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Rainwater Harvesting Ancient to Modern

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Abstract: Rainwater harvesting has been essential throughout history, from primitive techniques to modern ones. Rainwater harvesting began in ancient cultures like the Indus Valley, Roman Empire, and Mesopotamia using rudimentary catchment and storage technologies. It then discusses modern water scarcity solutions using improved filtration, storage, and delivery systems. The paper shows how combining ancient wisdom and modern advancements can provide sustainable water management solutions.

Keywords: Rainwater Harvesting, Water Conservation, Ancient Water Systems, Sustainable Water Management, Traditional Practices, Modern Technology.

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1. Introduction to Rainwater Harvesting

Rainwater harvesting involves storing rainwater for later use. Its simplicity, potential to reduce dependence on external sources, and water supply reliability make it useful to all communities. Due to population increase and rising water consumption, urban water management has become more difficult in recent decades. Rainwater harvesting can expand water resources or delay infrastructure building. Rain water harvesting lowers traditional water supply system loss since it collects water from local catchment areas and only requires piping or pumping over the building or tank area. Due to lesser organics and dissolved solids, rain water is usually better than surface water. Rain water can be stored for a long time with proper collection and treatment. In many countries, rising ground water withdrawal has caused soil subsidence. Thus, rainwater collection supplements ground water and sustains urban water systems (Thuy Lan Chi et al., 2015).

2. Historical Overview

RWH collects, stores, and uses rainfall to ensure water supply for diverse operations. The traditional methods have adapted to meet urban water needs. In cities, RWH enables irrigation, drinking, and washing.

Historical data show RWH technology progress from antiquity to today. Since the Bronze Age, Mediterranean and Near Eastern civilisations have used natural runoff to move floodwaters into catchments. Basic collection mechanisms absorbed roof and sealed ground runoff. The flexibility of RWH appeals to locations with low water supplies; many supply schemes still use traditional tactics. In late antiquity, new technologies channelled runoff from terraces into a conduit network while crypts gathered groundwater from the subsurface in a core East Mediterranean water-harvesting cluster. By mediaeval times, such methods were known for great collecting efficiency (Beckers et al., 2013).

2.1. Traditional Rainwater Harvesting

Water supply affected ancient Mediterranean and West Asian dryland settlements (Beckers et al., 2013). Water-harvesting technology collects and manages natural landscape runoff. A common method was to convert rainfall into surface flow and direct runoff to a specific location. Water-harvesting systems are usually multipart. Catchments are locations having surface and soil features that allow water to accumulate and generate runoff. The system may include artificial catchments like bunds, pits, or trenches. RWH involves capturing rainfall on a storage medium, filtering, routing, and storing it. For millennia, people have used RWH, and at least 100 million do it worldwide. After centralised water-distribution schemes were introduced in the 20th century, it lost popularity (Bin Aftab et al., 2012).

2.2. Mediaeval Innovations

Floodwater harvesting, which was important at Petra, is still relevant, since Harraoubia and Jorf describe systems that maximise surface runoff collection from large catchments and reservoirs. An enhanced infiltration gallery, called locally as a qanat, kareez, or foggara, emerged in Eastern Arabia during the Iron Age and was widely adopted and used throughout the Islamic era (Beckers et al., 2013). The aser, a mechanical device for pulling water, was widely used from the Iron Age to relatively recently to move water from storage to fields and was a basic component of most irrigation systems. The integration of surface catchment water harvesting with groundwater extraction at Mediterranean and Northwest

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European Iron Age sites shows ancient efforts to diversify water supplies and protect precious resources.

2.3. Modern Changes

Independent rain water harvesting systems (RHS) are developed for rural areas lacking potable water. A catchment area and reservoir gather precipitation and convey water optically through capillary tubing and diffused light illumination (DLI) or combine rain water harvesting with daylighting to produce potable water and lights. A suspended solids filtration system using activated carbon, zeolite, or sand can be added to the basic design. In heavy rainstorms, spill-over methods drain excess water. Advanced systems capture rainwater from large roofing areas, store it in storage tanks with overflow systems, and pre-filter it on-site using easy-to-extract and clean sand and diatomaceous earth filters or automatic mechanical pre-filtration devices at larger, commercial-scale systems.

RHS water can be transformed into potable, non-potable, or dual-grade water. Bio-filtration, UV disinfection, groundwater recharge, and open-atmosphere storage are well-established methods for generating non-potable water from precipitation worldwide. An ultraviolet (UV) purifier can destroy 99.9944 % of microorganisms in rainwater, making it an effective pathogen-reduction technology. Ozone, chlorination, boiling, nano- and ultra-filtration, and micro-filtration reduce aquatic microorganisms.

Some countries have separate requirements for harvested rainwater since catchment water might be very different from storage reservoir water. The first-flood diversion technique diverts the initial flow of leftovers from the catchment surface to garbage, preventing them from entering a storage reservoir. The initial diversion volume (or “first flush” volume), catchment slope, and atmospheric deposit quality are all adjusted in such systems. Australian researchers developed a technique to calculate the initial runoff volume to divert based on catchment area and time since the previous rainfall. The projected rainfall and catchment filtering capacity were also evaluated. Beckers et al. (2013)

3. Cultural Importance

The cultural aspects of rainwater harvesting generate distinctive fabrications globally. Japanese rain chains feature frogs and turtles, whereas UK rain chains include vedes and gargoyles and cat and toad figurines. Mediaeval wells with gargoyle-like rills and spouts, going back to the 12th century, are among the oldest adaptations of the system for water flow and regulation (Beckers et al., 2013). One of the oldest water-supply devices in dry locations, it may predate the Neolithic site of Shillourokambos in Cyprus' stone walls. While not water-harvesting installations, similar tanks near Kohriya and Kuzundere demonstrate local communities' historic awareness of the need to store freshwater for future usage. Collectors dressed as chhatris in Rajasthan, western India, provide shade and water for camels and donkeys. The Mediterranean island of Pantelleria has renowned burial chambers with exquisite water-harvesting structure. By the Mediaeval time, municipal law understood Tanka's role as water reservoir and required the installation of a sundial to monitor water usage (Arabindoo, 2011). In the context of sacred religious functions, these cultural linkages provide technologically sound, practical backups for small water catchments and models for modern landscape architects seeking a deep contextual integration of water allocation and use without restriction or prescription. Pharaonic mythology glorifies ancient Egyptian rainwater harvesting and retention as a life-giving and sustaining force, while also acknowledging the dangers of water mismanagement and abuse (Wayne Honaker, 2018).

Southern Rajasthan, India, uses many local names and distribution systems for collecting, distinguishing collectors and their traits. Non-irrigation collecting techniques provide soil moisture for cultivation of arable, pasture, and wooded productive land. Water allocation and use is not a right without irrigation; catchment runoff makes it impossible. It is a constant negotiation between the water system, environment, cultivating groups, and social groupings. For thousands of years, rainwater collecting and precipitation seasonality have kept the landscape occupied.

3.1. Different Cultures' Rainwater Harvesting

Hydrologic interactions between populations and nature have traditionally relied on rainwater harvesting. Geomorphologies, regional climates, civilisations, religions, and social structures vary in ancient systems.

The Levant's Bronze Age saw the first systematic rainwater use. However, archaeological, faunal, and isotopic evidence suggests pre-pottery Neolithic B rainwater gathering techniques. Traditional ritual rituals inspired community cistern design and construction. This significance emerges in Babylonian, Islamic, and Roman cultures and persists in Punjabi bhunga-house courtyard steps.

Post-Roman rainwater catchers were universally reused. Water was gathered in painted hollows and water holes once the Gulf of Carpentaria basin dried up. Ritual prohibitions prevent pollution of these assets in prehistoric Aboriginal civilisations. Open, renewing trough-cisterna are found across Castile and the Balearic Islands. Trough-cisternas are formed of tightly placed bricks rendered using mortars rich in red and ochre clays and painted with them to promote tightness and block light to prevent algae growth.

Cisterns and grave-pools systems in the Outer Hebrides and Shetlands show that resting water limits rainwater catch and storage sizings and collective interactions. Large-scale capture increases operation and maintenance expenses, discouraging users. Constrained functionality axioms stabilise catch and store modalities throughout distribution.

Galvanised metal sheet roof catchments are spreading across rural areas, prompting the building of massive plastic tanks in El Salvador. Sealed cisterns are also increasingly popular in the Mediterranean basin, threatening to disrupt the traditional water harvesting discontinuum (Beckers et al., 2013) (Bin Aftab, 2012) (Thuy Lan Chi, 2015).

3.2. Religion and Spirituality

Rainwater collection was an environmental issue and a spiritual practice in many civilisations to connect to nature and the water cycle. Drought rites were linked to Chaahk, the rain, thunder, and lightning god of the classical Maya. One practice involved removing a saint's effigy from the cathedral, bathing it in a spring or sunbathing it until it sweated, and then pouring water on it (Jobbová et al., 2018). When rain prayers failed in the 1930s, similar activities were observed. The saint was exposed to the sun to signal drought severity, followed by processions around the church and prayers to Huitz-Hok and Santa U. Rainmaking rites often included effigies. God effigies were put in rivers, cleaned, sacrificed, and eaten together. Modern Turkish youngsters make dolls, parade with them, and splash water over them at each house before eating. Myanmar, Cambodia, and Laos celebrate the New

Year with Songkran ceremonies that pray for copious rainfall and harvests.

4. Technology Advances

Rainwater harvesting systems use concrete, brick, stone, or ferro-cement. Open wells, wells in a household courtyard, and cement tanks filled with rooftop rainwater collected through a catchment surface connected by roof gutters are collection methods. To ensure water safety and usage, technologies have evolved to prevent contamination (Beckers et al., 2013).

4.1. Materials for Rainwater Systems

Rainwater harvesting involves storing rainwater for later use. Roof rain water harvesting requires collection systems and surfaces (Bin Aftab et al., 2012). Sandstone, stone, concrete, brick, reinforced concrete, wood, sand, masonry wall, domestic containers, pollution traps, underground tanks, and surface ponds are common water collection and storage materials in several nations (Beckers et al., 2013). Metals, plastic, ceramics, and concrete are employed to collect water today (Abdul Mu'iz, 2017). Materials utilised do not affect fertilisation, gardening, or irrigation water use. Collection materials affect residential rainwater quality. Rainwater quality depends on its physio-chemical qualities, contaminants, organic materials, and microbes. Rainwater from rooftops or ground catchments is directed through gutters into delivery pipes or channels and finally into a storage tank or cistern to prevent contamination. Roof or catchment materials usually determine roof runoff quantity and quality. For rain water collection systems, galvanised iron and aluminium, polyvinyl chloride, and concrete gutters are best. Gutter materials must be tested for chemical stability and corrosiveness due to wind, rain or a mixture of hexavalent chromium and chromium oxide as discolouration agents. Roof materials must be chosen carefully to avoid potable discharge.

4.2. Modern Collection Methods

Rainwater harvesting is ancient and utilised worldwide. Strong rationales have supported the practice in numerous cultures and ages depending on climate. Water shortages plague arid and semi-arid countries. Rainwater harvesting covers agricultural runoff and intermittent flood systems in flood-prone catchments. Water collecting devices collect rainwater (Beckers et al., 2013). Rainwater collection and water quality management are common today. Buildings and rain catchments capture large amounts of water. One roof panel or many hectares of catchment surfaces can be used for collection. Long collecting times can modify physical and chemical characteristics in water (Bin Aftab et al., 2012). Research evaluates water quality under different storage durations and designs. Catchment components recycle a little amount of water, hence process dynamics must be considered in water quality assessments. A thorough understanding of rainwater quality variations allows for treatment, storage, and usage. Keeping water safe during storage for various uses is the eventual goal. Several operations and water quality concerns are involved in rainwater collection, transit, and storage.

Physical characteristics like topography, slope of the ground, type of soil, and type of vegetation, geographical characteristics like drainage pattern, basin area, and presence of local drainage channels, and meteorological characteristics like amount, distribution, and time of occurrence affect the design, efficiency, and scale of rainwater harvesting structures. Subjects examined flexural strength, coefficient of elasticity, fracture toughness, and impact resistance of cork-concrete, cork- and cellulose-cement plasters, as well as the definition of plaster with cement, fly ash, cork, This work advances the development of a bio-based, eco-friendly, thermally insulated wall rendering/plaster.

The paper “Design and analysis of a model rain water harvesting system” covers the initial stages of system development, from runoff model and storage reservoir design to economic and energy analysis. The analytical work presented will be used in a later stage of system module integration, where each RWH system subsystem will be subjected to a set of system design parameters, performance indicators, and constraints to determine its contribution to system performance.

4.3. Manage Water Quality

With proper stormwater management, rainwater harvesting can supply high-quality drinking water. Simple gravity-based filtration systems reduce organic and inorganic debris contamination, while enclosing tanks and utilising sealed taps reduce overall contamination (Bin Aftab et al., 2012). Many chemical contaminants decrease in storage, improving water quality, and first flush diverters reduce contaminant influx. Even without filtration, pre-tank filtration using sand, soil, or gravel can remove suspended solids, and chlorination can oxidise organic particulates that filtration cannot. The physical, chemical, and biological properties of the rainy surface determine the quality of any water collected. Many rainfall research have focused on trace elements with known toxicity and microbiological pollutants because it is often potable. Today, rainwater harvesting systems need modern technology and water quality management. Rainwater harvesting technologies are important for conjunctive groundwater and surface storage and should be part of a complete water-resource management plan.

5. Environmental Impact

Kerala's conventional water sources were failing, leaving rain water the sole option. Rainwater harvesting (RWH) has been utilised worldwide since ancient civilisations had little water, although it was not widely used until the 1970s. Rainwater collection infrastructure from 4000 years ago is still used. People in these catchments relied on carved-out tanks at lower Himalayan hill areas for water. Ancient central Indian deserts have stone-lined ponds for rainwater storage and special roof toppers. A Harappan (2500–1700 BC) site in Saurashtra, India, demonstrates a systematic rainwater gathering system. Ancient civilisations' water conservation practices show a well-planned water management approach (Beckers et al., 2013). All early dryland settlements in the Mediterranean and western Asia needed water gathering systems. Archaeological evidence suggests some water harvesting technologies have evolved since the early Bronze Age and are still utilised now. Thus, water collecting has been crucial to dryland civilisation and civilisation. Some culturally significant water-harvesting sites were both religious and spiritual, demonstrating that they were more than utilitarian. By providing reliable water in water-scarce places, ancient water-harvesting techniques may have helped many ancient cultures evolve and regenerate. Thus, these proven approaches have been reintroduced for global use as an option to ensure water supply. Engineers, planners, and hydrological experts can assess the viability and reliability of run-off farming systems for future water-supply projects by drawing inspiration from their heritage.

Stormwater management in water-sensitive communities aims to reduce flooding, diminish peak flow, and improve water quality. rainwater drains carry a lot of rainwater runoff into municipal sewer systems due to urbanisation. Thus, treatment plants struggle with high rainfall, releasing partially treated wastewater into receiving streams. RWH systems can store and use stormwater runoff to increase water supply, relieving treatment plant strain and lowering pollutants. RWH is especially useful in summer when residential water consumption is high. Since 1987, residential development plans in Singapore have included RWH systems, and water use from developed catchment regions has increased (Sukmahartati, 2018).

5.1. Sustainability, Conservation

Sustainability and conservation are key to rainwater gathering. Sustainable water management and household and city water conservation are achieved by these solutions. They control drainage and recharge groundwater by collecting rainwater (Wayne Honaker, 2018). Governments favour rain water gathering due of its sustainability. The 2005 Australian Rainwater Harvesting Act provided tax incentives for rainwater collection. Indian municipal governments have created cost-benefit models to anticipate the long-term financial benefits of rain water gathering.

5.2. Impact on Urban Planning

Rain water-harvesting in urban development plans has many benefits. Rain water harvesting (RWH) increases urban resilience by storing water locally during droughts and distribution disruptions (Carollo et al., 2022). As a decentralised auto-consumption mechanism, RWH diverts a portion of the public urban tap-water supply and reduces demand during peak hours, reducing pipe bursts (Beckers et al., 2013). Washing is a big water consumer, and replacing potable water with RWH non-potable water affects water system peak power. Harvested rain water cools the environment through evapotranspiration whether used for irrigation or cooling (Sukmahartati, 2018). Urban growth increases impermeable surfaces, reduces aquifer recharge, and alters runoff. Restoration of precipitation infiltration by RWH partially recharges aquifers. Finally, large-scale RWH reduces runoff and sewage network pressure, lowering urban floods. Urban planning can use stored water directly or integrate manmade infrastructure into a strategy that mimics and enhances natural penetration.

6. An economic perspective

Due to the growing need for more water, rain water harvesting (RWH) economics have garnered attention (Beckers et al., 2013). Civil engineers must code economic-productivity factors to consider cost reductions, small-scale, on-site opportunities, and downstream economic losses. To combine the relevant aspects and determine economic feasibility, use a life-cycle cost benefit analysis. RWH's harvestable potential will remain untapped without government commitment and incentives, even if economic incentives are high.

6.1. Cost-benefit analysis

Ancient civilisations like Mesopotamia, Egypt, India, and Kenya collected or redirected rainwater for harvesting. Early religious and scientific writings believe it important for holistic existence and a charitable gesture. RWH reduces water scarcity and is a sustainable water management approach in arid and semi-arid settings. In mediaeval England, RWH techniques and technologies were developed to capture rainfall from impermeable and massive urban surfaces, known as urban catchments. RWH is a viable tactical solution for orderly growth planning and stormwater drainage, despite its high evaporation and low runoff efficiency. The devices collect rainfall through impermeable surfaces in urban catchments and store it until needed, but RWH's poor quality prevents its broad use (Carollo et al., 2022).

Each solution's costs and benefits must be estimated for cost–benefit analysis. Spilt rainwater minus collection and conveyance losses, additional supply linked to the system, overflows, and unmet demand determines collected rainwater. Domestic RWH is often seen as a private option rather than a community water supply. RWH applications are extendable and can be used for local, national, and rural water-supply planning and development. RWH from urban surfaces can be used for irrigation, washing, fire protection, and other procedures when potable water quality is not needed, or as an alternative to residential water. New legislation provides tax relief for domestic RWH installations and grant schemes to increase uptake. These incentives allow for long payback periods and, when combined with a reasonable water supply tariff upgrade, will strengthen the economic case for RWH schemes (A. Appiah et al., 2017).

6.2. Government incentives and policies

To address environmental and economic issues, governments worldwide have encouraged rain water harvesting (RWH). RWH meets water demands sustainably and decentralizedly, reducing potable water use and grey-water discharge pressures. Policy frameworks can encourage municipalities and SMEs to embrace RWH and invest in related technology industries. Sanitation, hot water safety and delivery, and water efficiency are regulated in the UK. Modelling has examined energy and carbon impacts, centralised versus decentralised regulation, and system lifespan costs. UK policy is open to revisiting RWH's role in addressing water shortages. The Landscape Irrigation Act of 1991 in the US restricted RWH to prevent groundwater aquifer depletion, but emerging evidence of its environmental, economic, technical, and policy benefits has promoted wider adoption. Senate Bill 032 of 2010 allows 2,500 gallons of harvesting in dry Utah. Local socio-economic, cultural, climatic, and urban form elements must be considered when developing policy instruments, with a focus on pro-environmental behaviour and regional collaboration (Ward et al., 2013) (Way et al., 2010) (Wayne Honaker, 2018).

7. Case Studies

Global cases demonstrate rain water harvesting's success. In El Culiacan, a dry district in Zacatecas, Mexico, the system was withdrawn due to cheap cost to give water to five-story residences with four apartments each. The roof apron (catchment area) is 300 m2/house and the average yearly collection volume is 221 m3 (105 m3 of water consumed per year). The 70 m3 storage tank was installed in the last week of October under a local aid scheme (F.I.D.E., 1980), but the water table rose after the first rainfall in December, thus no water was collected. Water is 4 m deep around buildings. The system's major flaw, already political, is avoiding local conservation. It was hard to get residents to stop using the water and accept supply. After three years, surveys show that the tanks are either used for garden irrigation or filled with garbage. Money and effort squandered on tanks could have been better used for local management, changing catchment and tank forms and sizes. Providing water to rural schools and hospitals in the Philippines typically involves interesting technical advances. Two classrooms and one office were created at the Imperial Government, a national institution, for 180 pupils. An RWH system with a 1750-gallon tank supplied water. The school was established in 1986 during the dry season after studying a local rainfall chart and designing the system utilising catchment and storage data. Later ad hoc modifications changed the system efficiency significantly; the tank is now used for gardening, a second tank was added to store potable water for the school and environment, and a flow analysis increased collection. Other effective approaches in the country involved commercial or industrial collection (Beckers et al., 2013).

7.1. Successful global implementations

In a highly evolved and industrialised world that needs steady water flow, rain water harvesting is essential. It improves living and creates different economic growth prospects worldwide. Many ancient Mediterranean and Western Asian settlements relied on water gathering. Some Bronze Age water collection methods are still used today. These are groundwater, runoff, and floodwater harvesting methods. The basic idea is to collect transformed rainwater runoff in riverbeds or on hills (Beckers et al., 2013). Catchment sites, storage structures, conveyance systems, and distribution stations make up water harvesting systems. Surface and soil characteristics in suitable catchments generate runoff, but they can be manipulated or intentionally created to induce runoff.

Geographically and culturally, rainwater collection is old. The Bible and other holy writings mention the technology, which Hindus and Buddhists have used for over 4000 years. Although diverse, these activities reveal a shared vision of water and water management at the individual and societal levels. Heaven gave water, which can produce or save life, wealth, and prosperity. Water harvesting tactics develop followers' beliefs in their rulership, reinforcing the sacred intermediary between humans and the divine. Sacred art and spiritual accessory: rainwater collection. The historical and cultural integration of rainwater collection technologies and water is significant. Traditional knowledge and experience enable widespread adoption of such techniques. Rainwater can support local resource utilisation with appropriate rules and incentives (Thuy Lan Chi et al., 2015).

7.2. Learning from Failures

Tropical land receives 135 cubic kilometres of rain yearly, a renewable resource. Storing rain is required between excess supplies and dry periods when water is needed. Bird droppings and soil leave the catchment with the first rain. Pathogen contamination is highest during the initial flush because birds flock around water. To avoid water contamination, this initial flush can be diverted for water retained for weeks or months after a rainy event (Bin Aftab et al., 2012).

Ignorance of cause and effect might cause RWH system implementation failures. A feasibility analysis is required before copying or adopting a rain water harvesting system. Borrowing and installing rain water harvesting systems without modifying them for local operational conditions has caused many failures (Beckers et al., 2013).

8. Problems and Limits

Technical challenges and a lack of equipment, technology, and capacities limit rain water harvesting (RWH) growth. This, together with negative social norms and a lack of enabling frameworks, rules, and laws, often contributes to RWH adoption resistance, especially in urban regions where public perception is a major role. Promoting and expanding the practice requires exploring challenges and enablers (Bin Aftab et al., 2012).

8.1. Technical Issues

Comprehensive rain water gathering is hindered by technical issues. The quality and treatment of processed water are crucial technological issues (Bin Aftab et al., 2012).

Ancient people harvested rainwater. Dry regions globally have large rainwater gathering dams. Catchments, gutters, channels, and pervious surfaces gather surface runoff. Domestic and irrigation rainwater tanks have been installed. A rainwater harvesting system needs a collection area, pipeline network, filtering, disinfection, and storage tank (Beckers et al., 2013).

8.2. Cultural and social barriers

Social and cultural barriers hinder rain water harvesting adoption. Misunderstandings, insufficient data, and low RWH system awareness are important obstacles. Health concerns concerning alkaline water, air pollution, and water storage are hurdles to harvesting rainwater (Beckers et al., 2013). These concerns often cause community pushback that hinders RWH technology implementation. To overcome these obstacles, the government must promote public awareness and rain water gathering initiatives.

9. Future Trends

Dry years are becoming more frequent, shortening benefits return, but future markets seem optimistic. To replace water filtration chemicals, renewable energy demand will increase the usage of ozone and ultraviolet (UV) radiation for water purification. As catchments with individual storage on communal discharge points, architectural rainwater collecting systems may be more popular (Beckers et al., 2013). To promote sustainable water use, government rules and regulations will increase, while industries will be required to manage water more strictly to reduce pollution. Controlling the culture and custom of rainwater use is still difficult, but great case studies throughout the world show that HDPE is the most sought product. Local manufacturers profit from the materials' advantages, especially lifespan. HDPE is cheaper to produce and install and maintain locally, which boosts a nation's economy. Rainwater collection, which communities can design, can indirectly prevent rural migration to cities. Many remote systems still work and undergo water tests. This remains an appealing drought solution (Thuy Lan Chi et al., 2015).

9.1. New Technologies

Rain water harvesting (RWH) systems improve individual and catchment-scale catchment and use. New materials like pre-cast concrete and polymers have made roof and yard RWH systems simple, affordable and straightforward to install. For 7-21 days, RWH procedures separate first-flush and store runoff from unlined catchments at rates of 0·2 to 5 L s^{-1}, with catchments varying in size according on demand. Storage is generally far from demand, but pumps and storage prolong supply from months to decades. Runoff storage above ground and pond lining and turbidity removal through filtration and sedimentation decrease groundwater contamination.

RWH is used to supplement water supply by waterworks, but its limited reliability limits its utilisation. RWH is often a primary potable water source in inconsistent supply or expensive groundwater areas. The approach has been widely employed for drinking, washing, bathing, and other domestic functions. Town water supply is always supplemented by individual schemes when distance or water quality limit use. Quality is assured by tank or cistern detention times over 1 month, roof protection, insect screening, and basic filtering. Metal roofing, subsurface runoff catchment, and artificial groundwater recharge are innovative RWH technologies (Beckers et al., 2013) (Thuy Lan Chi et al., 2015).

9.2. Possible Policy Changes

Scientists and engineers are studying citywide rainwater harvesting and retrofitting Los Angeles structures. Natural water resource management offers a low-cost solution to California's water problem and ecological issues (Beckers et al., 2013).

Household rainwater consumption is driven by economic, social, and environmental factors. Rainwater collection has lower initial and lifecycle costs than mains water, especially in rural areas. Governments may offer rebates on purchase price or water rate reductions to encourage rainwater supply. As water shortages and environmental degradation worsen, communities may compel governments to include alternative water suppliers in development standards. Herded design principles can help developers and local authorities plan and review developments (Thuy Lan Chi et al., 2015).

Successful combined rainwater collecting and greywater reuse schemes involve precise assessment of local and home circumstances, user expectations, and lifestyle preferences, as well as simple, robust, and reliable treatment and delivery technology. In many regions of the world, roof-collected rainwater can significantly reduce a household's dependence on mains water and mitigate broad water source depletion in the medium- to long-term. Public acceptability may accelerate the adoption of appropriate methods, but wider implementation will require larger-scale benefit demonstration.

10. Conclusion

Rain water harvesting for water conservation and management is appropriate for urban, rural, and household use, as shown in the paper (Beckers et al., 2013). Due to copious monsoon rainfall, societies have historically used rain water collection techniques to supplement other water supplies (Thuy Lan Chi et al., 2015). India and Israel's archaeological finds show rain water harvesting's origins. Mediaeval advances improved design efficiency, irrigation, drainage, and water quality. Modern advances introduce new materials, showing field improvements. The persistence of rain water gathering systems shows their resilience as water scarcity remedies.

Ancient water gathering methods were crucial to Mediterranean and Western Asia dryland communities. In the Bronze Age or earlier, technologies were developed to support agricultural and animal husbandry. Scholars call these technologies groundwater, runoff, or floodwater harvesting. Systems included catchment areas with artificial structures like bunds and trenches to maximise runoff and minimise infiltration. These early ideas help engineers and planners understand arid-zone water delivery system distribution and reliability.

Roof-based rainwater collection systems in Ho Chi Minh City are viable based on rainfall statistics, catchment area dimensions, and water consumption rates. These flexible, affordable solutions can meet a large portion of home water needs during rainy seasons. Encouraging wider adoption benefits the economy, society, and ecology, especially water conservation. To assure long-term water availability, city managers can promote consumption, help impoverished households with collection and storage equipment, and build extensive rainwater-harvesting infrastructure.

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