Community Participation

in Rainwater Harvesting

A Case Study of Delhi

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Rain Water Harvesting in Delhi -Role of Community Participation

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Foreword

In a country like India, where water scarcity is increasingly pressing, rainwater harvesting has emerged as a vital sustainable solution. Delhi, as one of the world's fastest-growing metropolises, faces significant water management challenges. As the demand for water rises and traditional sources strain, methods like rainwater harvesting gain prominence. This technique involves collecting and storing rainwater for various purposes, from domestic use to recharging groundwater. In Delhi, where monsoon rains bring limited precipitation, using this resource is not just wise but crucial.

Delhi's journey toward sustainable water management through Rainwater Harvesting (RWH) is closely tied to collaboration between its city government and local communities. The Delhi Government, through its policies, incentives, regulations, and awareness campaigns, has set the stage for widespread adoption of community-level rainwater harvesting systems. From integrating these systems into public infrastructure to promoting them in residential and commercial spaces, the government's role is pivotal for the city's water resilience.

The purpose of this research paper is to highlight how community involvement plays a significant role in adopting, implementing, and maintaining rainwater harvesting projects. Through the examination of case studies and examples related to rainwater harvesting, the paper illustrates whether policy decisions, stringent regulations, and government initiatives serve as catalysts that motivate civil societies to take the lead in rainwater harvesting practices at the grassroots level. Alternatively, the paper also explores whether these factors might impede the full engagement of civil society in water harvesting campaigns in Delhi.

We express our gratitude to Delhi Jal Board, especially Shri Harish Chander, Addl. CE (C) - 8 Under CE (GW), for providing essential information about the "Financial Assistance Scheme for Promotion of Rooftop Rain Water Harvesting System." Our thanks also extend to representatives of all participating societies and institutions for their

cooperation in the survey. Without them, this study wouldn't have been possible.

I'd like to congratulate Dr. Amit Singh, faculty member at the Institute, for preparing the document and making it available for wider dissemination among various stakeholders. I'd also like to acknowledge Prof. K.K. Pandey, Coordinator of the Centre for Urban Studies along with other faculty members of the centre for their constant support. Shri Harish Krishna and Shri Anand Singh, who provided crucial professional support, also deserve our appreciation. I am confident that this paper will capture the attention of policymakers, citizens, and those interested in protection of environment adoption for climate change.

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Abstract

Water, the essence and sustenance of life, is among the most important natural resource. However, due to the rapid population growth, the per capita availability of water on earth reduced significantly as compared to even 100 years ago. As per UNICEF, four billion people i.e. almost two thirds of the world's population experience severe water scarcity for at least one month each year. In India, the continuous depletion of water resources is one of the major concerns of the Government of India. Situation in urban areas are more complex and severe. Among them, Delhi is one of the water-stressed cities of the world and is going to become a water scarce city in due course. The main sources of water in Delhi are the Yamuna River, groundwater, and the Ganges Canal. However, these sources are not enough to meet the growing demand for water in the city. A large amount of rain water in Delhi translates into surface runoff and empties into the nearby storm drains. So tapping of storm water from the localized catchment surfaces such as roofs of housing colonies, educational institutions, official buildings, and open areas surfaces etc is a good option either to recharge the groundwater aquifers or storing it for direct use. Basically, rainwater harvesting can be done at individual household levels and at community level in both urban as well as rural areas. This paper discusses the possibilities of rain water harvesting keeping in view the water crisis of Delhi.

Executive Summary

India is grappling with significant water scarcity despite its abundant surface water resources due to overexploitation and pollution of water bodies. The per capita water availability has drastically reduced over the years, and by 2030, the country might face a severe water crisis. This crisis is exacerbated by rapid population growth, industrialization, climate change, and urbanization. Among Indian cities, Delhi stands as an example, where water management difficulties stem from inadequate rainfall and urban expansion. Consequently, the city is heavily reliant on water sources from neighboring states, leading to groundwater depletion and declining water tables.

This research paper delves into water resource management in India with a specific focus on Delhi's water issues. It proposes community participation in rainwater harvesting (RWH) as a solution to water scarcity. The paper consists of three main sections: an overview of India's water resources, an analysis of water management challenges in Delhi, and an assessment of the Delhi Government's Financial Assistance Scheme for Promoting Roof Top Rainwater Harvesting (RWH) using field observations and surveys.

Key findings from the study include:

1. **Groundwater Depletion:** Delhi is facing severe groundwater depletion due to excessive groundwater extraction surpassing recharge rates. This has led to a substantial drop in groundwater levels, causing some areas to experience a decline of up to 2 -4 meters per year.

2. **Encroachment of Water Bodies:** The Ministry of Jal Shakti's Report indicates that Delhi has 893 water bodies, with 24.19% of them encroached upon, the highest among all Indian states. According to the report Delhi has the highest percentage of encroached water bodies among all Indian states underscores the pressing need for comprehensive measures to protect and conserve these natural resources.

3. **Delhi Jal Board Rainwater Harvesting Initiatives:** The Delhi government has made rainwater harvesting mandatory for new buildings and provides financial assistance for installation. The Delhi Jal Board offers incentives, rebates, and conducts awareness campaigns to encourage RWH implementation. The Delhi Jal Board has identified 10,704 Institutions/Organizations/RWAs for rainwater harvesting system installations.
4. **RWH installation Status:** As of year 2022, 8532 of RWH installations have been successfully completed by DJB across Delhi. The Delhi Jal Board itself has installed all 594 RWH systems under its jurisdiction, and other departments have also completed their 89 installations. Among schools and colleges, 4144 out of 4549 systems have been installed, while in other departments, 3705 out of 5472 systems are in place. This indicates that there are 405 systems yet to be installed in educational institutions and 1767 systems pending in other departments
5. **Focus on Community Participation:** Delhi Jal Board is giving more emphasis on Community participation in RWH initiative. The study focuses on 11 RWH sites in Delhi to understand community engagement patterns and participation in rainwater harvesting initiatives. Lack of awareness among residents is a challenge, but most societies have successfully implemented RWH systems.
6. **Operational RWH Systems:** Almost all surveyed RWH systems are operational, primarily focusing on groundwater recharge and, in some cases, utilization for cleaning, domestic tasks, and gardening.
7. **Challenges:** Challenges faced by RWAs and other surveyed institutions include non release grant from Delhi Jal Board, insufficient funds for maintenance, limited technical knowledge, lack of communication between government and societies, and maintenance difficulties.

Based on the findings, the paper suggests several recommendations to address water scarcity and improve the effectiveness of rainwater harvesting:

1. **Location-Specific Solutions:** Rainwater harvesting strategies need to be carefully designed and planned to the specific local situation of Delhi, taking into accounts its geographical characteristics and socio-economic conditions. There is need for in-depth hydrological assessment of Delhi. This involves detailed mapping of regional aquifers, water flow paths, and existing water infrastructure is essential to identify potential areas for rainwater harvesting implementation.
2. **Integrated Urban Planning:** It is crucial to integrate the protection and conservation of water bodies into the framework of urban planning. Equally important is the recognition of designated buffer areas surrounding water bodies, which must remain free from development, thus ensuring the implementation of sustainable land utilization strategies.
3. **Enhancing Community Engagement:** Community involvement is key to the success of any rainwater harvesting initiative. Research should identify ways to effectively engage and educate residents about the benefits of rainwater harvesting and encourage their active participation in the implementation and maintenance of systems. For that increasing administrative, financial, and technical support to encourage more community members to embrace rainwater harvesting is essential.
4. **Focusing on Communication and Training:** Regular communication through Information, Education, and Communication (IEC) initiatives to engage the community and provide training to local community members, RWAs and organizations/institutions' leaders on RWH system operation and maintenance.
5. **Success Stories:** Utilizing success stories of rainwater harvesting implementations within communities can serve as inspirational examples and will encourage and propel others towards embracing similar practices.
6. **Funding and Rebates:** Compulsory waiver of water bills for functional RWH systems along with timely release of funds by Delhi Jal Board to RWAs, institutions and organizations.

7. **Augmenting Traditional Water Bodies:** Reviving traditional water body structures such as ponds, lakes and tanks, as well as pre-harvesting structures such as check dams and contour dams, which are important components of local water management systems, will enhance water availability and conservation.
8. **Sustainable Management of Water Resources:** Delhi Jal Board should implement holistic rainwater harvesting management strategies and adopt sustainable water consumption practices at the community level in the context of Delhi.
9. **Grey-Water Recycling:** Ultimately, there is a requirement to incorporate recycling and reuse strategies into the urban master plans of Delhi, aiming to establish a decentralized mechanism for distributing recycled water.

In conclusion, the paper underscores the urgency of addressing water scarcity through community-led rainwater harvesting and highlights the need for a multi-faceted approach involving government support, community engagement, and sustainable water resource management practices. Further research is recommended to explore additional opportunities and benefits of community-led rainwater harvesting in the study area.

CHAPTER 1

Water Resources in India: An Overview

1.1 Introduction

Depleting water resources is one of the major concerns of urban India and it is likely to create a severe crisis in future as our urban population is expected to increase from 377 million in 2011 to 600 million by 2031 (Amarasinghe 2004). Despite being rich in surface water resources, water scarcity is being recognized as an important problem facing India. Currently, India is home to about 18% of the world's population and accounts for about 2.4% of the world's geographical area. India consumes 4% of the total water resources. As an important economic resource, water is essential for all forms of livelihood activities, agriculture, animal husbandry and most of the industrial production processes (Merrett 1997; Kay et al. 1997). Along with that, various reports and scientific studies suggest that the absence of provision of public water will pose difficulties for local governments in the majority of Indian cities. This extends to other civic services such as sanitation, housing, healthcare, transportation.

In India, the demand for freshwater resources has been steadily growing over the past few decades, making it one of the most water-challenged countries in the world (WRI 2015). Rivers and lakes are dying, and groundwater levels are dropping due to the overexploitation of surface and groundwater by farmers, city dwellers, and industries. Furthermore, the limited available water is highly polluted (TERI 2021). The per capita water availability has declined by almost 75%, from 6008 m3 per year in 1947 to approximately 1545 m3 per annum in 2011.

The country's water demand is projected to be twice the available supply by 2030, resulting in extreme scarcity that will affect millions of people as well as industrial and economic processes (NITI Aayog 2019). From a macro perspective, the average rainfall across India remains relatively consistent at 118 cm, with some annual variations. However, from a micro-perspective, freshwater supplies in many states, river basins,

geographical areas, and localities are declining due to changes in hydrologic balances, over-exploitation, and increased pollution of freshwater reserves. Rapid population growth, industrialization, and climate change have emerged as the primary factors contributing to India's water crisis. Many western, southern, and northwestern states, which happen to be relatively more urbanized, are experiencing severe water scarcity."Water scarcity in urban India has been exacerbated in two ways by the country's growing urban population. On one hand, urban areas in India are consuming greener areas, agricultural land, eco-sensitive areas, and permeable open spaces to create developed, salable land. On the other hand, we are over-exploiting the already depleted groundwater resources. Across the globe, urbanization is typically associated with the expansion of impermeable, concretized built-up regions over agricultural fields and natural areas like wetlands, lakes, and rivers. This reduction in the land's ability to absorb and recharge groundwater leads to a decrease in aquifer levels and an increase in rainwater runoff, ultimately resulting in a higher risk of floods. The downside is that large, heavily populated urban areas can impose an enormous burden on the region's natural resources, with water being the most notable. (Horward & Gelo 2002).

This working paper aims to provide an analytical overview of the emerging water resources management issue in India and to comprehend the gravity of the current water situation in Delhi. The study also seeks to explore the role of community participation in rainwater harvesting (RWH) as an alternative water conservation method in Delhi. To assess the feasibility of RWH, a field survey of 11 rainwater harvesting systems across various areas of Delhi has been conducted. The present study assumes that Delhi can enhance groundwater levels through a decentralized approach to rainwater harvesting.

The paper is divided into three sections. The first section provides an overview of water resources in India. The second section delves into the water management issues and challenges faced by Delhi City. The final section examines the outcomes of the Delhi Government's Financial Assistance Scheme for Promoting Roof Top Rainwater Harvesting Systems using field observations and a primary survey.

1.2 Water Availability in India

India has an average annual precipitation of around 3880 billion cubic meters (BCM) and boasts a vast river system and snow-capped mountains. However, due to the uneven distribution of rainfall and high evaporation rates, the net available water resources for use are estimated to be around 1,123 BCM. This figure includes water from various sources, such as precipitation (rainfall and snow), surface water in rivers, lakes, and reservoirs, and replenishable groundwater. Out of the total available water resources, approximately 690 BCM is surface water, while the remaining 436 BCM is groundwater. Out of the total available water resources, around 690 BCM is surface water, and the remaining 436 BCM is groundwater. According to the most recent estimate, India's annual groundwater recharge totals 437.60 BCM. When accounting for natural discharge, the yearly extractable groundwater resource is projected to be 398.08 BCM. In 2022, the annual groundwater extraction is 239.16 BCM (CGWB 2022). Thus, with the extraction of 239 billion cubic meters groundwater per year, India stands as the largest groundwater extractor in the world.

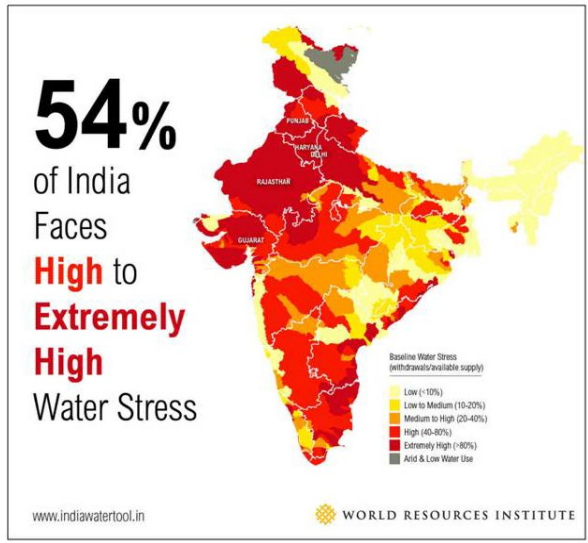
Table 1.1: Water resources in India

Sl. No.	Parameter	Unit (Billion Cubic Meter/Year)
1	Annual water availability	1,869
2	Usable water	1,126
3	Surface water	690
4	Ground water	436

Sources: Central Water Commission, 2015

However, over the last few decades, rapid population growth, changes in agricultural practices, food consumption patterns, lifestyle shifts, and alterations in land use have placed an enormous strain on our water resources. Despite India receiving ample rainwater during the monsoon season, only a small percentage of it contributes to water reserves due to a lack of storage capacity. Notably, rivers in India receive 80 percent of their annual flow during the four months of the southwest monsoon season (Kaul, 1999).

Figure 1: Level of Water Stress in India



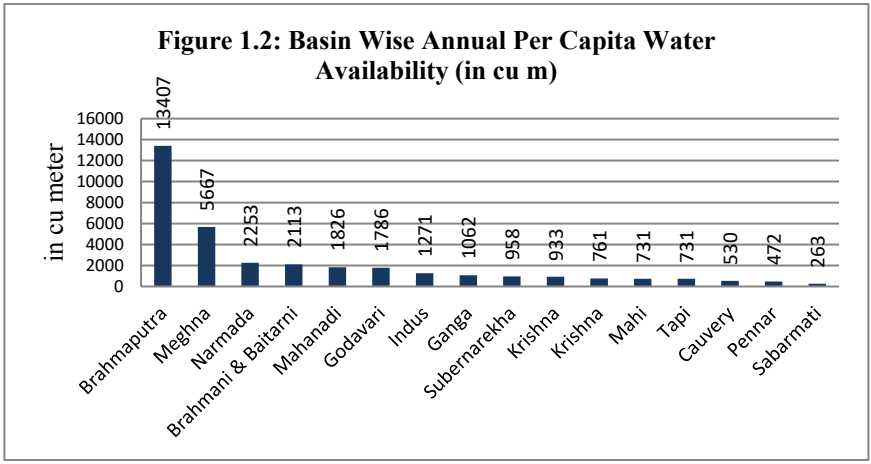
Regarding groundwater resources, they have steadily emerged as the backbone of India's agricultural and drinking water security. Groundwater contributes nearly 62% to irrigation, 85% to rural water supply, and 50% to urban water supply.

The situation is particularly worrying in India, where a significant mismatch exists between available water and the spatial distribution of the population. Surprisingly, regions and states in India with higher populations tend to have less accessible water (Figure 1.1). The number of rainy days varies from about 5 in Rajasthan to around 150 in northeastern India (Rao, 1976).

Additionally, there is significant regional variation in water availability due to differences in rainfall patterns, geographical features, and hydrological factors. India boasts an extensive surface water network, including major rivers like the Ganges, Yamuna, Brahmaputra, and Godavari, among others. However, the availability of surface water varies across different regions and seasons. Some areas face water scarcity, especially during dry seasons, while others experience seasonal flooding.

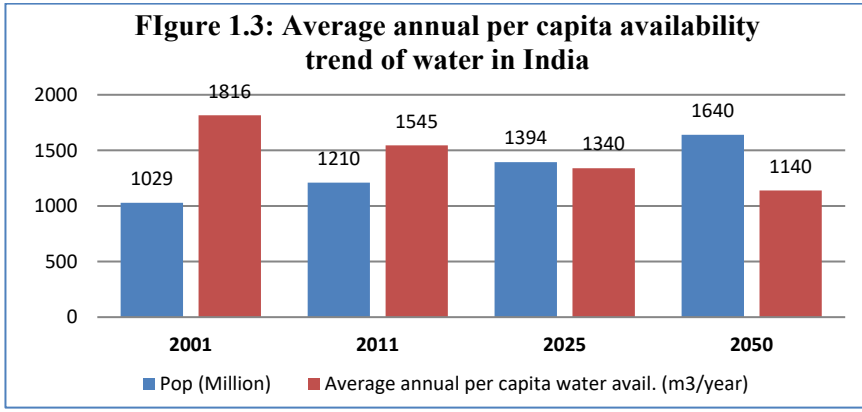
For instance, India's hydrological area can be divided into 19 major river basins. The per-capita water resource availability of these basins varies

from a low of 263 m3 in the Sabarmati basin to a high of 13407 m^3 in the Brahmaputra basin. Water withdrawals also vary from 243 m3 in the Meghna basin to 1,670 m^3 in the Indus basin.



As per United Nations criteria, a region with an annual water supply of less than 1700 m^3 per individual is categorized as being under 'water stress'. When annual water supplies drop below 1,000 m^3 per person, the population faces 'water scarcity', and below 500 cubic meters, it's considered 'absolute scarcity'. Looking at this standard in the Indian context, we find that in the year 1951, the per capita water availability was 5100 m^3, which has decreased to 1816 m^3 in 2001. Figure 1.3 clearly indicates that the availability of water per person in India is declining over time.

So, as per international standards, the per capita water availability in India is relatively low at around 1,545 cubic meters per person per year in 2011. This is expected to decrease further to 1340 m^3 in 2025 and 1140 m^3 2050 with increasing population growth and urbanization.



Source: PIB, 02 Mar 2020

In fact, over the last few decades, high population growth, changes in food consumption, lifestyle, and land use patterns have exerted tremendous pressure on our water resources. Although India receives ample rainfall during the monsoon season, only a small percentage of that water is actually stored due to a lack of storage capacity. In a country like India, where there is a significant mismatch between the spatial distribution of available water and the population, the situation becomes alarming. Ironically, less water is available where more people live

1.3 Pressure on Groundwater

Generally, utilizing surface water is more convenient than extracting water from underground sources. Nevertheless, in India, the extensive and dispersed availability of groundwater across the country has led to its widespread exploitation for agricultural purposes and the supply of drinking water. Eighty-nine percent of groundwater resources are used for irrigation in the agricultural sector, leaving 11% for household and industrial use. Again, when it comes to drinking water, groundwater is the primary source of domestic water supply for both rural and urban India, accounting for more than 80% of all supplies.

However, data from the Central Ground Water Board (CGWB) indicates an alarming situation as many states are excessively extracting their groundwater. In these states, groundwater resources are either critical or overexploited. According to CGWB, at the state level, Punjab, Haryana,

Rajasthan, and Delhi are states where the Stage of Groundwater Extraction is more than 100%, indicating overexploitation. This implies that in these states, annual groundwater consumption exceeds annual groundwater recharge. Similarly, in the states of Himachal Pradesh, Tamil Nadu, Uttar Pradesh, and the Union Territory of Puducherry, the level of groundwater development is 70% and above. In the rest of the states, the level of groundwater development is below 70%, as illustrated in Table 1.2 Over the years, the usage of groundwater has increased in areas where the resource was readily available.

Table 1.2: State wise ground water extraction

State	Category	Stage of GW extraction (%)	% of over-exploited & critical blocks
Punjab	Overexploited	166 %	80 %
Rajasthan		140 %	74 %
Haryana		137 %	63 %
Delhi		120%	71 %
Himachal Pradesh	Semi-Critical	86 %	50 %
Tamil Nadu		81 %	46 %
Puducherry		74 %	25 %
Uttar Pradesh		70 %	17 %
Karnataka	Safe	70 %	30 %
Telangana		66 %	23 %
Gujarat		64 %	12 %
N.E. States		< 10 %	**0 %**

Source: Central Groundwater Board, 2017.

Groundwater resources in these states are either critical or overexploited. According to CGWB, at the state level, Punjab, Haryana, Rajasthan, and Delhi have more than 100% groundwater extraction, indicating overexploitation. This means that annual groundwater use in these states exceeds annual groundwater replenishment. Similarly, the states of Himachal Pradesh, Tamil Nadu, and Uttar Pradesh, as well as the Union

Territory of Puducherry, have groundwater development rates of 70% or higher. Table 1 shows that the amount of groundwater development in the remaining states is less than 70%. Groundwater use has expanded over time in various locations.

1.4 Projected Water Demand in India

The changing composition of India's population over the past few decades, which has witnessed a significant shift from rural to urban areas, has had a profound impact on the country's water resources. This change has several ramifications on consumption patterns, water resource management, and India's overall water security. As the urban population continues to grow, the demand for water in other sectors is also increasing exponentially.

When discussing the largest consumers of water in India, the main users of water resources can be broadly grouped under five major categories (Table 1.3) – (i) irrigation, (ii) domestic, (iii) industrial, (iv) energy, and (v) other (including environmental requirements and evaporation losses). Of these, irrigation is by far the largest consumer of water resources

Table 1.3: Projected Water Demand in India (By Different Use) in Billion Cubic Mt

Demand Sector	2010	% Share in Demand	2050	% Share in Demand	% increase (2010-50)
Irrigation	557	78.4	807	68.4	44.9
Drinking Water	43	6.0	111	9.4	158.1
Industry	37	5.2	81	6.9	118.9
Energy	19	2.7	70	5.9	288.9
Other	54	7.7	111	9.4	105.6
Total	710	100.0	1180	100.0	**50.5**

Source: Basin Planning Directorate, CWC, XI Plan Document.

This change in water demand from different sector will have several implications for water availability, usage patterns, and overall water resource management. As mentioned earlier, agriculture is the largest

consumer of water in India, accounting for around 78 % of the total water withdrawals in 2010. As per the table 1.3, the demand for water in the agricultural sector is projected to grow due to population growth, increasing food demand, and the need to enhance agricultural productivity. However, with more people migrating from rural-to-urban areas, other sectors will demand additional water for domestic consumption, industrial growth, energy production and other activities. This shift will result in reduced share of water demand in agriculture sector (68.4 % in 2051). Expansion of irrigation facilities, adoption of more water-intensive crops, and changing cropping patterns will also contribute to the efficient use of water resources in this sector.

Most importantly, India intends to become the world's third largest economy by 2030. To meet this goal, the demand for energy will surge as industrial and commercial expansion accelerates. As a result, there will be an increased need for water resources for energy production. Various reports also show that the energy sector will account for the majority of the expected rise in water consumption. According to the Basin Planning Directorate, CWC, XI Plan Document, the demand for water in the sphere of energy production will increase by 288 percent by the year 2050. Similarly with urbanization and population growth, the demand for water in the domestic sector is projected to increase by 158 %. The domestic sector includes residential areas, public institutions, and commercial establishments. Apart from this, to reduce the damage caused by climate change, we have to maintain the natural flow of the rivers. Thus we can take special care of the ecological health and sustainability of our water resources.

1.5 Growing Water Concerns in Urban India

At present, India holds the distinction of being the largest user of groundwater in the world, and many cities heavily rely on groundwater for their daily needs. However, due to rapid urbanization, population growth, and inadequate management of water resources, the groundwater table has been rapidly declining in many parts of the country. The situation is particularly severe in cities like Hyderabad, Delhi, Jalandhar, Jaisalmer, Amritsar, Gurugram, Jaipur, Jodhpur, Nagpur, Chennai, and Bengaluru, where the groundwater table has dropped to alarming levels due to their

excessive groundwater usage that surpasses what is replenished by both natural and artificial processes. This has led to the depletion of aquifers, saltwater intrusion, and even land subsidence in some areas..

Table 1.4: Over exploitation of Ground Water Resources in Urban Areas

City	% of GW Utilization/ GW Recharge	City	% of GW Utilization/ GW Recharge
Hyderabad	294.48	**Jaipur**	219.83
Delhi	360	**Jodhpur**	218.6
Jalandhar	472.16	**Amritsar**	363
Jaisalmer	292.85	**Chennai**	171.88
Gurugram	299.8	**Bengaluru**	143.81

Source: CGWB, 2022

Overall, the extraction for ground water in India is projected to increase due to population growth, economic development, and changing consumption patterns. Managing this growing demand while safeguarding water resources and ensuring sustainable water management practices remains a critical challenge for the country. Various strategies, including water conservation, efficient water use practices, recycling and reuse, and integrated water resource management, will be essential to meet the future water demands of different sectors in India.

Cities in India are facing significant challenges when it comes to recharging their groundwater due to following reasons:

1. **Over-Extraction of Groundwater:** One of the primary reasons for groundwater depletion in India is excessive pumping for various purposes like irrigation, industrial use, and domestic water supply. As we are seeing that the demand for water in our cities often exceeds the natural recharge rate, leading to a decline in groundwater levels.
2. **Urbanization and Land Use Changes:** India is having rapid urbanization which results in increased impervious surfaces like concrete and asphalt, reducing the area available for rainwater infiltration. At the same time, as cities expand, natural recharge areas like forested lands and open green spaces are converted into built-up

areas, further limiting the potential for groundwater recharge. Rainfall in India is very sporadic and this prevents rainwater from percolating into the ground and recharging the aquifers.

3. **Lack of Rainwater Harvesting:** Many cities in India have not amended their building bylaws to make rainwater harvesting systems compulsory, which would capture and store rainwater during the monsoon season. This water could otherwise recharge groundwater and offset water demand during drier periods.

4. **Encroachment on Water Bodies:** Natural water bodies like ponds, lakes, and wetlands, which play a crucial role in groundwater recharge, are often encroached upon or converted for other purposes, reducing their capacity to recharge aquifers. The first-ever census report on water bodies undertaken by the Ministry of Jal Shakti reports that almost 1800 water bodies in urban areas are reported as encroached (MoJS 2023). The same report says that of the 893 water bodies in Delhi, 216 or 24.19% are encroached, indicating the city's poor water conservation status.

5. **Pollution and Contamination:** Pollution from various sources, including untreated sewage, industrial effluents, and agricultural runoff, can contaminate groundwater, making it unsuitable for consumption and reducing its recharge potential. About 70% of India's surface water is thought to be unsafe for human consumption. Only a small portion of the nearly 40 million litres of effluent that enter rivers and other water bodies each day is properly treated (WEF 2019).

6. **Inefficient Water Management:** In many cities, water supply networks have leaks and losses, leading to wastage of treated water. The inefficiency in water management reduces the availability of water for recharge. According to Mehreen Mattoo (2019), 40 to 50 percent of potable water in India is wasted during distribution due to water theft and pipeline leaks.

7. **Lack of Skilled Manpower:** Despite the availability of technologies and solutions, there is often a lack of awareness among our human

resources about the importance of groundwater recharge and inadequate implementation of recharge projects in cities.

8. **Inadequate Policy and Regulation:** Some cities lack effective policies and regulations to promote and enforce groundwater recharge practices. The absence of proper incentives and penalties for water management can hinder progress.

To address these challenges, cities need to adopt integrated water management strategies that encompass rainwater harvesting, the safeguarding of water bodies, efficient water distribution, and strict regulations to prevent over-extraction and contamination. Community involvement and public awareness campaigns are also vital to create a sense of ownership and responsibility toward groundwater conservation and recharge.

The Conceptual Background

The water table in NCT Delhi is depleting due to increasing water demand and extensive dependence on groundwater. In the city, surface water storage is limited, and people rely heavily on groundwater sources. The situation has been aggravated by the paucity of open wells in various regions over the last two decades, leading to large-scale digging of deep bore wells and groundwater extraction.

Tragically, natural groundwater recharge has decreased during this period, primarily as a result of urban development, which has made more parts of the city impermeable to water infiltration. Consequently, there is an urgent need to prioritize efforts towards enhancing groundwater recharge to ensure the sustainability of the current groundwater supply.

1.7 Purpose of this study

Against this backdrop, this article examines the developing concerns and management challenges related to water resources in Delhi. The paper argues that the demand for water will grow by leaps and bounds during the next few decades due to high population growth in Delhi. Studies suggest that while water resources would continue to deplete due to groundwater degradation, surface water pollution, and depletion of existing surface, government should involve local community to conserve

and augment the ground water resources of Delhi along with other measures.

This paper attempts to shed light on the role of the government in rainwater harvesting implementation and identify areas for improvement. The study's outcomes can help policymakers make informed decisions, allocate resources effectively, and develop strategies to address water scarcity challenges in the city. Studying the role of the community in rainwater harvesting in Delhi can provide valuable insights into how collective efforts can contribute to sustainable water management in urban areas. Here are some potential objectives for such a study

1.7.1 Objectives

Here are some potential objectives for such a study:

1. To evaluate the existing government policies and regulations related to rainwater harvesting in Delhi.
2. To evaluate the level of awareness and knowledge among the community members in Delhi regarding rainwater harvesting techniques, its benefits, and the importance of conserving water resources.
3. To investigate the extent of community involvement in rainwater harvesting initiatives. Identify the factors that motivate or hinder active participation in such projects.
4. To identify the barriers and challenges faced by the community in implementing rainwater harvesting systems.
5. To examine the existing policies and institutional frameworks in Delhi that promotes or hinders community-based rainwater harvesting initiatives.

By pursuing these objectives, the research paper tries to gain a comprehensive understanding of how community engagement and participation can contribute to sustainable water management through rainwater harvesting in Delhi. The findings can inform policy decisions, community outreach programs, and future urban water planning initiatives.

1.7.2 Methodology

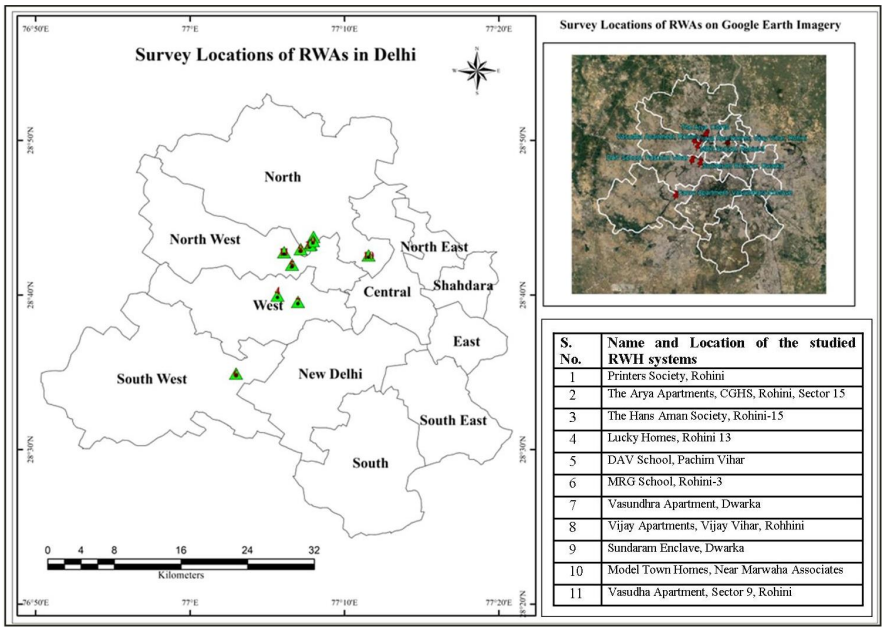
This research paper presents an empirical investigation aimed at identifying key aspects of the Delhi Government's Financial Assistance Scheme for Promoting Roof Top of Rainwater Harvesting (RWH) Systems. The study involved comprehensive fieldwork, examining 11 RWH systems installed in various residential and office spaces across different parts of Delhi (Table1.5). Both official data from Delhi Jal Board and data from primary surveys were utilized for analysis. The data collection methods included interviews and focus group discussions with scheme beneficiaries and other stakeholders, using semi-structured questionnaires. To complement the findings, qualitative observations were also subjected to appropriate qualitative research methods. The evaluation of the scheme aligns with its objectives, and the research concludes by offering recommendations to enhance its implementation.

Table 1.5: Details of the studied RWH systems

S. No.	Name and Location of the studied RWH systems	District
1	Printers Society, Rohini	North
2	The Arya Apartments, CGHS, Rohini, Sector 15	North
3	The Hans Aman Society, Rohini-15	North
4	Lucky Homes, Rohini 13	West
5	DAV School, Pachim Vihar	West
6	MRG School, Rohini-3	North West
7	Vasundhra Apartment, Dwarka	South West
8	Vijay Apartments, Vijay Vihar, Rohhini	West
9	Sundaram Enclave, Dwarka	South West
10	Model Town Homes, Near Marwaha Associates	North
11	Vasudha Apartment, Sector 9, Rohini	North West

For this study, the effectiveness of scheme implemented in different societies and offices was assessed through a primary survey. The survey employed a specially designed semi-structured questionnaire, primarily consisting of closed-ended questions tailored to the objectives of the research. The gathered primary data will be compiled, cleaned, and analyzed based on the responses received through the structured schedules.

Map 1.1: Location of Sample RWH Systems



S. No.	Name and Location of the studied RWH systems
1	Printers Society, Rohini
2	The Arya Apartments, CGHS, Rohini, Sector 15
3	The Hans Aman Society, Rohini-15
4	Lucky Homes, Rohini 13
5	DAV School, Pachim Vihar
6	MRG School, Rohini-3
7	Vasundhra Apartment, Dwarka
8	Vijay Apartments, Vijay Vihar, Rohhini
9	Sundaram Enclave, Dwarka
10	Model Town Homes, Near Marwaha Associates
11	Vasudha Apartment, Sector 9, Rohini

As part of the research process, the IIPA Research team conducted on-site inspections of constructed Rainwater Harvesting (RWH) Systems, some of which have already received or are yet to receive financial assistance under the Delhi Government Scheme. During the physical inspections, the research team documented project sites through photographs for further analysis. Additionally, a focused effort has been made to ascertain the level of community participation in achieving the success of Roof Top Rainwater Harvesting (RWH).

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    %20rainfall,Billion%20Cubic%20Metre)%20including%20 snowfall.

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CHAPTER II

Water Resources in Delhi

Introduction

Delhi, India's vibrant and fast-growing capital, hosts a population of 32,941,308 (World Population Review 2023), ranking it among the world's most populous and dense cities. The city stands as a testimony to India's progress and urbanization, with its population growing from 1.47 million in 1951 to 32.94 million in 2023. Similarly, its urban area has expanded from 201.36 sq.kms. in 1951 to 1467 sq.kms. in 2011 (Census 2011).

Amidst the substantial increase in urban population in this metropolis, the availability and management of water resources are of paramount importance for its sustenance and growth. As the economic hub of northern India, the adequate provision of water resources in Delhi is a vital lifeline, supporting the city's diverse needs, ranging from domestic consumption to industrial and agricultural demands.

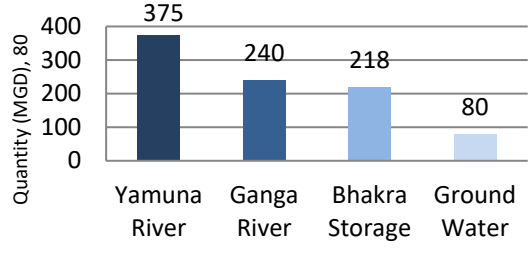
Over the years, the city has witnessed significant changes in its water resources, evolving from traditional water bodies, river system and wells to a more complex network of reservoirs, transporting water from distant places through pipelines, and building water treatment facilities for recycling and sustainable uses. As urbanization continues to reshape the face of Delhi, ensuring sustainable water resource management becomes an ever-pressing concern. This chapter seeks shed light on the intricacies of water availability and quality in the city through an examination of surface water sources and groundwater aquifers and look for opportunities of roof top rainwater harvesting initiatives and offer valuable insights and recommendations that can guide policymakers, stakeholders, and communities towards a more resilient and equitable water future for the vibrant heart of India - Delhi.

2.1 Delhi's Water Resources Situation

Delhi, being located in a semi-arid zone, receives about 61.18 cm annual rainfall and about 81% of this rain fall is received during the months of July to September. The balance is received in the remaining months of the year. With this low rainfall, Delhi faces significant challenges in managing its water resources due to its rapidly growing population, urbanization, and limited access to natural water bodies. In the past, this limited amount of rainwater was able to fall on the forest surface, infiltrate the soil, and be converted into groundwater for use by people. Since last few decades the area of impervious surfaces, like roads, and buildings has increased manifold in the city, which ultimately prevents rain water from infiltrating, or soaking, into the ground. Therefore, a large amount of rain water over Delhi translates into surface runoff and empties into the nearby storm drains. Point of concern is that the intensity of urbanization in Delhi is increasing day by day and as a result the runoff generation will continue to increase in the years to come. Till now, Delhi is somehow managing its water demand, however, is likely to face increasing water crisis if the government doesn't take any concrete steps.

At present, Delhi relies on various types of water resources to meet its diverse needs. The major types of water resources managed and utilized by the Delhi Jal Board and other agencies in the city include: (i) Surface water, which includes water from Yamuna River (ii) Water from neighbouring states (Ganga River & Bhakhra Storage) and (iii) Ground Water. The Yamuna River flows along the eastern border of Delhi and serves as one of the primary surface water sources for the city. Water is withdrawn from the river and treated at water treatment plants before being distributed to consumers. Delhi receives a significant

Figure 2.1 : Water Resources of Delhi Jal Board

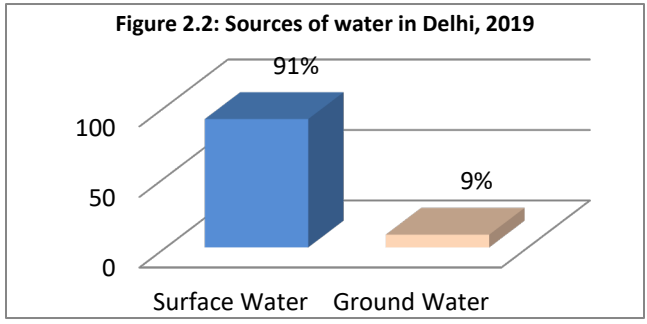


Source: Delhi Jal Board, 2022

portion of its water supply from neighboring states, such as Haryana and Uttar Pradesh, through various inter-state water sharing agreements. These agreements govern the allocation and distribution of water from rivers and canals that originates from multiple river basins (Ganga, Yamuna and Sutluz River). At present neighboring states are supplying nearly 86 percent of Delhi's water needs. Consequently, the groundwater resource of Delhi is coming under immense pressure and it is adversely affecting Delhi's water supply condition. However, these sources have also become increasingly stressed due to the growing demand from Delhi's expanding population. Moreover, the water quality of some of these sources is also a matter of concern due to pollution and inadequate treatment.

In addition to surface water sources, DJB also manages and extracts groundwater from wells and tube wells. Groundwater serves as a valuable supplement to the city's water supply, particularly during periods of high demand or scarcity. Furthermore, the Delhi has undertaken initiatives to promote rainwater harvesting to recharge groundwater and capture rainwater runoff. These efforts are aimed at augmenting the water resources and mitigating the impact of water scarcity during the dry seasons. Despite its tireless efforts, Delhi faces numerous challenges in managing water resources effectively. Rapid urbanization, population growth, pollution, and climate change are some of the critical factors that put immense pressure on the available water sources. As a result, Delhi has become one of the water deficient cities in the world and it is going to become a water scarce city in the coming times. According to the recent Parliamentary Standing Committee Report, 2023, groundwater levels in Delhi, Ghaziabad, Faridabad, and 20 other cities dipped by more than 20 metres from 2017 to 2020. This scarcity of water

Figure 2.2: Sources of water in Delhi, 2019



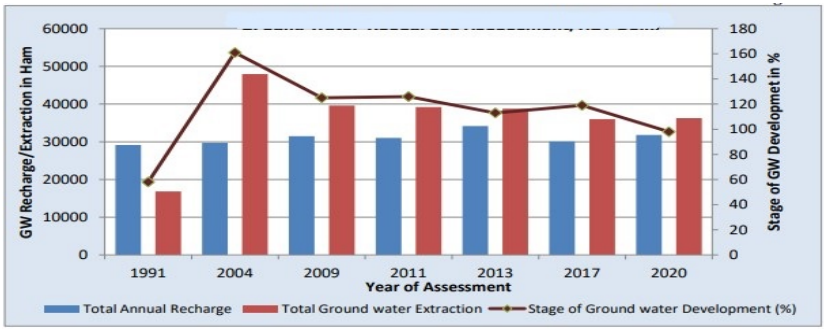
Source: Delhi Jal Board, 2022

in the city gets accentuated by many factors. The growing population, coupled with ever-increasing pollution, increasing demand from industrial and commercial water along with the leakage in the supply systems and wasteful consumption practices (The Economic Times 2017) pose major challenges for the City Administrators.

2.2 Overexploitation of Ground Water

The total area of Delhi is only 1483 sq. km and except a small sub-basin of the Yamuna River, the city has very limited surface water resources (i.e., rivers, lakes, and canals) (Singh 2022). Therefore, for water supply, Delhi also relies on groundwater for its daily water needs, with over 9 percent of the city's water supply coming from groundwater (Figure 2.2). However, the Central Ground Water Board's Report "Ground Water Year Book" states that the extraction of groundwater in the city far exceeds its recharge rate, leading to a decline in the groundwater table. The report says that the annual groundwater extraction in Delhi was more than 100 percent during 2017 (CWGB 2021). Figure 2.3 portrays the ground water resource assessment of NCT Delhi, which clearly indicates that after the year 1991, the total ground water extraction has always exceeded the total ground water recharge. In about 75% area of NCT Delhi the ground water level is declining at a high rate which is 0.4 m to 2.0 m/per year. Therefore, the groundwater table has dropped by more than 50 meters in the last few decades.

Figure 2.3: Ground Water Resources Assessment, NCT Delhi



Source: Central Ground Water Board, 2022, Report Dynamic Ground Water Resources of NCT, Delhi

2.3 Encroachment of Water Bodies

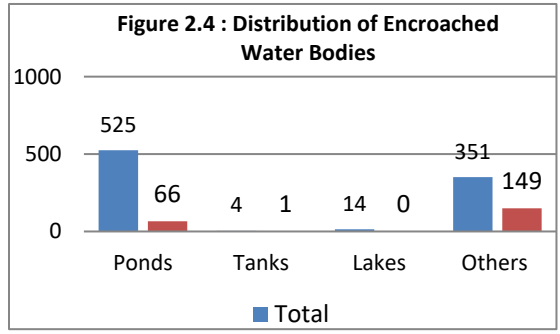


Figure 2.4 : Distribution of Encroached Water Bodies

Source: Delhi Jal Board, 2022

Ministry of Jal Shakti, Government of India has conducted the First Census of Water Bodies in 2021. Delhi was also included in the initial Water Bodies Census, which comprehensively considered all forms of water body usage. The objective of the Census of Water Bodies is to develop a database for all water bodies by collecting information on all important aspects of the subject including their size, condition, status of encroachments, use, storage capacity, status of filling up of storage etc. As per this report, total 893 water bodies have been enumerated in the Delhi, out of which 525 are ponds, 14 are lakes, 4 are tanks and rest of the 350 water bodies are enumerated as others.

The analysis also reveals that out of total 893 water bodies 216 (24.19%) are encroached upon in Delhi and it is highest among all the States of India. The report further said that 66 ponds (small water bodies) in the city were found to have been encroached, while out of the 14 lakes, (larger and deeper than ponds) that it identifies, none was encroached. The category of 'others' had the highest number of encroached water bodies — 149 out of 349. The report does not specify what sort of water bodies fall in the 'others' category.

2.4 Possible solution to Delhi's water problem

At present, Delhi Jal Board has managed to mitigate the water scarcity in Delhi. Yet, the uncertainty surrounding its capacity to fulfill future demand and to provide a sustainable solution from alternative sources will be very challenging. Therefore, there is a need to develop a comprehensive and strategic approach to tackle the impending water crisis effectively in Delhi. The water crisis in Delhi can be addressed through a combination of short-term and long-term remedies. Apart from enhancing

the efficiency of water management in Delhi which can help in to optimize water usage and reduce wastage, regulating groundwater extraction and increasing green cover and blue zone in the city, one effective long-term solution is rainwater harvesting, which can significantly increase the availability of water in the city. Here are some remedies for the Delhi water crisis and the scope for rainwater harvesting:

Rainwater harvesting involves collecting and storing rainwater during the monsoon season for future use. It can be implemented at various scales, from individual households to large commercial buildings. Here's its scope and benefits:

a. Rooftop Rainwater Harvesting: Delhi has a vast urban area with numerous buildings and rooftops. Implementing rooftop rainwater harvesting can help capture rainwater and direct it into storage tanks for later use, reducing the burden on groundwater and other water sources.

b. Community Rainwater Harvesting: Large residential colonies or apartment complexes can also set up community rainwater harvesting systems. These systems can collect rainwater from various buildings and common areas, providing a sustainable source of water.

c. Water Recharge Ponds: Constructing rainwater recharge ponds in open areas can help replenish the groundwater levels, leading to a more sustainable water supply in the long run.

d. Incentives and Policies: The government can offer incentives or enforce policies that encourage rainwater harvesting adoption across the city.

In conclusion, the implementation of rainwater harvesting and other water management techniques can play a crucial role in mitigating the water crisis in Delhi. However, a comprehensive approach involving sustainable practices, public awareness, and government policies is necessary to address this issue effectively.

2.5 Rainwater Harvesting Potential in Delhi

In view of this, Delhi has no options other than to look for multi-faceted and a long term water resource management plan in order to meet its future water demand. The efficient utilization of water and rainwater harvesting is an important method to improve the ground water level in Delhi. Delhi

has an average annual rainfall of about 658 mm. This translates to about 3.34 billion cubic meters of water that can potentially be harvested. If even a fraction of this is captured and used, it can help alleviate the water shortage in the city.

A large amount of storm water runoff is being generated from a number of constructed zones including residential areas, commercial and industrial areas, roads, highways and bridges. So tapping of storm water from the localized catchment surfaces such as roofs of housing colonies, educational institutions, official buildings, and open areas surfaces etc is a good option either to recharge the groundwater aquifers or storing it for direct use (HMWSSB 2023).

Basically, rainwater harvesting can be done at individual household level and at community level in both urban as well as rural areas (Sundaravadivel 2002). At household level, harvesting can be done through roof catchments, and at community level through ground catchments. In case of Delhi, there are a large number of housing societies, industrial premises; commercial and institutional establishments which have huge surface areas. Realizing the huge potential of Rain Water Harvesting (RWH), Ministry of Urban Development and Poverty Alleviation, GoI has made Rain Water Harvesting mandatory for all new buildings on plots 100 sqm and above in 2001 and asked States Governments to make modifications in Building Bye Laws (Rumi 2020). Accordingly in 2002, the Delhi government had implemented a financial assistance scheme to support installation of RWH structures. Under the scheme, grants-in-aid up to 50 percent of the total cost of RWH structure or INR 50,000, whichever is less, was given to eligible groups, such as registered Resident Welfare Associations (RWAs), Cooperative Group Housing Societies, recognised private and government schools, hospitals, charitable institutions, and NGOs.

Recently, Ministry of Housing and Urban Affairs, Government of India has issued new guidelines for Urban Water Conservation under Jal Shakti Abhiyan. Thrust areas include Rain Water Harvesting (RWH), Reuse of Treated Waste Water, Rejuvenation of Water Bodies and Plantation. As per the above guidelines it is the responsibilities of Urban Local Bodies (ULBs) to ensure that all government buildings (Central/State/ULB) must

have RWH structures as per building bye laws, and same should be checked before issuing Occupancy-cum-Completion Certificate (OCC).

Table 2.1: Criteria for disbursement of Financial Assistance

S. No.	Size of Plot	Financial Assistance
1.	100 sqm. and above up to 199.99 sqm.	50% of the total cost of RWH structure or Rs. 10,000 wherever is less
2.	200 sqm. and above up to 299.99 sqm.	50% of the total cost of RWH structure or Rs. 20,000 wherever is less
3.	300 sqm. and above up to 399.99 sqm.	50% of the total cost of RWH structure or Rs. 30,000 wherever is less
4.	400 sqm. and above up to 499.99 sqm.	50% of the total cost of RWH structure or Rs. 40,000 wherever is less
5.	500 sqm. and above	50% of the total cost of RWH structure or Rs. 50,000 wherever is less

Source: Delhi Jal Board, 2021

Accordingly, the Delhi government has revised the building byelaws for Delhi and Delhi Water & Sewer (Tariff and Metering) Regulations in 2019. Now all Govt. departments have to make provision of RWH in their buildings. As per the Delhi Government Cabinet decision 2709 dated 02.07.2019, Delhi Jal Board has been assigned to implement Rain Water Harvesting Systems in Government Buildings/ installations which are not maintained by the PWD, GNCTD. For Delhi Government buildings which are maintained by PWD, GNCTD, the implementation of Rain Water Harvesting System is to be carried out by PWD, GNCTD itself.

Since 2019, DJB has made RWH mandatory in Delhi in new buildings for measuring at least 100 sq.ft. or more to improve the water table which falling alarmingly across the city. To encourage and ensure installation of rooftop RWH in houses and buildings over 100 sqm, the Delhi Government now gives financial assistance up to Rs. 50,000 depending on the size of the projects (Table 1.1) and a rebate of 10 per cent on water bills. However, provision has been made that if the RWH system is found non functional, rebate for RWH may be withdrawn and those who fail to

install the system have to pay 1.5 times the bill amount (DJB 2019). To facilitate this RWH scheme, the Delhi Jal Board has roped in its 12 Jal Shakti Kendras, located in every District.

The success of the Rainwater Harvesting (RWH) initiative hinges on the active cooperation of the public. The Delhi Jal Board (DJB) has implemented its rainwater harvesting schemes at community level to promote sustainable water management and recharge the groundwater table. The main objective of these schemes is to collect rainwater, store it for later use and recharge the ground water at local level and, thereby reduce the depletion of groundwater and other sources of water.

The DJB has implemented two main rainwater harvesting schemes in Delhi:

1. **Rooftop Rainwater Harvesting:** Under this scheme, the rainwater falling on rooftops is collected and stored in underground tanks or recharge wells. The collected rainwater is used for various non-potable purposes such as gardening, washing, and cleaning. The DJB has made it mandatory for all new buildings in the city to have rainwater harvesting systems installed.
2. **Groundwater Recharge through Artificial Recharge Structures:** Under this scheme, artificial recharge structures such as recharge pits, trenches, and borewells are constructed to recharge the groundwater. The structures are designed to allow the rainwater to percolate into the ground and recharge the aquifers. The DJB has identified several areas in the city where groundwater recharge structures have been constructed.

The DJB has also implemented several other initiatives to promote rainwater harvesting and groundwater recharge in the city, such as:

1. Creation of awareness and training programs for the local community.
2. Encouraging the use of rechargeable devices such as soak pits, recharge wells, and recharge trenches.
3. Promotion of rainwater harvesting in schools and other educational institutions.

4. Development of rainwater harvesting models for public spaces such as parks and gardens.
5. Implementation of rainwater harvesting in government buildings and institutions.

Delhi Jal Board also provides financial assistance to those RWH units which have waste water recycling plant with an additional rebate of 5% on the monthly water bills, thus making 15% total rebate if both the systems have been set up and are functional. The penalty for non-implementing rain water harvesting systems will not be applied where ground water levels are shallower than 5.0 m. below ground levels.

Table 2.2 Number of RWH System installed in Delhi as on 31.08.2022

S. NO.	Departments	Total	Installed	RWH System yet to be installed
1.	Delhi Jal Board	594	594	0
2.	Other than DJB	89	89	0
3.	Schools, Colleges	4549	4144	405
4.	Other Deptt	5472	3705	1767
	TOTAL	**10704**	**8532**	**2172**

Source: Delhi Jal Board, Govt of Delhi

In total, the Delhi Jal Board has identified 10,704 Institutions/ Organizations/RWAs for rainwater harvesting system installations. As of 2022, they have successfully installed RWH systems in 8532 of these institutions, leaving 2172 RWH systems yet to be installed across Delhi (Table 2.2). Further analysis reveals that the Delhi Jal Board has already installed all its 594 RWH systems, and the other departments have also installed all 89 RWH systems. However, in schools and colleges, out of 4549 systems, 4144 have been installed, leaving 405 yet to be installed. Similarly, in other departments, out of 5472 systems, 3705 have been installed, and 1767 are yet to be installed.

To make the RWH system cost-effective, the Delhi Government has decided to adopt the Dungarpur model, also known as inline RWH system.

This system does not require a complex setup. It channelizes the rain water directly to a bore well, instead of a regular rainwater-harvesting pit. While setting up a conventional RWH system costs Rs 75,000-1 lakh, the Dungarpur model can be set up for as little as Rs 16,000 (ToI 2021).

2.6 IEC Activities Organized by DJB to promote Rainwater Harvesting

The Delhi Jal Board (DJB) took part in the 'Catch the Rain: Where It Falls, When It Falls' initiative, led by the National Water Mission under the Ministry of Jal Shakti. As a part of this endeavor, DJB collaborated with Water Digest to conduct a series of specialized training programs focused on "Rainwater Harvesting and Management" for Resident Welfare Associations (RWAs) and schools across Delhi.

- In order to encourage active community involvement, the Delhi Jal Board (DJB) organizes workshops and awareness programs on water conservation and Rainwater Harvesting (RWH) at both the circle and division levels. During the months of June and July 2019, a total of 33 workshops were conducted, drawing the participation of 1,051 individuals.
- The Delhi Jal Board took a proactive step in organizing a series of training programs for Delhi colleges. These programs were held on 7th and 8th June 2022 with the aim of creating awareness, enhancing capacities, and encouraging active participation of students and faculties from Delhi colleges in conserving and managing water resources.
- To ensure a wider reach, common citizens are sensitized about Rainwater Harvesting (RWH) through various channels, including print and electronic media. This approach aims to promote a deeper understanding of the significance of sustainable water management practices.
- Furthermore, the Delhi Jal Board provides information regarding rebates and penal provisions related to the implementation and non-implementation of Rainwater Harvesting Systems at the Rain Centres/Jal Shakti Kendras. This initiative aims to incentivize the

adoption of RWH systems and reinforce the importance of responsible water usage among citizens.

- The Delhi Jal Board took the initiative to organize online training programs for the citizens of Delhi and Resident Welfare Associations (RWAs) across 11 Jal Shakti Kendra zones. These training programs were designed to enhance knowledge, build capacities, and provide technological solutions concerning grey water management, emphasizing best practices.
- The primary objective behind these programs was to empower every citizen of Delhi with the necessary skills and understanding to effectively manage wastewater. By doing so, the aim was to alleviate the burden on fresh water resources and promote sustainable water usage throughout the city.

2.7 Conclusion

In conclusion, the water situation in Delhi remains a critical concern, demanding immediate and sustainable solutions. The increasing demand for water resources, coupled with erratic monsoon patterns and depleting groundwater levels, underscores the urgency for proactive measures.

One promising avenue is the implementation of rooftop rainwater harvesting systems. This approach not only holds the potential to alleviate the strain on conventional water sources but also empowers individual households and communities to contribute to their water security. By capturing and utilizing rainwater through innovative technologies, such as rainwater harvesting systems, Delhi could substantially augment its water supply, particularly during the monsoon season.

However, studies have shown that the successful implementation of rooftop rainwater harvesting requires a comprehensive strategy. This includes public awareness campaigns to promote adoption, supportive policies and incentives from the government, effective monitoring and maintenance mechanisms, and collaborative efforts involving stakeholders across sectors.

As Delhi grapples with its water challenges, integrating rooftop rainwater harvesting systems could signify a significant step towards a sustainable

and resilient water future. The scope for innovation, policy reform, and community participation presents a beacon of hope for addressing the pressing water crisis while fostering a culture of responsible water management.

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CHAPTER III

Community Participation in Rainwater Harvesting – A Case Study of Delhi

Introduction

In urban settings like Delhi, the availability of open spaces is restricted, and not all built-up areas are conducive to rainwater harvesting due to space crunch, design limitations, accessibility issues, and safety concerns. However, the city has many government structures, private offices, educational institutions, and residential societies. In these settings, installing rooftop rainwater harvesting systems stands out as a versatile and scalable approach that will play an important role in guaranteeing water sustainability and resilience while having a substantial impact. Adopting rainwater harvesting allows urban areas to become more water-conscious, environmentally responsible, and better equipped to fulfill their water requirements by harnessing rainwater at its source.

The following built-up areas where rainwater harvesting can be implemented effectively:

1. Rooftops: As mentioned earlier, rooftops are one of the most common and suitable areas for rainwater harvesting in urban environments. Rainwater can be easily collected from residential, commercial, and industrial buildings with proper gutter and downspout systems.
2. Balconies and Terraces: In multi-story buildings, balconies and terraces can be equipped with rainwater collection systems to harness runoff water from these areas.
3. Parking Structures: Covered parking structures or carports can be modified to incorporate rainwater harvesting systems, capturing rainwater from the roof and directing it to storage tanks.

4. Courtyards and Atriums: In some buildings, inner courtyards or atriums can be designed to collect rainwater, providing a visually appealing and functional water harvesting feature.
5. Canopies and Awning Structures: Shops, restaurants, and public spaces often have canopies and awnings. These structures can be modified to collect and channel rainwater to storage tanks.
6. Permeable Pavements: As previously mentioned, permeable pavements in walkways or pedestrian zones can allow rainwater to seep through and be collected for reuse.
7. Sports Fields and Playgrounds: Artificial turf or natural grass sports fields and playgrounds can be designed with drainage systems that collect and store rainwater for irrigation purposes.
8. Public Plaza and Square: Public gathering spaces can be designed to incorporate rainwater harvesting features, making them environmentally friendly and sustainable.
9. Bus Stops and Shelters: Bus stops and shelters with rooftops can be retrofitted with rainwater harvesting systems, contributing to water conservation efforts.
10. Industrial Facilities: Factories and manufacturing plants may have built-up areas with large rooftops and paved surfaces, making them potential candidates for rainwater harvesting.
11. Educational Institutions: Schools and universities often have various built-up areas like lecture halls, gymnasiums, and administrative buildings that can be considered for rainwater harvesting.
12. Apartment Complexes: Shared spaces in residential apartment complexes, such as clubhouse areas, can be used for rainwater harvesting.

When selecting built-up areas for rainwater harvesting, it's important to evaluate the structural integrity and sustainability feasibility of existing infrastructure. Involving the community, civil society, and obtaining financial and technical support from government agencies will ensure a successful and safe project implementation. Moreover, adhering to local

regulations and building codes is essential to meet guidelines and restrictions related to rainwater harvesting systems.

3.1 Scope of Community Participation in Rain Water Harvesting in Delhi

Delhi holds immense rainwater harvesting potential, which can be extrapolated from an illustrative calculation applied to a single building to the entire city. Considering the city's vast area of 1,486 sq. km., the rainwater harvesting potential of Delhi stands at a staggering 907 billion liters annually. This substantial amount is equivalent to fulfilling the water requirements for the entire city for approximately 270 days. According to the Delhi Master Plan 2021, there are approximately 1.7 million buildings within the city, making rainwater harvesting is more promising and vital approach to address water scarcity and ensure sustainable water management. These include residential, commercial, industrial, and government buildings. There are large numbers of buildings that can have immense potential for rainwater harvesting. In addition to that the number of buildings in Delhi is constantly increasing due to rapid urbanization and population growth. The government of Delhi has taken an important policy decision to mandate the installation of rainwater harvesting systems on all new buildings where the rooftop runoff is 10,000 litres or more per day. This decision ensures that these buildings must actively participate in the storage of rainwater.

In this context, the active involvement of the community can significantly augment the effectiveness of rainwater harvesting. Since the community typically owns a majority of the buildings, their contribution becomes essential in gathering and storing rainwater on a communal scale. Communities can come together to plan and implement rainwater harvesting systems, such as building rainwater harvesting pits, installing rooftop rainwater harvesting systems, and creating green spaces. Effort should be made to involve the public in the planning and implementation process.

The first step in promoting community participation in rainwater harvesting is to create awareness among the RWAs, common citizens and different institutions about the importance and benefits of rainwater

harvesting. Awareness campaigns can be organized at the local and community level, including residential societies, schools, colleges and government agencies. To encourage community participation government can also provide incentives to individuals and communities who adopt rainwater harvesting practices. This could include subsidies, tax breaks, or other financial incentives to encourage people to adopt rainwater harvesting systems. As we have seen that the Government of Delhi is also trying to connect people through one of its major rain water harvesting scheme. It can be expected that with active participation from individuals and communities, rainwater harvesting can become a successful solution to the water crisis in Delhi.

Rainwater harvesting in cities has several benefits, including:

1. **Groundwater Recharge:** Data of Delhi Jal Board shows that during August 2009 to August 2019, nearly 60 percent of monitoring wells show fall in water level of August 2019, comparing decadal mean of August water level of 2009-18, whereas rest 40 percent monitoring wells show rice in water level. So by capturing rainwater, it can be used to recharge the groundwater table, which can be beneficial for areas facing water scarcity.
2. **Water Conservation:** Rainwater harvesting reduces the dependence on freshwater sources for non-potable purposes like irrigation, flushing, and cleaning. It can also supplement the main water supply during water shortages. Rainwater can be collected from rooftops of buildings and stored in tanks or underground reservoirs. This water can be used for non-potable purposes such as flushing toilets, washing clothes, and watering plants.
3. **Reduced Flooding:** Urban areas often experience flooding due to the rapid runoff of rainwater. Many water bodies in Delhi have been encroached upon, which has led to a reduction in their storage capacity. Diverting and storing rainwater into these water bodies can reduce the volume of storm water runoff, which can help to mitigate flooding and the damage it causes.
4. **Cost-Effective:** Rainwater harvesting can reduce the demand for treated water from public utilities, which can save money on water

bills. Rainwater harvesting systems have low maintenance and installation costs as they require minimal upkeep. Rainwater harvesting can reduce the amount of water required from the main water supply, resulting in lower water bills. This is especially beneficial to the community living in areas where water scarcity is an issue, and water is expensive. As we have seen that the government in Delhi is providing monetary benefits and subsidy in water bill to people through one of its major programs.

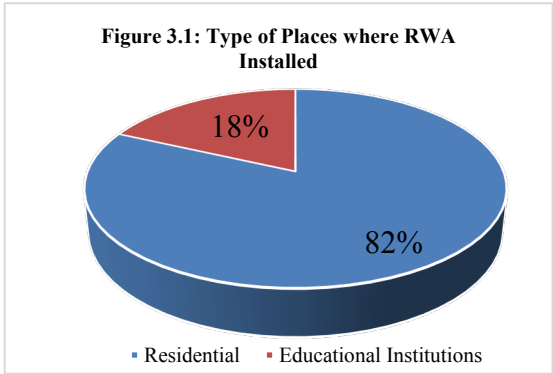
5. **Environmental Benefits:** Rainwater harvesting can help to reduce the impact of urbanization on the environment by reducing the amount of water runoff, decreasing soil erosion and reducing the demand for energy to transport water from distant sources.
6. **Improved Water Quality:** Rainwater is usually free from contaminants and is suitable for several non-potable purposes. By using rainwater, the demand for treated water is reduced, and the burden on the municipal water treatment plants is

In view of the above, conducting a case study to evaluate the community's engagement in rainwater harvesting across various housing societies, organizations, and institutions can serve as a model for others to follow. The primary objective of this study is to assess the level of community participation and the government's efforts in implementing and maintaining 11 rainwater harvesting systems in Delhi.

3.2 Site Description of RWH Systems at Societies and Organizations

While studying the community's engagement in adopting rainwater harvesting systems at societies and organizations in Delhi, our research team conducted interviews with different stakeholders, including residents, management committees, and members of Residents' Welfare Associations (RWAs). The primary objective was to assess the effectiveness and accomplishments of the Delhi Jal Board scheme in facilitating this process.

For this study, the research team randomly selected 11 distinct sites located in various regions across Delhi, as outlined in Figure 3.1. All these chosen locations are exclusively from the North, West and North West districts of Delhi. Out of the selected sites, 8 are residential societies, 2 are schools, and 1 falls into a different institutional category. The rationale behind this deliberate selection was to comprehensively explore and comprehend the extent of community engagement among diverse segments of society. By examining various types of organizations, the research sought to gain valuable insights into the patterns of participation among different sections of the community.



Source: IIPA Field Survey, 2023

3.3 Attributes of studied RWH Installed Systems

Table 3.1 describes about the attributes of the installed Rainwater Harvesting (RWH) systems in the studied locations. Some common attributes includes, the geographic location, plot area, roof area under RWH, storage capacity and number of people residing in the premise were analyzed and documented during the research. Each of the 11 societies and organizations has enough plot area to have functional RWH in their premises. As per the DJB guidelines

In estimating the harvestable rainwater in these societies, the mean annual rainfall figure is typically employed, though it's important to note that the actual amount may not be guaranteed. However, with a 95% likelihood, it can be expected. The calculation of rainwater that can be collected from a specific rooftop area can be determined using the Rational formula, which is as follows:

$Q = C \times I \times A$

Where, Q is amount of discharge from the roof (in m3) A is Area of the rooftop (in m2) I is depth of annual rainfall received on the roof (in m) c = runoff coefficient (no units)

Table – 3.1: Main Attributes of Rain Water Harvesting System Installed

Sl.No	Name of the RWAs/Organizations	Plot Area (M^2)	Roof Area Under RWH (M^2)	Capacity (M^3)	No of flats/people in premise	Potential amount of water being harvested (in Litre)
1	Printers Society, Rohini	6070	2500	45	180 flats	11,45,625
2	The Arya Apartments, Rohini, Sector 15	9000	6000	90	200 flats	27,49,500
3	The Hans Society, Rohini-15	8093	3500	60	225 flats	16,03,875
4	Lucky Homes, Rohini 13	5260	1800	40	150 flats	8,24,850
5	DAV School, Pachim Vihar	5000	1000	25	2800 St/Teach	45,8250
6	MRG School, Rohini-3	4500	1000	28	2500 St/Teach	45,8250
7	Vasundhra Apartment, Dwarka	6070	3000	50	200 flats	13,74,750
8	Vijay Apartments, Model Town	4046	2800	42	125 flats	12,83,100
9	Sundaram Enclave, Dwarka	8094	5500	65	240 flats	25,20,375
10	Model Town Apartments, Model Town	5000	3500	70	110 flats	16,03,875
11	Vasudha Apartment, Sector 9, Rohini	4500	2500	25	100 flats	89,09,838

Source: IIPA Field Survey, 2023

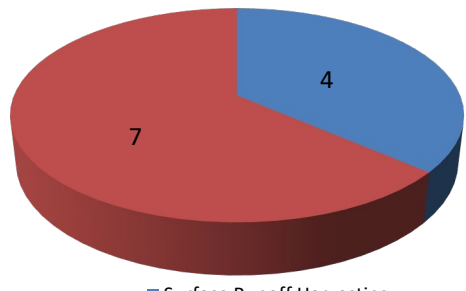
Delhi receives an average annual rainfall of approximately 611 mm. The runoff coefficient for concrete roofs typically ranges from 0.7 to 0.8, and the rooftop areas of each society/organization are provided in Fig. 2.1. Utilizing this data, we can calculate the potential amount of rainwater that can be harvested in these societies and organizations. The data from each

Rainwater Harvesting (RWH) system indicates that they have significant water storage capacity, which can be utilized for various purposes. Take Arya Society as an example, where the potential amount of harvestable rainwater is approximately 27.49 lakh litres. This quantity proves to be adequate for fulfilling various water-related needs, except for drinking purposes.

3.3.1 Types of installed rainwater harvesting systems

The quantity of water harvested through rainwater harvesting is influenced by the nature of the catchment area used to collect the rainwater. For instance, when rain falls on a concrete terrace, approximately 70% of it becomes runoff, while merely 10% of the rainfall on a wooded or grassy area flows away, with the majority being retained on the surface and naturally infiltrating into the ground. According to figure 3.2, two distinct methods are employed by the surveyed societies and organizations. Among the 11 locations surveyed, 4 of them (The Hans Society of Rohini-15, Lucky Homes of Rohini, Sundaram Enclave of Dwarka, Vasudha Apartment of Sector 9 Rohini utilize runoff harvesting on their premises, while the remaining 7 locations opt for rainwater harvesting from their rooftop areas.

Figure 3.2: Types of Rain Water Harvesting System



Source: IIPA Field Survey, 2023

3.3.2 Storage of rainwater

Table 3.2: Types of Rain Water Collection System

Sl. No.	Options/Methods	No. of Societies/ Organisations
1	Recharge pit /Trench	11
2	Recharging of Abandoned Borewell	0
3	Soakaway	0
4	Recharge trough	0
5	Raising of storm water drains	0

Source: IIPA Field Survey, 2023

From a technical perspective, distinct water storage systems can be employed for different rainwater harvesting method. During the study, all the societies and organizations which are studied emphasized the primary purpose of rainwater harvesting is to groundwater recharging (Table 3.2). As a result, each of them constructed rainwater recharge pit tanks within their premises, and rainwater was channeled to these tanks through connected pipes and channels. The collective objective was to replenish the groundwater levels and promote sustainable water management practices.

1.1.1 Proportion of Roof Area used for Rainwater Collection

The quantity and quality of water stored in a water harvesting system are directly influenced by the size of the catchment area and the catchment surface of the society/organization. To optimize rainwater storage, it is crucial to employ the entire roof area for rainwater harvesting. The study revealed that in 9 out of 11 societies utilize their entire rooftop for water harvesting. However, the two educational institutions selected in the survey, namely DAV School, Pachim Vihar, and MRG School, Rohini-3, reported using only two-thirds of their rooftop area for rainwater harvesting.

Table 3.3: Roof Area used for rainwater collection

Sl. No.	Roof Area Cover	No. of RWA
1	Whole Area	9
2	Two third area	2
3	Half Area	0
4	Quarter Area	0
5	Total	11

Source: IIPA Field Survey, 2023

3.3.4 Purpose of Rainwater Harvesting (RWH) installation

When surveying members of various societies and institutions were asked about the purpose of setting up Rainwater Harvesting (RWH), a range of answers were provided to the research team. However, the central objective of Rainwater Harvesting (RWH) installation in all 11 locations was to adopt sustainable water management practices and address water scarcity within their premises. Nine societies/institutions reported that they had previously experienced water crises, leading them to install RWH systems to reduce their reliance on conventional water supplied by the Delhi Government. As a result, this has helped them become less dependent on external water sources. Furthermore, seven societies/institutions acknowledged that one of their motivations for implementing RWH was to mitigate the flow of stormwater, thereby preventing flooding in nearby areas. By capturing and managing rainwater, they contributed to flood prevention measures in the region. In addition to water scarcity and flood prevention, two societies/institutions disclosed that they opted for RWH installations to avoid penalties imposed by the Delhi Government.

Table 3.4: Purpose of Rain Water Harvesting

S. No.	Purpose of installation of RWH	No. of Society/ Institution
1	Ground water recharge	11
2	To overcome Water scarcity	9
3	Reducing the flow of storm water to prevent urban flooding	7
4	Mandatory direction from Government of Delhi	2

Source: IIPA Field Survey, 2023

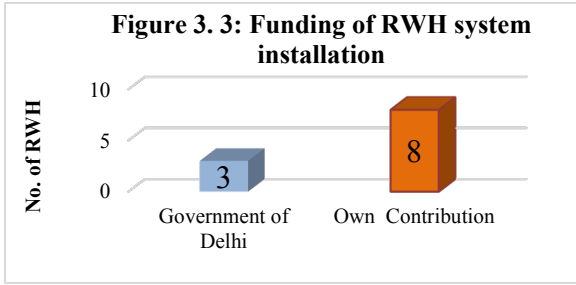
3.4 Government support to RWH system installation

RWH system installation in societies/intuitions involves initial setup costs, which might be challenging for some RWAs/Institutions to bear on their own. Financial support or subsidies from the government can incentivize and enable RWAs to implement RWH projects without putting excessive financial strain on their members. Apart from that these private entities may do not have technical expertise and the experience for designing, installing, and maintaining RWH systems. So government support ensures that the RWH projects are implemented efficiently and effectively, maximizing their water-harvesting potential. Government involvement also ensures proper monitoring and evaluation of RWH projects. This helps assess the effectiveness of implemented systems, identify areas for improvement, and measure the impact on water conservation and water table recharge.

3.4.1 Funding of RWH system installation

In 2012, the government of Delhi made it obligatory for properties with a plot area exceeding 100 sq.m. to have rainwater harvesting (RWH) systems installed. They also promised to provide the cost for construction and maintenance and provide a subsidy on the Water Bill. Many private societies and institutions took the initiative to install RWH systems on

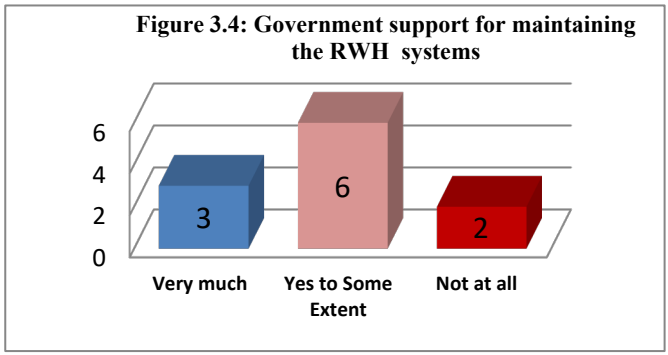
their premises and applied for the aforementioned benefits from the Delhi Government. However, out of the 11 surveyed places, only three societies, namely Printers Society of Rohini, The Arya, CGHS of Dwarka, and Lucky Homes of Rohini Sector 13, have reported receiving financial support for their RWH system installations. On the other hand, the following societies, namely The Hans Society - Rohini-15, DAV School - Pachim Vihar, MRG School - Rohini-3, Fancy Apartment - Vasundhra Enclave, Vijay Apartments - Model Town, Sundaram Enclave - Dwarka, Marwaha Associates - Model Town, Vasudha Apartment - Sector 9, Rohini, have stated that they independently funded the installation of their RWH systems. These societies had indeed applied for financial assistance from the government, but they have not received the promised amount to date.



Source: IIPA Field Survey, 2023

3.4.2 Government support in maintenance of RWH system

According to the guidelines, the Delhi Jal Board (DJB) is responsible for providing technical expertise and guidance to Resident Welfare Associations (RWAs) to obtain functionality certificates for their Rainwater Harvesting (RWH) systems. These certificates are necessary for RWAs to avail rebates on their water bills. The support from DJB ensures that RWH projects are implemented efficiently and effectively, optimizing their water-harvesting capabilities. In response to accessing



Source: IIPA Field Survey, 2023

government support for maintaining their rainwater harvesting systems, the survey revealed that only three societies/organizations reported receiving full support from the government for maintaining their RWH systems. This support likely includes technical assistance and financial aid, ensuring proper upkeep and functionality of the RWH installations.

Six societies/organizations stated that they received government support to some extent in maintaining their RWH systems. This support might involve partial technical guidance or limited financial assistance. Two organizations disclosed that they did not receive any technical or financial support from the government for the maintenance of their RWH systems. This lack of support could potentially pose challenges in ensuring the optimal functioning of their RWH installations. Overall, the survey reflects the varying degrees of government assistance received by RWAs and organizations in maintaining their RWH systems.

3.4.3 Level of communication between the government and the societies/RWAs

Transparent communication between the government and societies/institutions about the available grants, subsidies, or financial incentives enables eligible entities to access the necessary funding are crucial for successful Rainwater Harvesting (RWH) and water conservation efforts. It empowers communities with knowledge, resources, and support, fostering a collaborative and sustainable approach towards addressing water challenges in the region. However, if we look at the table 3.5, the current situation appears to be less than promising. There seems to be a lack of communication between the Government and societies/institutions. Only 3 societies/organizations have confirmed that there is regular communication between them and the government. On the other hand, 8 out of 11 societies/organizations reported that their communication with the government is either non-existent or very rare, which is a great challenge to the success of water conservation efforts in Delhi.

Table 3.5: Communication between the Government and Societies/Institutions

S. No.	Level of Communication	No. of Societies/Orgs
1	Always	2
2	Often	1
3	Rarely	6
4	Never	2

Source: IIPA Field Survey, 2023

3.4.4 Adequacy of financial support to the Societies/Oganisations for RWH System

RWH system installation involves initial setup costs, including equipment, materials, and labour. Adequate financial support helps societies/organizations cover these expenses, making it feasible for them to implement RWH projects. It motivates them to adopt RWH systems, leading to broader implementation and increased overall water conservation. Insufficient or delayed funding may lead to compromises in the quality of the RWH system. Adequate financial support allows for the use of high-quality materials and reliable technologies, leading to more efficient and long-lasting systems. Under the Rainwater Harvesting (RWH) guidelines, the Delhi government offers a 50 percent financial assistance, capped at a maximum of Rs 50,000, along with a 10 percent rebate on water bills. As per Table 3.6, all the surveyed Societies/Institutions have shown their dissatisfaction with regards to the amount of financial support or subsidies to societies/organisations. Although this much financial assistance is sufficient, it is necessary that it is fully implemented. It seems that the institutions are more worried about not getting the financial aid as promised and subsidy on the water bill.

Table 3.6: Adequacy of financial support or subsidies to Societies/Organisations

S. No.	Opinion regarding sufficiency of financial assistance or subsidies	No. of Studied RWH
1	No	11*
2	Yes	0
3	Total	11

Source: IIPA Field Survey, 2023

3.5 Status of RWH systems in Societies/Institutions

A well-maintained RWH system ensures efficient rainwater collection and storage by maximizing the amount of water harvested. The operational RWH is a vital asset in assuring Delhi's water security and a more resilient future for both societies/organizations and the surrounding environs. Accordingly, guaranteeing the appropriate operation and maintenance of RWH systems is also in the interest of societies and organizations adhering to Delhi Government requirements and reaping financial benefits.

3.5.1 Functionality of RWH systems in Societies/Institutions

An operational RWH systems help recharge the groundwater table by allowing rainwater to percolate into the soil. This replenishes underground aquifers, which are essential for maintaining a sustainable water balance. As seen in the table 3.7, except for the Printers Society of Rohini, all other Societies/Organisations' RWH systems are operational which is very encouraging.

Table 3.7: The rain water harvesting system of your housing society functional

S.No.	Status	No. of Societies/ Institutions	Name of the Society/Organisation
1	Functional	10	1. The Arya - CGHS, Dwarka 2. The Hans Society - Rohini-15 3. Lucky Homes, - Rohini 13 4. DAV School - Pachim Vihar

			5. MRG School - Rohini-3 6. Fancy Apartment - Vasundhra Enclave 7. Vijay Apartments - Model Town 8. Sundaram Enclave – Dwarka 9. Marwaha Associates - Model Town 10. Vasudha Apartment - Sector 9, Rohini
2	Functional to Some Extent	1	11. Printers Society, Rohini
3	Non Functional	-	-
Total		11	

Source: IIPA Field Survey, 2023

3.5.2 Use of Harvested Water

It is well known that rainwater captured by Rainwater Harvesting (RWH) is not fit for potable use because it has not been processed to satisfy drinking water standards. However, the gathered water can be used for a variety of non-potable uses. Furthermore, frequent maintenance of the RWH system is required to ensure the quality of the gathered water and the system's longevity. According to the findings of this study, all assessed RWH systems are predominantly used for recharging subsurface aquifers, hence promoting groundwater replenishment (Table 3.8). Additionally, 8 societies/organizations utilize the conserved water for cleaning purposes, 2 societies/organizations employ it for domestic tasks, and 1 society/organization employs it for gardening purposes.

Table 3.8: Uses of Harvested Rainwater

S. No.	Uses of RWH	No. of Studied RWH
1	Ground water Recharge	11
2	Recharge + Cleaning + Gardening	8
3	Recharge + Domestic	2
4	Recharge +	1

Source: Source: IIPA Field Survey, 2023

3.5.3 Maintenance of RWH system

The intricacy of the RWH system influences its maintenance requirements, and regular filter cleaning and maintenance are required to prevent clogging and provide optimal water flow. If the RWH system incorporates storage tanks, they must be cleaned on a regular basis to eliminate silt and debris. Tank maintenance ensures that the stored water is pure and free of contaminants. various societies/organizations have various perspectives in this setting. Nobody in the study has claimed that maintaining a RWH system is simple (Table 3.9). Seven societies claimed that managing the RWH system is challenging, while four societies stated that maintaining the RWH standard is tough.

Table 3.9: Complexity of RWH System Maintenance

S. No.	Managing RWH	No. of Studied RWH
1	Easy to manage	-
2	Somewhat Easy to Manage	7
3	Complicated	4
Total		11

Source: IIPA Field Survey, 2023

3.5.4 Measures Taken To Avoid Water Pollution

As said earlier, the maintenance of a Rainwater Harvesting (RWH) system can vary in complexity depending on the type of system, its design, and the environmental conditions. However, RWH systems with storage tank require different types of maintenance and demand more attention and effort to avoid water pollution. Table 3.10 talks about the 9 such measures, which are necessary to avoid contamination of water going to the storage tank. For example, 10 societies/organizations have said that they clean their roofs and maintain the examined RWH systems on a regular basis. It can be seen in the table 3.10 that only 7 societies/organizations have installed gutter guards and filters to prevent clogging and maximize water flow. Cleaning gutters and roofs is crucial to preventing the accumulation of leaves, dirt, and other debris that might taint collected rainwater. 5 have first flush mechanisms to prevent

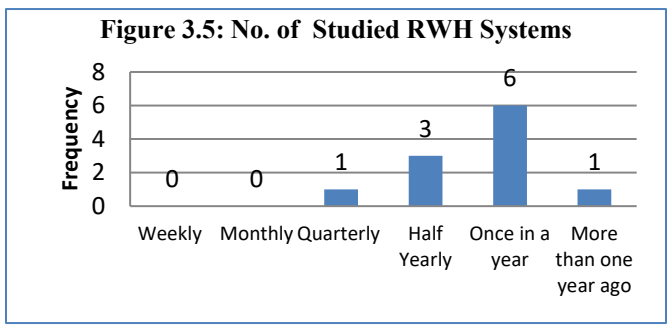
contaminated rainfall from entering the system for the first few minutes. Only three societies/organizations conduct periodic water quality monitoring, which is critical to ensuring that rainwater collected remains safe for its intended non-potable purposes. Two societies/organizations have admitted to installing a leaf diverter or rain head and cleaning their filter material on a regular basis. Only one has stated that they provide chemical roof treatments on regular basis. Nobody is using a sediment trap or installing a mesh or fine filter system. When members of RWAs/Institutions were asked about the cause of such delays in RWH maintenance, the most common response was a lack of funding.

Table 3.10: Measures Taken To Avoid Water Pollution

S. No.	Measures Taken	No. of Studied RWH Systems
1	Regular roof and gutter maintenance	10
2	Installation of gutter guards and filters	7
3	Installed First flush devices	5
4	Conduct water quality testing	3
5	Installation of a leaf diverter or rain head	2
6	Cleaning of Filter Media	2
7	Chemical treatments on roofs	1
8	Using a sediment trap	0
9	Installed a mesh or fine filter system	0

Source: IIPA Field Survey, 2023

3.5.5 Frequency of Cleaning of RWH Water Storage Tanks



RWH systems with storage tanks must be cleaned on a regular basis to remove silt and debris, ensuring that the stored water remains pure and uncontaminated. During the discussions, more

than half of the societies/organizations reported cleaning the RWH system once a year. Furthermore, three societies/organizations said they clean their RWH systems every six months, while one said they cleaned their water storage area within the last year.

3.5.6 Major difficulties with the RWH system's upkeep

Setting up and maintaining a Rainwater Harvesting (RWH) system in established societies and institutions involves various obstacles for both citizens and government officials. The challenges encountered during the implementation and maintenance of such systems is consistent across the societies/institutions analyzed for this study. Some of the prominent obstacles identified by members of these researched societies/institutions are as follows:

As shown in the table 3.11, numerous challenges have surfaced regarding the maintenance of Rainwater Harvesting (RWH) systems, with the government's pressure being a significant factor. Ensuring the optimal functioning of these systems is crucial, but societies are struggling to secure funds for appropriate equipment and hire qualified personnel to conduct regular upkeep. As a consequence, system efficiency is compromised, and potential failures loom.

According to 9 respondents, the government's support is lacking, making compliance with DJB regulations, obtaining no objection certificates, and accessing water bill subsidies time-consuming and demanding.

Table 3.11: Maintenance issues of Rain Water Harvesting System

S. No.	Major issues	No. of Studied RWH Systems
1	Difficult to maintain the system	11
2	Govt. does not seems very supportive	9
3	Not enough awareness among residents of its benefits	8
4	Not enough professional to design	4
5	Any Other Issue/Space	5

Source: IIPA Field Survey, 2023

Moreover, 8 representatives have emphasized on the lack of awareness and understanding among citizens about the benefits and operation of RWH systems. Many residents fail to recognize the significance of RWH and lack the know-how to operate and maintain the system effectively. Additionally, limited space poses a challenge, restricting the system's capacity and effectiveness in certain cases, particularly in shared societies where ownership, management, and responsibilities become contentious issues for RWAs.

3.5.7 Maintenance of the RWH System

Rainwater Harvesting (RWH) System maintenance is a huge concern for any community since it necessitates technical competence, citizen participation, and money. Most members of society do not know how to utilize or maintain the system effectively. They also have difficulty in getting individuals with technical expertise for their RWH systems. Conversely, rainwater harvesting (RWH) systems need regular upkeep to ensure their effective operation. As reported by two representatives from the society, their RWH system is in excellent condition. Four representatives indicated that their RWH system is functioning well, while five mentioned it is operating at an average level.

Table 3.12: Present condition of RWH

S. No.	Status	No. of Studied RWH Systems
1	Very Good	2
2	Good	4
3	Average	5
4	Poor	0
5	Very Poor	0
Total		11

Source: IIPA Field Survey, 2023

3.5.8 Penalty over non-functional RWH

As discussed earlier, the Delhi Government can imposed penalties on RWAs and other organizations/Institutions for non-functional RWH systems or improperly maintained RWH systems. The amount of the fine can depend on the severity of the violation and the specific regulations in place. We observed in the table 3.7 that in 10 surveyed locations the RWH system was fully functional and in only one case it was not working at full

scale. Due to this, no fine has been imposed in any society so far, which is a good thing.

Table 3.13 : Penalty for Non-functional RWH system

S. No.	Fine Imposed	No. of Studied RWH Systems
1	Yes	0
2	No	11
Total		11

Source: IIPA Field Survey, 2023

3.5.9 Satisfaction with the quality of the harvested rainwater for non-potable uses (e.g., gardening, cleaning)

The satisfaction of communities with the quality of harvested rainwater for non-potable uses is crucial for the effectiveness of Rainwater Harvesting (RWH) systems. The quality of the harvested rainwater depends on its filtration and treatment. Based on the data, six societies/institutions are very satisfied or satisfied to a large extent, while two are satisfied to some extent. Overall, the acceptance of the quality of water harvested through Rainwater Harvesting (RWH) systems is encouraging. However, three societies/institutions have expressed dissatisfaction with the quality of the harvested water.

Table 3.14 : Satisfaction with the quality of harvested water

S. No.	Satisfaction level	No. of Studied RWH Systems
1	Very much satisfied	3
2	Satisfied to large extent	3
3	Satisfied to some extent	2
4	Somewhat dissatisfied	3
5	Not at all satisfied	0

Source: IIPA Field Survey, 2023

3.5.10 Feasibility of strict rules or guidelines to ensure proper maintenance of rainwater harvesting systems

Clear regulations for RWH system installation and maintenance in societies/ institutions can promote better compliance and instill confidence in local communities that the government will provide more financial incentives for adopting effective water management practices.

However, before implementing stricter regulations, ensuring public awareness and full engagement of government agencies to support communities and institutions in meeting the new requirements is essential. The above table 3.15 talks about whether government should introduce stricter regulations or guidelines to ensure the proper maintenance of rainwater harvesting systems. Seven RWA said that they strongly agree that the government should introduce stricter regulations, while the rest of the RWA remain somewhat neutral on the introduction of these regulations.

Table 3.15 : Feasibility of strict rules or guidelines

S. No.	Satisfaction level	No. of Studied RWH Systems
1	Strongly agree	**7**
2	Somewhat agree	**2**
3	Neutral	**2**
4	Somewhat disagree	**0**
5	Strongly disagree	**0**

Source: IIPA Field Survey, 2023

3.6 Level of Community Participation

Assessing the extent of community participation reveals information about residents' awareness and understanding of RWH. It identifies places where further education and outreach may be required to emphasize the necessity of water conservation and the benefits of RWH. In general, when the community actively engages, it is more probable that they will take ownership of the project and maintain its long-term viability. Rainwater harvesting systems' performance and longevity are determined by how well they are integrated into the daily lives of the community. If the community is actively engaged and enthusiastic about the project, there is a higher likelihood that they will maintain and use the system effectively, thus ensuring its long-term sustainability. Consequently, evaluating the extent of community involvement in rainwater harvesting (RWH) holds significance in this study. Several essential indicators and methodologies has been employed to gauge the effectiveness of RWH systems in conserving water resources.

3.6.1 Resistance or Reluctance from Residents to adopt RWH Systems

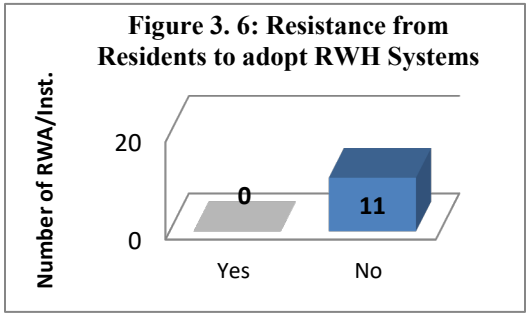


Figure 3. 6: Resistance from Residents to adopt RWH Systems

Installation of RWH system, particularly the roof-top RWH is a new phenomenon and many residents may not be aware of the benefits of RWH or how the system works. Without understanding its advantages, they might be hesitant to adopt new practices. It also involves some initial investment and modifications to existing structures. Some residents might view this as inconvenient and resist the changes. Similarly, residents who are heavily reliant on municipal water supply might not perceive RWH as necessary and might prefer the convenience of relying solely on the public system. Therefore, it was necessary to know whether the members of the Society had resisted before the establishment of RWH in their premises. It is good to find that no society had to face any resistance before the fitting of RWH system

3.6.2 Communication between the Government and the Community to make RWH successful

Table 3.16: Communication between Community and Government

S. No.	Status	No. of Studied RWH Systems
1	Always	2
2	Often	1
3	Rarely	5
4	Never	2
5	Sometimes	1
Total		11

Source: IIPA Field Survey, 2023

Table 3.16 displays the number of societies/organizations that have received information and recommendations from the government regarding the maintenance of rainwater harvesting systems for community members

The findings reveal that there is a lack of communication and coordination between the government and the community concerning rainwater collection. Specifically, five societies/institutions indicated rare communication with the government. Surprisingly, two societies stated that the government had never contacted them since the establishment of RWH. In contrast, three RWAs expressed that the government consistently communicates with them to ensure the successful implementation of water harvesting initiatives at the local level.

3.6.3 Cooperation of the Community Members in the establishment of the RWH system

Community participation is crucial for the successful implementation of RWH systems. Therefore, assessing the level of community participation provides insights into the awareness and understanding of RWH among the residents. Examples of across the world suggest that when the community actively participates, they are more likely to take ownership of the project and ensure its long-term sustainability. Representatives of 7 out societies/institutions said that their fellow residents actively contribute to the maintenance of the RWH system. 3 Societies/Institutions told that only a few residents come forward in the maintenance of RWH system. 1 said that they do not get any cooperation from the residents at all.

Table 3.17: Level of Community Participation in the Maintenance and Upkeep of the Rainwater Harvesting system

S. No.	Level of Participation	No. of Studied RWH Systems
1	Yes all society members actively support	7
2	Only few society members actively support	3
3	Only RWA members/Office in charge actively support	1
4	No one bothers about the RWH	0
Total		11

Source: IIPA Field Survey, 2023

3.6.4 Savings in Water Bills

The installation of the RWH system within the premises was expected to bring two main financial benefits to the society. Firstly, as per the government's promise, all society members would receive a 10% subsidy on their water bills. Secondly, by utilizing the collected rainwater for various purposes within the society, significant savings could be achieved on the overall water bill. Table 3.18 illustrates the cost savings achieved on water bills after the implementation of rainwater harvesting equipment. Among the 11 surveyed societies/institutions, only 3 have consistently recorded water bill savings, whereas another three of them reported such savings frequently. Four of them experienced occasional cost savings, while the remaining two never observed any such reduction in expenses.

Table 3.18: Savings in Water Bills

S. No.	Cost savings in water bills	No. of Studied RWH Systems
1	Always	3
2	Often	3
3	Sometimes	3
4	Never	1
5	Rarely	1
Total		11

Source: IIPA Field Survey, 2023

3.6.5 Capacity building of Local Community to maintain RWH system

The Delhi government's RWH initiative prioritizes capacity building among local inhabitants, with a focus on conducting training programs at the community level. When queried about their participation in these training programs, representatives from three societies confirmed attending the training sessions. Conversely, representatives from the other organizations indicated that they had not received any training regarding the upkeep and maintenance of the RWH system.

Table 3.19: Capacity Building for Community Members

S. No.	Received any training	No. of Studied RWH Systems
1	Yes	3
2	No	8
Total		11

Source: IIPA Field Survey, 2023

3.6.6 Organizing Society/Institution - led awareness campaigns or events for the local community

By organizing awareness campaigns or events, societies and institutions play a critical role in driving water conservation efforts at the grassroots level. These initiatives create a ripple effect, inspiring more community members to adopt rainwater harvesting and other sustainable water management practices, ultimately contributing to the larger goal of water security and environmental protection. Unfortunately, 8 of the societies/institutions had not organized any awareness campaigns within their premises to inform their residents about the RWH system in their community. It means the work of planning, management and maintenance of the RWH system has been left only to the members of the RWA or managing committee. Only three respondents said that they occasionally conduct public awareness campaigns for water conservation.

Table 3.20: Awareness Campaign for Community Members

S. No.	Awareness campaign	No. of Studied RWH Systems
1	Yes on regular interval	0
2	Occasionally	3
3	Never	8
Total		11

Source: IIPA Field Survey, 2023

3.6.6 Impact of RWH on Societies/Institutions water security

The primary purpose behind installing Rainwater Harvesting (RWH) systems in Societies/Institutions was to store rainwater and replenish groundwater. Additionally, ensuring water security in these communities was a crucial objective of the scheme. Here are some observations from society members: - None of the respondents reported a significant improvement in water security in their societies due to RWH initiatives (Table 3.21). However, three societies acknowledged that the installation of RWH systems has led to a partial increase in water availability within their premises. On the other hand, other societies or institutions mentioned that they have not observed any noticeable change in water availability since the installation of RWH systems. Some even stated that they do not have information about any such changes. It is essential to note that the actual impact of RWH on water security in Delhi may vary depending on factors such as the scale of implementation, community involvement, maintenance, and the integration of RWH with existing water management practices.

Table 3.21: Impact of RWH on water security

S. No.	Observations of Respondents	No. of Studied RWH Systems
1	To Large extent	0
2	Yes to some extent	3
3	Same as before	5
4	No Idea	3
Total		11

Source: IIPA Field Survey, 2023

3.6.8 Challenges of societies/institutions in maintaining RWH system

Table 3.22 presents whether the surveyed societies/institutions encountered challenges in maintaining their rainwater harvesting systems. All 11 locations analyzed admitted that they lacked the financial resources to maintain the RWH system. 9 reported issues with the routine maintenance of the RWH system in their society. 7 reported difficulties in coordinating with the government. 3 brought up the issue of insufficient space for rainwater harvesting. Additionally, two locations expressed

uncertainty about the future of their RWH system. This table highlights that the Resident Welfare Associations (RWA)/Institutions are facing four major issues: insufficient financial resources, limited technical knowledge, challenges in regular maintenance, and a lack of coordination and cooperation with the government as well as within the community members.

Table 3.22: Challenges faced by Society/Institution in Maintaining the RWH system

S. No.	Challenges	No. of Studied RWH Systems
1	Insufficient financial resources	11
2	Difficulty in regular maintenance	9
3	Limited technical knowledge	8
4	Lack of coordination and cooperation	7
5	Limited space or inadequate roof area	3
6	Uncertainty about the long-term effectiveness	2
7	Unnecessary interventions of local authorities	0

Source: IIPA Field Survey, 2023

3.6.9 Impact of RWH system on the Drainage System or Water Logging cases

One of the main purposes of installing RWH systems is to capture, store rainwater and reduce the amount of storm water runoff entering the drainage system. This decrease in runoff can alleviate pressure on the drainage infrastructure during heavy rainfall events. By collecting rainwater on-site, RWH systems can prevent excess water from pooling in low-lying areas, reducing the risk of water logging in the society.

Table 3.23 discusses the impact of Rainwater Harvesting (RWH) on the drainage system or water logging issues in the society after the implementation of the rainwater harvesting system. Seven RWA members said that there is no problem of water logging, while three RWA members expressed concern that yes, the road gets waterlogged and only one said that the areas around the water tank get waterlogged. However, as per the

society members, this problem of water logging is rarely seen when there is a lot of rainfall.

Table 3.23: Impact of RWH on the Drainage System or Water Logging matters

S. No.	Cost savings in water bills	No. of Studied RWH Systems
1	Easy drainage of rainwater & no water logging issue	7
2	Yes, the road still gets flooded	3
3	Nearby area of water tank gets flooded	1
Total		11

Source: IIPA Field Survey, 2023

3.6.10 Recommending installation of Rainwater Harvesting System to other residential societies

Table 3.24: Impact of RWH on water security

S. No.	Observations of Respondents	No. of Studied RWH Systems
1	Very Likely	4
2	Likely	5
3	Unlikely	2
Total		11

Source: IIPA Field Survey, 2023

Installing rainwater harvesting (RWH) system can be extremely helpful for any residential society, particularly in a city like Delhi where water supplies are limited and demand is increasing. There are various reasons why establishing a RWH system is advised, including the fact that it allows water to percolate into the earth, replenishing the groundwater table and contributing to the sustainable use of this essential water resource. The good news is that, with the exception of two cultures,

everyone stated they would recommend rainwater harvesting systems to other societies.

Table 3.25: Opinion of Societies/Institutions on the effectiveness of RWH system

Name of the RWAs Society	Scale of 1 to 5				
	1	2	3	4	5
1. Printers Society, Rohini					
2. The Arya, CGHS					
3. The Hans Socity, Rohini-15					
4. Lucky Homes					
5. DAV School, Pachim Vihar					
6. MRG School, Rohini-3					
7. Fancy Apartment at Vasundhra Enclave					
8. Vijay Apartments, Model Town					
9. Sunderam Enclave, Dwarka					
10. Marwaha Associates,Model Town					
11. Vasudha Apartment Sector 9 Rohini					
Overall Scaling	0	3	2	3	3

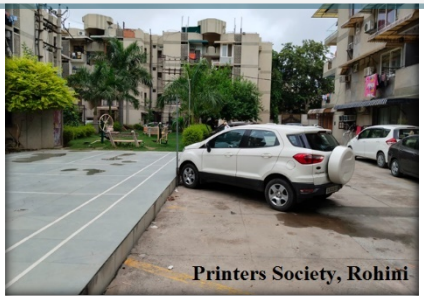
Source: IIPA Field Survey, 2023

3.6.11 Effectiveness of rainwater gathering systems in water resource conservation

Measuring the effectiveness of rainwater harvesting (RWH) systems in water resource conservation is essential to understand their impact and optimize their implementation. Table 3.25 assesses the efficacy of RWH systems in various societies/institutions from 1 to 5 scales based on the perspectives of their residents. Three scarcities, MRG School - Rohini-3, Sunderam Enclave - Dwarka and Vasudha Apartment - Sector 9 Rohini are highly satisfied with the outcome of the RWH system in their premises. Respondents of such societies like DAV School - Pachim Vihar, MRG School - Rohini-3 were also quite satisfied with the outcome of Rain Water Harvesting Systems. On the other hand, societies like Arya, CGHS of Dwarka and Vijay Apartments of Model Town, feel that the installation of RWH systems in their premises has not made much difference in terms of water conservations.

Location of Rainwater Harvesting Systems


Lucky Homes


Printers Society, Rohini


The Hans Socity, Rohini-15


Fancy Apartment at Vasundhra Enclave


Vijay Apartments, Model town

CHAPTER – IV

Summary and Conclusions

4 Summary

Despite having relatively abundant surface water resources, India faces significant water scarcity due to overexploitation and pollution of rivers, lakes, and groundwater. The per capita availability of water has almost decreased by more than 75% since independence and by 2030, we might not have enough water for everyone. Factors like rapid population growth, industrialization, and climate change worsen the water crisis. Urbanization further exacerbates water scarcity by reducing the ability to recharge groundwater through the expansion of urban areas over agricultural land and open spaces.

India is the world's largest user of groundwater, and many cities heavily depend on it. However, rapid urbanization and population growth have led to severe groundwater depletion in cities like Hyderabad, Delhi, and Chennai. Excessive groundwater extraction without replenishment has caused aquifer depletion, saltwater intrusion, and land subsidence. As India's population and economic development increase, the demand for groundwater is expected to rise, posing a critical challenge for sustainable water management.

Currently, Delhi is encountering difficulties in managing its water supply due to both inadequate rainfall and the expansion of urban areas. As a result, the city depends on water sources from neighboring states. Consequently, the excessive use of groundwater has resulted in a drop in the water table. To tackle these problems, it is imperative to adopt water conservation, rainwater harvesting, recycling, and holistic water resource management practices across various sectors within the city. Furthermore, safeguarding the city's water resources and advocating for sustainable practices are vital to ensure the quality and availability of water for future generations.

Since last few years government is emphasizing on adoption of rainwater harvesting at community level as a solution to mitigate water scarcity. However the effective water resource management practices remains a challenge for the city.

The working paper analyzes water resource management in India, focusing on Delhi's water issues. It explores the potential of community participation in rainwater harvesting as a water conservation method. The paper is divided into three sections, providing an overview of India's water resources, examining water management challenges in Delhi, and assessing the Delhi Government's Financial Assistance Scheme for Promoting Roof Top Rainwater Harvesting using field observations and surveys.

Overall, the paper emphasizes the urgency of addressing water scarcity in urban India and suggests rainwater harvesting as a decentralized approach to improve groundwater levels in Delhi. This research paper focuses on an empirical investigation of the Delhi Government's Financial Assistance Scheme for Promoting Roof Top Rainwater Harvesting (RWH) Systems. The study involved fieldwork examining 11 RWH systems installed in residential and office spaces across Delhi. Data was collected through interviews, focus group discussions, and questionnaires with scheme beneficiaries and stakeholders. The evaluation aligns with the scheme's objectives, and the research offers recommendations for its enhancement. The effectiveness of the scheme was assessed through a primary survey with closed-ended questions, and on-site inspections of RWH systems were conducted. The level of community participation in achieving the success of RWH was also studied.

4.1 Findings

- As for Delhi, the extraction of groundwater far exceeds its recharge rate, resulting in a decline in the groundwater table. Since 1991, total groundwater extraction has consistently exceeded recharge, causing a significant drop in groundwater levels, with some areas experiencing a decline of up to 2 meters per year, totaling over 50 meters in recent decades.

- The Ministry of Jal Shakti's Report indicates that Delhi has 893 water bodies, with 24.19% of them encroached upon, the highest among all Indian states. The 'others' category had the most encroached water bodies (149 out of 349), while none of the identified lakes were encroached.
- The Delhi government has made rainwater harvesting mandatory for new buildings and offers financial assistance for installation. Recent guidelines by the Ministry of Housing and Urban Affairs emphasize rainwater harvesting in government buildings, residential societiesand in other institutions. For that the Delhi Jal Board provides incentives and rebates to encourage RWH implementation.
- The Delhi Jal Board participates in IEC activities and conducts specialized training programs to promote rainwater harvesting and water conservation. They collaborate with different organizations to organize workshops for community members/RWAs, conduct training programs for colleges, sensitize citizens through media channels, and provide information on rebates and penalties related to rainwater harvesting systems.
- RWH system installation aims to adopt sustainable water management practices and reduce reliance on conventional water supplied by the Delhi Government.
- The research study selected 11 sites in North and North West districts of Delhi, including 9 residential societies and 2 schools, to understand community engagement patterns and explore their participation in rainwater harvesting initiatives.
- Roof-top RWH installation is a new concept for many residents, leading to a lack of awareness regarding its benefits and functionality. However, none of the surveyed societies faced resistance from their residents before implementing RWH systems in their premises.
- All surveyed societies and organizations have constructed pit tanks within their premises and channelize rainwater to replenish groundwater levels and promote sustainable water management practices.

- Only three societies/organizations reported receiving full government support for installing and maintaining their RWH systems.
- There is a lack of communication between the government and societies/institutions regarding water conservation efforts in Delhi. Only 3 out of 11 societies/organizations reported regular communication with the government, while 8 others mentioned non-existent or rare communication.
- Many societies/institutions express dissatisfaction with the amount of financial support or subsidies provided to them. Concerns arise about the full implementation of financial aid and subsidies on water bills.
- Almost all surveyed RWH systems are operational, which is very encouraging.
- In studied societies, RWH systems primarily focus on recharging groundwater, with some societies utilizing the conserved water for cleaning, domestic tasks, and gardening.
- Nine essential maintenance measures for RWH systems are listed, with some societies facing delays due to funding constraints. Regular water quality monitoring is reported by only three societies/organizations.
- Cleaning RWH systems once a year is common, with some societies cleaning every six months or within the last year.
- Many societies struggle to secure funds and qualified personnel for RWH system upkeep, compromising system efficiency and risking potential failures.
- Limited awareness among citizens hampers effective operation and maintenance, while limited space restricts system capacity in shared societies.
- 10 out of 11 surveyed locations have fully functional RWH systems, with no fines imposed on any society, indicating compliance and positive outcomes.

- A lack of communication and coordination between the government and the community regarding rainwater collection is evident in the survey.
- Savings on water bills are reported by various societies, with some experiencing consistent savings.
- Training on RWH systems is provided by the government to some representatives, while others report no such training.
- Awareness campaigns about rainwater harvesting are lacking in many societies, leaving responsibility for planning, managing, and maintaining the RWH system solely to the members of the RWA or managing committee.
- Significant improvement in water security due to RWH initiatives is not reported, with only a few societies acknowledging partial increases in water availability.
- The 11 analyzed locations face common challenges in maintaining RWH systems, including insufficient financial resources, low technical knowledge, maintenance difficulties, and a lack of coordination and cooperation.

4.2 Suggestions:

The paper emphasizes the complexity and contextual nature of rainwater harvesting as a water management practice. It underscores that effective rainwater harvesting cannot be approached with a one-size-fits-all strategy. Instead, it requires tailored and thoughtful management considering both geographical and socio-economic factors.

- **Conservation strategies:** It includes adoption of runoff harvesting from slopes, utilization of drainage flow, and groundwater recharge for the better outcome of the RWH system. Water logging is still happening at some places due to not taking care of the slopes.
- **Location specific solutions:** To enhance water availability and management, it is crucial to develop location-specific solutions based on comprehensive research. This entails creating reliable hydrological databases and monitoring essential factors such as rainfall,

temperature, stream flow, and groundwater recharge potential. By implementing these measures, we can make informed decisions and optimize water resources for each specific location.

- **Integrated Urban Planning:** It is crucial to integrate the protection and conservation of water bodies into the framework of urban planning. Equally important is the recognition of designated buffer areas surrounding water bodies, which must remain free from development, thus ensuring the implementation of sustainable land utilization strategies.
- **Changing institutional strategies:** To enhance community participation in rainwater harvesting, it is essential to increase administrative, financial, and technical support to civil society, institutions, organizations, and urban land use management. By offering greater assistance, we can encourage more community members to embrace rainwater harvesting initiatives and actively contribute to water conservation efforts.
- **Continuous engagement with local community:** Regular communication through IEC initiatives keeps the community engaged over time. It can provide updates, share maintenance tips, and address any queries, fostering a sustained commitment to rainwater harvesting practices.
- **Highlighting success stories**: Sharing success stories of rainwater harvesting implementation within the community or in similar contexts can inspire and motivate others to follow suit. These stories demonstrate the tangible benefits and outcomes that can be achieved through active participation.
- **More attention to awareness and training activities**: Need for regular awareness campaigns and training programs for residents to promote the benefits of rainwater harvesting and educate them on system operation and maintenance.
- **Timely release of fund:** Timely release of funds encourages RWAs to initiate the installation process promptly and ensures that the system is set up efficiently. Adequate funds allow RWAs to conduct

routine inspections, cleaning, and repairs, ensuring the system's longevity and optimal performance.

- **Mandatory 10% rebate on water bill for Functional RWH:** The long-term sustainability of RWH systems relies on ensuring a consistent rebate on water bills to those societies/institutions who are complying the directions of Delhi Government. With this assurance, RWAs can effectively plan for future investments, upgrades, or expansions to cater to increasing water demands and adapt to changing environmental conditions.

- **Revival of traditional water resources:** To tackle water scarcity and promote sustainable water resource utilization, it is imperative to revitalize traditional water harvesting structures. This requires conducting a comprehensive study to assess their quantity and storage capacity. By reviving these structures, the city government can efficiently store rainwater and recharge Delhi's water aquifers, leading to enhanced water availability and conservation measures.

- **Adoption of sustainable water resource management strategies:** It is essential to establish comprehensive rainwater harvesting management plan, incorporating sustainable water usage practices and well-designed storage facilities. This responsibility should be undertaken by city-level and community-based institutions to ensure efficient water management and conservation.

- **On-site Grey-water Recycling Solution:** The implementation of recycling and reuse measures has already been initiated in select cities. However, these strategies should be incorporated into all urban master plans to establish a comprehensive system for supplying recycled water, designated for non-human consumption purposes. Simultaneously, the use of Information, Education, and Communication (IEC) activities should be harnessed to foster a shift in people's perceptions towards the utilization of recycled water.

The study also suggests that further research is required to explore additional opportunities and possibilities related to community led rainwater harvesting and its potential benefits for water in the study area.

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ANNEXURE- I

Indian Institute of Public Administration

Questionnaire for Research Study on Community Participation in Rain Water Harvesting - A case Study of Delhi

Questionnaire for RWAs/Organisations

1. Name of the place where roof-top rainwater Harvesting System installed……
2. Type of Place a. Residential b. Educational Institution c. Office/Commercial
3. When your society has installed rainwater harvesting systems in your building?
   a. 1-3 year before b. 3-5 year before c. 5-10 year before d. Before 10 years
4. No. of people living/working in the premise……
5. How rainwater is being harvested in your promise?
   a. Surface runoff harvesting b. Roof top rainwater harvesting
6. Funding of RWH system installation

Government of Delhi	Own Contribution	From other Sources	Total

7. Project site description

Plot Area (m^2)	Roof area under RWH (m^2)	Capacity (m^3)

8. Number of Building/Tower having Roof-top rainwater Harvesting System

T. No.	Roof top Surface Area (m^3)	Area under Rain Water Harvesting (m^3)	Type of Storage Facility
1			
2			
3			
4			
5			
6			

9. What Portion of the roof used as catchment for rainwater collection?

a. Whole Area b. Two third area c. Half Area d. Quarter Area e. No Idea/Can't Say

10. Storage tank dimensions.

Tank No.	Total Area	Cost of Construction*	Storage capacity
1			
2			
3			
4			
5			

a. Cuboids, b. Irregular c. Oval d. Cylindrical e. Rectangular

**a. 1000 L, b. 1000 – 2000 c. 2000 L – 5000L d. Above 5000 L

11. Is the rain water harvesting system of your housing society functional? (i) Yes (ii) No

12. Do you face any problem in getting functionality certificate from EE (Civil) (i) Yes (ii) No

13. Is managing Rain Water Harvesting simpler?
a) Yes b) No. c) Can't Say

14. Which of the following are the options/methods for collecting /storing rainfall in subsoil / aquifer?
    a) Rainwater storage tank
    b) Recharging of Abandoned Borewell
    c) Soakaway
    d) Recharge trough
    e) Raising of storm water drains
15. What measures have you taken to avoid water pollution before letting rain water into the tank?
    a. Regular roof and gutter maintenance:
    b. Installation of gutter guards and filters:
    c. Installed First flush devices
    d. Installation of a leaf diverter or rain head
    e. Cleaning of Filter Media
    f. Using a sediment trap
    g. Installed a mesh or fine filter system
    h. No chemical treatments on roofs
    i. Educate residents on best practices
    j. Conduct water quality testing
16. **C**an Rain water replace water supply for public utility? (a). Yes (b). No (c). Can't Say
17. What are the major issues you have faced in setting up rain water harvesting system in your housing society?

    a. Not enough awareness among residents of its benefits
    b. Govt. does not seems very supportive
    c. Difficult to maintain the system
    d. Not enough professional to design
    e. Any Other Issue
18. Is harvested water good and safe for your family to drink? **(a). Yes (b). No (c). Can't Say**
19. What is the purpose of installation of rain water harvesting in your building?
    a. Ground water recharge
    b. Reducing the flow of storm water to prevent urban flooding
    c. To overcome Water scarcity

d. Unavailability of freshwater
e. Mandatory direction from Govt.
f. Any Other Purpose (Specific)……..

20. How are you using the water collected from your society's rainwater harvesting system? (Select Multiple)

    a. Ground water Recharge b. Cleaning c. Domestic d. Gardening e. No Response

21. Frequency of cleaning of recharge structure during rainy seasons

    (i) Weekly (ii) Fortnightly (iii) Monthly (iv) Quarterly (v) Once in a year

22. Does your society/organization have ever been fined for non functional RWH? a. Yes b. No

23. On a scale of 1 to 5, how effective do you find the rainwater harvesting system in conserving water resources?

1.	2.	3.	4.	5.

24. Have you noticed any improvement in water availability since the installation of the rainwater harvesting system?
    (i) Yes (ii) No (iii) Same as before (iv) No Idea

25. How satisfied are you with the quality of the harvested rainwater for non-potable uses (e.g., gardening, cleaning)?
    (i) Very mush satisfied
    (ii) Satisfied to large extent
    (iii) Satisfied to some extent
    (iv) Somewhat dissatisfied
    (v) Not at all satisfied

26. Do you feel that the rainwater harvesting system has reduced your society's dependency on external water sources?
    (i) Yes (ii) No (iii) No Idea

27. How well-maintained is the rainwater harvesting infrastructure in your society?
    (i) Very Good (ii) Good iii) Average (iv) Poor
    (v) Very Poor

28. Have you noticed any cost savings in water bills since the implementation of the rainwater harvesting system?
    (i) Always (ii) Often (iii) Sometimes (iv) Never (v) Rarely

29. Have your RWA/Office received any training or information regarding the proper use and maintenance of the rainwater harvesting system?
    (i) Yes (2) No

30. Would your RWA/Office recommend implementing a rainwater harvesting system to other residential societies?
    (i) Very Likely (ii) Likely (iii) Unlikely (iv) Neutral

31. Have you noticed any impact on the drainage system or water logging issues in your society after the implementation of the rainwater harvesting system?
    (i) No water Logging issue (ii) yes the road gets flooded (iii) nearby area of water tank gets flooded
32. How satisfied are you with the level of government support for the maintenance of the roof-top rainwater harvesting system in your society?
    (i) Very mush satisfied
    (ii) Satisfied to large extent
    (iii) Satisfied to some extent
    (iv) Somewhat dissatisfied
    (v) Not at all satisfied
33. Have you received any financial assistance or subsidies from the government to support the maintenance of the rainwater harvesting system?

    (i) Yes (ii) No

34. Do you believe that the government should provide more financial incentives or subsidies to encourage the maintenance of rainwater harvesting systems?

    (i) Yes (ii) No

35. If yes they how much more financial incentives or subsidies you expect from Government?

36. Do you believe that the government adequately communicates information and guidelines regarding the maintenance of roof-top rainwater harvesting systems?

    (i) Always (ii) Often (iii) Rarely (iv) Never (v) Sometimes

37. Are there any challenges or issues you have faced in accessing government support for maintaining the rainwater harvesting system?
    (i) Not at all (ii) Yes to Some Extent (iii) Very much

38. If yes, please specify your concern……

39. How well do you think the government collaborates with local communities and organizations to promote the maintenance of rainwater harvesting systems?

    (i) Extremely concern (ii) Very concern (iii) Moderately concern (iv) Slightly concern (v) Not at all concern

40. Do you believe that the government should introduce stricter regulations or guidelines to ensure the proper maintenance of rainwater harvesting systems?

    (i) Strongly agree (ii) Somewhat agree (iii) Neutral (iv) Somewhat disagree 9v) Strongly disagree

41. Do your society member actively support and participate in the maintenance and upkeep of the rainwater harvesting system?

    (i) Yes all society members actively support
    (ii) Only few society members actively support
    (iii) Only RWA members/Office incharge actively support
    (iv) No one bothers about the RWH

42. Was there any resistance or reluctance from residents to adopt new systems or change existing practice in your Society?

(i) Yes (ii) No

43. If your society/office faced any challenges maintaining the rainwater harvesting? If yes, please specify about the objections

(i) Insufficient financial resources
(ii) Limited technical knowledge
(iii) Limited space or inadequate roof area
(iv) Lack of coordination and cooperation
(v) Unnecessary interventions of local authorities
(vi) Difficulty in regular maintenance
(vii) Uncertainty about the long-term effectiveness

44. Are you satisfied with the level of community involvement and cooperation in utilizing and maintaining the rainwater harvesting system?

(i) Very mush satisfied
(ii) Satisfied to large extent
(iii) Satisfied to some extent
(iv) Somewhat dissatisfied
(v) Not at all satisfied

45. Do you believe that the community should allocate resources or funds to support the maintenance and expansion of the rainwater harvesting system?

(i) Yes (ii) No (iii) Can't Say

46. Are there any community-led awareness campaigns or events initiated by RWA/Organisations focused on promoting the importance and benefits of rainwater harvesting?

(i) Yes on regular interval (ii) Occasionally
(iii) Never

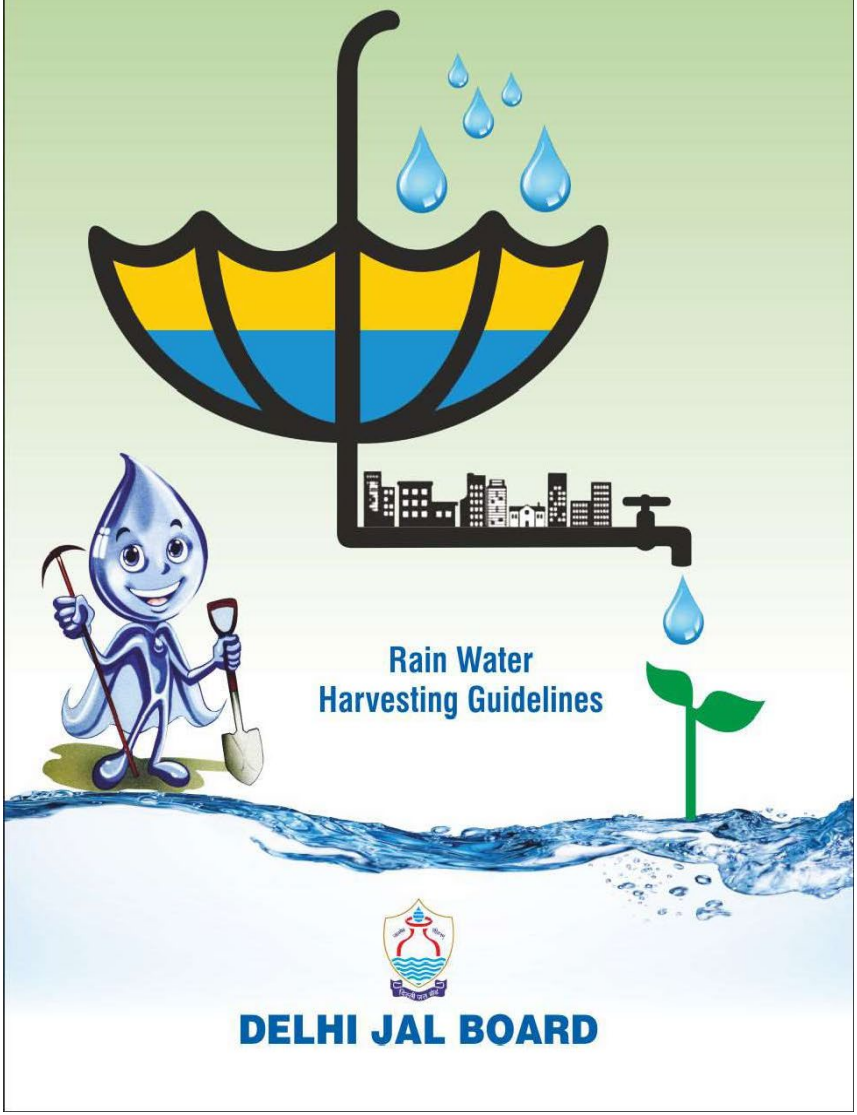
47. How well do you believe the community recognizes the value and benefits of rainwater harvesting for water conservation and sustainability?

(i) Not at all concern (ii) Slightly concern (III) Moderately concern (IV) Very concern
(V) Extremely concern

48. How much savings your RWA is getting for associating with implementing roof-top rainwater harvesting?
49. Are there any suggestions or improvements you would like to see in the rainwater harvesting system?
……
……

Signature of the respondent

Easy Rain Water Harvesting
Easy Tomorrow



Rain Water Harvesting Guidelines

DELHI JAL BOARD

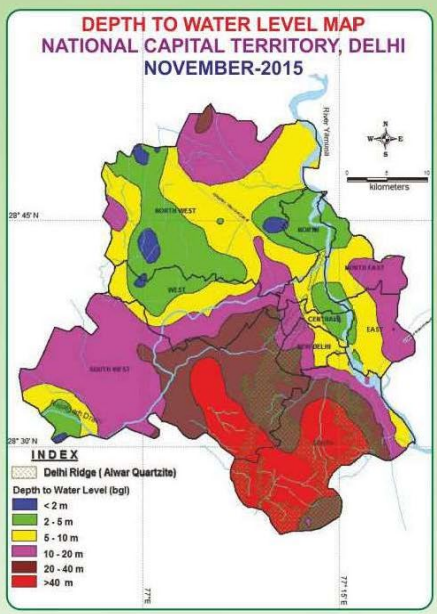
Easy Rain Water Harvesting
Easy Tomorrow

WHY ?

RAIN WATER HARVESTING THE NEED OF THE HOUR

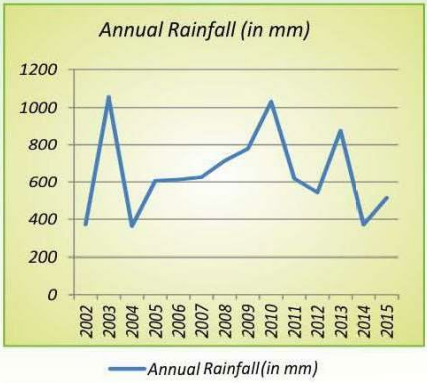
Rainwater Harvesting is critical for Delhi's Water Security. By adding to Delhi's own limited water resources it will

- Help cater to the potable water needs of the ever growing population
- Stop the rapid fall in Ground Water Level
- Increase availability of Portable Water
- Help maintain Green Cover
- Help revive Water Bodies



Annual Rainfall of Delhi NCT

Year	Annual Rainfall (in mm)
2002	372.8
2003	1052.8
2004	364
2005	607
2006	613.1
2007	626.7
2008	713.9
2009	779
2010	1031.5
2011	618.5
2012	544.3
2013	875.8
2014	370.8
2015	515.1



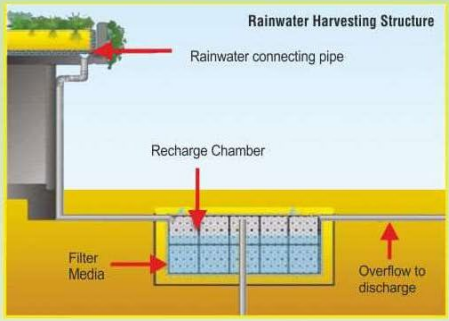
Source: India Meteorological Department

What is Rainwater Harvesting (RWH) ?

Rainwater harvesting is

- Collection and storage of rainwater
- That runs off from catchment area likes roofs, roads, pavements, etc.
- This rainwater can recharge the ground water.

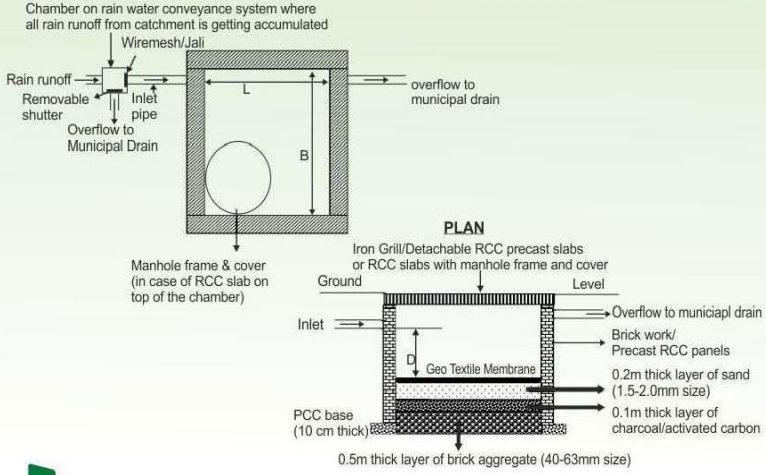
HOW ?



Rainwater Harvesting Structure in a building

Two Type of RWH Recharge Chambers

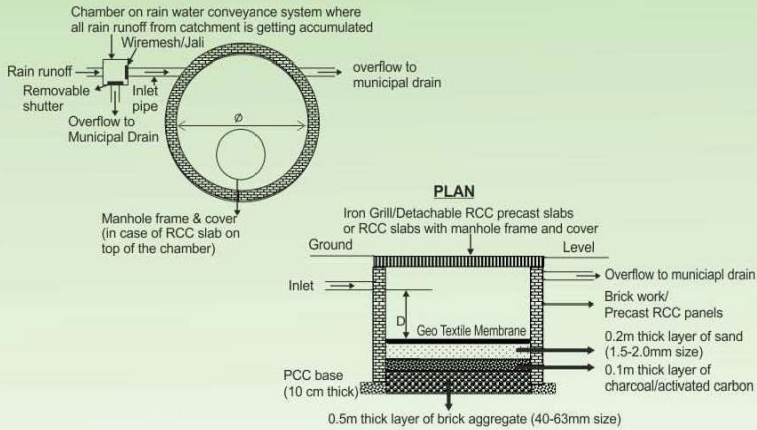
Fig. 1 Rectangular Recharge Chamber for RWH



AREA REQUIREMENT

S. No	Plot Area (sq.m)	Maximum Roof-top area as per DDA MPD-2021	Required Capacity (cum)	Suggestive dimensions of Recharge Chambers/Trenches {length (L) X breadth (B) X depth (D) in meters}
1	100	90	1.8	1.2X 1.2 X 1.25
2	200	150	3	1.2 X 1.2 X 2.1
3	300	225	4.5	1.5 X 1.5 X 2.0
4	400	300	6	1.8 X 1.8 X 1.85
5	500	375	7.5	1.8 X 1.8 X 2.30

Fig. 2 : Circular Recharge Chamber for RWH



AREA REQUIREMENT

S. No	Plot Area (sq.m)	Maximum Roof-top area as per DDA MPD-2021	Required Capacity (cum)	Suggestive Diameter (Ø) (internal) of Circular Chambers (mtrs)	Depth (D) of Circular Chambers (mtrs)
1	100	90	1.8	1.2m (4 ft)	1.6
2	200	150	3	1.5m (5 ft)	1.7
3	300	225	4.5	1.5m (5 ft)	2.5
4	400	300	6	2 structures of size mentioned in S. No. 2	
5	500	375	7.5	1 structure of size mentioned in S. No. 2 & 1 structure of size mentioned in S. No. 3 (i.e. total 2 structures)	

Remember: The above calculations give the 'effective' capacity i.e. the space inside the pit that will actually hold water. So the depth X width X length of the pit should be equal to the figures 1 & 2. The depths should be calculated from the inlet pipe down to the top of the filter media.

How to make and maintain RWH system?

Your Rainwater Harvesting systems should be designed in such a way that:

- even if it rains with high intensity continuously for 1 hour, your system should be able to store and recharge the runoff that flows into it.
- It is safe, easy to make and easy to maintain.
- It complies with the DJB guidelines so that you are able to avail of the RWH rebate.

Based on this, some recommendations for Implementation, Operation and Maintenance of RWH systems are:

✓ Calculate the water holding capacity of the pit (in cubic metres or kilolitres) that you will build by using this simple formula:

Rooftop area* (in sq.m.) X 0.8** (runoff coefficient for roof top/concrete area) X 0.025*** (average maximum rain fall intensity in meters per hour)

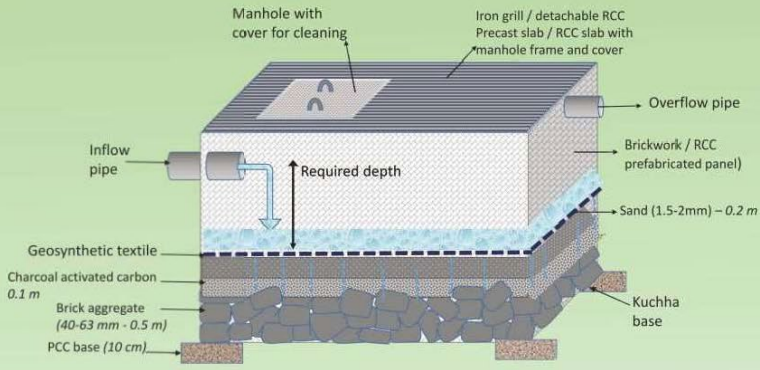
= roof top area x 0.02

* Rooftop Area – This is the total area of the rooftop of the building for which RWH is being made.

** Approx 20% of the rainwater that falls on a rooftop evaporates or is absorbed by the concrete. The balance 80% flows as runoff. That is why 0.8 is taken as the 'Coefficient of Recharge for rooftops

*** 0.025metre or 25 millimeters is the average rainfall that falls in an hour over 1 metre square area in Delhi.

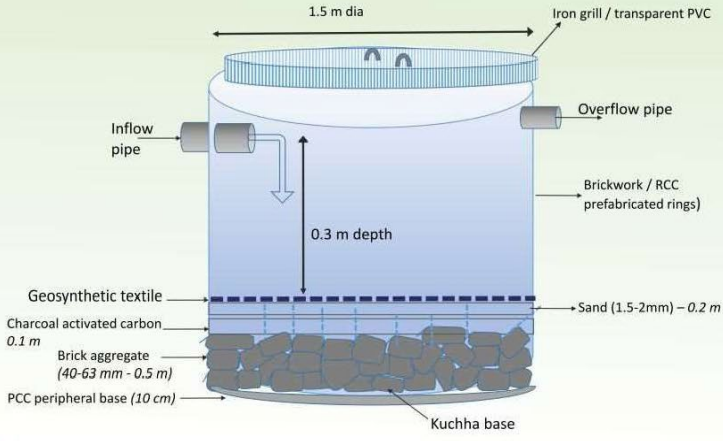
Rectangular Recharge Chamber for RWH



- ✓ Instead of filter media as mentioned in the drawings above, residents may also use multiple layers of jute mats in recharge chambers / modular filters in rain water pipes from rooftops. The objective is simply to arrest the silt in the rain runoff generated from the catchments before its percolation into the natural soil strata.
- ✓ It has to be ensured that no waste water enters Recharge Structures.
- ✓ Depths of recharge structures should be 1.0m - 4.0m.
- ✓ Recharge systems should be located at a safe distance away from the buildings/foundations.
- ✓ Run-off coefficient for bituminous roads/paved areas and open/green areas without steep slopes should be 0.6 and 0.1 respectively.
- ✓ Only non-polluted rain water from the catchment areas should be directed to recharge structures.

- ✓ All catchment areas should be cleaned before the onset of the monsoon to avoid any contamination.
- ✓ An overflow pipe in recharge structures should be provided leading out/ falling into municipal storm water drains / open areas. Under no circumstances should they be connected to the sewer.
- ✓ Recharge structures with requisite structural soundness must be implemented and adhered to all the construction and structural norms. The structure should not pose any danger to people and building. The design should be based on the soil type and land use. Thickness of RCC cover slabs and reinforcement shall be dependent on structural loads.
- ✓ Filter media consisting of brick aggregates (40/50/63 mm size)/charcoal and activated carbon/coarse sand (1.5-2.0mm) /geo textile membrane ought to be provided. For membrane even thick blankets can be used.
- ✓ Recharge structures are to be cleaned after every 2 rainfalls during the rainy season.
- ✓ Post monsoon cleaning and maintenance of recharge chambers shall be carried out.

Circular Recharge Chamber for RWH



- Roof should not be painted since most paints contain toxic substances and may peel off.
- Chemicals, rusting iron, manure or detergent should not be stored on the roof.
- Terraces should not be used for toilets either by human beings or by pets.
- Polluted water should not be used to recharge ground water.
- Rain water should not be harvested where post monsoon ground water levels are less than 5m.

Is Rainwater Harvesting Necessary in Delhi?

1. **Regulations from Ministry of Urban Development, GOI:**
   By law it is mandatory for all NEW buildings or plots of 100sqm and above or discharge of 10,000 litres and above per day
2. **Regulations from Delhi Jal Board**

a. Water permission to be granted to new house, only when a certificate given by the concerned Zonal Engineer, DJB, that applicant has provided the requisite systems in the building plans sanctioned by the MCD/DDA/any other land developing authority

b. Bulk water connection is given to an applicant only when he has a certificate of installation of functional rainwater harvesting structure in his building by Executive Engineer / Superintending Engineer of the area.

c. All plot / property of size 100sqm and above can avail the benefit

d. Intimation needs to be given to the nearest ZRO

e. Failing to install RWH structure will invite **penalty** of 1.5 times the water bill for all property 500 sq. mtrs and above.

f RWH through artificial ground water recharge structures is not recommended where post monsoon ground water levels are shallower than 5m. Penalties as per the Delhi Water & Sewer (Tariff & Metering) Regulations, 2012 will not be levied on DJB consumers for non-provision of RWH system in such areas. However, in such areas rain water storage for its use in non-potable purposes after required treatment may be carried out as a voluntary option.

Such areas are **Sidharth Extension, Okhla Phase 3, Jahangirpuri** and **Civil Lines.** Areas like **East Delhi colonies along Yamuna** exempted from RWH. The above list of places are only illustrative and not exhaustive.

3. BENEFITS OF INSTALLING RWH STRUCTURE :

I. Rebate of 10% of water bill for all plot/properties above 100 sq.m for installing functional RWH structure.

ii. Each individual member from that society will be entitled to the 10% rebate if a society installs functional RWH structure as per the guidelines issued.

Use the water when its falls ....

Guidelines on Rain Water Harvesting are available at DJB

Website: www.delhijalboard.nic.in or Call on our Tollfree No. : 1916.

You may also visit Office of EE (RWH/GWC)

Delhi Jal Board, Room No. 11, Varunalaya Phase-I, Karol Bagh, New Delhi-110005, Tel. No. 011-23558264

May be contacted for technical assistance on Rain Water Harvesting.

हिन्दुस्तान 25 APR 2016

जुलाई के पीक ऑवर में दिल्ली जल संकट से दो चार हो सकती है, इस बांध से दिल्ली को करीब 300 क्यूसेक पानी मिलता है

भीषण गर्मी में टिहरी का पानी घटने से दिल्ली में बढ़ सकता है संकट

कहां से आता है दिल्ली में कितना पानी

जल बोर्ड निर्माण के लिए दे रहा है पानी : भाजपा

26 APR 2016

दैनिक जागरण

अभियान बने जल संरक्षण

दैनिक भास्कर 25 APR 2016

दैनिक भास्कर आज से शुरू कर रहा है जल सत्याग्रह, क्योंकि...

हम पानी बना नहीं सकते, सिर्फ बचा सकते हैं...इसलिए एक ही रास्ता है- पानी चाहिए तो उसे अभी से बचाइए

जलसंकट की बोलती तस्वीरें और घर में पानी बचाने के 9 तरीके

PIONEER 2 MAY 2016

THE WATER SAGA

- The Central Ground Water Board (CGWB) estimated the annual replenishable groundwater resources in NCT Delhi as 29,710 hectare meter (Ha m) and the net groundwater availability of NCT Delhi as 28,156 Ha m
- In other potential fresh water areas of Delhi, the annual rate of decline is nearly 1m per year. It is to be noted that minimal decline in groundwater level is observed in areas where saline water is found at shallow level
- The Yamuna flood plain of NCT Delhi is the only potential area where possibility of recharge to compensate groundwater abstraction exist, while in other fresh water areas either there is dense habitation or the formation characteristics limits groundwater recharge
- The growing demand of portable groundwater has led to rapid depletion in groundwater levels of the areas where the fresh saline water interface is at greater depth (Southwest Delhi)

TRIBUNE 26 APR 2016

Tribune -5

Yamuna level drops, water crisis in many districts

SUSHIL MANAV

CHANDIGARH, APRIL 25

Drop in water level of Yamuna has led to scarcity of drinking water in several districts, including Yamunanagar, Hisar, Bhiwani, Mahindergarh and Rewari. These districts are supplied water through the Western Jamuna Canal and other water channels emanating out of Yamuna.

The daily gauge slip of the ...

which, 761 cusecs is meant for the national pool, leaving 887 cusecs to distributed on 1/3rd and 2/3rd basis between Uttar Pradesh (299 cusecs) and Haryana (588 cusecs) respectively.

Due to soaring heat, the average discharge of water at Hathnikund Barrage on the Yamuna this month stood at 2,278 cusecs against 5,716 cusecs recorded in 2014 and 6,323 cusecs in April 2015.

The average discharge of ... touched a record low of

Average discharge from Hathnikund Barrage

Year	Monthly/ Cusecs	Daily/ Cusecs
2016	2,278	1,064
2015	6,323	5,954
2014	5,716	6,280

age flow of 5,954 cusecs in 2015, 6,280 cusecs in 2014 and 5,055 cusecs in 2013.

The Supreme Court has directed the state to give Delhi its share of water ...

ordered Haryana to leave 352 cusecs in the Yamuna for to support aquatic life and other ecological reasons.

Angad Bishnoi, superintending engineer (SE), Public Health Engineering (PHE) Department, where 62 out of 235 waterworks get their water supply from Western Jamuna Canal (WJC), said the situation was very gloomy.

"Now, water is supplied for ... supply are followed by 16 days of closure," Bishnoi added. In Bhiwani district, villagers have been sitting on dharna for the past 13 days in protest against acute water shortage in Siwani Mandi.

"As many as 30 villages of the district are facing serious water crisis. The situation might turn even worse than in Latur district of Maharastra," alleged Balwan Bagri, a protestor.

दैनिक जागरण 26 APR 2016

दिल्ली में बढ़ सकता है पेयजल संकट

टिहरी बांध से पानी आपूर्ति घटी तो यमुना पार सहित कई इलाकों में लोग बूंद-बूंद पानी को तरस जाएंगे

राज्य ब्यूरो, नई दिल्ली: राजधानी के कई इलाकों में अभी से पेयजल किल्लत शुरू हो गई है। उत्तराखंड के टिहरी बांध से जिस तरह पानी का स्तर घटने की सूचनाएं आ रही हैं यह दिल्ली के लिए अच्छे संकेत नहीं हैं। इसलिए दिल्ली में पेयजल संकट बढ़ सकता है। टिहरी बांध से पानी आपूर्ति घटी तो दिल्ली के यमुना पार सहित कई इलाकों में लोग बूंद बूंद पानी को तरस जाएंगे। ऐसे में भूजल का दोहन भी बढ़ने की आशंका है।

दिल्ली पानी के लिए दूसरे ...

संयंत्र से दक्षिणी दिल्ली में भी पानी की आपूर्ति होती है। बताया जा रहा है कि टिहरी बांध के पास नदी का जल स्तर गिर रहा है। अप्रैल महीने में ही करीब 16.50 मीटर तक जल स्तर गिर चुका है। मई में जल स्तर और गिरने की आशंका है। इससे दिल्ली जल बोर्ड भी चिंतित है। क्योंकि टिहरी बांध से पानी आपूर्ति प्रभावित होने पर सोनिया विहार व भागीरथी जल शोधन संयंत्रों से पानी आपूर्ति कम हो जाएगी। इससे पूर्वी दिल्ली और दक्षिणी दिल्ली में पानी के लिए हाहाकार मच सकता है। वैसे भी ...

Millenium Post 30 MAY 2016

Rainwater harvesting yet to catch up despite dip in groundwater level

ANUP VERMA

NEW DELHI: The national Capital is witnessing sharp decline in the groundwater level, but residents are reluctant to complying with rainwater harvesting bye-laws.

While the three MCDs, government agencies and environmentalists have earnestly been urging people to adopt ...

... ally and the number of rainy days are as low as 20-30, yet the water-saving technique is a workable model to gather water from precipitation.

Deputy Chairman Standing Committee, North MCD, Rajesh Bhatiya, who is likely to move a proposal for strict implementation of rainwater harvesting under its jurisdiction, said the groundwater was being used extensively in ... Delhi for both irrigation ... raw water requirement. ... the water level had gone ...

PIONEER 2 MAY 2016

Groundwater table dips in Southwest, normal in other parts

In South district, the level of groundwater was found at 51.76 meters down from earth's surface; Land usage and rainfall both contribute in fluctuating groundwater, says CGWB experts

SAPNA SINGH ■ NEW DELHI

Situation of groundwater level in South and Southwest districts of Delhi is critical as water level has depleted, however, hydrogeologits in the Central Ground Water Board (CGWB) said the situation is not alarming because condition of groundwater in other places is normal.

In January CGWB moni-...

Capital, groundwater tab was measured very below in South and Southwest district. Groundwater level in Asola Bhatti range was found at 45.98 meters to 51 meters. It is less populated area. Groundwater was found 34.28 and 59.51 meters below the ground surface at Hauz Kahs and Pusp Vihar vihar area.

Sources in the CGWB said land usage and rainfall both ...

GROUNDWATER REPORT

State: Delhi

District: East

1 Chilla Regulator	8.4 (mbgl)
2. MayurVihar	8.08
3.Nagali Rajapur	3.46
4. Nizamuddin Bridge -1	4.39
5.Nizamuddin Bridge -2	3.76

New Delhi

India Gate	8.13
Lodhi Garden	8.31
Mahabir Vansth	27.19
Nehru Park	21.9

CGWB.

While stating about the deeper and shallower water levels in the National Capital Territory (NCT), the hydrogeologist in the CGWB said the ...

meters below ground level (mbgl) and nearly 30 per cent wells showed depth to water level in the range of 20 to 40 meters below ground level.

In New Delhi district 70 per cent of wells showed depth to water level in range of 8 to 12.36 mbgl while only 30 per cent wells showed depth to water level from ground above 20 per cent.

Notably in North Delhi ten per cent of well showed depth to water level is ...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Dr. AMIT KUMAR SINGH

Dr. Amit Kumar Singh is currently working as Assistant Professor at Indian Institute of Public Administration, New Delhi. He holds his M.Phil and PhD in Urban Development from Jawaharlal Nehru University, New Delhi. He has research and teaching experience on urban development with specialization on housing, regional planning, natural resource management, poverty alleviation and gender equality. He has contributed number of research papers/ chapters in journals of high repute and also authored two books. He has organized a number of training programmes/workshop for various Ministries, Departments and Organizations. He has also been associated with various studies focusing on Tribal Development and Welfare. He has been awarded Junior Research Fellowship in the discipline of Geography by UGC and is a recipient of "N.P. Aiyar Young Geographer of the Year", awarded by National Association of Geographers, India (NAGI). He is a member of the Editorial Board of 'NAGARLOK'; a UGC refereed quarterly journal of IIPA.