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RAIN WATER HARVESTING AN EMERGING TECHNOLOGY IN CHANGING CONDITION A CASE STUDY OF GRAPHIC ERA UNIVERSITY

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Abstract
Often, as a frantic response to problems of water scarcity and consequent hardships faced by both urban and rural communities, India has invested heavily in rainwater harvesting. Unlike investment in large water resource systems, these efforts, by and large, lack hydrological planning and sound economic analysis: research on the impact of local water harvesting/groundwater recharge activities in India is very sparse. This paper identifies six critical issues in rainwater harvesting efforts in water-scarce regions of India. First: there is no emphasis on potential local supplies and the demand they have to cater for: local supply potential is low in most water scarce regions, a fact compounded by poor reliability, and demand far exceeds the supply potential. Second: there are complexities in the economic evaluation of RWH, due to lack of scientific data on inflows, runoff collection and storage efficiency, beneficiaries, value of the incremental benefits generated and scale considerations. With higher degrees of basin development, the marginal benefit from water harvesting at the basin level reduces, while marginal cost increases. Third: in many basins, there is a strong 'trade-off' between maximizing hydrological benefits and improving cost effectiveness. Fourth: many water-scarce basins are characterized by wide disparity in demand between upper catchments and lower catchments, so that there is a trade-off in maximizing benefits of upstream water harvesting with optimizing basin-wide benefits. Fifth: in many water-scarce basins, local water harvesting merely divides the hydrological benefits rather than augmenting them. Finally, poor integration between surface water and groundwater systems, and lack of inclusion of natural recharge, ultimately leads to reduction in potential for artificial recharge in hard rock areas.

Introduction
Water is basic to the human health, welfare and economic development. It is equally vital for the preservation of wild life and natural environment. Fresh water is a central feature and can be a source of energy, avenue of transportation, means of production and aesthetics. It exerts a major influence on demographic patterns. Water is a finite and limited resource, and thus its efficient and effective use of water resources is necessary for sustainable economic and social development (Ritu Batra,1990).

India is one of the few countries in the world endowed with abundant land and water resources. It is the seventh largest country in the world and Asia's second largest country, with an area of 3,287,590 km^2. Most of the Indian landmass is in the semiarid tropical belt characterized by seasonal rainfall lasting over a period of three to four months. Total population of India was 846 million in 1991(census 1991). It is expected to be one billion in May 2000. The water resources of India are enormous but they are unevenly distributed in space, time and quantity. Due to lack of proper water resources planning and budgeting, famine in the vast tracts of the western and southern peninsula plateau region and floods in northern and eastern India ravage the lives of millions of the human and animal population. Famine, especially scarcity of drinking water, is causing havoc in Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. (A.G. Bobba, V.P. Singh, Lars Bengston, 1997).

Average annual precipitation including snowfall over the country is 4000 billion cum. (BCM) in addition; it receives another 200 BCM from river flowing in from other countries. Average annual water resources in various river basins are estimated to be 1869 BCM of which the utilized volume of water that has been estimated to be 1086 BCM including 690 BCM surface water and 396 BCM of ground water. Rest of the water

is lost by evaporation by flow into the sea. The utilization of water is expected to be 784 to 843 BCM by the year 2025. "Though the present utilization level is only about 50% of the total available water resources, the availability of water is highly irregular. It is not available in places of need, at the time of need and in required quantities." (D.K. Chadha, C.G.W.B 2000).

In the major part of the country, rainfall is the only source of water, which is available mainly during monsoon season lasting for less than three months. Due to tropical climate and its geography, the country experience vast spatial and temporal variations in precipitation. About one third of the country's area is drought prone (D.K. Chadha, 2000). The south and western parts comprising the state of Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu are drought prone states. On the other hand, north and northern region including states of U.P, Bihar, West Bengal and Assam are subjected to periodic flooding. The recent drought that the country has faced has not only created water scarcity but also led to migration of people and cattle from water scarcity areas to adjoining areas causing hardships to them. This has also brought social and economic problem in the areas where they migrate. In such areas women have fetch water from ponds, wells, lakes etc. from long distances which consumes lot of time, energy and affect the women folk. Therefore, concentrated and dedicated efforts are needed not only to harness the rainwater but also conserve it so that it can be used in the time of needs. The demand is the maximum during summers when the available water resources dwindle. In the time of crisis, ground water is the most dependable source. The problem is more severe in urban areas where natural recharge is reduced due to reduction in preamble area, consequent to increase in urbanization, (D.K. Chadha, 2000).

Rural Water Needs

Thousands of Indian villages still do not have any local source of drinking water. Women often have to walk many miles to collect a pot of drinking water of dubious quality. About 2.31 lakh villages in the country, were designated problem villages by the drinking water mission during sixth plan. Under rural needs mainly two sectors are there. First one is irrigation and second one drinking and livestock. It has been estimated that under irrigation sector the present demand is 630 BCM and by the year 2025 it will increase to 770 BCM. The world's average rural water consumption per capita is only 50lpcd or about 18 cum/year.

Urban Water Needs

Urban water needs can be divided into various sectors on the basis of the diverse kind of uses. The water demand of a city has two aspects a) Domestic water demand, b) Water demand at city level the following tables from 5 to 7 show various standards for water demand and sector wise and population wise breakup.

The city level demand varies according to the population size. On an average, the per capita demand for Indian cities may vary as shown in the following table. It must be noted that there is a big gap urban and rural demands. As urban demand is about 150lpcd to 300lpcd, rural demand is 70 to 100lpcd. On an average rural water consumption is only 50lpcdor 18 cum./year.

Table 1: Variation in Water Demand as Per City Size
(SOURCE: Bureau of Indian Standards)

S.NO.	POPULATION SIZE	DEMAND(LPCD)
1	Less than 20,000	0 - 110
2	20,000-50,000	110-150
3	50,000-2,00,000	150-180
4	2,00,000-5,00,000	180-210
5	5,00,000-10,00,000	210-240
6	More than 10,00,000	240-270

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TABLE 2: Breakup of City Level Demand
(SOURCE: Bureau of Indian Standards)

S.NO.	USE	DEMAND(LPCD)
1	Domestic	135
2	Industrial	50
3	Commercial	20
4	Public	10
5	Waste and theft	55
	Total	270

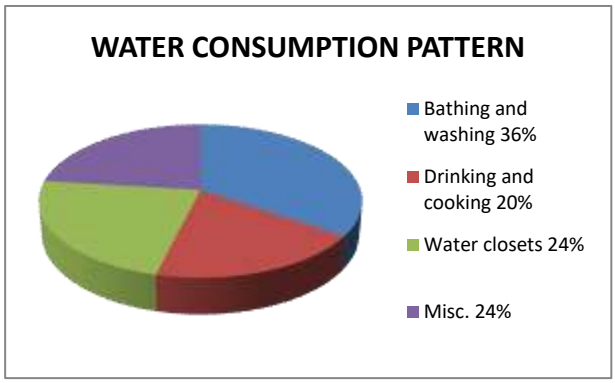

FIGURE 1: Breakup of Domestic Water Use Pattern (SOURCE: CGWB)

The purpose of this study is to give an overall picture of the different type of water resources and their pattern of distribution. This also includes the consumption of water and its breakup at city level and national level. From the above mentioned information it is clear that there is no shortage of water as such but there proper management and utilization is of utmost importance. If we don't pay attention to the natural cycle of water then the natural process of recharging of ground water will not take place and will create the water crisis. In fact it is the balanced utilization of the various water resources which is necessary. Presently a huge resource of water that is rainwater is not utilized properly and it going waste as runoff causing inundation in one area and brought in other area. One of the preventive measures for this kind of havoc is rainwater harvesting.

Elements of Roof Top Rain Water Harvesting

The basic elements/functional parameters of any roof top rainwater are as follows:

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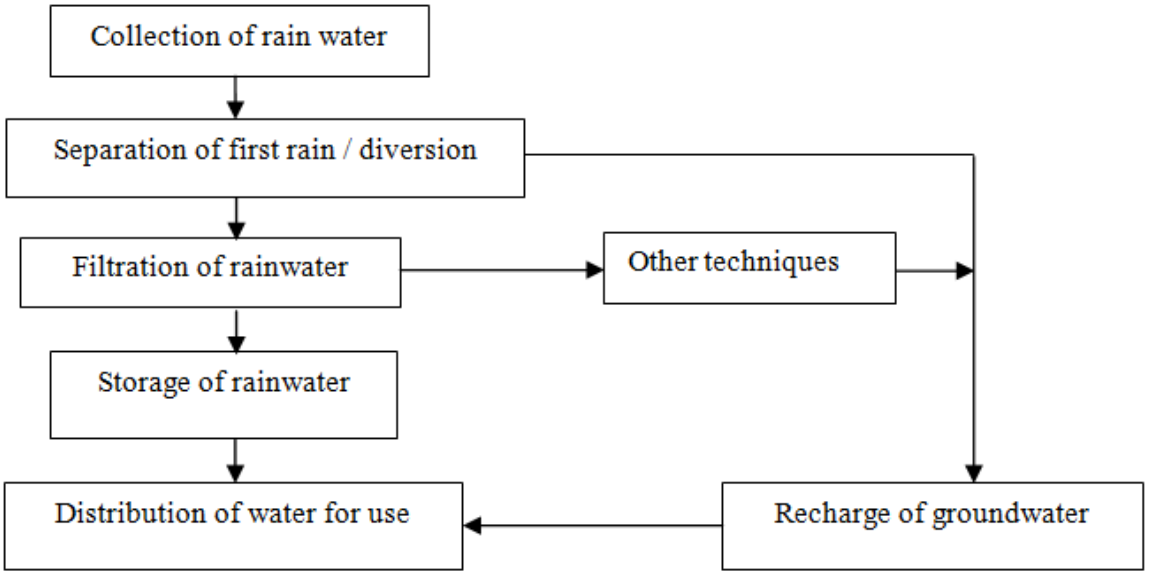

FIGURE 2: Elements of Rooftop Rainwater Harvesting

Collection of Rainwater: Catchment is the first thing; the rainwater comes in contact with. Hence it is the first thing where one should pay attention very first. The quality and quantity of harvested rainwater depend very much on the type and surface finish of the roof, its size, its slope and maintenance etc. sloping roofs have the maximum potential of harvesting rainwater, next comes the flat roofs. Surface finish of the roof is also important. It should not be of any harmful material. Even thatch roof can be used for rainwater harvesting; the only thing is that the water will have some color and odour, which can be avoided by putting the plastic sheet on the roof.

Separation of First Rain/Diversion: The water from the rooftops can be divided towards an operating by providing mild slopes. This opening connected with a PVC pipe will enable the water to flow down to a tank of a well. If there are many rainwater pipes then they may be joined at some suitable point and the total rainwater can be then directed to the filter section.

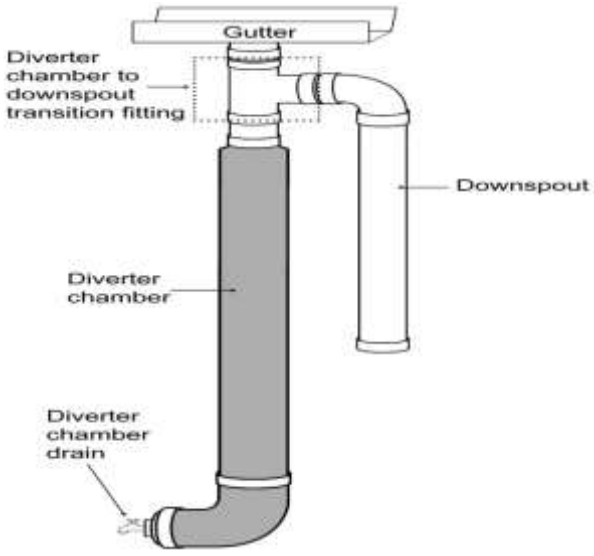

FIGURE 3: First Flush System

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Study Area

The study has to be conducted in Graphic Era University, Dehradun therefore the data has been assessed covering the project area. The study area is also determined giving the urgency of problems found from the base line survey. The study area covers the whole Graphic Era University campus in the different sections.

Graphic Era University is a center for research and specialized studies, an institution that has created engineers, managers, technocrats and entrepreneurs with a world class rating. Graphic Era University has been appreciated over the years by numerous parents owing to its excellent services. Graphic Era University is declared as Deemed University U/S 3 of the UGC Act, 1956. Graphic Era University is known for its international recognition, inquiry driven, and ethically engaged diverse community, whose members work collaboratively for positive transformation in the world through leadership in teaching, research and social action. Graphic Era University is formed by Graphic Era educational society. The Graphic Era Educational Society is a non-profit organization that aims to mobilize world class education and generate resources for providing and supporting quality education for all masses & public.

Established in the year 1996, the society recognizes the need of time to build the capacities of both individuals and communities empowering them to face the ever changing global environment and excel in the fields of education, research and industrial interface. Under the aegis of Graphic Era Educational Society, a state-of-the-art "Graphic Era Hill University" has also been setup in order to cater the needs of professional and technical education in the hilly regions of Uttarakhand.Graphic Era Hill University has campuses at Dehradun and Bhimtal.

Graphic Era University is the culmination of the dream of Prof. Kamal Ghanshala, an eminent academician and computer engineer of international repute.Prof. Kamal Ghanshala founded Graphic Era in the year 1993 as one of his bold venture in providing service to the society through a private educational system, without looking for any form of assistance from other agencies. He is a recipient of Uttarakhand Ratan Award, the International Millennium Gold star award and the lifetime achievement award from Indian economic development and research association, New Delhi.

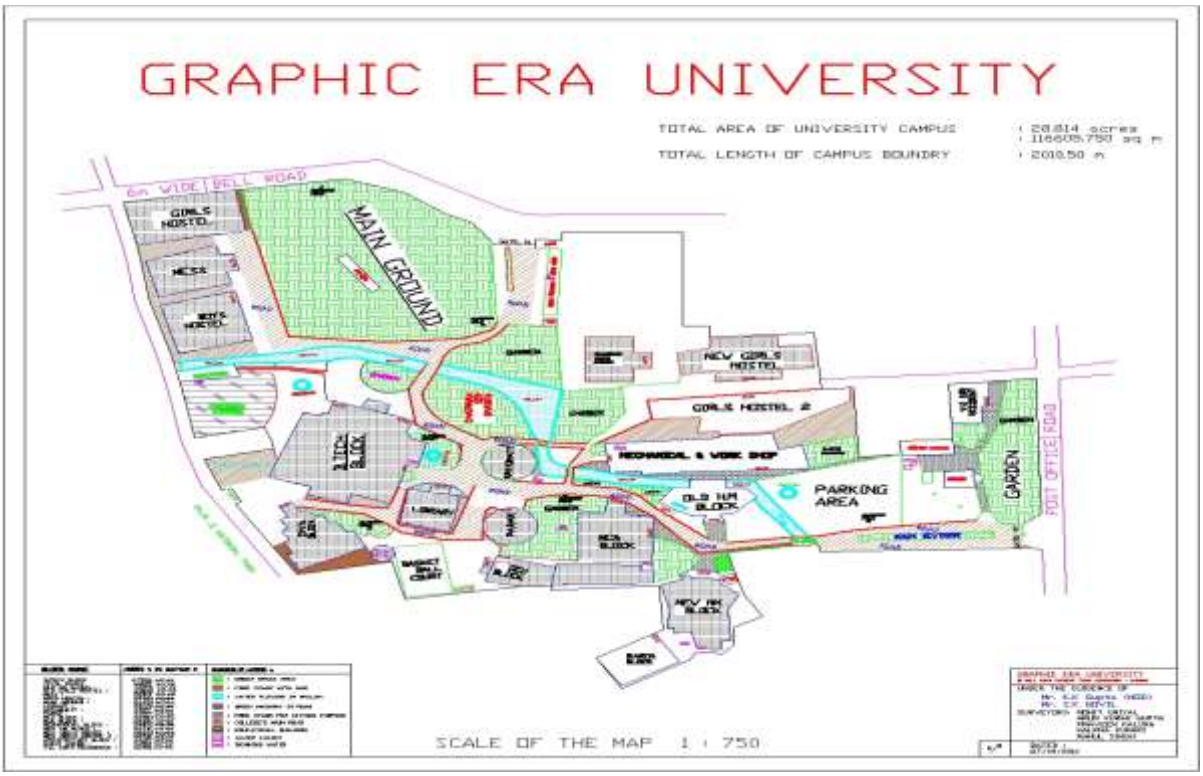

FIGURE 4: Graphic Era University Campus, Dehradun

Result and Discussions

The entire university campus has been designed along a seasonal stream. The teaching departments are located in the main campus. The B.Tech block also houses and amphitheater. There is a central library, adjoining two blocks dedicated to computer labs. Further up the stream is the engineering block that houses the high roof manufacturing workshop, the Robotics laboratory and Computer Aided Design lab. A separate management block caters to the lecture halls and facilities for Management studies. The hotel management block and new hospitality block has university restaurant, Seminar Hall, Conference Halls and dedicated libraries. Cafeterias and canteens are spread all over the campus. There is in-house book store and a fully-fledged national bank. There is an international class guest house near main entrance. A sport complex and grounds for different games, basketball, tennis, cricket and football are well equipped. Many flowering gardens have been established along the stream, and have become star attractions on the campus.

We designed such a tank which can store a lot amount of water which generally get wasted throughout the year in all the rainy days. If we somehow can utilize the rainfall water for our using purposes, then this technique will adoptable to keep storage of the rainwater. The Graphic Era University is spread in a very big land. So a lot of water is wasted here. So to overcome by this problem we just proposed a rainwater harvesting system for the campus. The whole Graphic Era University campus is divided in 7 different sites which are the combinations of 2 or 3 blocks in each. It is all depends on the type of the building and surroundings.

These are the different sites which are located in the Graphic Era University Dehradun campus, for which we are designing the Rain Water harvesting system

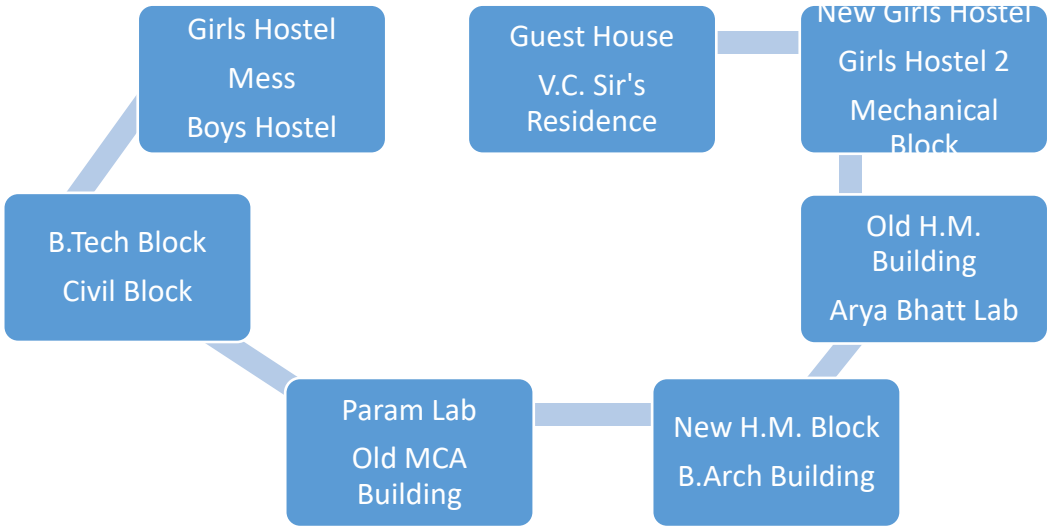

FIGURE 5: Different Sites for Rainwater harvesting system

TABLE 3: Site (A) Girls Hostel & Boys Mess rainwater collected

Months	Site Name	Roof Top Area (A) in m^2	Rainfall Data (mm)	Rainfall Data(B) in m	C = A X B (m^3)	20% losses	20% Losses of Rainwater (m^3)	Rainwater collected (m^3)
January	A	3116.88	27.97	0.0280	87.17	0.20	17.4337	69.7347
February	A	3116.88	27.88	0.0279	86.90	0.20	17.3797	69.5189
March	A	3116.88	20.70	0.0207	64.52	0.20	12.9039	51.6155
April	A	3116.88	13.93	0.0139	43.42	0.20	8.6836	34.7345
May	A	3116.88	23.79	0.0238	74.15	0.20	14.8301	59.3205

June	A	3116.88	103.71	0.1037	323.25	0.20	64.6503	258.6013
July	A	3116.88	291.44	0.2914	908.38	0.20	181.6767	726.7068
August	A	3116.88	288.80	0.2888	900.15	0.20	180.0310	720.1240
September	A	3116.88	146.14	0.1461	455.50	0.20	91.1002	364.4007
October	A	3116.88	18.08	0.0181	56.35	0.20	11.2706	45.0826
November	A	3116.88	6.48	0.0065	20.20	0.20	4.0395	16.1579
December	A	3116.88	10.64	0.0106	33.16	0.20	6.6327	26.5309
							TOTAL	**2442.5282**

Rainwater collected on SITE-A = **2442.5282 m^3 or 2442528.20 Liters**
Volume of the tank for storing rainwater = **70 m^3**
Cost of the tank per cubic meter = **Rs. 10400 /-**

TABLE 4: Site (B) B.Tech Block & Civil Block rainwater collected

Months	**Site Name**	**Roof Top Area (A) in m^2**	**Rainfall Data (mm)**	**Rainfall Data(B) in m**	**C = A X B (m^3)**	**20% losses**	**20% Losses of Rainwater (m^3)**	**Rainwater collected (m^3)**
January	B	3720.87	27.97	0.0280	104.06	0.20	20.8120	83.2480
February	B	3720.87	27.88	0.0279	103.74	0.20	20.7476	82.9903
March	B	3720.87	20.70	0.0207	77.02	0.20	15.4044	61.6176
April	B	3720.87	13.93	0.0139	51.83	0.20	10.3663	41.4654
May	B	3720.87	23.79	0.0238	88.52	0.20	17.7039	70.8156
June	B	3720.87	103.71	0.1037	385.89	0.20	77.1783	308.7131
July	B	3720.87	291.44	0.2914	1084.41	0.20	216.8821	867.5283
August	B	3720.87	288.80	0.2888	1074.59	0.20	214.9175	859.6698
September	B	3720.87	146.14	0.1461	543.77	0.20	108.7536	435.0144
October	B	3720.87	18.08	0.0181	67.27	0.20	13.4547	53.8187
November	B	3720.87	6.48	0.0065	24.11	0.20	4.8222	19.2890
December	B	3720.87	10.64	0.0106	39.59	0.20	7.9180	31.6720
							TOTAL	**2915.8421**

Rainwater collected on SITE-B = **2915.8421 m^3 or 2915842.10 Liters**
Volume of the tank for storing rainwater = **70 m^3**
Cost of the tank per cubic meter = **Rs. 10400 /-**

TABLE 5: Site (C) Library, Param, OMC and GEU Block rainwater collected

Months	**Site Name**	**Roof Top Area (A) in m^2**	**Rainfall Data (mm)**	**Rainfall Data(B) in m**	**C = A X B (m^3)**	**20% losses**	**20% Losses of Rainwater (m^3)**	**Rainwater collected (m^3)**
January	C	2909.69	27.97	0.0280	81.37	0.20	16.2748	65.0992
February	C	2909.69	27.88	0.0279	81.12	0.20	16.2244	64.8977
March	C	2909.69	20.70	0.0207	60.23	0.20	12.0461	48.1845
April	C	2909.69	13.93	0.0139	40.53	0.20	8.1064	32.4256
May	C	2909.69	23.79	0.0238	69.22	0.20	13.8443	55.3772

June	C	2909.69	103.71	0.1037	301.76	0.20	60.3528	241.4112
July	C	2909.69	291.44	0.2914	848.00	0.20	169.6000	678.4000
August	C	2909.69	288.80	0.2888	840.32	0.20	168.0637	672.2548
September	C	2909.69	146.14	0.1461	425.22	0.20	85.0444	340.1777
October	C	2909.69	18.08	0.0181	52.61	0.20	10.5214	42.0858
November	C	2909.69	6.48	0.0065	18.85	0.20	3.7710	15.0838
December	C	2909.69	10.64	0.0106	30.96	0.20	6.1918	24.7673
							TOTAL	**2280.1647**

Rainwater collected on SITE-C = **2280.1467 m^3 or 2280164.70 Liters**
Volume of the tank for storing rainwater = **70 m^3**
Cost of the tank per cubic meter = **Rs. 10400 /-**

TABLE 6: Site (D) New HM & PCB Block Rainwater Collected

Months	Site Name	Roof Top Area (A) in m^2	Rainfall Data (mm)	Rainfall Data(B) in m	C = A X B (m^3)	20% losses	20% Losses of Rainwater (m^3)	Rainwater collected (m^3)
January	D	1711.01	27.97	0.0280	47.85	0.20	9.5702	38.2809
February	D	1711.01	27.88	0.0279	47.70	0.20	9.5406	38.1624
March	D	1711.01	20.70	0.0207	35.42	0.20	7.0836	28.3343
April	D	1711.01	13.93	0.0139	23.83	0.20	4.7669	19.0675
May	D	1711.01	23.79	0.0238	40.70	0.20	8.1410	32.5639
June	D	1711.01	103.71	0.1037	177.45	0.20	35.4898	141.9591
July	D	1711.01	291.44	0.2914	498.66	0.20	99.7314	398.9254
August	D	1711.01	288.80	0.2888	494.14	0.20	98.8279	395.3118
September	D	1711.01	146.14	0.1461	250.05	0.20	50.0094	200.0376
October	D	1711.01	18.08	0.0181	30.94	0.20	6.1870	24.7480
November	D	1711.01	6.48	0.0065	11.09	0.20	2.2175	8.8699
December	D	1711.01	10.64	0.0106	18.21	0.20	3.6410	14.5641
							TOTAL	**1340.8249**

Rainwater collected on SITE-D = **1340.8249 m^3 or 1340824.90 Liters**
Volume of the tank for storing rainwater = **70 m^3**
Cost of the tank per cubic meter = **Rs. 10400 /-**

TABLE 7: Site (E) Old HM Block & Arya Bhatt Rainwater Collected

Months	Site Name	Roof Top Area (A) in m^2	Rainfall Data (mm)	Rainfall Data(B) in m	C = A X B (m^3)	20% losses	20% Losses of Rainwater (m^3)	Rainwater collected (m^3)
January	E	1089.41	27.97	0.0280	30.47	0.20	6.0934	24.3736
February	E	1089.41	27.88	0.0279	30.37	0.20	6.0746	24.2982
March	E	1089.41	20.70	0.0207	22.55	0.20	4.5102	18.0406
April	E	1089.41	13.93	0.0139	15.18	0.20	3.0351	12.1404
May	E	1089.41	23.79	0.0238	25.92	0.20	5.1834	20.7337
June	E	1089.41	103.71	0.1037	112.98	0.20	22.5965	90.3862
July	E	1089.41	291.44	0.2914	317.50	0.20	63.4995	253.9981
August	E	1089.41	288.80	0.2888	314.62	0.20	62.9243	251.6973
September	E	1089.41	146.14	0.1461	159.21	0.20	31.8413	127.3651
October	E	1089.41	18.08	0.0181	19.70	0.20	3.9393	15.7572
November	E	1089.41	6.48	0.0065	7.06	0.20	1.4119	5.6475
December	E	1089.41	10.64	0.0106	11.59	0.20	2.3183	9.2731
							TOTAL	**853.7110**

Rainwater collected on SITE-E = **853.7110 m^3 or 853711 Liters**
Volume of the tank for storing rainwater = **70 m^3**
Cost of the tank per cubic meter = **Rs. 10400 /-**

TABLE 8: Site (F) Girls Hostel 1&2 and Mechanical Block rainwater collected

Months	Site Name	Roof Top Area (A) in m^2	Rainfall Data (mm)	Rainfall Data(B) in m	C = A X B (m^3)	20% losses	20% Losses of Rainwater (m^3)	Rainwater collected (m^3)
January	F	4237.06	27.97	0.0280	118.50	0.20	23.6992	94.7968
February	F	4237.06	27.88	0.0279	118.13	0.20	23.6258	94.5034
March	F	4237.06	20.70	0.0207	87.71	0.20	17.5414	70.1657
April	F	4237.06	13.93	0.0139	59.02	0.20	11.8044	47.2178
May	F	4237.06	23.79	0.0238	100.80	0.20	20.1599	80.6397
June	F	4237.06	103.71	0.1037	439.43	0.20	87.8851	351.5404
July	F	4237.06	291.44	0.2914	1234.85	0.20	246.9698	987.8790
August	F	4237.06	288.80	0.2888	1223.66	0.20	244.7326	978.9303
September	F	4237.06	146.14	0.1461	619.20	0.20	123.8408	495.3632
October	F	4237.06	18.08	0.0181	76.61	0.20	15.3212	61.2848

November	F	4237.06	6.48	0.0065	27.46	0.20	5.4912	21.9649
December	F	4237.06	10.64	0.0106	45.08	0.20	9.0165	36.0659
							TOTAL	**3320.3519**

Rainwater collected on SITE-F = **3320.3519 m^3 or 3320351.90 Liters**
Volume of the tank for storing rainwater = **70 m^3**
Cost of the tank per cubic meter = **Rs. 10400 /-**

TABLE 9: Site (G) V.C. residence and Guest House rainwater collected

Months	**Site Name**	**Roof Top Area (A) in m^2**	**Rainfall Data (mm)**	**Rainfall Data(B) in m**	**C = A X B (m^3)**	**20% losses**	**20% Losses of Rainwater (m^3)**	**Rainwater collected (m^3)**
January	G	594.83	27.97	0.0280	16.64	0.20	3.3271	13.3083
February	G	594.83	27.88	0.0279	16.58	0.20	3.3168	13.2671
March	G	594.83	20.70	0.0207	12.31	0.20	2.4626	9.8504
April	G	594.83	13.93	0.0139	8.29	0.20	1.6572	6.6288
May	G	594.83	23.79	0.0238	14.15	0.20	2.8302	11.3208
June	G	594.83	103.71	0.1037	61.69	0.20	12.3380	49.3519
July	G	594.83	291.44	0.2914	173.36	0.20	34.6715	138.6858
August	G	594.83	288.80	0.2888	171.79	0.20	34.3574	137.4295
September	G	594.83	146.14	0.1461	86.93	0.20	17.3857	69.5428
October	G	594.83	18.08	0.0181	10.75	0.20	2.1509	8.6036
November	G	594.83	6.48	0.0065	3.85	0.20	0.7709	3.0836
December	G	594.83	10.64	0.0106	6.33	0.20	1.2658	5.0632
							TOTAL	**466.1357**

Rainwater collected on SITE-G = **466.1357 m^3 or 466135.70 Liters**
Volume of the tank for storing rainwater = **70 m^3**
Cost of the tank per cubic meter = **Rs. 10400 /-**

Conclusions

During the last five decades there has been sharp increase in water consumption owning to the population explosion, unprecedented rise in standard of living and enormous development. The problem is caused not only by natural factors, but also due to mismanagement and lack of knowledge about existing water resources. Therefore, a proper management plan can only be adopted by knowing the balance of different hydrologic components of hydrological unit. The present study is an attempt to know the importance of Rain Water Harvesting as an option for groundwater recharge and storage in Graphic Era University, Dehradun Uttarakhand. As the consumption of water has increased, it is recommended to adopt artificial measures to increase groundwater recharge i.e. rainwater harvesting and artificial recharge schemes. This would also help in increasing recharge in changing climate.

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References

[1] Anil Agarwal and Sunita Narain(eds), 1999, Dying Wisdom, Centre for Science and Environment, New Delhi.
[2] G. Bobba, V.P. Singh and lars Bengston, 1997, Environmental Management Vol. 21, No 3, Published by Springer-Verlag New York Inc.
[3] Ashish Banergee and Manu Bhatnagar, 2000, 'Planning for a sustainable urban water resource base'. In preceedings of National Seminar on Rainwater Harvesting organized by Central Ground Water Board (CGWB), New Delhi.
[4] C.S.Agarwal, Dr. Satyendra Mittal Himani Goyal, 2000, 'Rainwater harvesting-An appropriate technology for Rural water supply'. In preceedings of International Seminar on Rural Water Supply, Roorkee.
[5] Compendium of Environment Statistics, 1997, prepared by Central Statistical Organization, Department of Statistics of Ministry of Planning and Programme Implementation Government of India, New Delhi.
[6] D.K. Chadha, 2000, ' Key note address on ground water recharge: Strategy for sustainable water world'. In All India Seminar on Ground Water Recharge: Strategy for sustainable Water World organized by The Institution of Engineers (India), Lucknow.
[7] Dhaneshwar Rai, 2000, 'Appropriate Methodologies of Ground Water Recharge In Different Hydrological Setup of U.P.'. In All India Seminar on Ground Water Recharge: Strategy for sustainable Water World organized by The Institution of Engineers (India), Lucknow.
[8] International Conference on Habitat 7 Sustainable Development, 1997, organized by The Institution of Engineers (India), under the aegis of World Federation of Engineering Organization, New Delhi.
[9] Kyeong Ae Choe and Robert C.G Varley, 1997, 'Conservation and Pricing- raising tariffs to an economic price for water make people worse off?' paper prepared for the "Best management practice for water conservation" Workshop , supported by Sa-USA Bi-National Commission, 7-10 September, 1997 Hermanus, South Africa.
[10] M.B. Raju and B. Umapathi, 2000, 'Rainwater harvesting in a coastal urban agglomeration-a case study'. In proceedings of National Seminar on Rain Water Harvesting organized by Central Ground Water Board(CGWB), New Delhi.
[11] M.Mohan Rao, 2000, 'Roof water harvesting–an effective solution to combat water crisis in Devas'. In proceedings of National Seminar on Rain Water Harvesting organized by Central Ground Water Board(CGWB), New Delhi.