Design of Rainwater Harvesting in HBTU West Campus for Upcoming 25 Years

[1]**Archangel Singh**, [2] **Dr. Pradeep Kumar**

[1]Research Scholar, [2] Professor
[1]Department of Civil Engineering,
[1] HBTU, Kanpur, India

Abstract: As per recent metrological data for Kanpur city, its observed that there is reduction in annual rainfall which ultimately led to reduction in ground water table. Today because of rising population and increasing global temperature the need for water has increased manifold. The water resource harvesting technique involves primary land survey, available water resources, filtration technique. In the current research the design of rainwater harvesting system of GECA campus is done using geographic information system (GIS).From the current research the HBTU campus is found to be feasible for installation of rain water harvesting systems. The approximate expenditure for underground storage tank is determined and evaluated. The annual runoff potential, total runoff potential and approximate expenditure for 3 recharge pits is evaluated.

Index Terms – GIS, Water Resource harvesting

I. INTRODUCTION

Water harvesting is typically used for agriculture in arid & semi-arid locations. It works best in places close to hillsides or when cultivation is challenging due to a significant amount of bare soil. Dams and ponds may be built to keep enormous amounts of rainwater so that during times when little rainfall happens, enough is accessible to irrigate growing crops.
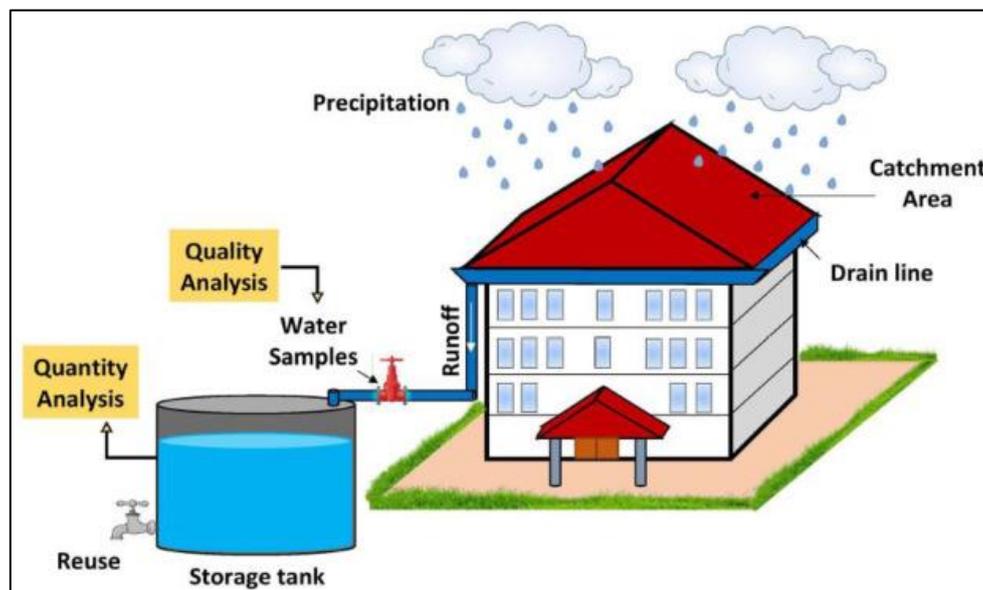

Figure 1: Rainwater harvesting [1]

In order to collect rainwater, a system must convey it through pipes or drains, filter it, and then store it in tanks for later use or recharge.

II. LITERATURE REVIEW

Semaan, et al. [3] completed an assessment of the research on the best size for rainwater collection systems. The most crucial optimization goal was determined to be storage sizing, whereas the most commonly used optimization result was cost-conscious sizing.

Musayev, et al [4].'s investigation of the effectiveness of rainwater collection (globally) across climate circumstances made the case that even in arid areas, changing climate would have no effect on the effectiveness.

Haque, et al. [5] According to the design model by The efficiency of the RWH system would suffer as a result of climate change.

Liu, et al. [6] Membrane filtration was investigated for the treatment of collected rainwater. The suggested method, it was determined, has the potential to considerably enhance the quality of the water; nevertheless, the main issue with this method is membrane fouling.

Deng [7] examined the effects of pollutants on urban agriculture in the rainwater collected. it was suggested that the RWH technology be supplemented by a customized treatment system to ensure that the crops received water of the highest standard.

III. OBJECTIVES

The objective of current research is to:

1. To estimate the ground water generation for upcoming years on basis of approximate population forecast for selected areas of HBTU west campus, also will stimulate certain methods which will make equilibrium to the ground water table by using rainwater harvesting techniques.
2. To evaluate small recharge pits over the 3 study areas of HBTU west campus.

IV. METHODOLOGY

The survey is conducted on HBTU West Campus to determine water sources, water consumption and proposed location for installation of ground water harvesting system.

Table 1: Roof area of different buildings

Abdul Kalam Hostel (WCH I)	6250 m^2
Visvesvaraya Hostel (WCH II)	5116 m^2
Raman Hostel (WCH III)	3602 m^2
Vishwakarma Hostel (WCH IV)	2489.82 m^2
New Gymnasium	320.89 m^2
Multipurpose Hall	3321.25 m^2
Total Plinth/Roof Area	20100 m^2

Table 2: Water Consumption on Daily Basis

Activity	Liters
Drinking	3
Cooking	4
Bathing	20
Sanitation	40
Washing Clothes	40
Washing Utensils	20
Gardening	23
Total Consumption	150

On average urban Indian uses about 150 Ltr of water everyday = 1300 * 150 = 1,95,000. So, 1,95,000 per day is being used by HBTU west campus. Water usage is approx. more than liters per day. The annual rainfall data is procured from online portal of metrological department and Kanpur Nagar Nigam [10]. The data is shown in table 3.

Table 3: Kanpur Nawabganj Annual Rainfall Data (2021)

Month	Average Rainfall
January	11.60mm
February	18.59mm
March	9.64mm
April	4.77mm
May	7.45mm
June	55.82mm
July	228.99mm
August	250.77mm
September	120.99mm
October	27.95mm
November	4.90mm
December	3.74mm
Total	745.21mm

The plinth area is determined from internal audit report available in HBTU maintenance department. The details are presented in table 4.

Table 4: Plinth Area of Different Campus Buildings

Community Center	150 m^2
New Gym	320.34m^2
New Audi	595m^2
Multipurpose Hall (Shatabdi Bhawan)	2321.25m^2
Residence Buildings Type I, Type II, Type III, Type IV, Type V VC residence	18514m^2

The sewerage water and storm water is discharged in to the municipal corporation main sewer line. The rainwater is to be fed in to lower lying areas for natural course of percolation.
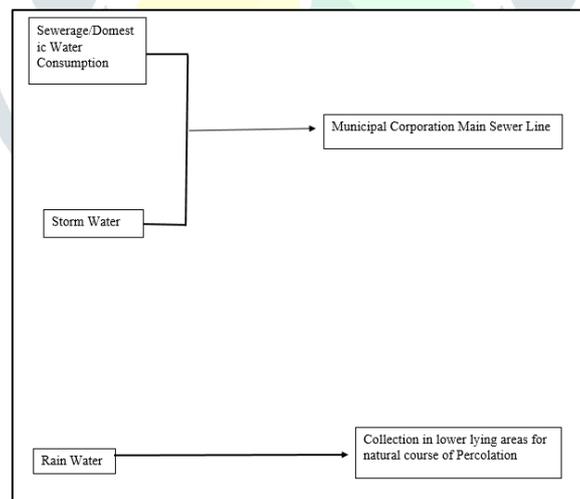

Figure 2: Schematic of waste water and rainwater flow inside campus

The green audit report is procured from HBTU official website [11]. The report includes details of consumption rate, personal usage, total requirement and waste water generation as shown in table 5.

Table 5: West Campus Hostels Water Consumption Data

Purpose	Consumption Rate (Ltr/D)	Usage Personal D	Total Requirement (KL/D)	Waste Water Generation @80% D
Hostel W/C	125	1232	154	123.2

The catchment area is procured from maintenance department of HBTU campus.

Table 6: Plinth Area

WCH I	6250 m^2
WCH II	5116 m^2
WCH III	3602 m^2
WCH IV	2489.82 m^2
New Gym	320.89 m^2
Shatabdi Bhawan	2321.25 m^2
Residential buildings	18514 m^2
Total Plinth Area	38614 m^2

Annual RWHP is given by

V=K*I*A

Where V is volume of water that can be harvested annually in m^2

K= Runoff coefficient

I = Annual rainfall (mm)

A= catchment area (mm)

Part I

For Abdul Kalam Hostel

(WCH I)

Total Catchment Area = 6250m^2

K_1 = 0.80 (I=745.21mm or .74m)

Annual Rain Water Harvesting Potential i.e.

V=K * I *A

 = 0.8 * 0.74 * 6250

= 3700m^3

Table 7: Annual Calculated Volume of Rainfall Potential (Study Area)

Building Name	K	I (m)	A (m^2)	V (annual) m^3
WCH I	0.80	0.74	6250	3700
WCH II	0.80	0.74	5116	3028.67
WCH III	0.80	0.74	3602	2132.38
WCH IV	0.80	0.74	2409.52	1473.80
New Gym	0.80	0.74	320.89	190
Shatabdi Bhawan	0.95	0.74	2321.25	1631.84
Residential Building	0.5	0.74	18514	6850.18

VI. CONCLUSION

The water resource harvesting is vital in zones of less rainfall and where ground water level is depleting. The water resource harvesting technique involves primary land survey, available water resources, filtration technique. From these processes, the HBTU west campus is found to be feasible for installation of rain water harvesting systems.

1. Design of rainwater harvesting system of HBTU west campus is done using geographic information system (GIS).,
2. For All 7 catchments
   - Runoff potential Volume (one Storm) = 5,88,168 litres/yrs
   - For recharge, size of recharge pit (1&2 each) is taken as = m *10m * 1.5m
   - For 25 years Runoff potential Volume =1,47,04,200 liters/25years
3. For 3rd Recharge Pit
   - For recharge, size of recharge pit (3) is taken as 5m *5m *1.5m
4. Total annual runoff potential from catchment area considered (all 7 areas)=190006870 liters.
5. Total annual rainfall (predictions) for 25 years =18,630.25mm
6. Filter material for filling the recharge pit is decided as 60mm metal (30% depth), 40mm metal (30% depth), 20mm metal(20% depth), fine sand (20% depth)
7. Approximate expenditure for:
   - Recharge pit 1: Rs 144637.5
   - Recharge pit 2: Rs 144637.5
   - Recharge pit 3: Rs 37409.375
8. Approximate expenditure for underground storage tank (5m*5m*1.5m) optional is Rs182052.875
9. Recharge pit/underground tank can be connected to bore well for bore well recharge of HBTU West Campus Study Areas.
10. As Shown that ground water be in its equilibrium condition, GWT will remain 200 square Foot if we recharge / revive the water as described in methods.
11. Hence GWT will be maintained at it maximus plus points for West Campus Regions

REFERENCES

[1] Sanjith S. Anchan, H.C. Shiva Prasad, "Feasibility of roof top rainwater harvesting potential - A case study of South Indian University" Cleaner Engineering and Technology 4 (2021).

[2] Semaan, M.; Day, S.D.; Garvin, M.; Ramakrishnan, N.; Pearce, A. Optimal sizing of rainwater harvesting systems for domestic water usages: A systematic literature review. Resour. Conserv. Recycl. X 2020, 6, 100033. [CrossRef]

[3] Musayev, S.; Burgess, E.; Mellor, J. A global performance assessment of rainwater harvesting under climate change. Resour. Conserv. Recycl. 2018, 132, 62–70. [CrossRef]

[4] Haque, M.M.; Rahman, A.; Samali, B. Evaluation of climate change impacts on rainwater harvesting. J. Clean. Prod. 2016, 137, 60–69. [CrossRef]

[5] Liu, X.; Ren, Z.; Ngo, H.H.; He, X.; Desmond, P.; Ding, A. Membrane technology for rainwater treatment and reuse: A mini review. Water Cycle 2021, 2, 51–63. [CrossRef]

[6] Deng, Y. Pollution in rainwater harvesting: A challenge for sustainability and resilience of urban agriculture. J. Hazard. Mater. Lett. 2021, 2, 100037. [CrossRef]

[7] Hindiyeh, M.Y.; Matouq, M.; Eslamian, S. Rainwater harvesting policy issues in the mena region: Lessons learned, challenges, and sustainable recommendations. In Handbook of Water Harvesting and Conservation: Basic Concepts and Fundamentals; Eslamian, S., Ed.; Wiley: Hoboken, NJ, USA, 2021; pp. 457–473.

[8] S. Ozden, L. Ge, T.N. Narayanan, A.H.C. Hart, H. Yang, S. Sridhar, R. Vajtai, P.M. Ajayan, Anisotropically functionalized carbon nanotube array based hygroscopic scaffolds, ACS Appl. Mater. Interfaces 6 (2014) 10608–10613.

[9] H. Bai, L. Wang, J. Ju, R. Sun, Y. Zheng, L. Jiang, Efficient water collection on integrative bioinspired surfaces with star-shaped wettability patterns, Adv. Mater. 26 (2014) 5025–5030.

[10] www.worldweatheronline.com

[11]www.hbtu.ac.in