# A Global Performance Assessment of Rainwater Harvesting Under Climate Change

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***ABSTRACT: Rainwater collecting is one option that may enhance drinking water availability directly at home, given that water security is expected to deteriorate as a result of climate change. Although rainwater collecting systems have the potential to decrease drinking water insecurity, they have never been rigorously evaluated in a range of regions for various climate change scenarios using consistent assumptions. As a result, the purpose of this paper is to evaluate the ability of rainwater harvesting devices to improve domestic water security in each of the major climate zones under various climate change scenarios, as well as to make design recommendations for each climatological region to achieve high levels of reliability. The linked model includes a stochastic weather generator (LARS-WG) that uses historic weather data from 94 locations selected to represent all Koppen – Griegel climatic categorization zones to generate synthetic daily rainfall. Three distinct climate change scenarios are simulated using 15 downscaled General Circulation Models up to the year 2099. Rainwater harvesting system dependability is evaluated using a variety of roof area and tank sizes. Climate change will have minimal effect on rainwater collecting, according to the findings, and rainwater harvesting may decrease household water insecurity even in dry areas. Implementing agencies may utilize the findings of this research to assist communities build systems that satisfy certain levels of dependability and to select areas where rainwater collecting can be successful.***

***KEYWORDS: Climate, Collect, Harvesting, Rainwater, Technology.***

## 1. INTRODUCTION

More than 2.1 billion people across the world do not have access to clean, easily accessible water at home, and another 2.3 billion do not have adequate sanitation (WHO and UNICEF). Even individuals with better water supplies must often walk several kilometers each day in search of water sources (Mellor), which has a negative effect on health. Furthermore, even better water sources are often contaminated by microbes. As the climate changes, water security, especially in low-income areas, will become more endangered [1], [2].

Almost all glaciers in the tropical Andes have been quickly melting, which is consistent with observed warming. Similarly, Himalayan glaciers are melting, posing a significant threat to runoff contributions, particularly in the drier westerly dominated headwaters. In West Africa, southern Europe, southern and eastern Asia, eastern Australia, western North America, and northern South America, a worldwide study of stream flow revealed declining trends in low and mid-latitudes, consistent with recent drying and warming. The global average precipitation is expected to rise, but there will be significant regional differences, including some reductions. Precipitation is expected to decrease at subtropical latitudes, especially in the Mediterranean, Mexico and Central America, and portions of Australia, while increasing elsewhere, particularly in India and Central Asia. The Mediterranean, center Europe, central North America, and southern Africa are all expected to experience longer and more frequent drought.

Globally, increased precipitation and temperature variability, as well as severe events linked to them, are expected to impact water supply and quality[3]–[5].

Rainwater harvesting (RWH), which enables water to be collected directly at home, is one potential option for improving water security. According to the particular environmental and socioeconomic circumstances, such systems may provide between 12 percent and 100 percent of a household's drinkable water. Rainwater harvesting storage was simulated in three Iranian cities with different meteorological conditions [4]. The research showed that in humid, Mediterranean, and dry Iranian climates, it is feasible to provide at least 75% of household water demand 70%, 40%, and 23% of the time, respectively. These findings indicate that RWH may assist families in dry areas in maintaining water security [6].

RWH may supply a significant percentage of home water supplies in poor nations since household water use is minimal, in Africa. In addition, large surveys using GIS techniques have shown RWH possibilities in a number of African nations, including Botswana, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Uganda, Zambia, and Zimbabwe. As a result, RWH has expanded throughout Africa, with Rainwater Harvesting Associations forming in a number of nations.

Many Asian nations rely heavily on RWH. The Thai government has also backed RWH because of its cheap implementation costs, which are achieved via the use of jar tank systems with tank capacities ranging from 0.1 to 3m3. During the dry season, which lasts up to six months a year, rainwater is collected and utilized. Since 2001, more than 5.5 million tanks have been constructed throughout China to provide supplementary drinking and agricultural water. Australia has one of the highest rates of RWH systems since it is one of the driest inhabited continents with extremely variable rainfall. According to the Australian Bureau of Statistics (ABS, 2010), 19.3 percent of homes, or around 1.5 million people, have installed rainwater tanks as a supply of domestic waste.

Our finding is likely due to the fact that LARS-WG includes climate change-induced precipitation variability by changing monthly precipitation totals. It has no impact on the frequency of rainy and dry seasons. LARS-WG calculates probability distribution parameters based on observed data. To generate synthetic weather time series, the values from these distributions are then chosen at random [7]. These distributions may be influenced by global climate models. Using a semi-empirical distribution, LARS-WG produces probability distributions for wet and dry periods, as well as daily precipitation. Changes in the dry and wet series are difficult to accomplish since daily output from global climate models is not available. Prolonged droughts, particularly in desert regions, are known to decrease RWH efficacy. Future studies should look at this limitation. The quantity of water rather than the quality of water was the focus of our study. RWH systems are implemented in a variety of ways throughout Europe. With one-third of new buildings fitted with this system, Germany leads the way in promoting the broad usage of this technology for residential non-potable uses [8].

In North and South America, several systems are used. More than 100,000 people in the United States utilize RWH in the form of a basic rain barrel or huge capacity tanks, including those used for drinking. In 2001, Brazil started the “One Million Cistern” RWH initiative to provide water to about two million people living in rural regions. Figure 1 shows the Flowchart of rainwater harvesting model.

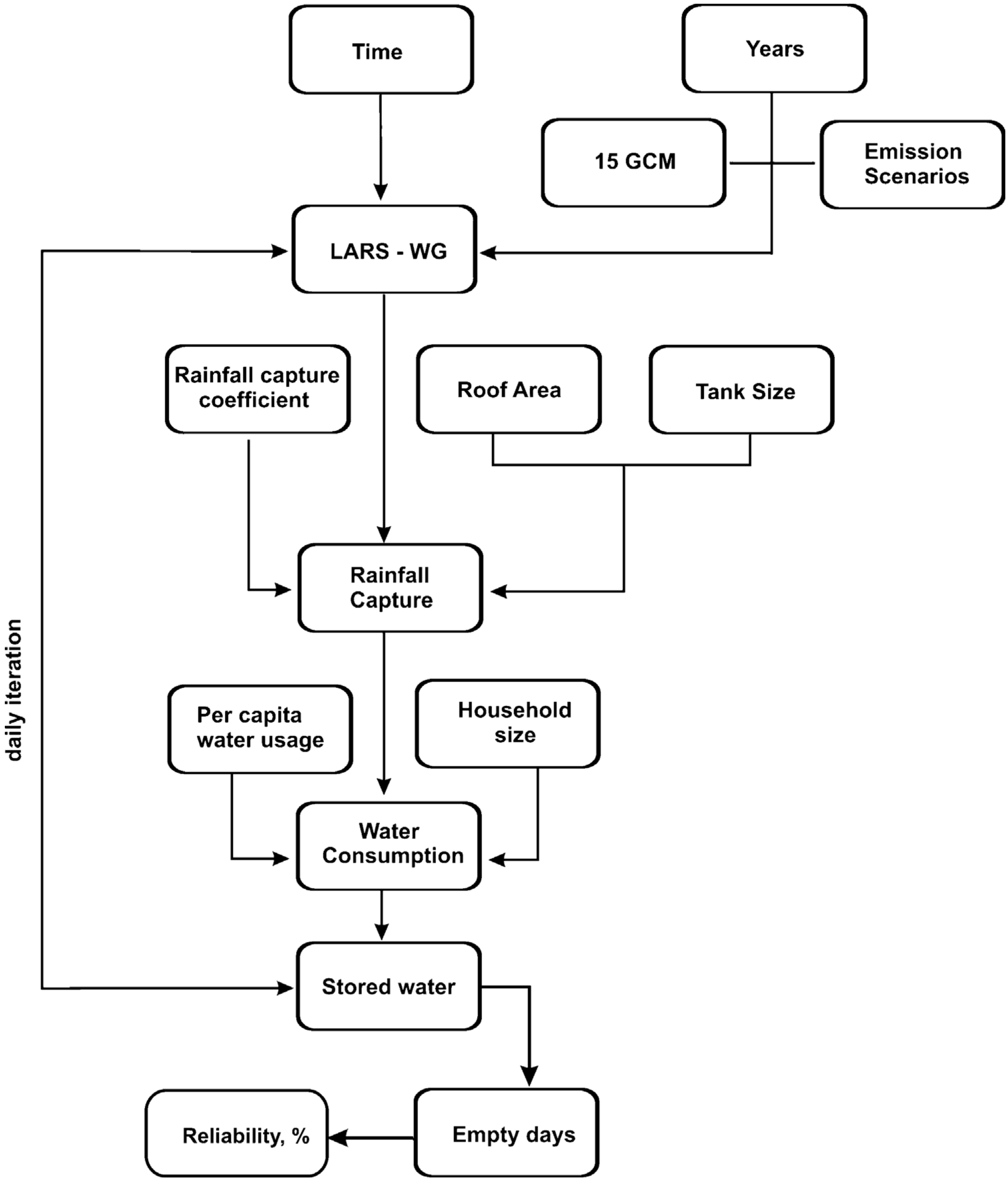

**Figure 1: The above figure shows the Flowchart of rainwater harvesting model.**

Although previous study has shown that RWH has the potential to enhance water security, further research is needed to see how successful the technology is across a range of climates using similar assumptions as they are affected by climate change. Furthermore, for each climatological zone, essential design variables such as household water consumption, roof area, and storage tank size must be considered. This kind of study is required to assist in the planning, design, and implementation of RWH systems for a range of climates.

The objectives of this paper are:

- Determine the impact of climate change on RHW reliability.
- Assess RWH's ability to improve water security in a variety of climates around the world.
- Make design recommendations for achieving levels of reliability for each climatological region and countries with various income levels.

This will be accomplished by employing 15 downscaled General Circulation Models (GCMs), three Special Report on Emissions Scenarios (SRES), and three timeframes to simulate baseline and future climates using a stochastic weather generator guided by historic weather data. Implementing agencies may utilize the findings of this research to assist communities develop successful RWH structures and to select areas where RWH can be most effective.

## 2. DISCUSSION

Climate change will have minimal effect on the ability of RWH systems at the home level, according to the findings of this research.

Our findings also show that, with a big enough tank and roof size, RWH may be an effective technique for improving water security 80% of the time, especially in dry areas. Others have discovered that seasonal rainfall fluctuations may restrict the quantity of water accessible during dry times.

In most instances, RWH in tropical and temperate regions can sustain adequate water supply 80% of the time. Even in tropical conditions, however, maintaining 100% dependability is challenging. Stakeholders may use these findings to determine if RWH is suitable as a climate adaptation strategy for a specific area.

With increasing roof area and tank capacity, the system's % dependability improved in all conditions, as anticipated. When tank sizes above 5000 L, however, the rise was non-linear, with diminishing advantages per volume increase. Prior research has discovered similar threshold effects. In Kerman, Iran, where the environment is dry, the impact of increasing tank capacity for the same roof surface from 5000 to 15,000 L was not significant. In dry and humid zones, and found that increasing tank capacities from 5000 to 10,000 L did not significantly improve water security. This discovery may aid families in reducing tank building expenses.

Prior, regional investigations have found a high degree of RWH effectiveness similar to ours. In central India, small systems with a 50m2 roof and a 500–1,000 L storage system are proven to be efficient for urban consumers (Cain). Imteaz (2011) shown that for a home with two inhabitants in Melbourne, Australia, a roof area of 150–300m2 and a tank size of 5000–10,000 L may achieve about 100 percent dependability. In many regions, it is apparent that the RWH can offer consistent access to basic amounts of water for most of the year.

In light of the predicted increased intensity of extreme precipitation events over most of South America and western Amazonia (Marengo) and the predicted increase in droughts in East and Southern Africa, the finding that climate change will have little impact on RWH reliability is somewhat surprising (Field).

Wallace has looked at the impact of future climate change on RWH systems in the Federated States of Micronesia.

They discovered that in the future, systems will need bigger storage tanks to attain comparable levels of dependability. Other studies have discovered that RWH systems can function well in the face of climate change (Campisano). The fact that LARS-WG incorporates climate change-induced precipitation variations by altering monthly precipitation totals is likely to be the cause of our discovery. It has no effect on the number of wet and dry periods that occur. Based on observed data, LARS-WG computes parameters for probability distributions. The values from these distributions are then randomly selected to create synthetic weather time series. Global climate models may be used to alter these distributions [9][10]. LARS-WG generates probability distributions for wet and dry periods, as well as daily precipitation, using a semi-empirical distribution. Changes in the dry and wet series are impossible to achieve since they would require daily output from global climate models, which is not accessible (Semenov and Stratonovitch). It is known that protracted droughts, especially in arid areas, may reduce RWH effectiveness. This restriction should be addressed in future research. Our research concentrated on the amount of water rather than the quality of water.

In certain areas, national or municipal restrictions will render RWH difficult or economically unviable. Rainwater is generally devoid of physical and chemical pollutants including pesticides, lead, and arsenic, as well as color and suspended particulates, and has a low salt and hardness content (Abdulla and Shareef). However, air pollution, soil dust, tree leaves, insects, chemical deposits, and bird droppings may all have an effect on RWH water. These effects may also be influenced by the kind of roof (GhaffarianHoseini). Asbestos, plastic, and tile roofs are favored over metallic roofs (Vasudevan).

While we have shown that RWH is a theoretically feasible alternative, capital investment costs may be significant, but operating and maintenance expenses are often modest (DTU, 2001). RWH is not commercially feasible without government assistance, according to Australian experts.

The fact that we anticipated a consistent 10% loss rate is another drawback of our methodology. Leaky faucets, ineffective roofs, and evaporative losses may all contribute to a reduction in the quantity of precipitation stored and consumed. Thatched roofs, for example, typically have runoff coefficients around 0.2, making them unsuitable for RWH.

## 3. CONCLUSION

The most significant finding of this study is that climate change seems to have minimal impact on RWH feasibility and may assist families have access to water for the majority of the year. Even in dry areas, RWH can be an effective strategy for improving water security 80 percent of the time. Regardless of the greenhouse gas emission scenario, evidence from many climatic scenarios and time periods suggest that RWH may be an essential technology. This is critical for future RWH system design and demonstrates that it is a technology that will last far beyond the twenty-first century. However, it is essential to remember that it is simpler for families to raise their tank capacities than it is for them to expand their roof areas when interpreting these findings. As a result, it's likely that RWH won't be as effective in dry areas where people have tiny roofs. In dry and humid zones, the results also indicate that increasing tank sizes beyond a certain number of sizes did not significantly improve advantages. In the face of climate change, the estimated design curves may help RWH system designers identify the best roof and tank sizes for their specific site.

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