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A Review on Recent Trends in Rooftop Rainwater Harvesting Technologies

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Abstract: Water is one of the world's most valuable resources. Water is required for a variety of tasks in our daily lives. The traditional method of damming rivers and transferring water to urban areas has its own set of social and political difficulties. In order to preserve water and satisfy our daily demands, we must consider alternative cost-effective and relatively simple technical techniques of water conservation. Rooftop rainwater collecting is one of the most effective ways to meet these needs. To begin, the necessary data, such as catchment regions and hydrological rainfall data, are gathered. The collected water must be analysed physically, chemically, and biologically in a laboratory setting. The rooftop's water collecting potential must be calculated. In this review paper methods of analyzing rooftop materials, basic rooftop designing for rainwater harvesting and new technological updates in identification and evaluation of a potential rooftop for rainwater harvesting are reviewed.

Keywords: Rwh , Gis , Materials , Remote Sensing

I. INTRODUCTION

As the world's population grows, so does the need for food. The need for high-quality drinking water is growing. Groundwater and surface water supplies are being depleted. They are depleted quicker than they can be replenished. Rainwater harvesting is a centuries-old activity that is still used today. Many countries have accepted it as a viable option as water supply that is not centralized Rainwater collected by individuals One of the various tools available is harvesting systems, satisfying the ever-increasing need for water Rainwater Harvesting is a safe and ecologically friendly way to resolving challenges raised by huge projects Using a centralized water management system approaches. The world's population is increasing. is producing comparable issues and questions about how to deal with it. Ensuring that everyone has access to safe drinking water is ne important parameter that has to be considered. Cities are developing vertically as land demand grows, and more forest areas are encroached and exploited for agriculture in the countryside. Small farmers in India rely on the Monsoon, which occurs from June to October and causes most of the valuable water to be lost as surface runoff. While irrigation is the most obvious answer to drought, it is also the most expensive and only benefits a select number Rain water harvesting, or 'Rain Water Harvesting,' is a low-cost option that is gaining popularity (RWH). Rainwater harvesting is a technique for collecting, transporting, and storing rainwater from relatively clean surfaces such as a roof, a land surface, or a rock catchment for later use. The rainfall is usually collected in a rainwater tank or used to recharge groundwater. Rainwater infiltration is another component of rainwater collection that plays a critical role in storm water management and groundwater replenishment. Rainwater collection has been used to produce drinking water, residential water, water for cattle, and modest irrigation for over 4,000 years around the world, usually in arid and semi-arid locations. Rainwater harvesting is now widely recognised as a contemporary, water-saving, and easy technique. Roof-based rainwater harvesting is the process of collecting rainwater runoff from roof surfaces, which typically results in a considerably cleaner supply of water that may also be consumed. Rainwater harvesting systems may be placed in new and existing buildings, and captured rainwater can be utilised for a variety of non-drinking water uses such toilet flushing, garden watering, irrigation, cleaning, and laundry washing.

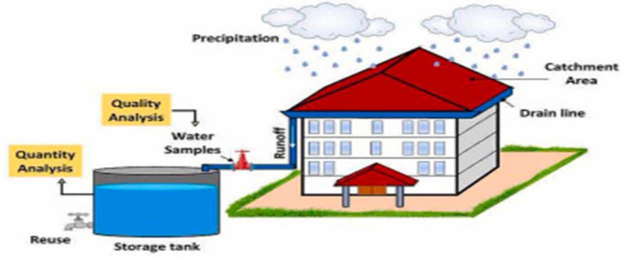

Fig 1.1: Generalized diagram for rooftop rainwater harvesting

Rainwater harvesting is also employed as a source of drinking water in many regions of the world. Because rainwater is so gentle, it requires less detergent and cleaning powder. Rainwater harvesting might save up to 50% of total family use in potable water. Rainwater harvesting technologies selection criteria When choosing rainwater collecting systems for home use, there are several variables to consider:

1) The size and kind of the catchment area
2) Data on rainfall and weather trends in the area
3) The duration of the drought
4) Sources of alternative water
5) The price of the rainwater collection system.
6) When rainwater collection is primarily used for irrigation, a number of issues must be addressed. These are some of them:
7) Rainfall volumes, intensities, and evapo-transpiration rates are all factors to consider.
8) Infiltration rate, water storage capacity, fertility, and soil depth are all factors to consider.
9) Crop features such as water need and growing season duration.
10) The site's hydrogeology.

II. LITERARTURE REVIEW

According to Krishnaveni et.al. (2016), This work is supported by a potential rain water harvesting system in Anna University, a central location in the city where a thousand people pass through each day. The college water supply appears to be at risk of occasional going away, but expanded water preservation will ensure a plentiful water supply in the future. In this approach, the amount of water that could be harvested was calculated. After that, accurate rainfall data was computed. The demand calculations are then completed, which include net inflow, sump capacity, and the number of sumps. They also believe that this study would provide useful information for the progress of water harvesting practices in Chennai and other parched and semi-arid regions of the world. According to G. Karthik Rajan, the PAVED AREA, such as a rooftop paved road or a driveway, is covered with pavements with a firm surface, such as concrete or asphalt. The paved area's runoff coefficient is 0.7. Rainwater may be collected in the paved area to the tune of 70%. The UNPAVED AREA is an area that is not covered with pavements and has no hard concrete or asphalt surface, such as a green surface area (lawn surface) The unpaved area's runoff coefficient is 0.2. In the unpaved area, 20% of the rainfall may be collected.

A. Effect of Materials used in Rooftops for rainwater harvesting

According to Carolina B. Mendez et.al,(2020)The main objective of this research was to provide information to the rainwater harvesting community in Texas regarding the impact of roofing material on harvested rainwater quality, In this study, rainwater sampling devices were installed on five pilot-scale roofs (asphalt fibreglass shingle, Galvane metal, concrete tile, cool, and green) as well as three full-scale residential roofs (two asphalt fibreglass shingle and one Galvalume metal) to collect the "first flush" and water after the first flush. pH, conductivity, turbidity, total suspended solids (TSS), total coliform (TC), faecal coliform (FC), nitrate, nitrite, total organic carbon (TOC), dissolved organic carbon (DOC), selected synthetic organic compounds, and selected metals were all measured in rainwater collected from multiple rain events. The quality of gathered rainwater is influenced by a variety of factors, including the roofing material used. The results of the full-scale investigation revealed that the quality of rooftop-harvested rainwater differed between two shingle roofs of similar age. In some cases, one of the full-scale shingle roofs had the highest concentration of a particular contaminant while the other shingle roof had the lowest concentration of the same contaminant (i.e., Shingle 2 consistently had higher TSS, FC, and TC concentrations than Shingle 1), implying that harvested rainwater quality is affected by geographical location. Third, as compared to other roofing materials, metal roofs did not necessarily leach larger quantities of metals. For example, the amounts of Al and Fe in rainwater collected after the firs

The concrete tile roof's flush was continually higher as metal Fourth, if the water is cleaned with chlorine, green roofs are not the greatest choices for rainwater gathering for interior domestic use. Although the rainwater collected after the first flush from the green roof had the lowest TSS, turbidity, nitrite, Al, Fe, Cu, and Cr, it had the highest TSS, turbidity, nitrite, Al, Fe, Cu, and Cr. DOC values were also the highest. The high DOC would be reduced if the rainwater was chlorinated. Excessive disinfection by-product concentrations might result from high concentrations of disinfection by-products. As a result, It is recommended that rainwater collected from a green roof not be chlorinated. Fifth, while metal and tile roofs are frequently suggested for rainwater gathering in the United States, Asphalt fibreglass shingle and cool roofs may also be beneficial in developed nations, according to our findings. This is something that should be considered

B. Use of GIS in Evaluation of Rooftops for Rain Water Harvesting

With developments in geospatial technology, the arduous task of estimating available roof top space may be simplified. The goal of this work is to create a roofing layer that uses high-resolution satellite images (1 m) from Google Earth Pro in a GIS context to estimate possible rooftop area. Roof surfaces are regarded as micro catchments, and GIS is used to assess the area of various roof types and their potential for water harvesting plans.

According to Preeti Preeti et.al, (2021), Jasrotia et al. (2009) studied the water balance in the Devak-Rui watershed, Jammu Himalaya, using GIS and remote Role of statistical remote sensing for Inland water quality parameters prediction sensing techniques,India. For the creation of the maps, GIS software was employed. Various theme maps, such as slope, drainage, and soil, are available. which were then used to determine the appropriateness of the RWH location Kim et al. (2012) conducted a year-long study. RWH research and non-potable water applications GIS was used in six distinct types of buildings. a crucial function in detecting and estimating building kinds places on the roof Fonseca et al. (2017) created a decision-making model, a technique for calculating the ideal tank size for nine case studies on the state of RWH systems, Mexico, to be precise.

High-resolution remote sensing can also assist monitor and understand the more diffuse and complicated effects of wetland restoration on water quality, according to the newest technologies in visible/near-infrared imaging spectroscopy (Fichot et al., 2016). By allowing simultaneous displays of many water quality indicators at a very high spatial resolution, this technique can help with water quality monitoring. Furthermore, contamination zones mapped by high-resolution (Ramadas & Samantaray, 2017) can be used to remediate the significantly impacted regions, using the mapping procedure based on the spectral signatures acquired by sensors. Surprisingly, with proper in situ validation, remotely sensed satellite pictures may give high-accuracy interpolation, allowing for more efficient generation of spatially explicit water quality maps, even in regions where in situ sampling is restricted (Haji Gholizadeh et al (2016). In conclusion, the fast development of remote sensing techniques, particularly the deployment of hyper-resolution satellites, permits the use of remotely sensed data for monitoring large-scale and long-term water quality monitoring. Furthermore, it illustrates how high-resolution satellite images may be used to analyse water quality utilising remote sensing. Various strategies and criteria have been devised and implemented by many researchers to determine suitable venues and techniques for RWH (Arshad, Shabbir, & Shakoor, 2013; Singh, 2014; Tiwari, Goyal, & Sarkar, 2018). Environmental pollution in metropolitan settings may be described using dynamic models that can deal with spatial–temporal data in a comprehensive way. The geographic description of urban areas is managed by GIS. Modeling is concerned with the operation of environmental processes, which include many types of urban pollution.

Country	*Use of GIS*	*Reference*
India	Identify RWH potential and suitable sites for RWH using GIS-based MCDA.	Singh et al. (2017)
Iraq	Identify and select suitable sites for potential dam site using ArcMap 10.4.1.	Ibrahim et al. (2019)
Australia	Evaluate rooftop rainwater harvesting potential using GIS.	Baby et al. (2019)
USA	GIS surface maps are analysed in combination with local utility consumption data to determine potential reduction in potable water consumption for households.	Grant et al. (2018)
South Africa	GIS-based RWH decision support system (RHADESS) which indicates suitable areas of different types of RWH and quantifies their hydrological impact in terms of change in runoff.	Kahinda et al. (2009)
India	Assess rainwater harvesting potential and identify suitable sites/zones for different RWH structures using remote sensing, GIS and MCDA techniques.	Jha et al. (2014)
Sri Lanka	Remote sensing and GIS techniques to develop a methodology to determine the main reason for the abundance of abandoned tanks in the Hambantota District and select the suitable areas for locating tanks.	Senanayake et al. (2012)
Iraq	Remote sensing approach was integrated with GIS to estimate the physical variables of a reservoir system.	Sayl et al. (2016)
Malaysia	Remote sensing and GIS are used in an urban environment to analyse, map and model the effect of various factors on rainwater quality.	Norman et al. (2019)
Palestine	Develop domestic water poverty and map of domestic RWH suitability for the West Bank. The map identifies the spatial distribution of water needs (water-poor areas) and the potential of RWH techniques for domestic water use.	Shadeed et al. (2019)

Table 1.1: Use of GIS for RWH in various countries

C. Remote Sensing in the Detection of Roofing Materials and Conditions

The urban surface contributes to long-term environmental degradation (Clark et al., 2008), and building rooftops play a critical role in urban storm water runoff, although accounting for about half of the total surface area in metropolitan areas (Ugai, 2016). Existing research has revealed that urban sustainability is dependent on various elements, including the quality of roof runoff in terms of roofing materials, roof conditions, roof geometry, weather conditions, and land use. Roofing materials and circumstances, on the other hand, have been recognised as the most critical factors of RRWH quality. The ability to retrieve roof data is valued, and knowledge of various materials and their circumstances can aid in the quality evaluation of rooftop harvested rainwater.

Data from remote sensing, such as land usage and land cover, was used to identify appropriate rooftop areas as prospective water collecting locations (Gaikwad, 2015). Taherzadeh and Shafri (2013) suggested a model for predicting and detecting four common roofing materials in Malaysia: concrete tile, clay tile, asbestos, and metal. These roofing materials data were then utilised to determine the RRWH quality. Intriguingly, existing geospatial data and derived data from satellite images were utilised to predict the water requirements for irrigating fruits and vegetable gardens in Rome's metropolitan area by collecting and using harvestable rainfall from roofs (Italy). RRWH benefits urban agriculture in residential areas, according to the findings (Lupia, Baiocchi, Lelo, & Pulighe),2017.

III. CONCLUSION

The review indicates that the quality of harvested rainwater is influenced by the quality of collected rainwater and the various storage medium utilised to store rainwater. As a result, their impacts on relevant parameters should be assessed. Standard methodologies should be used to examine physicochemical and microbiological samples in the future. This paper also reviews various rooftop materials and for rainwater harvesting also an understanding of use of GIS and remote sensing applications in the field of Rooftop rainwater harvesting are considered

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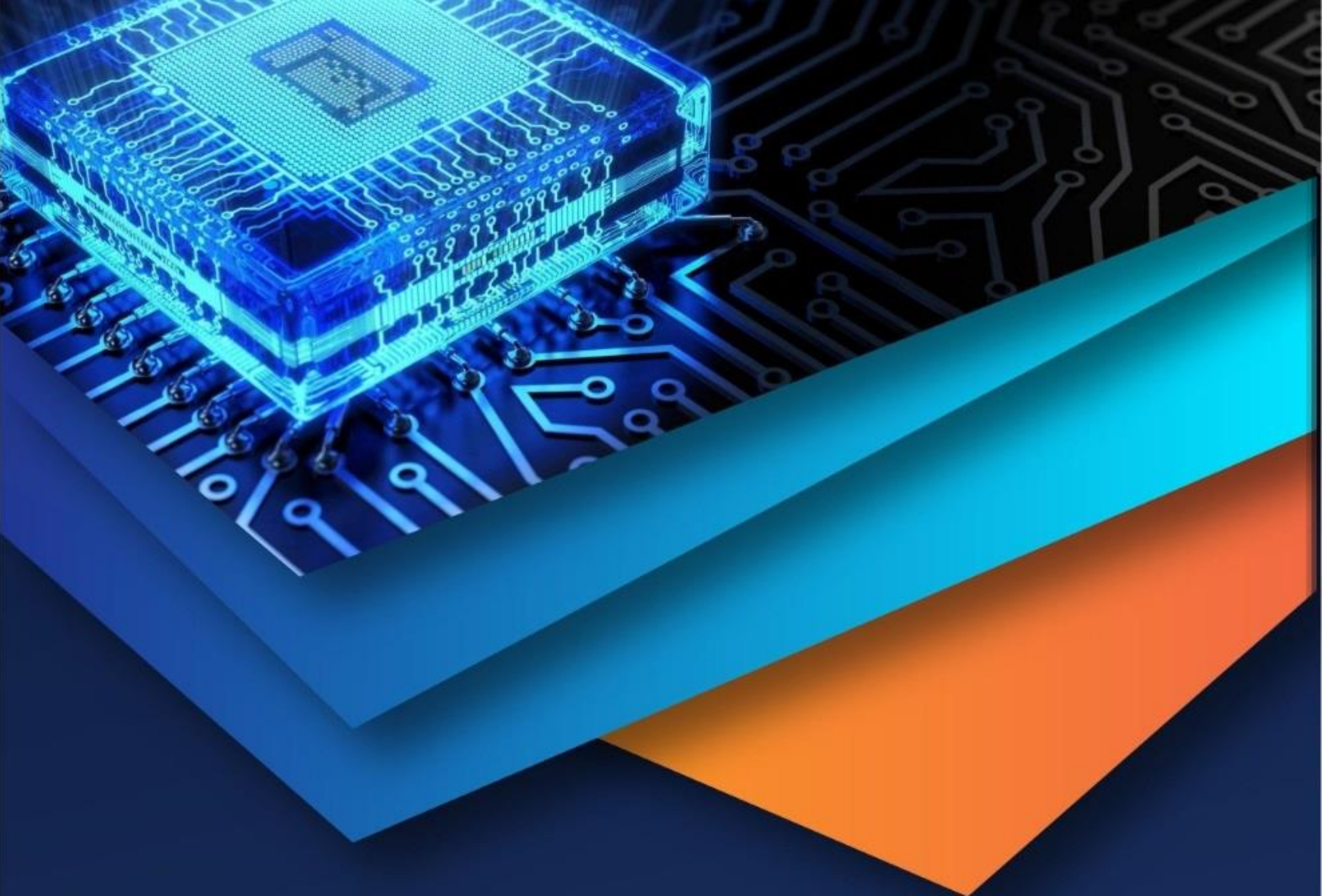

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