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Effective Strategies for Rainwater Harvesting, Conservation, and Management in Indian Context

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Abstract

The research paper delves into the vital domain of Rainwater Harvesting (RWH) encompassing its diverse applications, conservation techniques, and tailored management strategies tailored to both urban and rural settings. With mounting global concerns over water scarcity, this study seeks to dissect the multifaceted dimensions of RWH as an indispensable solution. The paper critically evaluates the efficacy of RWH systems in accumulating and utilizing rainwater for a myriad of purposes, thereby alleviating pressure on conventional water sources. By analyzing distinct approaches for urban and rural contexts, it uncovers the intricate interplay between technological, infrastructural, and socioeconomic factors that influence successful implementation. In addition, the study assesses potential challenges and opportunities in integrating RWH into existing water management frameworks. Through a comprehensive exploration of existing literature, case studies, and innovative methodologies, this research contributes practical insights that can inform policymakers, planners, and practitioners in their pursuit of sustainable water resource management.

Keywords: Water Scarcity, sustainable water resource, socioeconomic factors etc.

Introduction

Water, the essence of life, serves diverse purposes while intricately connecting to larger ecosystems that sustain biodiversity. Beyond arid regions, the challenge of freshwater scarcity extends even to areas with seemingly abundant supplies. Low water storage, limited infiltration, volatile precipitation patterns (such as monsoons), and high evaporation intensify this issue. The concept of water harvesting, initially coined by Geddes and evolved by visionaries like Meyer and Currier, involves collecting and storing various forms of water runoff-be it from rainfall or creek flow-for productive use. Once limited to arid domains, this practice now extends its reach to sub-humid and humid regions. In India, water harvesting ingeniously leverages erratic monsoons to nurture crops in arid tracts and conserve excess runoff for drinking and recharging aquifers. This transformational approach catalyzes sustainable solutions amid the intricate tapestry of water dynamics.

History of Rain Water Harvesting

The history of rainwater harvesting in India is deeply rooted in the country's rich tradition and cultural practices. Dating back to ancient civilizations, such as the Indus Valley and Vedic periods, ingenious water management techniques were employed to harness and conserve rainwater. Historical texts and archaeological evidence highlight the construction of intricate systems like step wells, tanks, and reservoirs, which were ingeniously designed to capture and store rainwater for agricultural and domestic purposes. These early water harvesting practices were not only utilitarian but also symbolic of the communities' respect for water as a sacred resource. Over time, this knowledge was passed down through generations and adapted to various geographical and climatic conditions across the subcontinent. As modern challenges of water scarcity and urbanization continue to emerge, understanding the historical evolution of rainwater harvesting in India offers valuable insights for sustainable water management strategies in the present day.

The history of rainwater harvesting unfolds as a testament to human ingenuity and adaptation across diverse civilizations worldwide. From the ancient Nabateans of Jordan, who ingeniously channelled rainwater into cisterns for arid survival, to the Anasazi Native Americans' intricate systems in the American Southwest, cultures have grappled with water scarcity through innovative solutions. In regions like Rome, ancient aqueducts exemplified sophisticated rainwater collection techniques, reflecting a deep understanding of hydrological principles. Moreover, the sustainable farming

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practices of the Inca civilization, utilizing terracing and reservoirs in the Andes, highlight the integration of rainwater into agricultural productivity. The historical tapestry of rainwater harvesting is woven with a shared awareness of water's vital importance and the need to harness its life-sustaining potential. This historical continuum resonates today, offering invaluable insights as contemporary society confronts pressing water challenges within an ever-changing global landscape.

Need for Rain Water Harvesting

Water is a becoming a scarce commodity and it is considered as a liquid gold in this part of the country. The demand of water is also increasing day by day not only for Agriculture, but also for household and Industrial purposes. It is estimated that water need for drinking and other municipal uses will be increased from 3.3 MHm to 7.00 MHm in 2020/25. Similarly the demand of water for industries will be increased by 4 fold i.e. from 3.0 MHmti 12.00 MHm during this period At the same time more area should be brought under irrigation to feed the escalating population of the country, which also needs more water. But we are not going to get one litre more water than we get at present though the demand is alarming. The perennial rivers are becoming dry and ground water table is depleting in most of the areas. In Coimbatore, the depletion is about 30-50m in the last 30-40 years. Country is facing floods and drought in the same year in many states. This is because, no concrete action was taken to conserve, harvest and manage the rain water efficiently. The rainfall is abundant in the world and also in India. But it is not evenly distributed in all places. India being the monsonic country, the rain falls only for 3 to 4 months in a year with high intensity, which results more runoff and soil erosion. Total rain occurs only in about 100 hours out of 8760 hours in a year. It also erratic and fails once in 3 or 4 years. This is very common in many parts of the country. 2 The availability of water in the world, in India is given below with rainfall.

Table 1: Rainfall Comparison, India and the World

Places	Rainfall in mm	Population	Availability of Water/Person/Yr M3/P/Year
World	840	6 Billion	700
India	1150	1.0 Billion	2200

If the availability of water is 1700 M3/p/y, there will be occasional water stress, and if it is less than 1000 M3/p/y, it is under water scarcity condition. Though India is not under water stress conditions but Tamil Nadu state is already under water scarcity condition, but there is no need for panic since it is possible to manage this condition as in the case of Israel where the availability is only about 450 M3/p/y, by means of water harvesting, water conservation and water management. Water scarcity/stress is not limited to the arid regions; only but also occurring in high rainfall areas also. Cherrapunji Gets more than 11,000mm of average annual rainfall but face drinking water problem before monsoon commences whereas in Ralegoan Siddhi, in Maharastra there is no water scarcity problem though the annual average rainfall is only about 450mm. Hence to mitigate water problem/drought etc, there is an urgent need to follow our ancestral way of water harvesting and the latest technologies adopted in Soil and water conservation measures on watershed basis including roof water harvesting etc which are described in detail below. The Theme paper on Water vision 2050 of India, prepared by Indian Water Resources Society (IWRS) has indicated that a storage of 60 MHm is necessary to meet the demand of water for irrigation, drinking and other purposes. But the present live storage of all reservoirs put together is equivalent of about 17.5 MHm which is less than 10% of the annual flow in the rivers in the country. The projects under construction (7.5 MHm) and those contemplated (13 MHm) are added, it comes only 37.50 MHm and hence we have to go a long way in water harvesting to build up storage structures in order to store about 60 MHm. More than 75% of the areas comes under hard rock in Tamil Nadu. Further the porosity of the rock is only about 3%. The natural recharge of rainwater in this region is only about 8-12%, which is very minimal. Therefore there is an urgent need to take up the artificial recharge of the rain for which water harvesting and water conservation structures are to be build up in large scale. The rainfall in coastal area is more than 1200 mm (Chennai) still; drinking water is a problem in almost every year. This is because the entire rainwater is collected in masonry drains (from houses, streets/roads etc.) are taken to the sea instead of taking into the ground water aquifers or in surface reservoirs by pumping if need be. The ground water available can be used during summer and make the aquifer empty so that the rainwater can be put into the aquifers during rainy period by suitable water harvesting measures. All the above details indicate the need for water harvesting measures in urban and rural area for the use of Agriculture, drinking and other purposes.

The need for rainwater harvesting in Indian villages is pressing and multi-faceted. As the backbone of rural life, agriculture heavily relies on timely access to water resources. Erratic monsoons and depleting groundwater levels have intensified water scarcity, exacerbating the vulnerability of rural communities. Rainwater harvesting offers a crucial solution by empowering villages to capture and conserve rainwater for agricultural needs, livestock care, and domestic consumption. Moreover, it mitigates the adverse effects of droughts, ensuring a more reliable water supply during dry spells. In a broader context, rainwater harvesting aligns with sustainable development goals, addressing both water scarcity and environmental preservation. By reviving traditional water management practices tailored to local conditions, Indian villages can enhance their resilience against climatic uncertainties and secure a more prosperous and water-secure future.

Methods of Water Harvesting in Rural and Urban Areas

There are different/various system of water harvesting depending upon the source of water supply and places as classified below

a) In Situ Rainwater Harvesting

- Bunding and terracing.
- Vegetative/stone contour barriers
- Contour trenching.
- Contour stone walls.
- Contour farming.
- Micro catchments.
- Tie ridging methods
- Farm ponds

b) Direct Surface Runoff Harvesting

- Roof water collection
- Dug out ponds/storage tanks
- Tankas
- Kundis
- Oorans

- Temple tanks
- Diversion bunds
- Water spreading

c) Stream Flow/Runoff Harvesting

- Nalla bunding
- Gully control structures
- Check dams-Temporary Permanent
- Silt detension tanks
- Percolation ponds

d) Sub Surface Flow Harvesting

- Sub surface dams
- Diaphragm dams

Plan of Action for Rainwater Harvesting

Rainwater harvesting, an age-old practice woven into the fabric of civilizations across the globe, including India, often resurfaces when water scarcity reaches dire levels, notably for drinking purposes. The wisdom of investing substantial resources into mitigating scarcity becomes apparent only when the well runs dry, affecting not just domestic supply but also industrial and agricultural sectors. To avert such crises, it's imperative to proactively implement water management strategies before the onset of the rainy season. By harnessing rainwater that would otherwise escape as runoff beyond sub-watershed or city confines, direct usage or groundwater replenishment becomes feasible. Despite government-led initiatives in watershed development, these efforts often lack holistic integration of various water harvesting methods. Thus, the systematic implementation of watershed development programs, particularly focused on scientifically sound water harvesting techniques, becomes indispensable. While the Tamil Nadu government mandates water harvesting provisions in construction, execution remains imperfect. Effective monitoring by concerned authorities is vital to alleviate drinking water challenges across municipalities and corporations. In conclusion, varied water harvesting systems tailored to specific needs can be successfully implemented across different regions of the country, contributing to sustainable water management.

Table 2: Usage of water in different area

No.	Region	Types of Water	Use
1	Arid area	Artificial catchments to capture rainfall (tankas or kundis in Rajasthan)	Drinking
		Tanks or talabs in Rajasthan to capture surface runoff	Drinking and Irrigation
		Embankments/obstructions across drainage/Nalla to capture surface runoff	Irrigation water & for recharging
2	Semi-arid places	Tanks/Ponds/Eri to capture surface runoff and also chains of tanks called cascade	Irrigation water and drinking water through recharge of ground water
3	Flood plains	Mud embankment which may be breached during the floods.	Irrigation and water drinking water through recharging ground water
4	Hill and Mountain region	Diverted stream flows Jammu, M.P., Maharashtra	Irrigation water

Case Study in Water Harvesting

A wealth of case studies showcases the effectiveness of water harvesting strategies across both rural and urban contexts. In rural areas, the focus lies on watershed-level Soil and Water conservation initiatives aimed at preserving and enhancing groundwater resources. Conversely, urban sectors emphasize roof water harvesting for immediate consumption and groundwater recharge, alongside the collection of surface runoff from roads and pavements. This collected water is then channelled into the ground through methods like recharge pits or repurposed wells. The implementation of rainwater and roof water harvesting has yielded fruitful outcomes in various locations, demonstrating its viability. Successful instances can be observed in:

Cherrapunji, India: Renowned for its heavy rainfall, Cherrapunji employs rainwater harvesting to capture and store rainwater for essential domestic use, addressing frequent water shortages.

Singapore: Overcoming limited water resources, Singapore's integrated urban water management utilizes roof water harvesting and advanced purification methods to ensure a sustainable water supply.

Berlin, Germany: The city's progressive approach includes green rooftops and permeable pavements for rainwater collection, aiding in groundwater replenishment and flood prevention.

Melbourne, Australia: Facing water stress, Melbourne promotes rooftop rainwater collection and storage, reducing strain on conventional water sources.

Tucson, USA: Employing rainwater harvesting systems on a community level, Tucson offsets water scarcity through innovative collection and distribution methods.

These instances spotlight the adaptability and success of rainwater and roof water harvesting in addressing diverse water challenges, endorsing their relevance in both rural and urban landscapes.

Case Study: RWH in Singapore

Singapore, densely populated city-state facing limited water resources due to its geographical constraints, has become a global model for innovative water management strategies. Among these, rainwater harvesting stands out as a sustainable solution to supplement the nation's water supply. With a commitment to water security and self-sufficiency, Singapore's comprehensive approach to rainwater harvesting showcases its adaptability to urban environments.

Implementation and Infrastructure: Singapore's public housing program, which accommodates around 80% of its population, incorporates rainwater harvesting systems. Rooftop catchment areas are designed to channel rainwater into storage tanks. These tanks, often located on elevated platforms within housing complexes, can hold thousands of litters of harvested rainwater. This decentralized approach optimizes space and captures rainwater before it enters the drainage system.

Integration with Water Supply: Rainwater collected through this method is primarily used for non-potable purposes, such as flushing toilets, irrigation, and industrial processes. This lessens the burden on Singapore's potable water sources, which are primarily imported from neighbouring countries. By offsetting demand for treated drinking water, rainwater harvesting conserves resources and reduces reliance on external suppliers.

Technological Advancements: Singapore has also leveraged technological innovations in rainwater harvesting. Smart

sensors monitor tank levels, ensuring efficient utilization and timely maintenance. This integration of technology optimizes water usage, preventing wastage and overflow.

Challenges, Successes and Conclusion: Challenges faced include maintaining water quality within storage tanks and addressing public awareness and acceptance. However, Singapore's success in rainwater harvesting is evident in its multifaceted achievements-from reducing reliance on external water sources to enhancing its water security and promoting sustainable urban living practices.

Singapore's rainwater harvesting model provides a compelling case study for urban water management. By integrating this technique into urban planning, Singapore showcases the feasibility of utilizing rainwater to mitigate water scarcity in densely populated settings. Its commitment to innovation, technology, and sustainable practices positions the nation as a global leader in water resource management, setting an example for other urban centers grappling with similar challenges.

Conclusions

Promoting universal involvement in water management is paramount. This entails engaging every individual and community in both the provision and safeguarding of water resources. By fostering a collective effort focused on water, we instigate a grassroots movement, empowering both urban and rural communities to oversee their own affairs, with the state serving a crucial supportive role. Enhanced community participation not only fosters a sense of ownership over water projects, including watershed development, soil and water conservation, and water harvesting, but also mitigates the misallocation of government funds. Moreover, when communities take charge of their water supply systems, they are more inclined to ensure their proper maintenance. Through such inclusive approaches, we can effectively address the water challenges confronting our nation in the 21st century.

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