International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Green Building Development of Existing Structure of Educational Building (Rainwater Harvesting, UIT) in Shimla City

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Abstract
This study presents a comprehensive approach toward the development of sustainable green building practices through the implementation of rainwater harvesting (RWH) systems in existing structures. Green building strategies minimize the adverse effects of construction activities on the environment while improving energy efficiency, water conservation, and occupant comfort. The project focuses on the application of RWH technology at the University Institute of Technology (UIT), Himachal Pradesh University, Shimla, to conserve water resources, enhance groundwater recharge, and reduce dependency on external water supplies. The study evaluates rainfall data, system design, cost-effectiveness, and operational outcomes, emphasizing the importance of eco-friendly retrofitting for sustainable campus development.

Keywords: Green Building, Rainwater Harvesting, Sustainable Development, Water Conservation, Renewable Resources,

1. Introduction
The construction industry is a major contributor to global resource consumption and environmental pollution. Green building, also known as sustainable construction, aims to reduce these impacts by promoting efficient use of energy, water, and materials throughout the building's lifecycle. In India, where water scarcity is a growing concern, rainwater harvesting (RWH) has emerged as a practical and sustainable approach for mitigating water shortages. This paper presents the development and implementation of an RWH system at the University Institute of Technology (UIT), Shimla, focusing on design, operation, and environmental benefits. In recent years, the issue of water insecurity has emerged as a global challenge. Rainwater harvesting (RWH) has increasingly been recognized as a sustainable approach to address this problem, particularly for domestic water needs. In several regions, however, RWH serves as the only available water source for both domestic and non-domestic applications. Growing interest in RWH research has primarily focused on its technical efficiency and engineering aspects. Yet, for rainwater utilization to be widely accepted and deliver tangible social advantages, research must also examine the policy and management dimensions that influence its implementation [1]. The study emphasizes that achieving and sustaining green performance levels requires commitment and active participation from every section of society. A conceptual framework was developed to examine the interrelationships among nine key factors — issues, challenges, government, corporate entities,

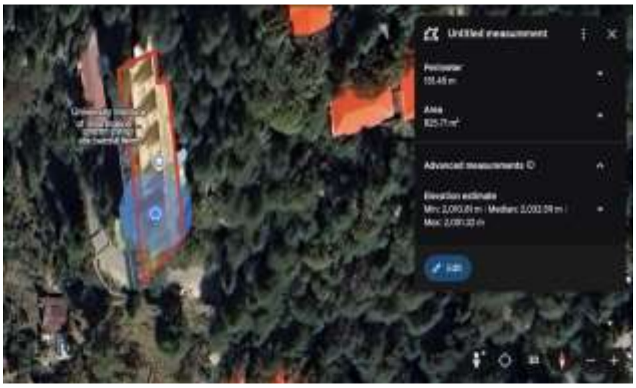
developers, buyers, private organizations, strategic mix, and sustainable development — resulting in twelve proposed hypotheses. Data for the study were collected using a questionnaire survey.
The findings indicate that coordinated efforts among the government and various stakeholders, including corporations, developers, buyers, and private bodies, are essential for forming a strategic mix that promotes sustainable development. Among these, the government holds the most crucial position as the primary regulatory authority in shaping strategies that lead to resource-efficient growth.
The main contribution of this research lies in formulating and empirically validating a novel Green Building Sustainability Model, addressing a key gap in existing literature. Although the model was designed and tested in the Indian context, its framework holds broader applicability [2]. This research provides a detailed assessment of the hydraulic efficiency of various rainwater harvesting techniques, highlighting that pitting methods alone may not ensure optimal performance during intense rainfall events. The findings contribute valuable insights into the hydraulic dynamics of rainwater harvesting technologies—an area that has received limited attention in prior studies. Additionally, the work introduces the first scientific use of the HEC-RAS model for rainfall-runoff simulation. Although the model has certain constraints, it effectively incorporates high-resolution topographic data for precise hydraulic analysis. The outcomes of this study aim to motivate policymakers and practitioners to expand the implementation of rainwater harvesting systems as a means to mitigate flooding and land degradation in arid and semi-arid regions [3]. The quality of rainwater collected through Rainwater Harvesting and Storage Systems (RWHSS) depends on several factors, including the type of materials used, the level of maintenance, and prevailing weather conditions. Researchers have examined key parameters to assess the suitability of harvested rainwater and compared them with the World Health Organization (WHO) standards. The most commonly analyzed parameters include pH (66.66%), turbidity (53.33%), *E. coli* (53.33%), lead (40%), and nitrates (40%) [4]. A rainwater harvesting system can vary in scale and complexity, but its essential components generally include a catchment area, conveyance system, storage unit, distribution network, and treatment mechanism. This study focuses on assessing the potential and feasibility of rainwater harvesting in the Shimla region of Himachal Pradesh, an area that faces significant water shortages during summer due to rising population and climatic variations.
Findings from the study reveal that with careful management, rainwater collected throughout the year can be effectively stored without substantial losses. It is also observed that the water stored from one month of rainfall can fulfill a household's sanitation needs for up to two months. Furthermore, the architectural design of houses in Shimla—with their sloped roofs—offers a natural advantage for efficient rainwater collection. The proposed non-dimensional design parameters can be applied to other regions facing similar water scarcity challenges. Additionally, the paper includes a simple benefit–cost analysis demonstrating the economic viability of the designed rainwater harvesting system [5]. Several studies presented in this volume address the challenges related to contamination and the siting of water harvesting systems. They also assess various approaches and techniques employed in this field. By examining both traditional and contemporary methods applied across diverse sectors and environments, this book underscores the importance of systematic and well-planned strategies in the design and implementation of water harvesting and management systems.
It is intended to serve as both a practical reference guide for individuals and organizations engaged in rainwater harvesting, and as a valuable resource for policymakers and researchers. This special volume represents a collaborative initiative between UNESCO, New Delhi, and the Institution of Engineers (India), Nagpur Local Centre.

We extend our gratitude to all contributors and reviewers for their valuable input. Owing to space constraints, several authors who presented multiple papers on related themes were requested to consolidate their work into a single contribution — any inconvenience caused by this is sincerely regretted.
We also wish to acknowledge the dedicated efforts of the staff of UNESCO, New Delhi, and IEI, NLC, whose commitment made this publication possible. Special appreciation is extended to Ms. Jessica Kennedy, Editor, Science Sector, UNESCO, New Delhi, and Mr. Prashant Kawale of Square Communications & Creatives, Nagpur, for their significant roles in shaping and finalizing this volume [6][7].

2. Methodology

The project was carried out in multiple phases, including assessment of rainfall data, site selection, system design, installation, and performance evaluation. The rooftop area of approximately 825 m^2 was selected as the catchment surface. Rainwater from the rooftop was directed through PVC conduits into collection tanks, passed through filters, and stored for reuse. A submersible pump was installed to lift stored water to overhead tanks. Safety devices such as overflow alarms and float switches were integrated to automate water management. The stored water is used in civil engineering laboratories, toilets, and landscaping applications.

1. **Catchments:** The catchment of a water harvesting system is the surface which directly receives the rainfall and to provides water to the system. Catchment area is considered as phase I roof top of University Institute of Technology (UIT), Himachal Pradesh University Building. Area of catchment is approximately 825m^2 of GI sheets.



Conduits: Conduits are pipe lines or drains that carry rainwater from the catchment or rooftop area to the harvesting system. Conduits can be of any material like polyvinyl chloride (PVC) or galvanized iron (GI), materials that are commonly available. The diameter of 3 inches.
Coarse mesh: At the roof top Prevent the passage of debris course mesh is provided Gutters: Channels all around the edge of a sloping roof to collect and transport rainwater to the storage tank. Gutters can be semi-circular or rectangular. Narrow troughs fixed along the eaves of a roof to collect rainwater and direct it to downpipes.
Filter: A filter plays a crucial role in purifying the rainwater collected from rooftops by eliminating suspended impurities. It is generally a chamber packed with filtration materials such as coarse sand, gravel, and fiber. As rainwater passes through these layers, dust particles, leaves, and other floating matter are trapped, ensuring that only clean water flows into the storage reservoir or groundwater recharge unit. This process helps maintain the quality of harvested rainwater and prevents clogging or contamination within the system.

Storage Tank: Different alternatives are available for constructing storage tanks, depending on the required capacity, shape, and construction materials. The selection of the storage system is usually based on factors such as site conditions, available space, water demand, and cost considerations.

Water collecting tank: To collect the water from rooftops of University Institute of technology (UIT), Silver Wood Estate HPU Shimla, firstly we installed the water collecting tanks of capacity 2000 liters. The capacity of collecting tanks hould be increases in future when we have need to expand the project. Two tanks are used to collect the rain water from the rooftops having storage capacity 1000 liters each. Collecting tanks are installed back side of UIT Campus.

Water Lifting Pump: When we store the water in storage tanks, we need to lift the water from collecting tank to storage tanks that are installed at the roof top of UIT Campus. To lift the water from collecting tanks to storage tanks with the help of pump of one horsepower is used. The pump is also installed back side of campus where the collecting tanks are placed.

Water overflow alarm sound system. A water overflow alarm is an electronic device designed to prevent wastage of both water and electricity. It alerts the user when the water level in a tank reaches its maximum limit, reminding them to switch off the motor and thereby avoiding unnecessary overflow and power consumption. In most systems, the device operates through electrical conductivity when water makes contact between two terminals or sensors; the circuit is completed, triggering an audible alarm and sometimes an indicator signal. This simple mechanism helps detect overflow conditions effectively.

Advantages of Using Overflow Alarms and Float Switches

The float switch automatically turns off the pump, saving electricity.

It helps conserve water and reduce utility costs by preventing wastage.

The system is fully automatic, minimizing the need for manual monitoring.

It is a one-time investment, offering long-term savings and operational efficiency.

Water float switch A float switch is a sensing device used to monitor and control the liquid level within a tank or container. It is designed to operate in both domestic and industrial water management systems. The device is waterproof and comes with IP68 protection, allowing it to function effectively even under submerged conditions. It can operate at temperatures up to 70°C, with a maximum working pressure of 1 bar, and is typically supplied with a 5-meter cable, although customized cable lengths are available. The installation of a float switch involves two main points — a fixed point and a counterweight. As the liquid level changes, the float moves accordingly, causing the internal mechanical switch to open or close the circuit. This mechanism enables the float switch to automatically control devices such as pumps, valves, or alarms, ensuring that the liquid level remains within the desired range. By doing so, it prevents overflow or dry-running conditions, contributing to efficient water and energy management.

Table 1

Values of Runoff Coefficients based on different surfaces according to IS 15797: 2008, CPHEEO Manual, 2019

S. No.	Type of Surface Runoff	Coefficient (C)
1	Roof surface (RCC, tiles, asbestos, metal, etc.)	0.85 – 0.95

2	Paved area (cement concrete, bituminous roads)	0.70 – 0.85
3	Rocky area / hard soil surface	0.60 – 0.80
4	Gravelled surface	0.50 – 0.70
5	Compacted soil (courtyards, playgrounds)	0.40 – 0.60
6	Open ground with vegetation / lawns	0.20 – 0.35
7	Loose sandy soil	0.10 – 0.20
8	Agricultural field (depending on slope)	0.30 – 0.60

Table 2
Water requirement of University Institute of Technology (UIT), HPU

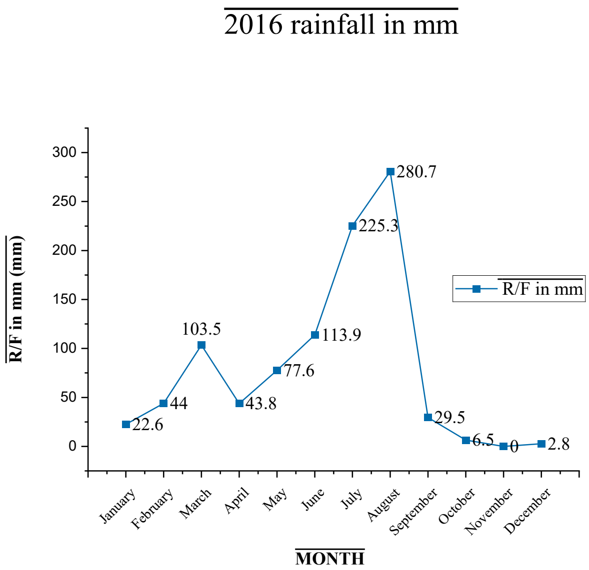
S.NO.	Population Approximately	NO.of Working Days (Approximately)	Per Capita Demand Liters/Day	Total Water Requirement per annual.
1	Students (1500)	268	45	18090000
2	Faculty& Staff (58)	268	45	699480
3	Workers (11)	300	45	148500
Total	1569			18937980

Table 3
Average Yearly Rainfall in mm / Monthly/ Daily/ Hourly

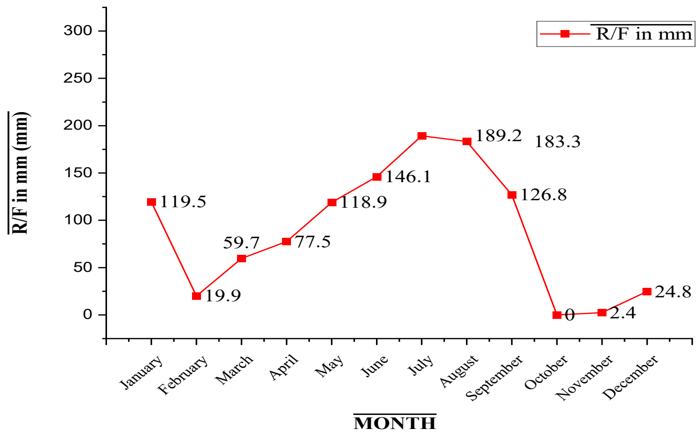
Sr. No.	Year	Average Yearly Rainfall in mm	Monthly Runoff in ml/sec	Daily Runoff in Metrecube/Day	Hourly Runoff in Litre/ hour
1	2016	79.18	22.7	1.96	81.65
2	2017	89	25.14	2.202	91.75
3	2018	86.72	24.8	2.146	89.41
4	2019	96.72	27.5	2.376	99
5	2020	78.6	22.51	1.945	81.05
6	2021	91.96	26.3	2.276	94.84
7	2022	112.4	31.75	3.091	128

Nomenclature
IS Indian Standard Code
CPHEEO Central Public Health and Environmental Engineering Organization
PVC Polyvinyl chloride
GI galvanized iron
C Runoff Coefficient
R/F Rainfall

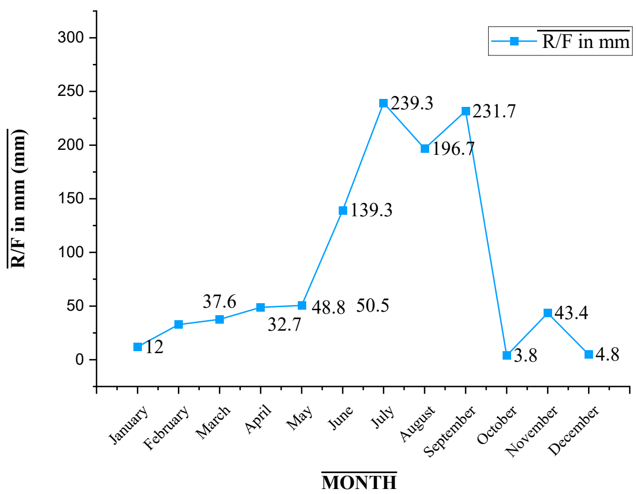
Graphical representation of rain fall dada:



2017 rainfall in mm



2018 rainfall in mm



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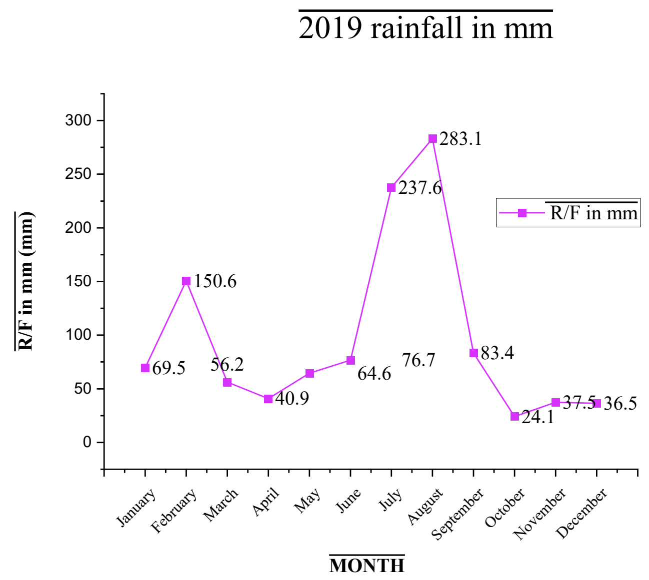
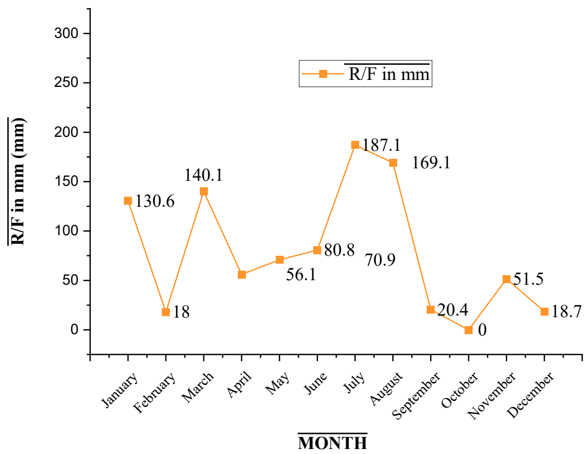
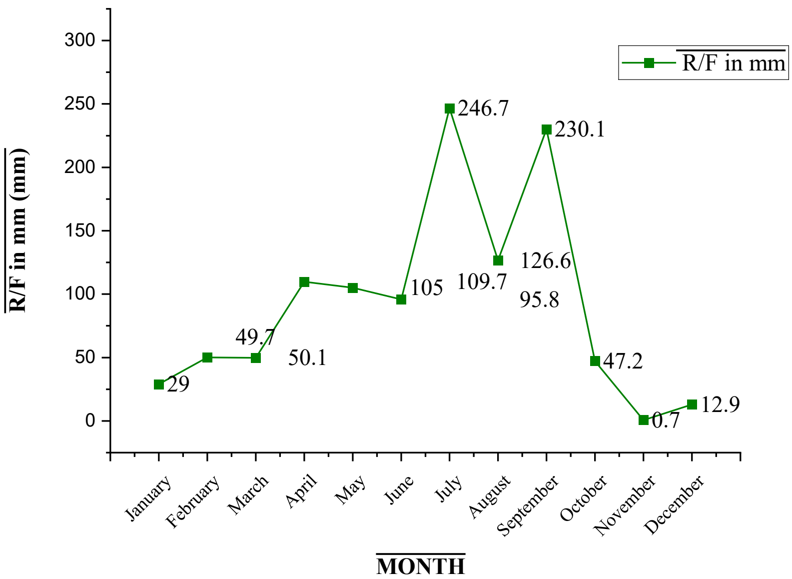
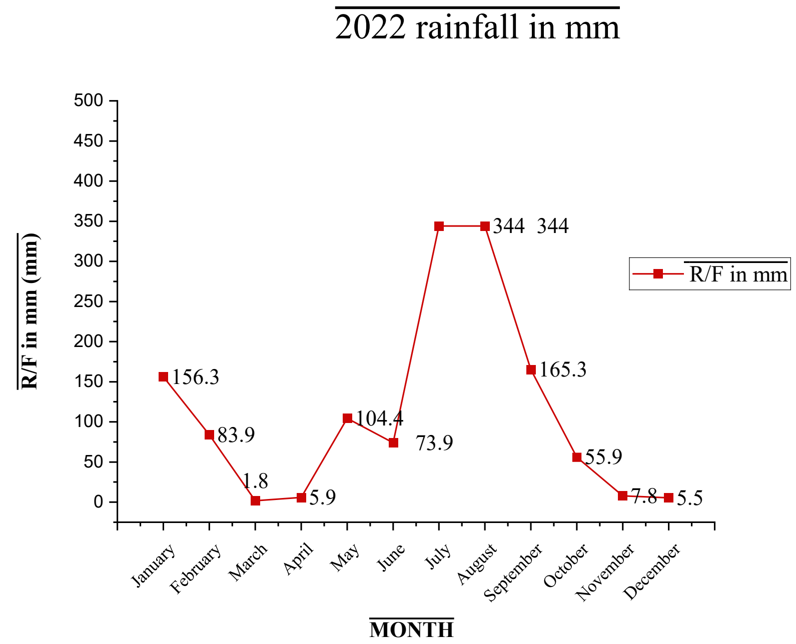


2020 rainfall in mm



2021 rainfall in mm





3 Results and Discussion

Implementation of the RWH system demonstrated a significant reduction in dependence on municipal water supply. An estimated 30–35% of non-potable water demand in the UIT campus was met through harvested rainwater. The cost of implementation was approximately INR 55,000, which was found to be economically viable with low maintenance requirements. The system also contributed to groundwater recharge and reduction of stormwater runoff. Data analysis from rainfall records between 2016 and 2021 showed sufficient annual precipitation to sustain the system effectively. Moreover, the integration of green infrastructure contributed to better indoor and outdoor environmental quality, aligning with the principles of the Indian Green Building Council (IGBC).

Average Rainfall in year 2022 is 112.4mm

Catchment Area is 825$m^{2,}$ Rainfall(R) IS 112.4mm = 0.1124m

- Calculate Total Rainfall Volume on Roof top:

Rainfall Volume = Area× Rainfall (825 × 0.1124 = 92.73 m3)

- Runoff Coefficient for GI sheet (0.9-0.95)

Take c=0.9

Runoff Volume= Area× Rainfall× Runoff Coefficient

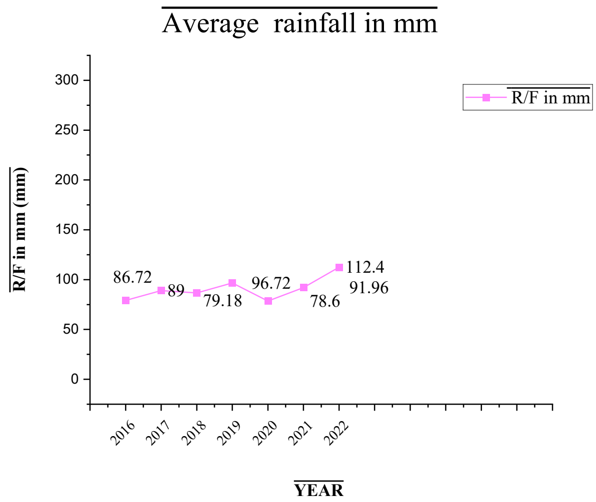
(825× 0.1124×0.9=83.457m^3/month)

Average discharge rate per month =30 days

30×24×3600=2592000 Seconds

Discharge (Q) = 92.73/2592000 =31.75mL/Sec.

- Daily Runoff : 92.73/30 =3.091m^3/Day
- Hourly Runoff : Daily hours = 3.091/24 = 0.128m^3/ hours= 128 l/hours



4. Conclusion

The study confirms that integrating rainwater harvesting within existing institutional structures can significantly contribute to water conservation, sustainability, and green building certification goals. The UIT project provides a replicable model for other educational institutions in hilly regions of India. Adopting such eco-friendly practices supports national initiatives toward sustainable development and resource conservation. Future research may focus on incorporating smart sensors, IoT-based monitoring, and hybrid renewable systems to enhance efficiency and automation in similar projects.

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