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Study of Rainwater Harvesting in University of Petroleum and Energy Studies in Support of the Eco-Campus Initiative

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Abstract: Rainwater harvesting is a technique for collecting rainwater that would otherwise be wasted, mainly in metropolitan settings. There is essentially no infiltration and percolation due to the completely different land use compared to the metropolitan region. As a result, groundwater levels have been steadily depleted. Rainwater harvesting is nearly completely unknown among the general public. There is a lack of community planning that may result in widespread participation and so replenish the groundwater table. The current research looks at several rainwater gathering techniques and how they may be implemented at the chosen location. The research is being conducted on the Dehradun campus of UPES. The focus is mostly on the water collected on the rooftop, which will be filtered and used for cleaning and gardening. Because it is a hilly location, the region receives a lot of rain, which provides excellent opportunities for rainwater gathering. The total runoff from the entire rooftop is calculated using a rational formula and then distributed to various uses. The paper's main goal is to advocate the wise use of this valuable resource while keeping in mind the economics of the method used.
Keywords: Rainwater harvesting, rational formula, groundwater.

I. INTRODUCTION

The provision of water is critical to a civilization's survival. Despite this important function, the World Water Council predicts that worldwide water consumption would rise in the next fifty years as a result of a 40-50 percent increase in population, aggravated by industrialization and urbanisation. The university is located in a hilly environment that receives approximately 600-650 mm of rainfall per year. If it is not conserved, it will be completely wasted and will flow downstream in valleys and rivers.

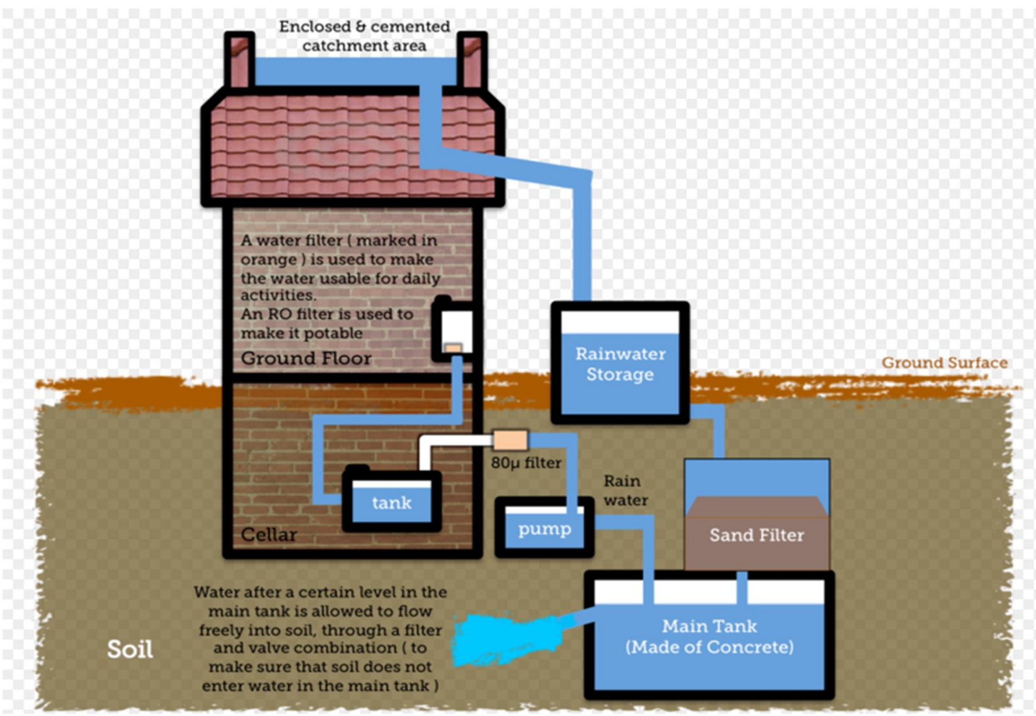


Fig.1: Schematics for Rainwater Harvesting

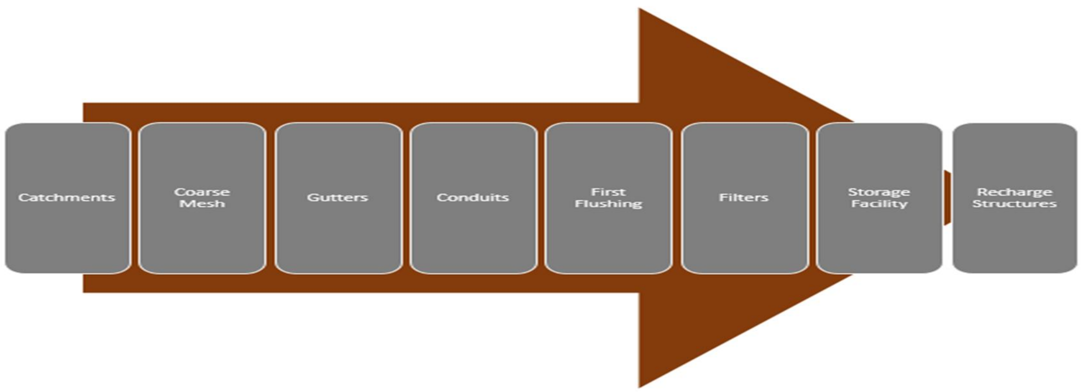
A. *Rainwater Harvesting Systems And Its Features*

Rainwater harvesting is a simple method of gathering and storing rainwater that falls. Depending on the situation, we can either store it in tanks or use it to recharge groundwater. Features of Rainwater Harvesting are:

1) It lowers the risk of floods in cities.
2) It is economically cheaper in construction than other sources, like as dams, diversion, etc. • Ease in constructing system in less time
3) Rainwater collection is the appropriate solution for places with insufficient groundwater supplies or surface resources.
4) It aids in the efficient use of the primary source of water by preventing runoff from entering sewer or storm drains, lowering the load on treatment plants.
5) Dilution helps to improve the quality of existing groundwater by recharging water into aquifers.

B. *Components Of Rainwater Harvesting System*

A rainwater harvesting system comprises of components for - transporting rainwater through pipes or drains, filtration, and tanks for storage of harvested water. The common components of a rainwater harvesting system are and the sequence of process are shown in the flowchart is given below:



II. METHODOLOGY

In general, a rainwater harvesting system is made up of five fundamental components:

1) The catchment zone (the surface area which catches the rainfall)
2) Transportation (to stream the harvested rainwater from the catchment area to a storage)
3) The initial flush (a filtering device to remove contaminants and debris washed during the initial period of a storm)
4) Tanks for storage (to store harvested rainwater)
5) Dispersion (to deliver the rainwater from the storage tanks to the point of use)

The first and most important step in rainwater harvesting is to determine the area of the tank where the water will be collected and processed. So, first and foremost, monthly average rainfall data were gathered. The rooftop area was then computed using Google Earth because we needed to know how much space was taken up. Water that will be collected each month from rainfall was calculated using the obtained data, rooftop area, monthly rainfall, and the runoff coefficient. Now, the runoff for all of the months can be easily acquired, allowing it to be determined which month had the most runoff. The ground area, or surface area, was computed so that water other than rooftops could be calculated using channels. Similarly, the water that will be gathered can be calculated by multiplying rooftop area . In a similar fashion, the maximum runoff can be calculated using the area, monthly rainfall, and the runoff coefficient. To analyse and estimate tank placement, an auto level instrument was used to level the entire area, and the results were collated. The maximum runoff for the rooftop and the surface were combined to determine which month has the most runoff. The rainfall for each day was calculated by dividing the runoff by 30. Because we need to build six tanks at different places to meet our requirements, the rainfall acquired for each day was divided for six tanks to estimate the capacity of each tank. In addition, four of the six tanks will have the same capacity, while the remaining two will have the same capacity. Rainwater must be filtered for a specific purpose, hence three filtration tanks will be required. Finally, all the tanks will be connected from top and bottom to one empty tank so that the overflow waster must not be wasted instead collected in the other tank.

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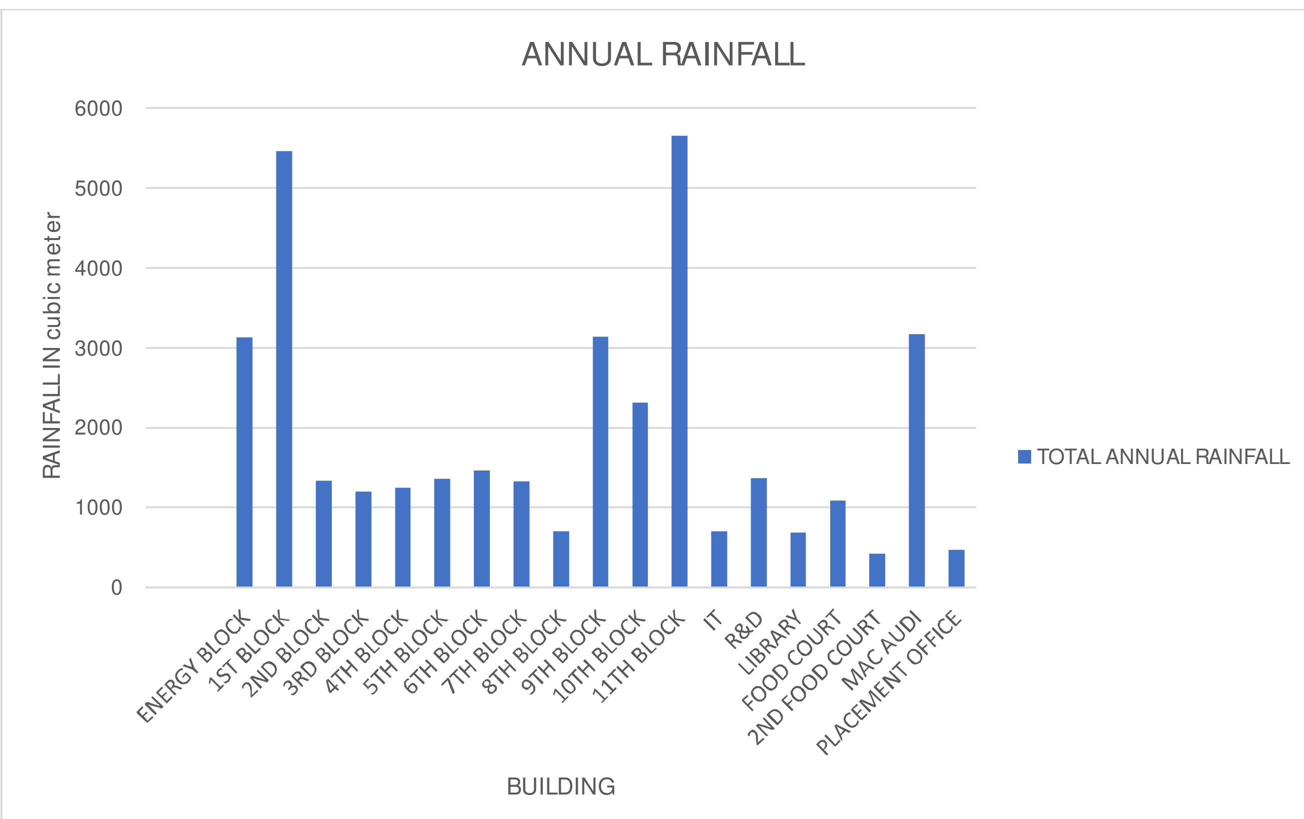
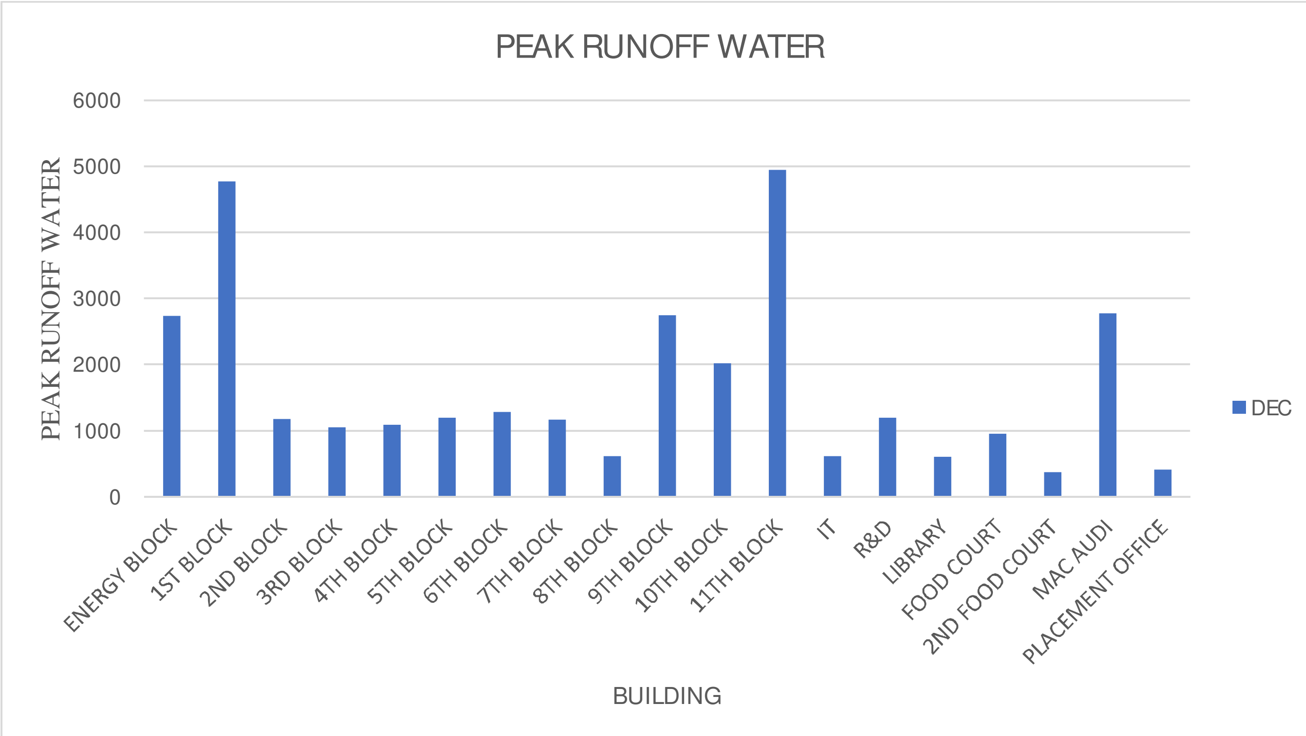
III. RESULTS

Table 1 Rooftop Water Collection and Estimation

BLOCK	PERIMETER	AREA	AVERAGE RAINFALL												TOTAL ANNUAL RAINFALL	RUNOFF FACTOR	TOTAL RUNOFF WATER (M^3)	PEAK RUNOFF WATER (M^3)
			JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC				
ENERGY BLOCK	164	1441	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	3128.411	0.875	2737.359625	867.48
1ST BLOCK	207	2514	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	5457.894	0.875	4775.65725	1513.43
2ND BLOCK	150	616	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1337.336	0.875	1170.169	370.83
3RD BLOCK	126	551	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1196.221	0.875	1046.693375	331.70
4TH BLOCK	124	573	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1243.983	0.875	1088.485125	344.95
5TH BLOCK	111	627	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1361.217	0.875	1191.064875	377.45
6TH BLOCK	133	675	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1465.425	0.875	1282.246875	406.35
7TH BLOCK	120	611	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1326.481	0.875	1160.670875	367.82
8TH BLOCK	106	324	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	703.404	0.875	615.4785	195.05
9TH BLOCK	193	1446	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	3139.266	0.875	2746.85775	870.49
10TH BLOCK	154	1064	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	2309.944	0.875	2021.201	640.53
11TH BLOCK	283	2604	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	5653.284	0.875	4946.6235	1567.61
IT	74	324	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	703.404	0.875	615.4785	195.05
R&D	108	631	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1369.901	0.875	1198.663375	379.86
LIBRARY	76	315	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	683.865	0.875	598.381875	189.63
FOOD COURT	109	501	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1087.671	0.875	951.712125	301.60
2ND FOOD COURT	58	194	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	421.174	0.875	368.52725	116.79
MAC AUDI	171	1461	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	3171.831	0.875	2775.352125	879.52
PLACEMENT OFFICE	64	215	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	466.765	0.875	408.419375	129.43



Graph 1 Annual Rainfall on Rooftop



Graph 2 Peak Runoff Water

Table 2 1st Quarter Rainfall Data

BLOCK	AREA				1st QUATER RAINFALL
		JAN	FEB	MAR	
ENERGY BLOCK	1441	0.07	0.041	0.06	246.411
1ST BLOCK	2514	0.07	0.041	0.06	429.894
2ND BLOCK	616	0.07	0.041	0.06	105.336
3RD BLOCK	551	0.07	0.041	0.06	94.221
4TH BLOCK	573	0.07	0.041	0.06	97.983
5TH BLOCK	627	0.07	0.041	0.06	107.217
6TH BLOCK	675	0.07	0.041	0.06	115.425
7TH BLOCK	611	0.07	0.041	0.06	104.481
8TH BLOCK	324	0.07	0.041	0.06	55.404
9TH BLOCK	1446	0.07	0.041	0.06	247.266
10TH BLOCK	1064	0.07	0.041	0.06	181.944
11TH BLOCK	2604	0.07	0.041	0.06	445.284
IT	324	0.07	0.041	0.06	55.404
RND	631	0.07	0.041	0.06	107.901
LIBRARY	315	0.07	0.041	0.06	53.865
FOOD COURT	501	0.07	0.041	0.06	85.671
2ND FOOD COURT	194	0.07	0.041	0.06	33.174
MAC AUDI	1461	0.07	0.041	0.06	249.831
PLACEMENT OFFICE	215	0.07	0.041	0.06	36.765
				TOTAL	2853.477

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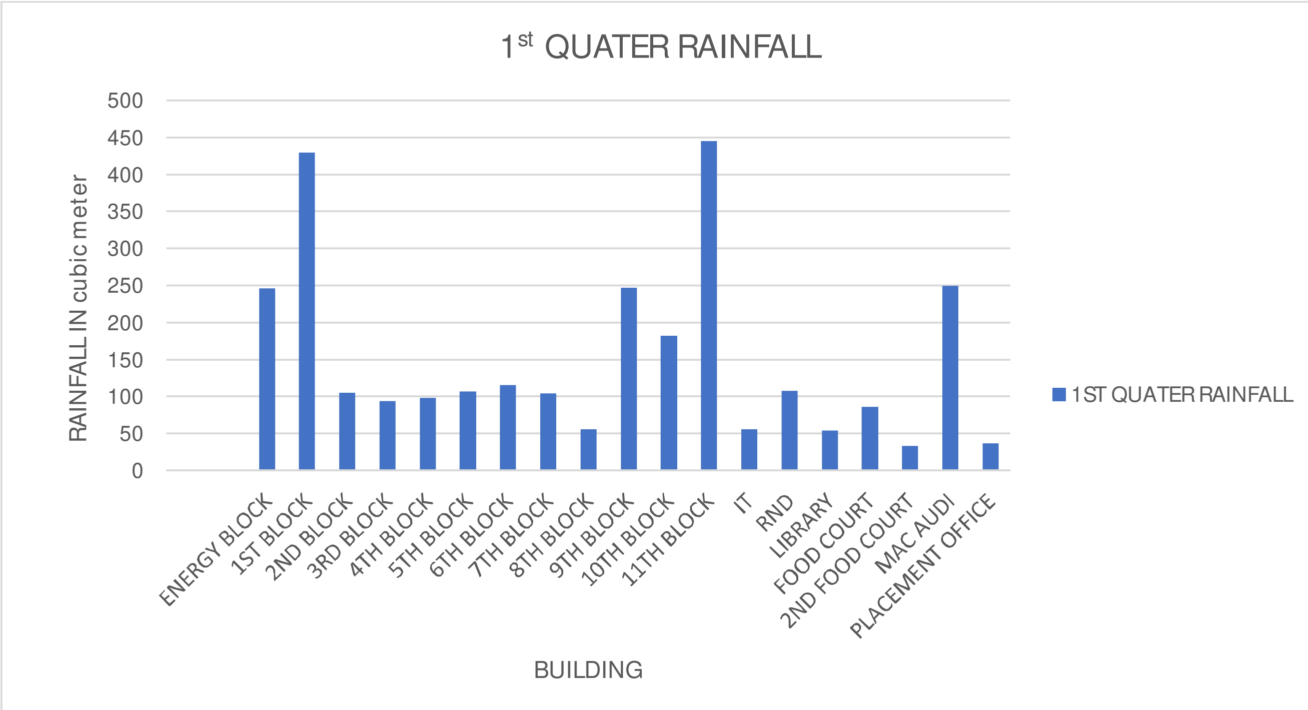

Graph 3 1st Quarter Rainfall

Table 3 2nd Quarter Rainfall Data

BLOCK	AREA				2nd QUATER RAINFALL
		APR	MAY	JUNE	
ENERGY BLOCK	1441	0.02	0.045	0.163	328.548
1ST BLOCK	2514	0.02	0.045	0.163	573.192
2ND BLOCK	616	0.02	0.045	0.163	140.448
3RD BLOCK	551	0.02	0.045	0.163	125.628
4TH BLOCK	573	0.02	0.045	0.163	130.644
5TH BLOCK	627	0.02	0.045	0.163	142.956
6TH BLOCK	675	0.02	0.045	0.163	153.9
7TH BLOCK	611	0.02	0.045	0.163	139.308
8TH BLOCK	324	0.02	0.045	0.163	73.872
9TH BLOCK	1446	0.02	0.045	0.163	329.688
10TH BLOCK	1064	0.02	0.045	0.163	242.592
11TH BLOCK	2604	0.02	0.045	0.163	593.712
IT	324	0.02	0.045	0.163	73.872
RND	631	0.02	0.045	0.163	143.868
LIBRARY	315	0.02	0.045	0.163	71.82
FOOD COURT	501	0.02	0.045	0.163	114.228
2ND FOOD COURT	194	0.02	0.045	0.163	44.232
MAC AUDI	1461	0.02	0.045	0.163	333.108
PLACEMENT OFFICE	215	0.02	0.045	0.163	49.02

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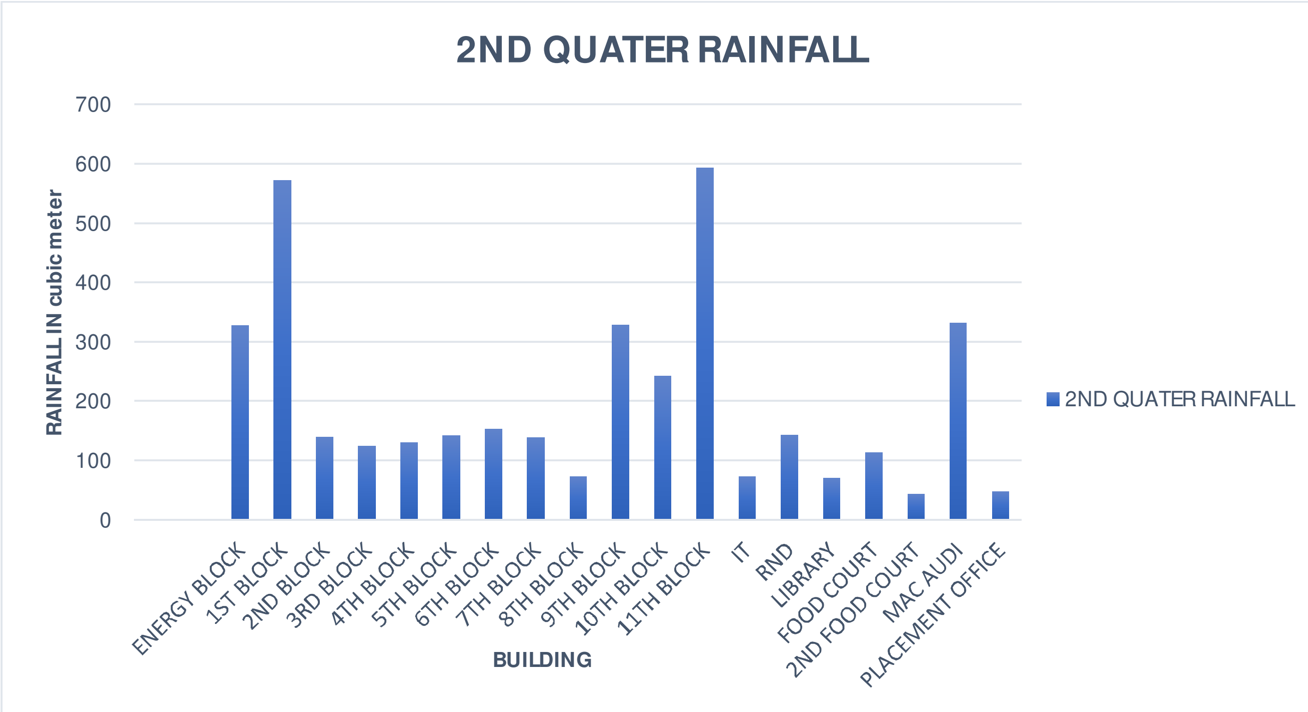

Graph 3 2nd Quarter Rainfall Data

Table 4 3rd Quarter Rainfall Data

BLOCK	AREA				3rd QUATER RAINFALL
		JULY	AUG	SEPT	
ENERGY BLOCK	1441	0.655	0.688		2354.594
1ST BLOCK	2514	0.655	0.688	0.291	4107.876
2ND BLOCK	616	0.655	0.688	0.291	1006.544
3RD BLOCK	551	0.655	0.688	0.291	900.334
4TH BLOCK	573	0.655	0.688	0.291	936.282
5TH BLOCK	627	0.655	0.688	0.291	1024.518
6TH BLOCK	675	0.655	0.688	0.291	1102.95
7TH BLOCK	611	0.655	0.688	0.291	998.374
8TH BLOCK	324	0.655	0.688	0.291	529.416
9TH BLOCK	1446	0.655	0.688	0.291	2362.764
10TH BLOCK	1064	0.655	0.688	0.291	1738.576
11TH BLOCK	2604	0.655	0.688	0.291	4254.936
IT	324	0.655	0.688	0.291	529.416
RND	631	0.655	0.688	0.291	1031.054
LIBRARY	315	0.655	0.688	0.291	514.71
FOOD COURT	501	0.655	0.688	0.291	818.634
2ND FOOD COURT	194	0.655	0.688	0.291	316.996
MAC AUDI	1461	0.655	0.688	0.291	2387.274
PLACEMENT OFFICE	215	0.655	0.688	0.291	351.31
				TOTAL	27266.558

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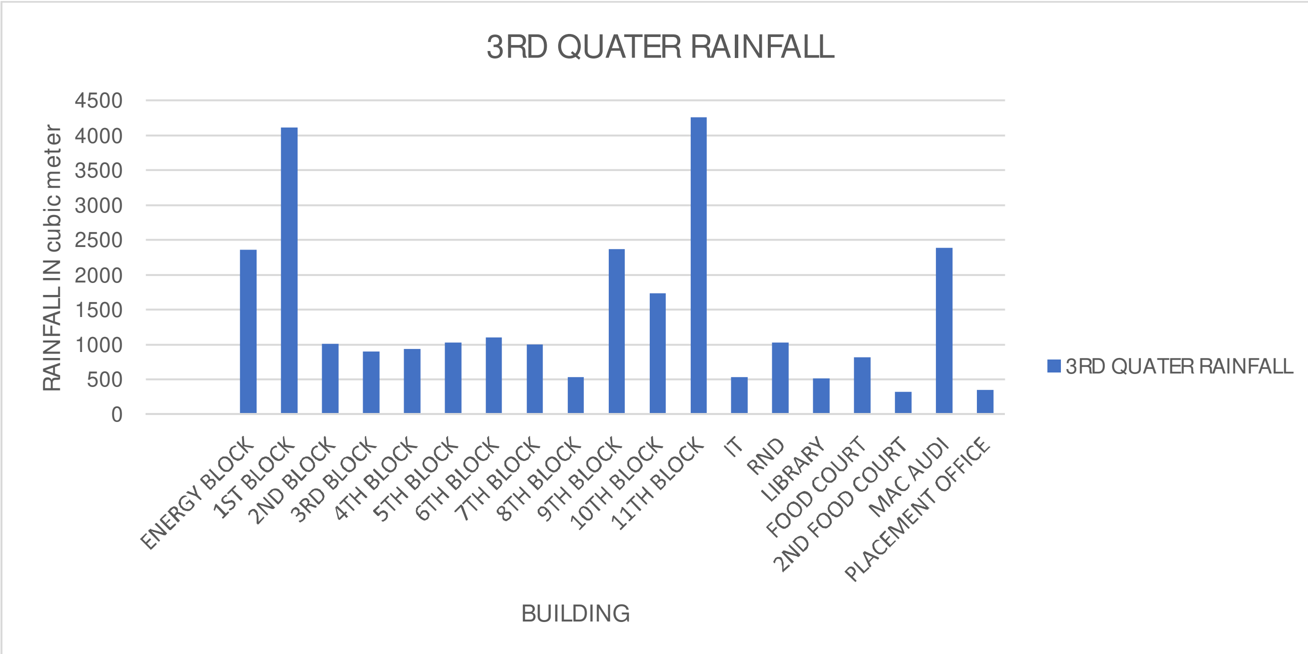

Graph 4 3rd Quarter Rainfall Data

Table 5 4th Quarter Rainfall Data

BLOCK	AREA				4th QUATER RAINFALL
		OCT	NOV	DEC	
ENERGY BLOCK	1441	0.095	0.018	0.025	198.858
1ST BLOCK	2514	0.095	0.018	0.025	346.932
2ND BLOCK	616	0.095	0.018	0.025	85.008
3RD BLOCK	551	0.095	0.018	0.025	76.038
4TH BLOCK	573	0.095	0.018	0.025	79.074
5TH BLOCK	627	0.095	0.018	0.025	86.526
6TH BLOCK	675	0.095	0.018	0.025	93.15
7TH BLOCK	611	0.095	0.018	0.025	84.318
8TH BLOCK	324	0.095	0.018	0.025	44.712
9TH BLOCK	1446	0.095	0.018	0.025	199.548
10TH BLOCK	1064	0.095	0.018	0.025	146.832
11TH BLOCK	2604	0.095	0.018	0.025	359.352
IT	324	0.095	0.018	0.025	44.712
RND	631	0.095	0.018	0.025	87.078
LIBRARY	315	0.095	0.018	0.025	43.47
FOOD COURT	501	0.095	0.018	0.025	69.138
2ND FOOD COURT	194	0.095	0.018	0.025	26.772
MAC AUDI	1461	0.095	0.018	0.025	201.618
PLACEMENT OFFICE	215	0.095	0.018	0.025	29.67
				TOTAL	2302.806

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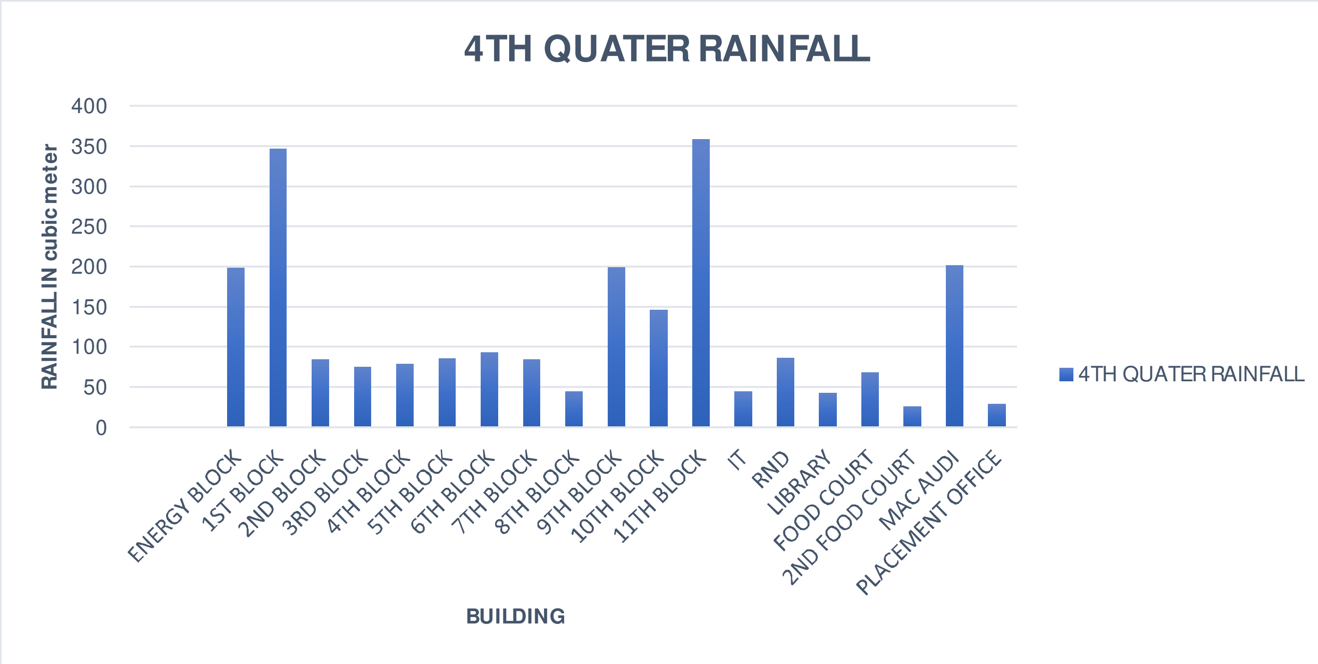

Graph 5 4th Quarter Rainfall Data

Table 6 Level Difference Between Two Points

ROUTE	FLOW DIRECTION	LEVEL DIFFERENCE (m)
11th BLOCK RIGHT SIDE	11th FRONT TO 11th BACK	2.58
FRONT OF 11th BLOCK	11th TO 10th BLOCK	0.865
B/W 9th & 10th	10th FRONT TO 10th BACK	0.6
GANDHI TO 10th	GANDHI TO 10th	0.97
R&D TO GANDHI	R&D TO GANDHI	0.51
LIBRARY TO MAC	LIBRARY TO MAC	0.255
LIBRARY TO GANDHI	LIBRARY TO GANDHI	0.31
	LIBRARY TO 2nd FOOD COURT	0.175
2nd FOOD COURT TO 8th BLOCK	LIBRARY TO 8th BLOCK	0.265
	MAIN ROAD TO 8th BLOCK	0.345
FOOD COURT FRONT	FOOD COURT FRONT TO 1st BLOCK	0.245
GANDHI TO FOOD COURT	GANDHI TO FOOD COURT	3.985

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Table 7 Rainfall Data

S.NO.	MONTH	RAINFALL (in m)
1	JANUARY	0.07
2	FEBRUARY	0.041
3	MARCH	0.06
4	APRIL	0.02
5	MAY	0.045
6	JUNE	0.163
7	JULY	0.655
8	AUGUST	0.688
9	SEPTEMBER	0.291
10	OCTOBER	0.095
11	NOVEMBER	0.018
12	DECEMBER	0.025

Table 9 Ground Water Collection and Estimation

LOCATION	PERIMETER	AREA	AVERAGE RAINFALL												TOTAL ANNUAL RAINFALL (M^3)	RUNOFF FACTOR	TOTAL RUNOFF WATER (M^3)	PEAK RUNOFF WATER OF PARTICULAR AREA(M^3)
			JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC				
GROUND	84	13169	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	28589.899	0.275	7862.22	2491.57
TOTAL PARK	832.2	5533	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	12012.143	0.175	2102.13	666.17
FROM PLACEMENT CELL, MDC TO GANDHI CHOWK	845	2597	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	5638.087	0.875	4933.33	1563.39
LIBRARY TO GANDHI CHOWK	159	351	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	762.021	0.875	666.77	211.30
LIBRARY TO MAC	170	501	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1087.671	0.875	951.71	301.60
GANDHI CHOWK TO MAC (DOWNSIDE)	322	889	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1930.019	0.875	1688.77	535.18
NEAR OLD AMPHI	234	765	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1660.815	0.875	1453.21	460.53
MAIN GATE,ENERGY HOUSE AND FIRST BLOCK FRONT	418	1413	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	3067.623	0.875	2684.17	850.63
R&D TO GANDHI CHOWK	228	530	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1150.63	0.875	1006.80	319.06
11TH BLOCK TO GANDHI CHOWK	337	1304	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	2830.984	0.875	2477.11	785.01
GANDHI CHOWK TO FOOD COURT	187	416	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	903.136	0.575	519.30	164.57
MAIN GATE TO FOOD COURT	284	719	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1560.949	0.875	1365.83	432.84
BEHIND 11TH BLOCK	293	908	0.07	0.041	0.06	0.02	0.045	0.163	0.655	0.688	0.291	0.095	0.018	0.025	1971.268	0.875	1724.86	546.62
	4393.2													Total	63165.245		29436.21	9328.47

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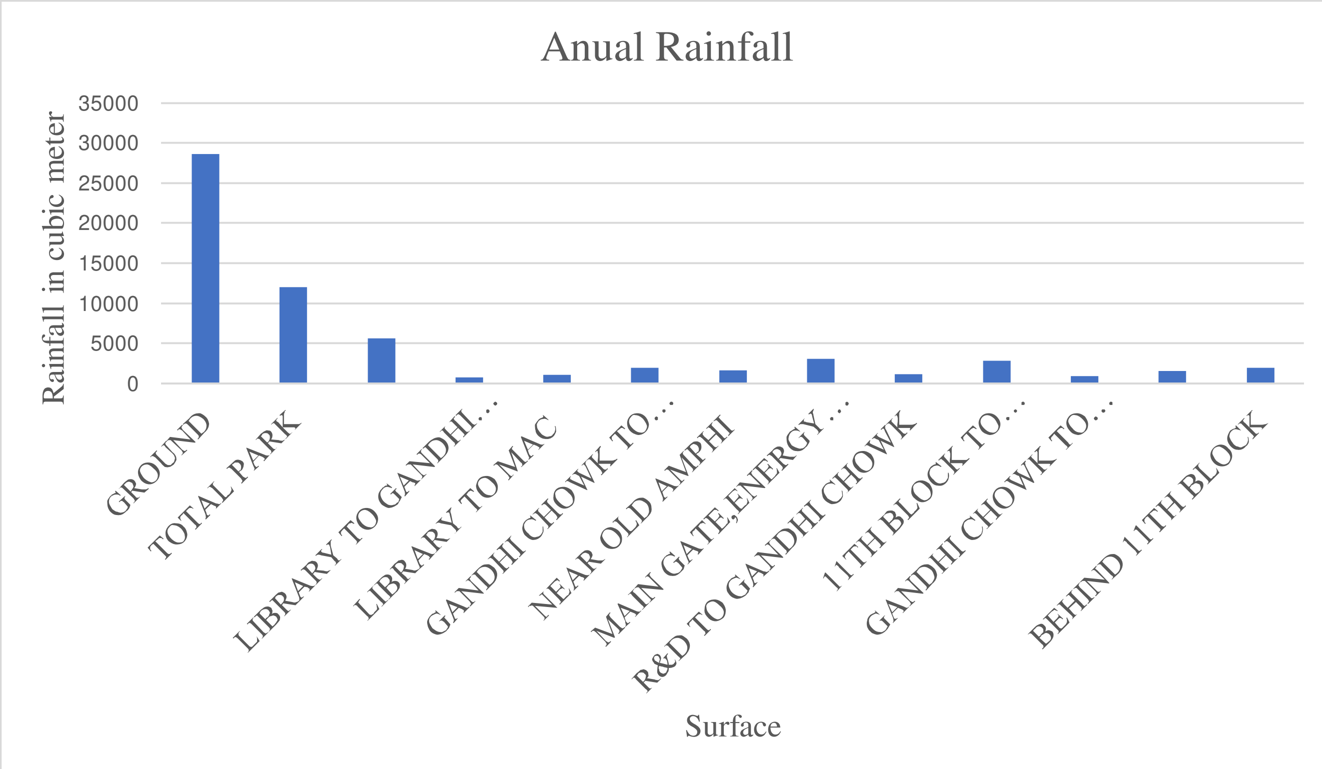
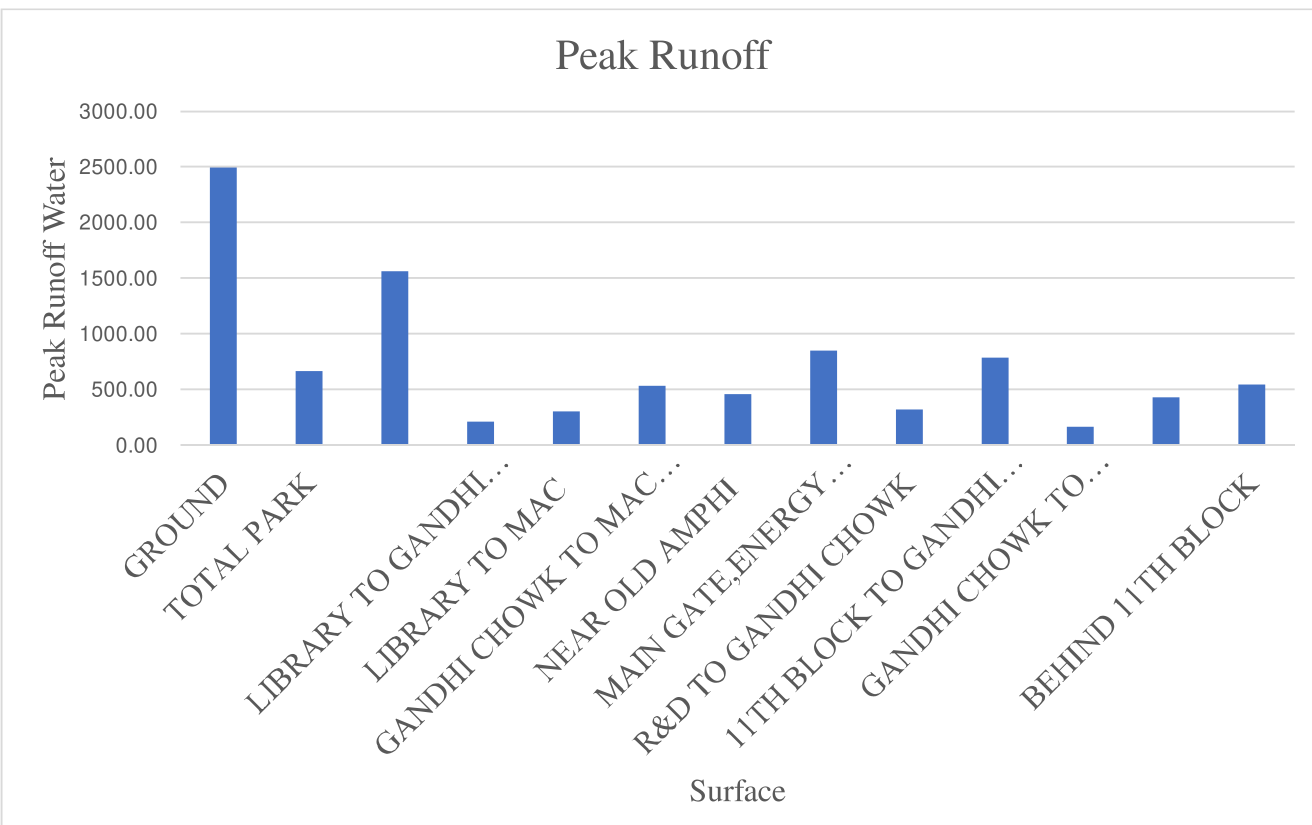


Graph 6 Annual Surface Water Collection



Graph 7 Peak Ground Runoff

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Table 10 Different Tanks with Specifications

	Max runoff water in one month			19374.04 m^3		
	Max runoff water in one day			645.8 m^3		
Tank No.	Location	NEW INTERNAL DIMENSIONS OF TANK				Filtration/Storing /Borewell
		LENGTH (m)	BREADTH (m)	DEPTH (m)	EXACT VOLUME(m^3)	
1	Play Ground	8	5	2.5	100	Filtration+ Storing Tank
2	Near MAC	8	5	2.5	100	Filtration +Storing Tank
3	Energy House's Backside	8	5	2.5	100	Filtration +Storing Tank
4	Near Main Gate	8	5	2.5	100	Filtration +Storing Tank +Borewell
5	11^{th} Block Backside	9	5.8	2.5	130.5	Filtration +Borewell
6	STP /FOOD COURT BACK	9	5.8	2.5	130.5	Filtration+ Storing Tank+ Borewell

IV. DISCUSSIONS

The total area of the entire blocks of UPES is calculated and is shown in the above tables. Then ruoff is calculated using Rational formula. After getting the total runoff, total potential of rainwater harvesting system became known. In order to use this water, filtration is required. After filtration, this water is fit fro any use as the rain water itself is devoid of any impurity. But mainly, its use in UPES is confined to flushing, washing and gardening purposes.

V. CONCLUSION

Because the ground water table on the UPES Campus and in the surrounding area is steadily declining, it is required to plan, design, and build a rain water harvesting system on campus to capture rain water from roof surfaces and paved surface (Road Surface) catchment. For the University of Petroleum and Energy Studies in Dehradun, the goal of this study was to construct a rooftop and ground rainwater harvesting system. This will aid in the artificial recharging of groundwater in this area, as well as alleviate water scarcity. Because of the water demand and supply on university campuses, the entire campus was chosen as the required catchment area for rainwater collection. Different components of the RWH system were also designed. According to the analysis, installing a RWH system on the UPES campus can solve water scarcity issues during non-monsoon seasons by storing a large amount of water throughout the year.

This programme will help to boost water supply for building, gardening, and artificial ground water recharge, thus enhancing both surface and ground water resources. It is concluded that implementing a RWH system on a university campus would be the best strategy to dealing with the current situation of water scarcity and water storage. There are numerous processes in the recharging system for recharging rainwater into the ground, with recommendations based on the maximum rainfall. Based on UPES University's water needs, the area's groundwater conditions, and rainwater data, it is proposed that a rainwater gathering system be developed.

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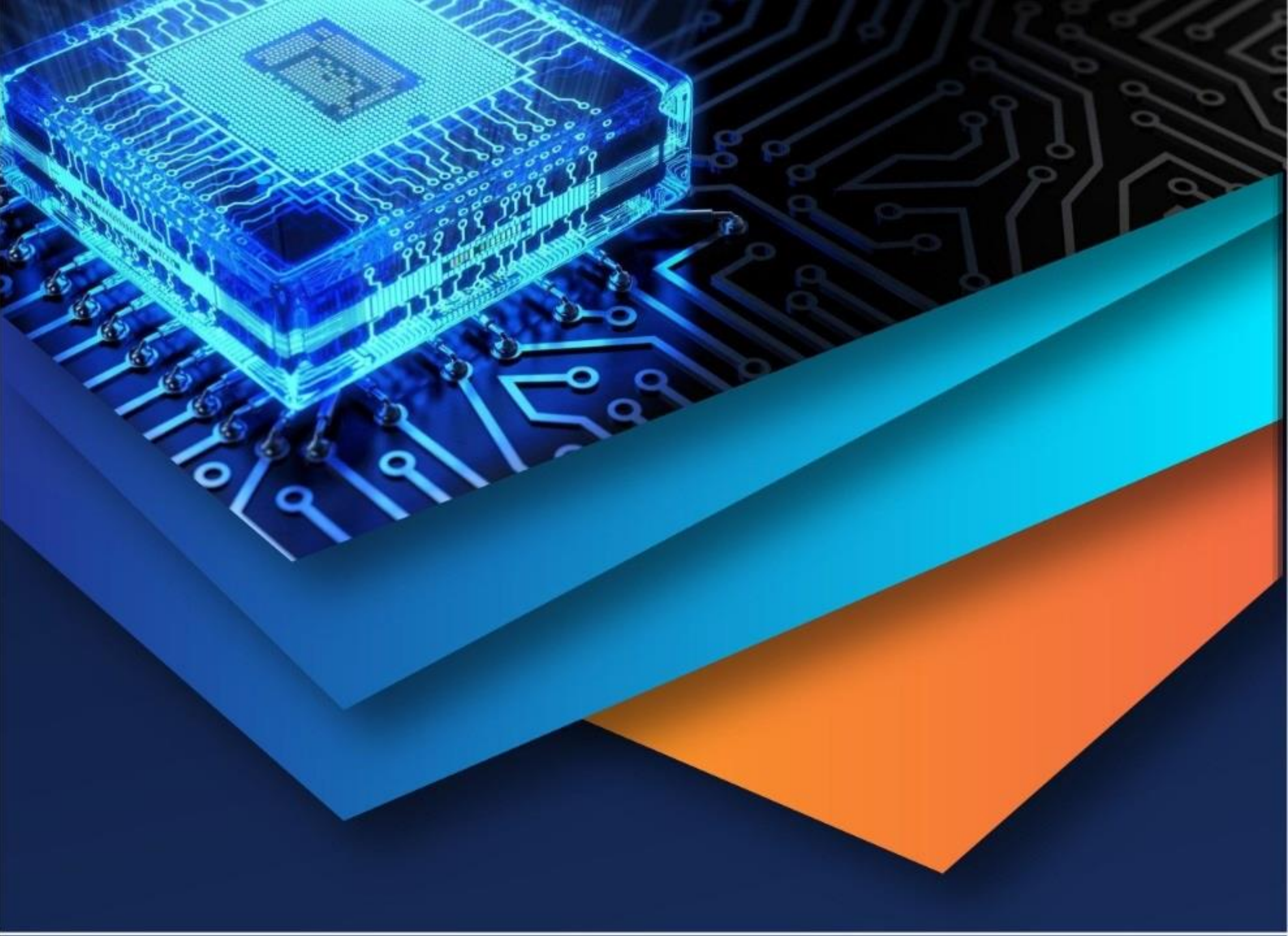

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