

# A Study of Rooftop Rainwater Harvesting at District Court, Tezpur, Sonitpur, Assam

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## Abstract :

Water scarcity has emerged as a critical global challenge, with India facing acute water stress driven by rapid population growth, industrial development & increase in agricultural field & production, variable rainfall patterns, and unsustainable groundwater exploitation. India accounts for only about 4% of global freshwater resources, resulting in an excessive dependence on groundwater extraction. Conventional water sources such as wells, rivers, ponds, reservoirs are not sufficient to meet the increasing demand for water while increasing urbanization and industrialization has led to degradation and depletion of water quality. This paper discusses the rainwater harvesting potential in District Court buildings of Tezpur, Sonitpur District, Assam by calculating the amount of water that can be collected based on rooftop area, annual rainfall, and runoff efficiency and considering the additional. The results demonstrate that the proposed RWH system can reliably meet a substantial proportion i.e. around 60.16% for average rainfall, 79% for maximum rainfall and 39.2% for minimum rainfall respectively of the building's non-potable water requirements, particularly for toilet flushing, cleaning, and gardening. The volume of the storage tank is also designed based on demand by considering its length, breadth and height. Overall, the study provides robust empirical and analytical evidence supporting the integration of rooftop rainwater harvesting (RWH) as a practical, scalable, and sustainable solution for meeting potable and non-potable water demands in public buildings and urban environments.

**Keywords:** Rainwater Harvesting; Civil Engineering, Urban Water Management, Runoff Analysis, Sustainable Water Management, Catchment, Area Efficiency, Artificial Recharge, Runoff Coefficient, Water Conservation, Tezpur Rainfall Patterns, Sonitpur Hydrogeology, rainfall, Sonitpur, Tezpur, District Court, Assam, India.

## I. INTRODUCTION

Water is crucial for meeting the fundamental requirements of all life forms. Rainwater harvesting (RWH) represents an environmentally sustainable approach to capturing and preserving precipitation, designed to provide water for diverse applications such as agricultural irrigation, household use, manufacturing operations, and aquifer replenishment—especially critical in arid, urban and drought-prone regions. A standard rainwater harvesting infrastructure consists of collection areas, transportation systems, initial-flush mechanisms, purification components, and containment or infiltration facilities.

Rainwater harvesting typically falls into two categories: Surface runoff collection and Rooftop rainwater harvesting (RTRWH). Surface runoff collection involves capturing and harnessing precipitation that streams across exposed, impermeable surfaces including streets, agricultural land, and other hardscaped areas—particularly beneficial in metropolitan settings as it aids in preventing soil degradation and flood mitigation. Rooftop rainwater harvesting entails gathering precipitation that lands on building roofs, then channelling it through piping systems into storage containers where the accumulated water can satisfy various non-drinking needs such as laundry,

sanitation, toilet flushing, and landscape irrigation; with appropriate purification, it becomes suitable for potable consumption as well. Given that rainwater harvesting offers an environmentally responsible and economically viable solution, adopting this technique at the Tezpur town court facility, which accommodates numerous staff members, would contribute to decreased reliance on underground water sources while also mitigating urban flooding issues.

## II. OBJECTIVE OF THE STUDY

- To assess the potential of rooftop rainwater harvesting at the District Court complex, Tezpur, Sonitpur District, Assam.
- To estimate the quantity of rainwater that can be collected from the rooftop catchment area based on rainfall data and runoff characteristics.
- To analyse the potable and non-potable water demand of the District Court complex.
- To design an appropriate rainwater storage system based on rainfall pattern, water demand, and safety considerations.

## III. STUDY AREA

The study area for the proposed project is the District Court Office, which is situated in the heart of Tezpur Town (Mahatma Gandhi Road) of Sonitpur district, Assam with

its 26.62N latitude and 92.8 E longitude. The total area of the project site is about 15489m<sup>2</sup>. For estimation of rooftop rainwater harvesting potential at the site, three office buildings of the campus i.e. District & Session court office, DLSA office and Bar and Council of Members office is taken with a total strength of 640 people.

The District Court of Tezpur was selected as the study location because it is a major public institutional building with a large rooftop area requires water for multiple non-potable purposes such as flushing, cleaning, and gardening. The location receives high annual rainfall, making it technically suitable for rainwater harvesting.

#### IV. METHODOLOGY

The methodology involves the following steps

**Step 1:** Determination of volume of water collected.

**Step 2:** Collection of annual precipitation data of the study area month wise from IMD.

**Step 3:** Visiting the sites for collection of surface area of the catchment surface and decide runoff coefficient according to the surface using IS codes. Runoff coefficient value is dependent on the type of catchment surface. Additional loss factor will also be applied for other losses.

**Step 4:** Collection of data on total numbers of people there and types of water use. This will help in calculating and designing of the storage tank and daily demand of water use. After keeping some factor of safety, the tank should have 20 percent more capacity than required.

**Step 5:** Monthly average, maximum and minimum RWH potential will be calculated for finding out probable month of maximum rainfall for storage tank design. For calculating effectively harvested water quantity i.e. The Annual Rainwater Harvesting Potential the following formula has been used: -

$$= \text{Area of the catchment} \times \text{Height of rainfall} \times \text{surface coefficient} \times \text{additional loss factor}$$

**Step 6:** Calculation of Potable and non-potable water use will be done for calculating potable and non-potable water demand and supply ratio.

**Step 7:** Evaluation of existing water storage and groundwater recharge facilities, if any, and assessment of space availability for proposed structures.

**Step 8:** The storage tank capacity is determined by matching the rooftop catchment area with the total rainwater harvesting potential, ensuring efficient storage and utilization of collected rainwater based on rainfall variability and demand patterns.

#### V. DATA COLLECTION

The data related to population has been obtained from the office. The rooftop areas of the three buildings have been obtained from the office staff. Google earth Pro is free and open-source software that provides high resolution data and photos. For the assessing the rainwater harvesting potential 43 years (1982-2024) rainfall data has been collected from IMD Pune portal.

- Total annual rainfall data from the 43 years table found = 76699.1 mm
- The annual average rainfall considered for the study area for 43 years is 1783.7 mm (**1.7837 m**).  
Monsoon Rainfall data = **1.55685 m**.  
Maximum annual rainfall data= **2.3433 m**.  
Minimum Annual rainfall data=**1.1622 m**.
- The rooftop areas of all the three buildings are = **2300 m<sup>2</sup>**

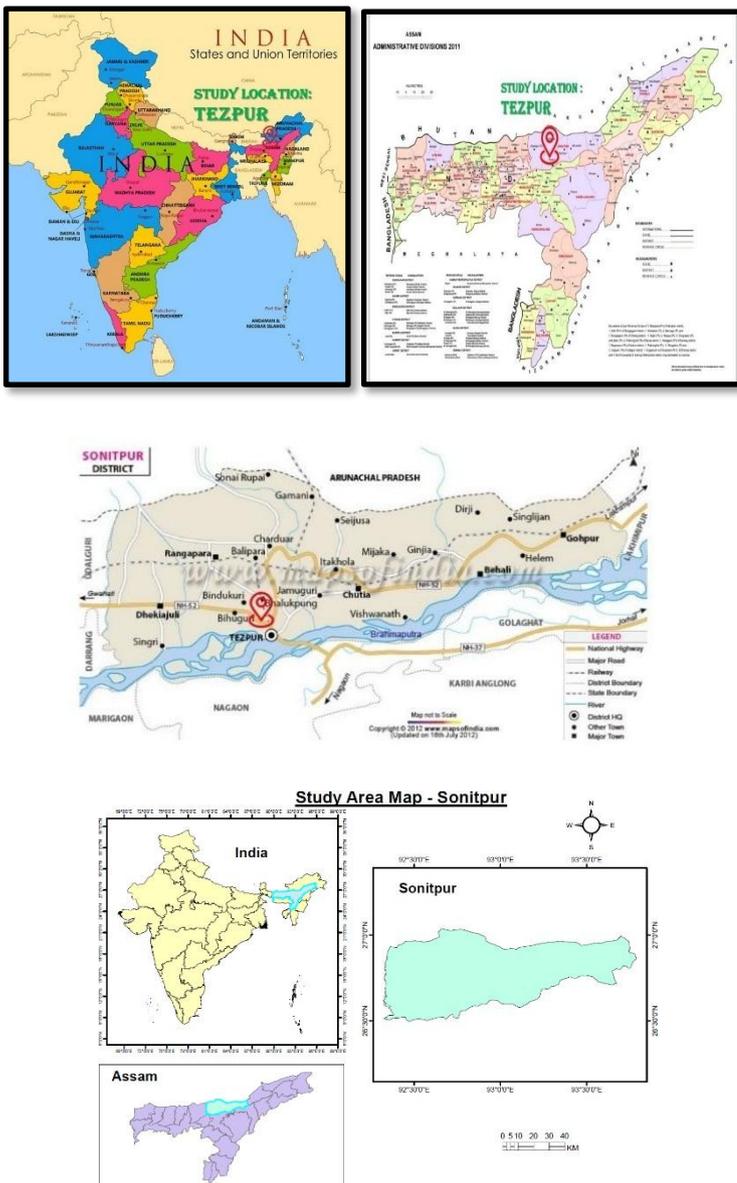


Fig 1: Study location, District Map and GIS map

- Since all the three offices have a concrete surface so we will be considering its coefficient for roof surface as 0.95.
- **Additional Loss Factor:** While the runoff coefficient is the primary factor, professional designs often include a withdrawal/efficiency factor (typically around 0.80) to account for losses from the first-flush diverter, filter efficiency, and spillage. First spell of rain is normally flushed out. This is done because first spell of rain always carries a larger number of pollutants from the air and catchment surfaces. So additional loss factor of 0.8 is considered.

Monsoonal rainwater harvesting potential of all the 3 buildings = 2721.285 m<sup>3</sup>

**b) Rainwater Harvesting Potential Month wise:**

Table 1: Monthly average, maximum and minimum rainfall

Months	Average Rainfall (mm)	Maximum Rainfall (mm)	Minimum Rainfall (mm)
January	11.84	81.4	0
February	22.49	100.6	0
March	51.12	120.4	0.9
April	178.08	337.7	23.9
May	249.20	378.3	108.1
June	320.93	624.2	80.3
July	313.37	549.5	106.2
August	271.52	518.9	97.4
September	223.75	478.1	68.7
October	113.02	307.6	4.7
November	18.81	100.8	0
December	9.51	75.6	0

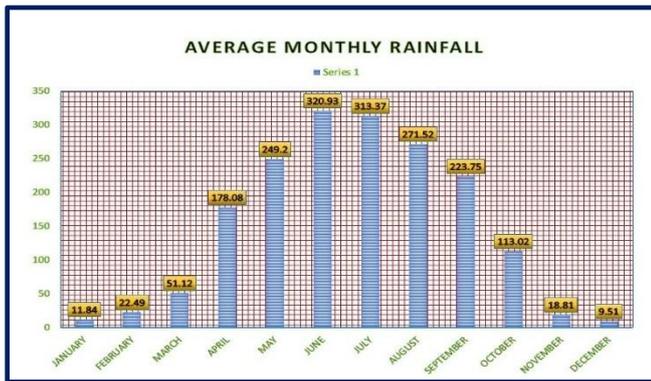


Fig 2: Graphical representation of Average Monthly Rainfall Data 1982-2024, Tezpur

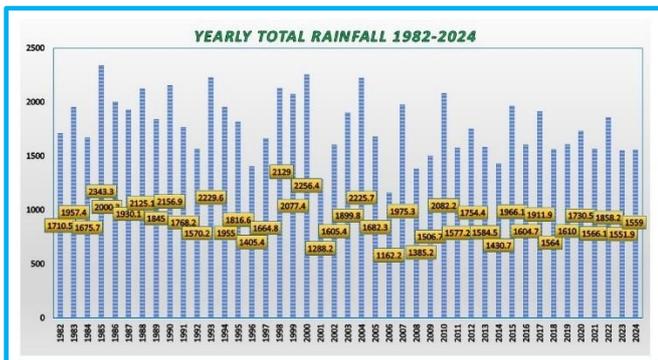


Fig 3 : Graphical representation of Total Yearly Rainfall Data 1982-2024, Tezpur

**VI. CALCULATIONS AND RESULTS**

**a) Annual Rainwater Harvesting Potential (ARHP):**

Following Formulas are used for calculating Volume of water that can be harvested, = **Area of the catchment × rainfall in meter × 0.95 × 0.80**

Total annual average rainwater harvesting potential of all the 3 buildings = 3117.906 m<sup>3</sup>

Minimum rainwater harvesting potential of all the 3 buildings = 2031.521 m<sup>3</sup>

Maximum rainfall harvesting potential of all the 3 buildings = 4096.088 m<sup>3</sup>

Table 2: Average, Maximum and Minimum RWH Potential Month wise

Month	Average, Maximum and Minimum	Rainfall (m)	Area (m <sup>2</sup> )	Surface coefficient	Additional loss factor	Water collected (m <sup>3</sup> )
January	Average Rainfall	0.0118	2300	0.95	0.8	20.6264
	Maximum Rainfall	0.0814	2300	0.95	0.8	142.2872
	Minimum Rainfall	0	2300	0.95	0.8	0
February	Average Rainfall	0.0224	2300	0.95	0.8	39.1552
	Maximum Rainfall	0.1006	2300	0.95	0.8	175.8488
	Minimum Rainfall	0	2300	0.95	0.8	0
March	Average Rainfall	0.0511	2300	0.95	0.8	89.3228
	Maximum Rainfall	0.1204	2300	0.95	0.8	210.4592
	Minimum Rainfall	0.009	2300	0.95	0.8	15.732
April	Average Rainfall	0.1780	2300	0.95	0.8	311.144
	Maximum Rainfall	0.3377	2300	0.95	0.8	590.2996
	Minimum Rainfall	0.0239	2300	0.95	0.8	41.7772

	Minimum Rainfall					
May	Average Rainfall	0.2492	2300	0.95	0.8	435.6016
	Maximum Rainfall	0.3783	2300	0.95	0.8	661.2684
	Minimum Rainfall	0.1081	2300	0.95	0.8	188.9588
June	Average Rainfall	0.3209	2300	0.95	0.8	560.9332
	Maximum Rainfall	0.6242	2300	0.95	0.8	1091.102
	Minimum Rainfall	0.0803	2300	0.95	0.8	140.3644
July	Average Rainfall	0.3133	2300	0.95	0.8	547.6484
	Maximum Rainfall	0.5495	2300	0.95	0.8	960.526
	Minimum Rainfall	0.1062	2300	0.95	0.8	185.6376
August	Average Rainfall	0.2715	2300	0.95	0.8	474.582
	Maximum Rainfall	0.5189	2300	0.95	0.8	907.0372
	Minimum Rainfall	0.0974	2300	0.95	0.8	170.2552
September	Average Rainfall	0.2237	2300	0.95	0.8	391.0276
	Maximum Rainfall	0.4781	2300	0.95	0.8	835.7188
	Minimum Rainfall	0.0687	2300	0.95	0.8	120.0876
October	Average Rainfall	0.1130	2300	0.95	0.8	197.524
	Maximum Rainfall	0.3076	2300	0.95	0.8	537.6848
	Minimum Rainfall	0.0047	2300	0.95	0.8	8.2156
November	Average Rainfall	0.0188	2300	0.95	0.8	32.8624
	Maximum Rainfall	0.1008	2300	0.95	0.8	176.1984
	Minimum Rainfall	0	2300	0.95	0.8	0
December	Average Rainfall	0.0095	2300	0.95	0.8	16.606
	Maximum Rainfall	0.0756	2300	0.95	0.8	132.1488
	Minimum Rainfall	0	2300	0.95	0.8	0

From the above calculations, it is concluded that maximum rainwater that can be harvested on account of maximum rainfall is the June month collecting 1091.102 m<sup>3</sup>.

c) **Water Demand:** For water demand: as per IS 1172-1993, water requirement specified for office buildings per capita per day is 45 LPCD Therefore, in the present study, the total demand has been redistributed into functional end uses to enable realistic assessment of rainwater harvesting and non-potable water substitution.

Table 3: Potable and Non-Potable Water Demand

POTABLE WATER (On lpcd)			NON-POTABLE WATER(On lpcd)			
Drinking water demand (lpcd)	Hand washing demand (lpcd)	Pantry (lpcd)	Cleaning demand (lpcd)	Flushing demand (lpcd)	Gardening (lpcd)	Total Water Demand (lpcd)
3	5	5	7	20	5	45
<b>TOTAL = 13 lpcd</b>			<b>TOTAL= 32 lpcd</b>			<b>45</b>

Reference: IS 1172:1993

The flushing water demand was adopted directly from the National Building Code (NBC) provisions, as it constitutes the predominant component of non-potable water consumption in office buildings and therefore represents the primary candidate for rainwater utilization. The demand allocated for floor and toilet cleaning was estimated based on built-up area, number of toilet units, and cleaning frequency, rather than on a per-capita basis, to better reflect operational requirements. Pantry washing demand includes water used for utensil cleaning and sinks operations within office pantry facilities, where large-scale cooking activities are not undertaken. Gardening and external washing demand was assigned as an average daily outdoor water requirement distributed across the total staff strength, while recognizing its seasonal variability.

This activity-wise disaggregation does not modify the total NBC-prescribed demand of 45 liters per capita per day (LPCD); instead, it establishes a functional framework for assessing rainwater harvesting potential and optimizing water management strategies within the office building.

d) **For Water Demand calculation:**

- Total employees in all three offices = 640
- Working days after removing holidays = 253 days.
- Potable water for daily use = 13 LPCD
- Non-potable water for daily use = 32 LPCD

**Formulas:**

- For calculating Daily water demand formula = Specified lpcd × No of employees
- For calculating Annual water demand formula = Daily demand × No of working days
- For calculating Daily Potable water demand = specified lpcd (13) × Number of employees
- For calculating Annual Potable water demand = Daily demand × No of working days
- For calculating Daily Non-Potable water demand

= specified lpcd (32) × Number of employees  
 For calculating Annual Non-Potable water demand  
 = Daily demand × No of working days

**Results:**

- Total Daily water demand of District Court (all the 3 buildings) = 45 Lpcd × 640 = 28,800 litres/day
- Total annual water demand = 28,800×253 days  
 = 72,86,400 Litres (7286.4 m<sup>3</sup>)
- Total Daily Potable water demand = 13 lpcd × 640  
 = 8,320 litres/day
- Total annual Potable water demand = (8,320 ×253)  
 = 21, 04,960 Litres (2104.96 m<sup>3</sup>)
- Total daily non-potable water demand = 32 lpcd × 640  
 = **20,480** litres/day
- Total annual non-potable water demand  
 = (20,480 ×253)  
 = 51, 81,440 Litres (5181.440 m<sup>3</sup>)

➤ Again, observing the maximum monthly rainwater collection, it can be seen that June month is the peak month for rainwater harvesting having 10,91,102 litres of water. After calculating average daily water collection for the month of June, 36,370 litres is found.

- ❖ So, we can say that on average annual rainfall, volume of rainwater that can be collected by this RWH project is 3117.305 m<sup>3</sup>. It is 60.17% of the total required non potable water.
- ❖ For maximum rainfall, volume of water that can be collected by this RWH project is 4096.088 m<sup>3</sup>. It is 79.05% of the total required non potable water.
- ❖ Daily demand of water for non-potable use is 20,480 litres/day. From RWH 16,190 litres/day can be supplied for maximum and 12,323litres/day for annual average rainfall.
- ❖ So, considering all these the tank size has to be designed.
- ❖ But due to limited space. So, based on the daily use of the offices, and comparing and calculating maximum daily collectible rainwater a tank of around 45000 litres can be designed for the reservoir by adding 20% more as safety factor to the daily demand of water.

$$= 36370 \text{ (maximum rainwater collected in a day in the month of June) } + 7274(20\%) = 43,644 \text{ litres.}$$

- The size and shape of the reservoir will be of rectangular type and 6 m x 3 m x 2.5 m size is proposed
- The material for the designed tank is concrete. The reservoir will be of ground type which may need checking and cleaning periodically. A cover will be placed above the reservoir for resisting pollutants and other items from entering the tank.
- Moreover, the overflowed water be will be used for groundwater recharging. For recharge pits the bottom layer consists of boulders (5-20cm), gravel layer(5-10mm) at middle, coarse sand (1.5-2mm) at top and a slotted pipe/mesh can be placed within layers to guide water into aquifer and keep debris out. Recharge pits are 2 m wide and 2 to 3 m deep.

Table 4: RWH Collectible Water Quantity, Replaceable Demand and Supply %

Type	On average rainfall	On maximum rainfall	On minimum rainfall	During monsoon
RWH Collected quantity	3117.906	4096.088	2031.521	2721.285
Total Replaceable Demand	5181.44	5181.44	5181.44	5181.44
% of Supply	<b>60.17 %</b>	<b>79.05 %</b>	<b>39.2 %</b>	<b>52.51%</b>

**VII. DESIGN OF RESERVOIR:**

- Water that will be collected from RWH per day for non-potable use (on annual average rainfall) = 3117906/253= 12,323 litres/day
- % of water fulfilment from RWH for daily use of non-potable water =12,323/20,480 = 60%
- Water that will be collected from RWH per day for non-potable use (on maximum annual average rainfall) =4096088/253= 16,190 litres/day
- % of water fulfilment from RWH for daily use of non-potable water =16190/20,480 = 79%
- Water that will be collected from RWH per day for non-potable use (on monsoonal rainfall) = 2721285/253= 10,756 litres/day.
- % of water fulfilment from RWH for daily use of non-potable water = 10,756/20,480=52%

**VIII. CONCLUSION**

This research evaluated the technical feasibility and performance of a rooftop rainwater harvesting (RWH) system for the district court buildings in Tezpur, Sonitpur, Assam with the objective of offsetting non-potable water

demand and promoting sustainable water resource management. The assessment integrated regional rainfall data from last 43 years (1982-2024), effective rooftop catchment area, runoff behaviour, potable and non-potable water demand to estimate the achievable rainwater supply. The study also quantifies the amount of rainwater that can be harvested and effectively utilized within the building.

The study concludes that the catchment area yields a total annual harvestable potential of 3117.305 m<sup>3</sup> (3117305 litres) for average rainfall, 4095.3048 m<sup>3</sup>(4095304.8 litres) for maximum rainfall and 2031.136 m<sup>3</sup> (2031136 litres) for minimum rainfall. The results demonstrate that the proposed RWH system can reliably meet a substantial proportion i.e. around 60.16% for average rainfall, 79% for maximum rainfall and 39.2% for minimum rainfall respectively of the building's non-potable water requirements, particularly for toilet flushing, cleaning, and gardening.

From a systems perspective, rooftop rainwater harvesting is technically suitable for government office infrastructures and public buildings due to its reliance on existing building components, technical simplicity and scalability of rooftop RWH. Additionally, the findings highlight environmental benefits such as reduced storm water/surface runoff and potential support to groundwater recharge, contributing to broader urban water sustainability goals with principles of integrated urban water management.

Overall, the study provides empirical and analytical evidence that confirms effectiveness and integration of rooftop rainwater harvesting that represents a practical, scalable, and sustainable strategy and low-impact engineering intervention capable of supplying a significant fraction of potable water or non-potable water demand in public buildings and urban development.

#### **IX. FUTURE SCOPE OF THE STUDY**

The future scope of this study includes the following potential extensions and improvements:

- a) Harvested rainwater can be analysed and treated with appropriate purification methods to make it safe for drinking. This helps address the issue of drinking water scarcity.
- b) Government incentives like tax rebates or subsidies could encourage the public to adopt rooftop rainwater harvesting systems.
- c) Expanding rainwater harvesting systems to more residential, institutional, and office buildings can reduce reliance on traditional water sources and cut down on electricity use related to water pumping.
- d) Promoting rainwater harvesting on a large scale will help reduce water waste and boost groundwater recharge.

e) Government agencies or municipal bodies could set up dedicated Rainwater Harvesting (RWH) Cells to raise awareness, track system performance, and offer technical help and affordable solutions to the public.

f) RWH Cells can involve schools, local communities, NGOs, and technical experts to enhance outreach and encourage public participation.

g) Public buildings like government offices, schools, colleges, and institutions with enough rooftop space should be prioritized for large-scale RWH implementation and upgrades.

h) Municipal bodies and water resource departments can promote rainwater harvesting through seminars, awareness campaigns, printed and digital media, and online platforms to improve public awareness and engagement.

i) Building codes and PWD guidelines may need to be updated to require rainwater harvesting and non-potable water reuse in new and existing structures.

j) Rainwater harvesting should be part of decentralized and sustainable water management plans, with performance monitoring systems to ensure long-term effectiveness.

k) This study uses historical rainfall data. Future research might include climate change forecasts, random rainfall models, and extreme event analysis to assess system resilience amid future climate uncertainties.

l) Future developments could involve Internet of Things (IoT)-based smart rainwater harvesting systems, using real-time sensors to monitor water levels, turbidity, and pH for automated flushing, remote monitoring, and better water quality management.

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