# Rainwater Harvesting Conservation for Old San Juan Buildings

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## Abstract

This study evaluates the feasibility of implementing a rainwater harvesting system in La Factoria, a commercial historic building in Viejo San Juan, Puerto Rico. The selected multi-story, high-demand facility was used as a representative case study to assess system performance under realistic operating conditions. The motivation for this work arises from recurring water service interruptions that negatively impact business operations and local residents. Monthly precipitation data from NOAA Climate Normals (1991–2020) were used to define rainfall patterns, and hydraulic equations were applied to estimate harvested volume, runoff, storage requirements, and energy demand. Results indicate monthly collection ranging from approximately 6,300 to over 20,000 gallons, with an annual potential of about 170,000 gallons. Pump sizing analysis yielded a required capacity of 0.3–0.5 kW, with low operational cost. These findings confirm that rainwater harvesting is a viable and cost-effective strategy that enhances water resilience and can be scaled across Viejo San Juan for sustainable urban water management.

## Introduction

Viejo San Juan faces recurring water supply interruptions due to aging infrastructure, limited natural freshwater sources, and high demand driven by tourism and dense urban development. These interruptions significantly impact both businesses and residents, especially in commercial buildings with continuous water use such as restaurants and bars. This study is motivated by real-world observations of these disruptions and their operational and economic consequences. As a result, there is a need for more resilient and decentralized water management strategies. Rainwater harvesting provides a practical solution by capturing locally available precipitation for non-potable uses. Although often viewed as a modern sustainability approach, this method has historical roots in Viejo San Juan, where colonial cistern systems (aljibes) were widely used to store rainwater. This project evaluates the feasibility of reintroducing rainwater harvesting as a reliable and scalable solution for improving water resilience in Viejo San Juan.

## Background

Viejo San Juan was historically developed in a location with limited natural freshwater resources, requiring early inhabitants to rely on engineered water solutions. During the Spanish colonial period, rainwater harvesting systems, known as aljibes, were widely implemented to collect and store water from rooftops and courtyards. These systems provided the primary water supply for residential, civic, and military structures for centuries. Today, although modern infrastructure has replaced these systems, the district still faces similar challenges due to its geographic constraints. This historical precedent demonstrates that rainwater harvesting is not a new concept in Viejo San Juan, but rather a proven and context-appropriate strategy that can be reintroduced using modern engineering principles.

## Problem

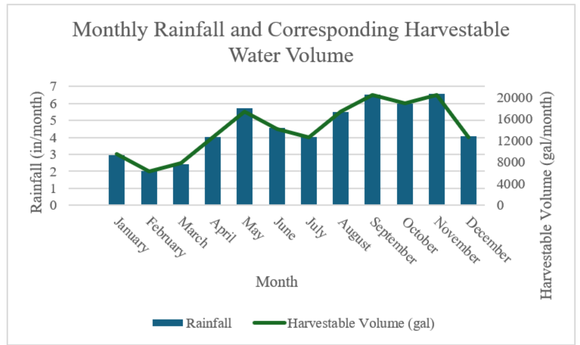
Viejo San Juan currently experiences recurring water service interruptions due to aging infrastructure, high water demand, and dependence on centralized distribution systems. These disruptions significantly affect both residents and commercial establishments, particularly high-demand facilities such as restaurants and bars. In these environments, water shortages can lead to operational shutdowns, economic losses, and compromised sanitation conditions, highlighting a critical vulnerability in the existing system. Given these challenges, there is a clear need for decentralized and resilient water supply strategies. The objective of this study is to evaluate the technical feasibility of implementing a rainwater harvesting system in a representative commercial building in Viejo San Juan. This includes quantifying the volume of water that can be harvested based on local precipitation data, assessing system performance under varying conditions, and determining appropriate storage and pumping requirements. Additionally, the study aims to examine the potential for reducing dependence on municipal water supply and improving operational reliability, with the broader goal of supporting scalable implementation across the district.

## Methodology

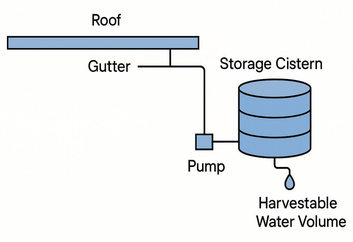
The methodology adopted in this study integrates climatic data analysis, hydrologic modeling, and engineering design principles to evaluate the feasibility of a rainwater harvesting system for a commercial building located in Viejo San Juan. The approach consists of four main components: (1) precipitation analysis, (2) rainwater harvesting calculations, (3) peak flow estimation, and (4) system design evaluation. Precipitation data used in this analysis were obtained from the National Oceanic and Atmospheric Administration (NOAA) Climate Normals (1991–2020), which are based on long-term measurements collected from official meteorological stations in the San Juan region. Specifically, these data are strongly represented by observations from the San Juan–Luis Muñoz Marín International Airport weather station (Station ID: SJU), which serves as the primary reference station for the metropolitan San Juan area. The selected station utilizes a standard tipping-bucket rain gauge system for precipitation measurement, providing continuous and quality-controlled rainfall data. The use of NOAA Climate Normals ensures that the precipitation values employed in this study are statistically reliable, spatially representative, and appropriate for engineering design applications in Viejo San Juan.

## Results and Discussion

| Month | Rainfall (in/month) | Yield (gal/ft²) | Total Volume (gal) |
|---|---|---|---|
| January | 2.97 | 1.57 | 9,460 |
| February | 2.01 | 1.06 | 6,300 |
| March | 2.42 | 1.28 | 7,880 |
| April | 4.01 | 2.13 | 12,610 |
| May | 5.73 | 3.05 | 17,340 |
| June | 4.56 | 2.42 | 14,190 |
| July | 4.03 | 2.14 | 12,610 |
| August | 5.48 | 2.92 | 17,340 |
| September | 6.52 | 3.46 | 20,490 |
| October | 6.00 | 3.19 | 18,910 |
| November | 6.56 | 3.49 | 20,490 |
| December | 4.09 | 2.17 | 12,610 |
| TOTAL | 54.40 | - | ~170,000 |




| Condition | Rainfall (in/month) | Volume (gal/month) | System Condition |
|---|---|---|---|
| Dry Month | 2.01 | 6,300 | Limiting condition |
| Average Month | ~4.5 | ~14,000 | Normal Operation |
| Wet Month | 6.52 | 20,490 | Excess Storage |




| Parameter | Value |
|---|---|
| Pump Power | 0.30-0.50 kW |
| Monthly Energy Use | 15-25 kWh |
| Annual Energy Use | ~288kWh |
| Electricity Cost | 0.28 USD/kWh |
| Monthly Energy Cost | $3-$7 |
| Annual Energy Cost | $70-$90 |
| Annual Water Harvested | ~170,000 gal |
| Potential Annual Savings | $1,000- $1,500 |

## Conclusions

This study demonstrates that rainwater harvesting is a technically feasible and economically viable solution for improving water resilience in Viejo San Juan. Using NOAA precipitation data and hydraulic analysis, the system showed the ability to capture up to 170,000 gallons of water annually, significantly offsetting non-potable water demand. The results highlight that system performance is governed by seasonal variability, with dry months defining storage requirements and peak rainfall periods providing surplus capacity. Despite realistic operating conditions, energy requirements remain low, confirming that system implementation is both efficient and cost-effective. Although the analysis focused on a single commercial building, the findings support the broader applicability of rainwater harvesting across Viejo San Juan. Reintroducing this historically proven strategy has the potential to reduce dependence on centralized infrastructure, improve operational reliability during outages, and promote sustainable urban water management at the district scale.

## Future Work

Future work should focus on refining system design and expanding its applicability across Viejo San Juan. This includes developing more detailed water demand models for different building types, integrating filtration and water quality treatment systems, and optimizing storage capacity based on real-time usage patterns. Additionally, further studies could evaluate the cumulative impact of widespread rainwater harvesting on reducing municipal water demand across the district. Future research may also explore policy development, incentives, and design guidelines to promote the adoption of decentralized systems in historic urban environments.

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