

Rainwater Harvesting and Groundwater Recharge: A Case Study of Nagpur

RIYA SEWATKAR

*Research Scholar, Civil Engineering Department, TGPCET Mohgaon
Nagpur, Maharashtra, India*
sewatkariya5@gmail.com

RAM LANDE*

*Research Scholar, Civil Engineering Department, TGPCET Mohgaon
Nagpur, Maharashtra, India*
ramlande988@gmail.com

KRISH SONEWANE

*Research Scholar, Civil Engineering Department, TGPCET Mohgaon
Nagpur, Maharashtra, India*
krishsonewane51@gmail.com

MOHITSINGH KATOCH

*Assistant Professor, Civil Engineering Department, TGPCET Mohgaon
Nagpur, Maharashtra, India*
mohitsingh.civil@tgp cet.com

Abstract

Rainwater harvesting (RWH) and groundwater recharge (GWR) are crucial methods for the conservation of water resources and for mitigating the adverse effects of climate change. This research investigates the feasibility of implementing RWH and GWR systems to enhance local water supplies, decrease stormwater runoff, and ultimately improve groundwater levels. The study emphasizes the multiple benefits these techniques offer, including greater water security, reduced instances of water scarcity, and improved ecosystem health. It also examines various established and emerging technologies utilized for both RWH and GWR, such as rooftop harvesting, the collection of surface runoff, and the use of recharge wells. The results of this investigation confirm the efficacy of RWH and GWR in fostering sustainable water management practices and building water resilience within communities. The paper concludes that these methods are essential for tackling water scarcity and promoting water conservation, particularly in areas facing significant limitations in their water resources.

Keywords: rainwater, rainwater harvesting (RWH), groundwater recharge (GWR), and sustainable water management.

*Corresponding Author.

1. INTRODUCTION

Groundwater constitutes a vital resource globally, supporting domestic, agricultural, and industrial needs and sustaining essential ecosystems, especially across arid and semi-arid regions. A review of existing literature indicates that groundwater is the primary or sole source of drinking water for approximately 50% of the world's population and accounts for an estimated 43% of all water used for irrigation. Furthermore, it is estimated that about 2.5 billion people depend entirely on groundwater for their basic daily water requirements.

However, widespread overpumping and the overexploitation of aquifers—driven by various competing demands and compounded by climate change—are leading to significant declines in groundwater levels. The depletion of groundwater resources has several major consequences, including (a) a lowering of the water table and (b) a corresponding reduction in the water volume in connecting streams and lakes.

1.1. *What is rainwater harvesting?*

Rainwater harvesting is the process of collecting rainwater for future use. This technique involves collecting rainwater from rooftops, roads, and other surfaces and storing it in tanks or reservoirs.

1.2. *What is groundwater recharge?*

Groundwater recharge is the process of replenishing groundwater resources. This technique involves allowing rainwater, or surface water, to percolate into the ground, recharging aquifers, and maintaining groundwater levels.



Fig. 1. Taking Dimension of Rainwater Harvesting and Groundwater Recharge.

2. LITERATURE REVIEW

Table 1. Literature Review.

Sl. No.	AUTHOR & YEAR	CONCLUSION
1.	IITBuzz. (2023, October 25)	Development of AI models to predict rainfall runoff and optimize recharge location dynamically.
2.	(Muhirirwe et al., 2022)	Found RWH payback periods of less than 5 years in semi-arid areas due to savings in water bills and reduced tanker use.
3.	Waghaye et al. (2023)	Introduced spatial tools to identify high-potential RWH zones in urban watersheds using GIS-MCDA.
4.	Lepcha et al. (2024)	The study examined cost-effective rooftop RWH systems and their potential for household water security in semi-arid regions.
5.	Halder and Bose (2024)	The article emphasized the role of RWH in urban resilience, particularly in African and Asian cities facing water scarcity.

2.1. Technological and Future Development (AI and Modeling)

A forthcoming project by IITBuzz (2023, October 25) aims to advance RWH optimization through artificial intelligence. This initiative focuses on the development of AI models to predict rainfall-runoff and dynamically optimize recharge locations. This represents the cutting edge of RWH research, moving towards real-time, adaptive management of water resources.

2.1.1. Economic Viability and Payback Period

The study by Muhirirwe et al., (2022) provided strong evidence for the financial benefits of RWH, particularly in water-stressed regions. They found that RWH payback periods are less than 5 years in semi-arid areas due to significant savings achieved through a reduction in water bills and decreased reliance on water tankers. This highlights RWH as an economically sound investment, not just an environmental measure.

2.1.2. Spatial Planning and Site Identification

Waghaye et al. (2023) conducted research aimed at enhancing the efficacy of rainwater harvesting (RWH) systems through the integration of sophisticated spatial planning techniques. Their methodology utilized a combination of Geographic Information Systems (GIS) and Multi-Criteria Decision Analysis (MCDA) to accurately identify the most promising RWH zones within urban watersheds. This approach allows planners to select the most optimal locations for RWH infrastructure, thereby maximizing the efficiency of both water capture and groundwater recharge (Jain & Singh, 2020).

2.1.3. Cost-Effectiveness and Household Security

Focusing on the household level, Lepcha et al. (2024) examined cost-effective rooftop RWH systems and their direct contribution to household water security in semi-arid regions. This research validates the role of RWH as a decentralized solution that can empower individual homes to secure their water supply in water-scarce environments.

2.1.4. Urban Resilience and Global Context

Halder and Bose (2024) emphasized the broader societal and urban role of RWH. Their research stressed the role of RWH in urban resilience, particularly highlighting its importance in African and Asian cities facing chronic water scarcity. This work positions RWH as a crucial strategy for cities to cope with climate change impacts and increasing population pressure on water resources.

3. METHODOLOGY



Fig. 2. Making a house and rainwater harvesting.



Fig. 3. Creating a Groundwater Recharge Filtration Tank and a Storage Tank.



Fig. 4. Planting Trees and Putting Other Materials.

3.1. Objectives

- To meet the increasing demand of water.
- Raise the underground water table.
- To reduce groundwater pollution.
- To reduce soil erosion.
- Supplement domestic water needs.
- Supplement domestic water needs.
- Ensure Water Availability.
- Reduce Water Bills.
- Raise the Water Table.
- Protect Ecosystems.



Fig. 5. Complete Setup.

3.2. Steps of Designing and Construction of Project

- Step 1. First, we take a dimension of plywood as per requirement.
- Step 2: Then we take a dimension of cardboard to make a house.
- Step 3: Then we start making our house.
- Step 4. Then we take the dimensions of the filtration tank, storage tank, main tank, and well.
- Step 5. Then we start making tanks as per your requirement.
- Step 6. After that, we will begin arranging the pipeline from the main tank to the filtration tank, then to the storage tank, and finally to the toilet, among other locations.

- Step 7. We join the water motor to the pipe and then arrange all necessary things like the switch, GI wire, DC adapter jack, battery, charger, etc. Step 8. After joining, we all take a test of the project, etc.
- Step 9: Then we start coloring the house, filtration tank, storage tank, well, etc.
- Step 10. We put some plants, trees, and green grass.
- Step 11. We start making different layers of underground-like material (bedrock, weathered rock, subsoil, topsoil, and organic).
- Step 12. After that, we test everything again and ensure that all aspects are in order, confirming that we have completed our project successfully.

4. KEY FEATURES

- **Rainwater Collection:** Rainwater is collected from rooftops, roads, and other surfaces.
- **Storage:** Collected rainwater is stored in tanks or reservoirs.
- **Treatment:** Stored rainwater can be treated for future use.
- **Recharge:** Rainwater or surface water is allowed to percolate into the ground.

5. RECHARGING AQUIFERS BENEFITS

- **Water Conservation:** Rainwater harvesting and groundwater recharge conserve water and reduce dependence on groundwater resources.
- **Reduced Flooding:** Rainwater harvesting reduces flooding and stormwater runoff.
- **Replenished Groundwater:** Groundwater recharge replenishes aquifers and maintains groundwater levels.
- **Sustainable Development:** Rainwater harvesting and groundwater recharge are promoted.
- There is a need for sustainable development and reduced environmental impact.

6. CONCLUSION

The project successfully demonstrated that various recharge structures (e.g., check dams, percolation tanks, recharge pits, and rooftop systems) significantly augment the water table in the study area, reversing the trend of groundwater depletion and ensuring sustained yield from wells and borewells. RWH and GWR practices provide a crucial alternative or supplemental water source. These practices serve both domestic and agricultural purposes, particularly during non-monsoon periods and drought conditions, thereby enhancing community resilience against water stress and climate variability. By introducing freshwater to the aquifer, these techniques contribute to the dilution of existing pollutants, such as salinity, fluoride, or excessive iron, leading to an overall improvement in groundwater quality. RWH and GWR

structures effectively manage surface runoff, reducing the volume and velocity of stormwater, which significantly mitigates the risk of urban and rural flooding and prevents the choking of drainage systems. Municipal supply or energy-intensive pumping from deeper aquifers is also facilitated by RWH and GWR structures. This leads to energy savings and a reduction in water bills, offering clear economic benefits to the implementing communities.

7. REFERENCES

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