSB) has recorded only about 1.65 lakh buildings that have installed RWH systems, domestic, commercial and industrial combined. The cause of this slow progress seems to be a public mind set problem. One reason is the availability of highly subsidized Cauvery water. The BWSSB charges only about Rs 7 for 1,000 liters, which makes water as a commodity relatively cheap and doesn't prompt people to try and use it judiciously.

There is also a fear of investment to install a RWH system. But the infrastructure required for RWH is very simple. The most common types of RWH systems in Bengaluru include Rooftop Rainwater Harvesting System, A tank built on the roof of buildings catches and stores rain water and can be brought down the house using a series of pipes and filters if need be, Surface Runoff Rainwater Harvesting System: A tank is dug out in the ground that collects rain water that flows on the surface during the rains. This is a great method for recharging ground water.

Objectives of the study are to study the effectiveness of rainwater harvesting as a domestic water supply option, to study the usage, advantages and expenditure of rainwater harvesting., to analyse the prevailing issues in promoting rainwater as an alternative drinking water source.

The survey is about understanding the knowledge and opinions people have about rainwater harvesting. We collected data from 202 people belonging to all educational backgrounds and work sectors from the age of 20 to 69. Our respondents are solely residents of Bengaluru, they either plan on installing a rainwater harvesting system or already installed it in their houses. A questionnaire was prepared and sent in the form of Google form to collect data from the respondents. Analysis of data was done using different statistical tools.

EXPERIMENTAL STUDIES and Statistical Analysis

Table 1: Count of type of system installed and reasons for installing

Type Of System/ Reason	Cost Effective	High Storage Capacity	More Hygienic	Suitable For My Place	Total
Roof Top Rain Water Harvesting	46	22	8	55	131
Surface Runoff Rain Water Harvesting	17	16	3	35	71
Total	63	38	11	90	202

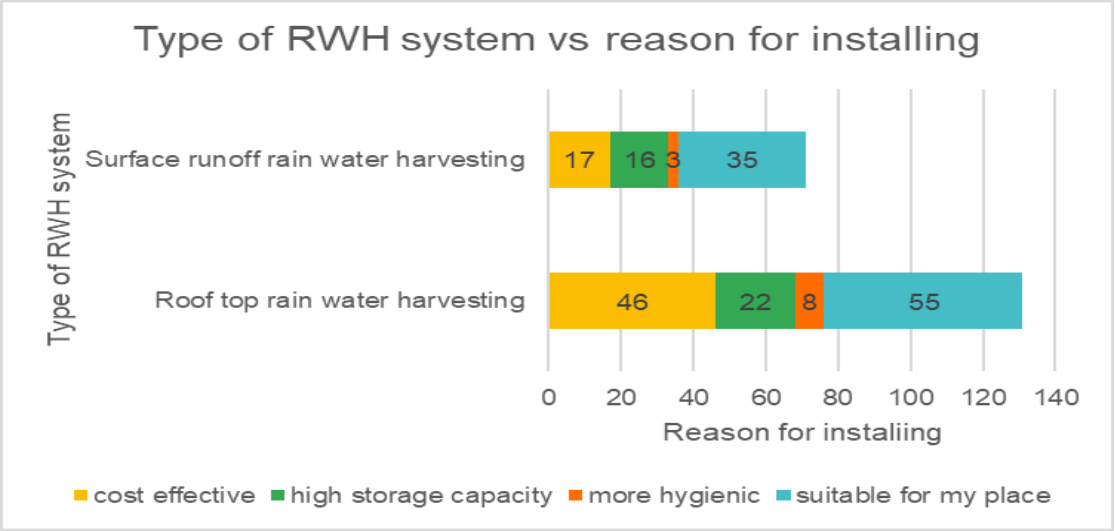

Figure 1: Bar chart: Type of system installed against reason for installing

We observe that the most preferred method of rainwater harvesting is roof top harvesting and the most popular reason for harvesting water using a particular type of system is because it is suitable to their place.

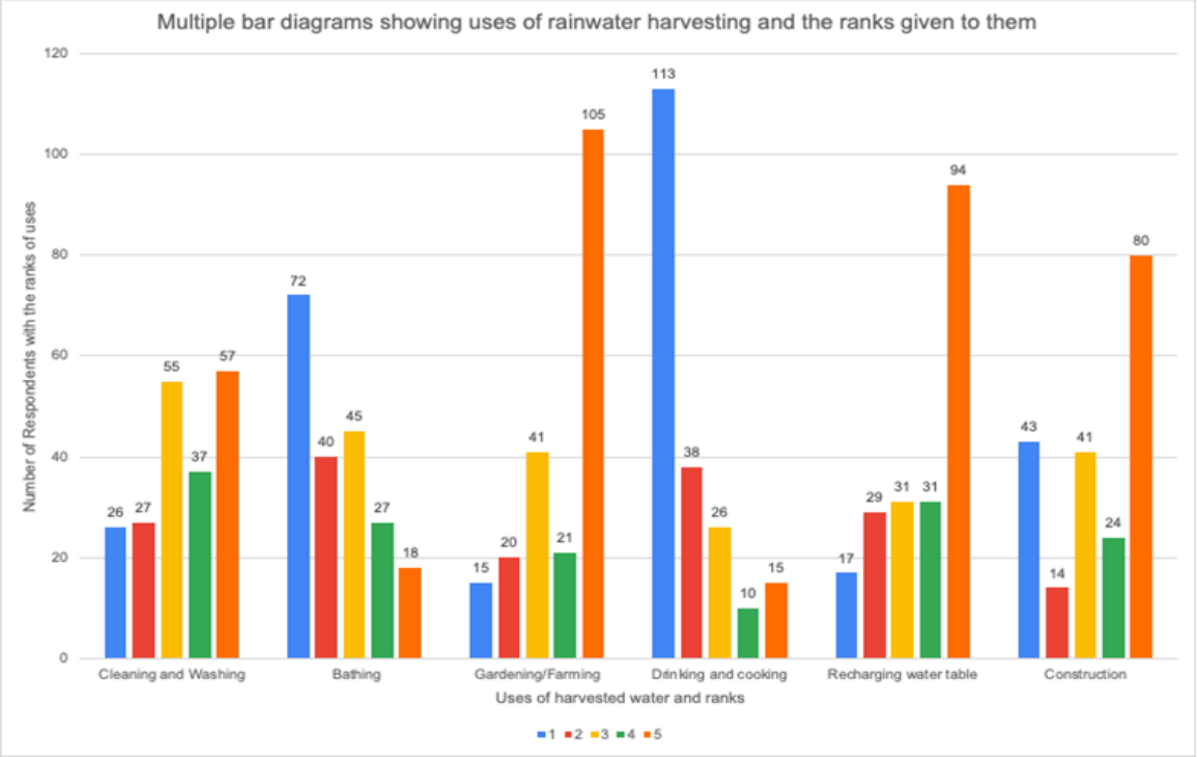

Figure 2: Multiple Bar Diagram: Usage of Rainwater Harvesting against the ranks allotted to them

From the graph above, we observe that the use "Recharging Water Table" has been given a ranking of 5 (most desirable use) and the use "Drinking and Cooking has been given a ranking of 1 (least desirable use

- Advantages of rainwater harvesting

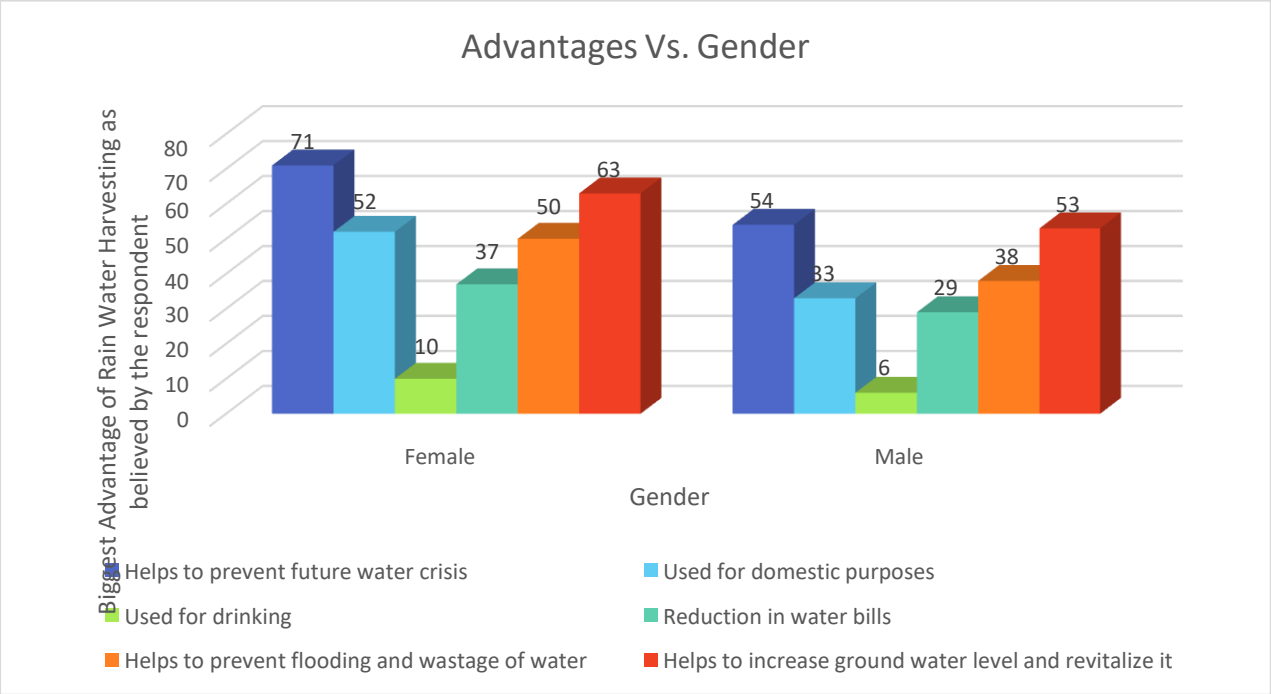

Figure 3: Multiple Bar Diagram: Advantages against Gender

The biggest advantage for rainwater harvesting as felt by both male and female respondents was that harvested water can be utilised to prevent future water crisis. However, at the same time, both genders also believed that harvested water has the least application for drinking purposes.

- Prevailing issues and constraints in promoting rainwater as an alternative drinking water source.

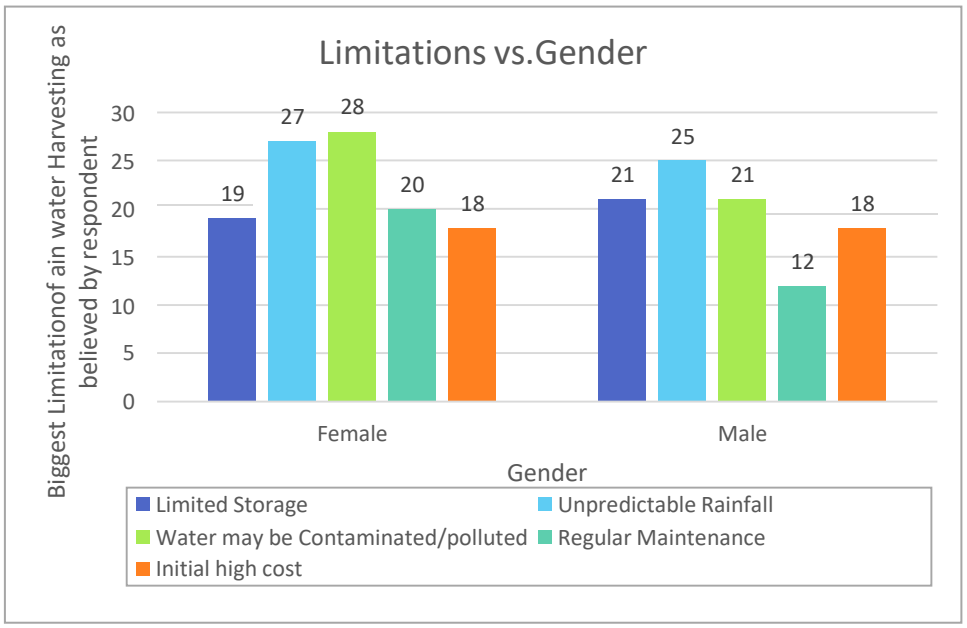

Figure 4: Multiple Bar Diagram: Limitations against Gender

It can be observed that the biggest limitation felt by female respondents is that the water collected may be contaminated/ polluted and will be unfit for usage, while male respondents believed it to be unpredictable rainfall.

Age and Advantages- Mosaic Plot

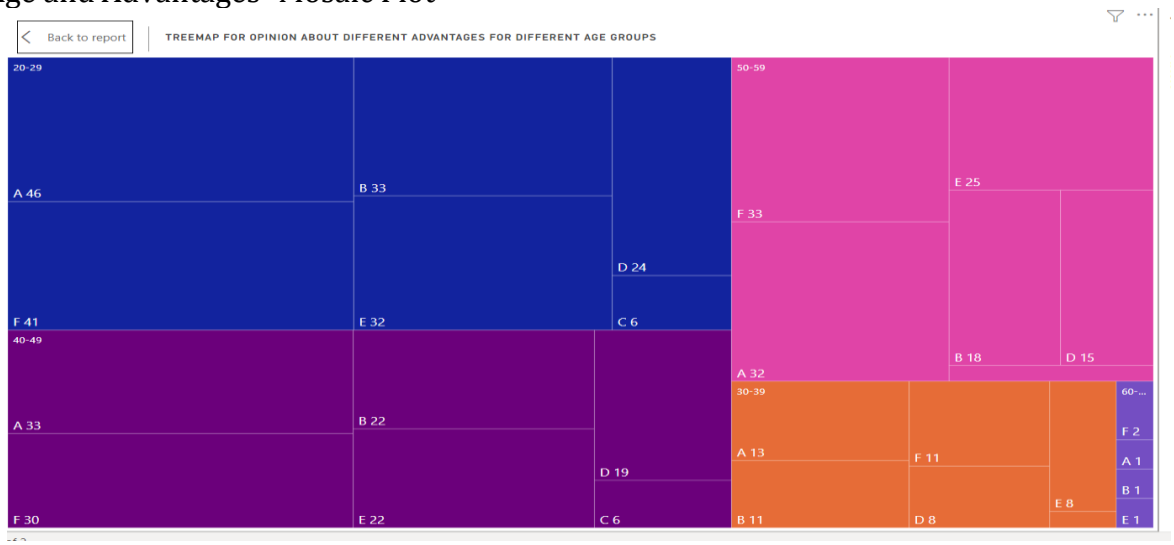

Figure 5: Tree map representing the opinion of respondents on different advantages of rainwater harvesting systems

The above graph is a treemap that represents the opinion of respondents on different advantages of rainwater harvesting systems and grouped according to their age. Only the advantages that were ranked 5 are considered.

Table 2: Age Group and advantages of rainwater harvesting systems

Age Group	A	B	C	D	E	F
20-29	46	33	6	24	32	41
30-39	13	11	1	8	8	11
40-49	33	22	6	19	22	30
50-59	32	18	3	15	25	33
60-69	1	1	0	0	1	2

Here A, B, C, D, E and F are different advantages. A-
Helps to prevent future water crisis
B-Used for domestic purposes
C-Used for drinking
D-Reduction in water bills
E-Helps prevent flooding & wastage of water
F-Helps increase ground water level and revitalize it

In almost all the age groups both, A-Helps to prevent future water crisis and F-Helps increase ground water level and revitalize it, are the most preferred advantages of harvested water.

Table3: Count of respondents for installation status and educational qualification

Educational Qualification	**Already Installed**	**Planning To Install**	**Total**
12th Or below	3	3	6
Graduate Level	72	67	139
Postgraduate Level or Above	25	32	57
Total	100	102	202

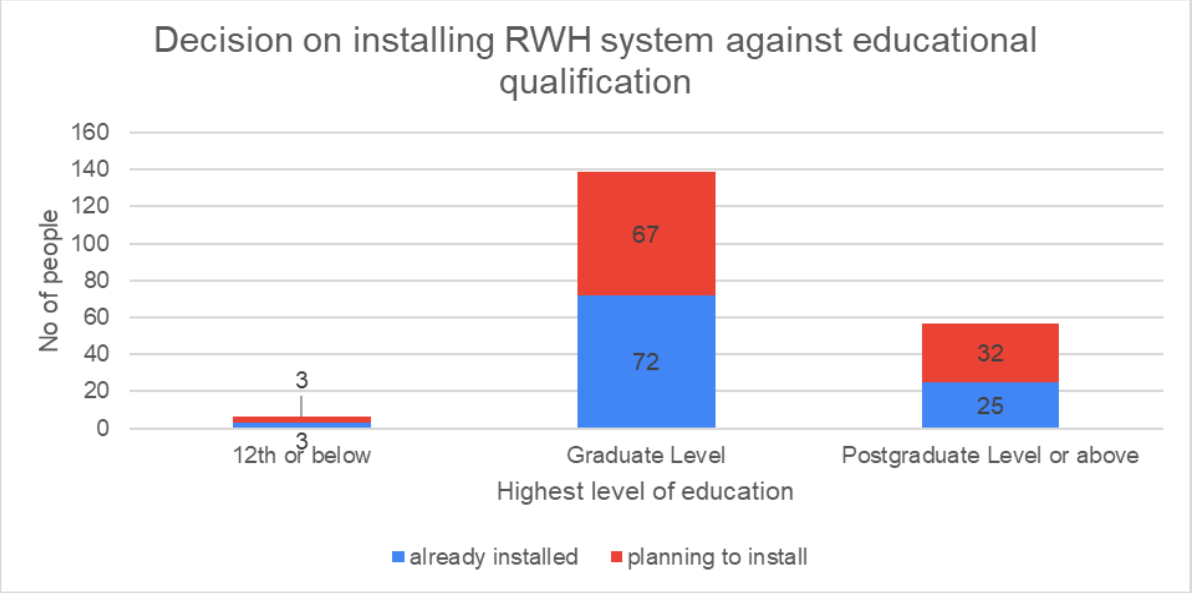

Figure 6: Multiple Bar Diagram: Decision on installing RWH system against educational qualification

Here, the number of people who have already installed a rainwater harvesting system is more in the graduate level than in other levels of education. Contradictory to the assumption that higher education implies higher installation of rainwater harvesting systems, the post graduate or above level has more people who have not installed the system as compared to the number of people who have installed the system. This could be attributed to the fact that with higher level of education, generally, there is a higher level of income and awareness is more, so the respondents can look at making improvements towards sustainability of one's home, which can be done with RWH.

- Awareness regarding Government Schemes against Type of Employment

From the data we also observe that 77.6% of Government Employees, 82.8% of Private Sector Employees, 81.8% of Self-Employed Individuals and 67.9% of Non-Working Individuals are aware that BBMP has made it mandatory for installation of RWH systems in apartments/industrial/residential complexes/educational institutions and government buildings, for sites of dimension 2400 sq. ft and above, in the sample. The total proportion of respondents who are aware of this legislation is 74.8%. This implies that roughly 25% of the population is still unaware of this rule. Also from the sample data we see that 61.11% of respondents in Bangalore who own a home have already installed a Rain Water Harvesting System whereas only 30% of those who live in a rented/leased house have a Rain Water Harvesting System installed. The BBMP can take steps to educate the citizens of Bangalore about this mandate by conducting workshops in workplaces such as techparks, in schools and colleges, whilst also educating them about the importance and benefits of RWH. This can go a long way in increasing the general awareness of citizens.

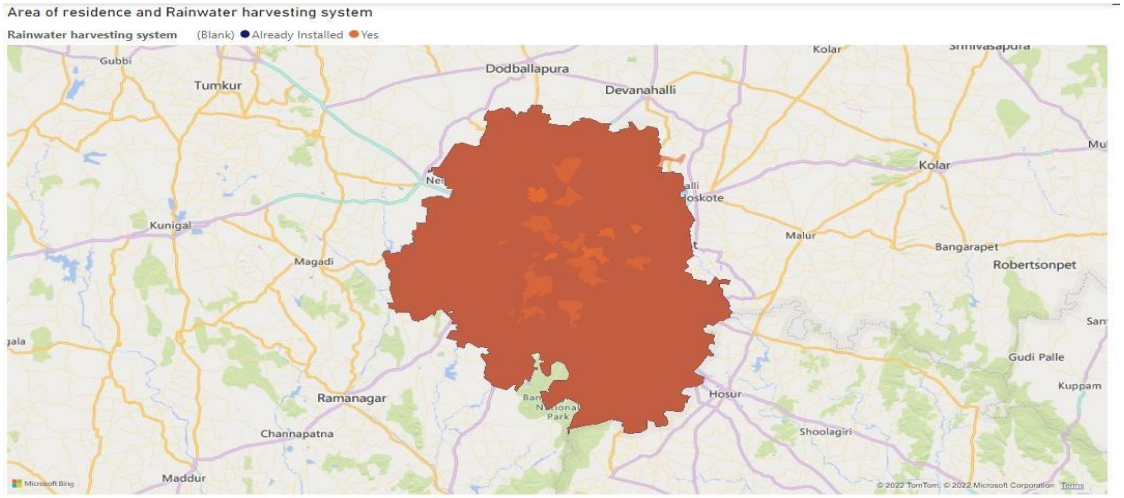

Figure 7: Heat Map for area of residence and rainwater harvesting system

Heatmap is a representation of data in the form of a map or diagram in which data values are represented as colours. Here we are using a Heatmap to represent the area of residence and if the respondent plans on installing a rainwater harvesting system. We see that there are fewer people in the central parts of the city planning to install rainwater harvesting systems when compared to the other parts of the city.

From the data we have the place where all the highest people have responded with a "yes" to installing a rainwater harvesting system is Hebbal (11 respondents) followed by Yelahanka, Sheshadripuram and Ulsoor.

We tested whether the amount of water harvested in liters and the dimension of the house are independent of each other.

Using chi-square test for independent of attributes on the data we came to the conclusion that the amount of water harvested in liters and the dimension of the house are dependent on each other.

Table 4: The Amount of Water Harvested in Liters and the Dimension of the House

Dimension of house	Litres of water harvested					
	less than 50000	50000-100000	100000-150000	150000-200000	more than 200000	Total
30x40	42	39	10	3	6	100
40x60	12	37	6	4	3	62
60x80	2	9	3	1	1	16
80x100and above	6	10	2	1	5	24
Total	62	95	21	9	15	202

We tested whether the cost of installation and the dimension of the house are independent of each other.

Using chi-square test for independent of attributes on the data we came to the conclusion that the Cost of installation and dimension of the houses are dependent on each other.

Table 5: The Cost of Installation and Dimension of the Houses

Dimension of house	Cost of installation						
	<20000	20000-40000	40000-60000	60000-80000	80000-100000	>100000	Total
30x40	28	42	13	10	4	3	100
40x60	14	22	15	1	6	4	62
60x80	3	6	2	3	1	1	16
80x100and above	4	4	7	0	3	6	24
Total	49	74	37	14	14	14	202

We tested whether the type of system installed or intended to install and the dimension of the house are independent of each other.

Using chi-square test for independent of attributes on the data we came to the conclusion that the type of system installed or intended to install and dimension of house are independent of each other.

Table 6: Type of rainwater harvesting system and Dimension of House

Dimension of House	Type of rainwater harvesting system		
	Rooftop RWH system	Surface RWH system	Total
30X40	70	30	100
40X60	38	24	62
60X80	9	7	16
80X100 and above	14	10	24
Total	131	71	202

We tested whether the proportion of respondents who have installed Rooftop Rainwater Harvesting Systems is equal to proportion of respondents who are planning to install Rooftop Rainwater Harvesting Systems.

Using equality of two population proportions test on the data we came to the conclusion that the proportion of respondents who have installed Rooftop Rainwater Harvesting Systems is not equal to the proportion of respondents who are planning to install Rooftop Rainwater Harvesting Systems.

Table 7: Rooftop RWH Systems and Rainwater Harvesting Systems

Rainwater Harvesting Systems	Rooftop RWH Systems		Total
	Yes	No	
Installed	56	44	100
Planning to install	75	27	102
Total	131	71	202

We tested whether the proportion of male respondents is equal to proportion of female respondents who are aware of BBMP rule regarding installation of RWH systems.

Using equality of two population proportions test on the data we came to the conclusion that the proportion of male respondents is equal to proportion of female respondents who are aware of BBMP rule regarding installation of RWH systems.

Table 8: Count of Gender Who are Aware Of BBMP Rule

Gender	Aware of BBMP rule		Total
	Yes	No	
Male	65	20	85
Female	86	31	117
Total	151	51	202

Conclusion

Bengaluru city has already started to feel the brunt of water shortage in many areas. Rain Water Harvesting seems like the most sustainable, affordable and accessible option to combat it. It is a silver lining that a majority of Bengaluru residents, from all walks of life, irrespective of age, gender, employment and education status know about the importance and benefits of Rainwater Harvesting. The most preferred method of harvesting rainwater is through roof top rainwater harvesting with 131 people who use this method. The most preferred use of harvested rainwater is for gardening and farming and the least preferred use of harvested rainwater is for drinking and cooking. The biggest advantage for rainwater harvesting as felt by our respondents was that harvested water can be utilized to prevent future water crisis. About 47% of the respondents think that the installation charges of a RWH system may cost 50,000- 1,00,000.

The BWSSB has been promoting RWH through their RWH theme park in Jayanagar, which demonstrates 27 working models. The theme park was set up as a one-stop solution to create awareness amongst citizens and to train architects, engineers, plumbers, etc. It used to get around 50,000 visitors per month before COVID. The efforts of many Bengaluru residents in rainwater harvesting (RWH) already show the way ahead for the city. Currently, Bengaluru is the Indian city with the second-highest number of RWH installations (1.55 lakh), next only to Chennai.

Limitations

The study may be biased towards students in the age group 20-29 as 70.8% of our respondents are students. Also 57.9% of our sample consists of females which implies inadequate representation of males.

Future Use

This study can act as a base for research conducted on rainwater harvesting in Bengaluru. It can be used to generate awareness on the importance of rainwater harvesting.

Acknowledgment

Student representatives have been involved in this sample survey for collection of data and to analyse it.

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