# Rainwater Harvesting
# Gutter System Manual
## *La Perla*

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Project files and resources are available at:
https://wp.wpi.edu/puertorico/projects/mar-apr-2024/perla/

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http://www.wpi.edu/academics/ugradstudies/project-learning.html

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# Foreword

Worcester Polytechnic Institute located in Worcester, MA has an Interactive Qualifying Project requirement for graduation. John Peabody, Lauren Simonian, Amelia McDonough, and Bella DeCilio were grouped and placed in San Juan, Puerto Rico to work in the La Perla community for about two months (March-May 2024). We were fortunate enough to work with Finca Escuela: a grassroots organization focused on promoting environmental education and sustainable action through a community garden and learning center. Headed by Jerome Zayas-Lopez, Finca Escuela works with the community and makes environmental changes throughout La Perla. We worked closely with Jerome as well as Keyla Baez and Brenda L. Martinez Quiñones. Our project focused on developing a rainwater harvesting and community garden in La Perla. Below, we walk through the stages of project development in a format that we hope will benefit others. In each section, which mostly follows rainwater harvesting system elements, we first enumerate some key ideas that informed or came out of our work, then we briefly describe that element in the La Perla project.

# 1.0 | Introduction

## 1.1 Preface

This handbook is prepared to be a tool to promote rainwater harvesting for marginally-resourced communities. This is intended as a reference guide for skilled personnel who understand the collection of rainwater at a household, community, and institutional level.

## 1.2 Background

The survival and well-being of humanity depends upon both the quality and quantity of water. Throughout history, countless individuals have mistakenly viewed water as abundant, assuming it as an endless natural gift to be freely utilized. Clean and safe water is a very scarce resource in La Perla, which makes growing vegetables and medicinal plants very difficult.

With it raining an average of 4.7" per month, harvesting rainwater is a simple way to promote gardening (Quinones, 2022). Rainwater harvesting can lower water bills by around 10% since most outdoor water use will be with rainwater instead of home water (Gonzalez, 2011). Few homes in La Perla currently have rainwater harvesting systems in place. The promotion of rainwater harvesting is limited as not a lot of people understand the importance of these systems and just find the construction to be noisy or an expensive process.

## 1.3 History of Rainwater Harvesting in Puerto Rico

Historically, communities and private individuals have been responsible for owning and overseeing water sources, often with little government intervention. "Rainwater harvested in the cisterns was crucial to the survival of the Spanish when building the cisterns in the mid-1700s" (Gonzalez, 2011). When the National Park in San Juan was established in 1949, those same cisterns were in place but were unused. Over the last 20 years, rainwater has been harvested for restrooms, maintenance facilities, and other non-potable applications (Gonzalez, 2011).

## 1.4 Description of Rainwater Harvesting

Rainwater harvesting is a sustainable method of collecting and storing water for various uses. It typically involves the capture of rainwater from surfaces like rooftops or paved areas, channeling it through gutters or pipes, and directing it into storage containers such as tanks or cisterns. This collected rainwater can then be filtered and used for a variety of purposes, including irrigation, household chores, and even drinking water in some cases. Water collected from roofs generally should not be considered potable, as it's not properly filtered. In our project, we did not include bacterial filters, and therefore the roof water is non-potable and mainly for garden use.

Rainwater harvesting systems can range from simple setups, such as collecting rainwater in buckets or barrels, to more complex systems integrated into buildings with sophisticated filtration and distribution systems (Figure 1).

*Figure 1: Examples of household rainwater storage items*

## 1.5 Pros and Cons of Rainwater Harvesting

### 1.5.1 Advantages of Rainwater Harvesting

There are a lot of advantages to utilizing rainwater harvesting in a low-cost, yet still effective way.

I. Affordable in low-income communities
II. Time is saved for water collection from other sources (wells, springs, etc.)
III. Opportunity for skill development and new jobs (Figure 2)
IV. Promotes agriculture production

*Figure 2: Rainwater harvesting creates new jobs for masons or construction workers*

### 1.5.2 Disadvantages of Rainwater Harvesting

I. Storage systems can be expensive and not accessible for every household
   "Prices can reach $17,000" (Cellucci, 2024).
II. The construction process can take a long time
III. Depends on seasons - rainwater may not fall every season

## 1.6 Rainfall in La Perla, San Juan

La Perla, which is the westernmost part of San Juan, Puerto Rico, is on the coastline. The annual rainfall ranges, but averages about 4.7" per month (Figure 3). The heaviest rain months are September, October, and November.

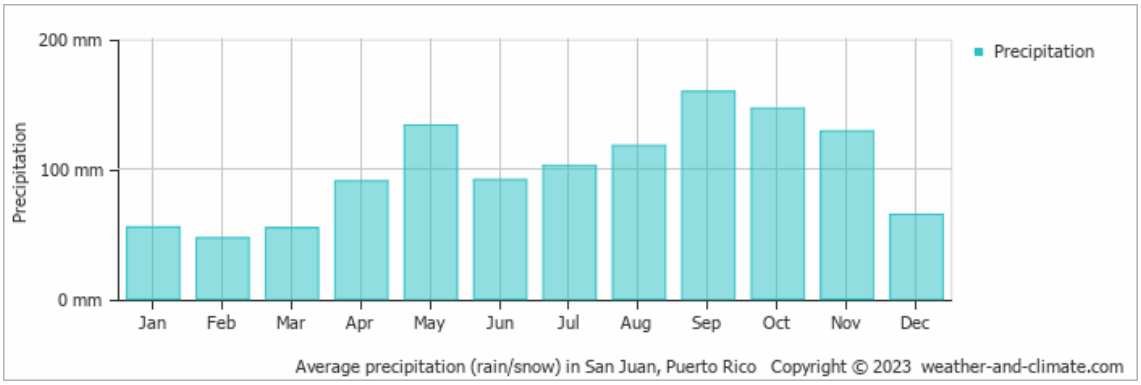


*Figure 3: Average Annual Precipitation in San Juan, Puerto Rico*

## *Section 1 Key Lessons*

- Rainwater harvesting comes with many benefits
  - Can increase planting and other gardens
- Rainfall is high in San Juan, and capturing rainwater is an easy solution to water shortages

# 2.0 | Considerations for Rainwater Storage Systems

Next, we looked at the different designs for the rainwater harvesting system. In this chapter, we will explore cisterns as well as gutter options.

## 2.1 Selection Options for Storage

When choosing the best storage device, there are a lot of factors to consider:

- Size (tank capacity)
- Cost of tank
- Purpose (household, industrial)
- Location of tank
- Available materials


*Figure 4: Some different examples of cisterns*

## 2.2 Location of Cistern

When placing a cistern, there are a few things to be taken into account:

- Leave enough room from the roof to ensure space during construction and that the stability of the house is not compromised.
- The cistern should be placed with the natural slope of the roof to use gravity to help water flow.
- The height of the cistern should be lower than the roof so that when there is a connection, the water will flow down into the cistern from the roof.

## 2.3 Guttering

When installing a gutter on a roof, there are multiple factors to take into account such as the material of the roof and what gutter material there should be.

### 2.3.1 Roof

The location, material, and size of the roof are all things to consider when choosing a gutter. Typically, roofs are asphalt or concrete and have walls that will provide additional support for the gutter. However, some atypical roofs will utilize a gutter system.

EXAMPLE: Finca Escuela Project

As seen in Figure 5, the roof is made out of aluminum and other metals.

*Figure 5: Corner of the roof at Libros Libres*

The roof is grounded with metal support beams around the entire roof and spanning down a hollow metal beam. The roof stood about 20 ft tall, with dimensions of about 21’ x 22’ with an overhang of about 2 ft. Unlike typical gutter projects, Libros Libres does not have a wall to act as an additional support and is made out of metal as opposed to asphalte. Since there are only metal beams supporting the roof, a lighter gutter is preferable. A light aluminum or a PVC pipe are both excellent choices here. For roofs that are stronger and more industrial, a galvanized steel gutter can be used (Figure 6).

*Figure 6: Example of a Galvanized Industrial Gutter*

### 2.3.2 Gutter Selection

- Gutters should be made from either PVC or galvanized sheet metal for households or industrial buildings respectively.
- A lighter gutter is preferred especially on roofs that have a large overhang (>5 in)
- Gutter brackets (made from either PVC or metal stripes) should be attached to the fascia board of the building frequently (every 4-5 ft for a 20 ft roof). The spacing depends on the size of the roof.
- There should be a slope of the gutter towards the cistern at about a 1% angle (drop 4 in for every 32 m) (*Handbook on Rainwater Harvesting Storage Options*, n.d.).
- The end of the gutter should be blocked to prevent water loss.

## *Section 2 Key Lessons*

- Choose a lightweight gutter (PVC or galvanized steel)
- Support with brackets frequently
- Slope the gutter down towards your cistern

# 3.0 | Construction and Assembly

This chapter will focus on the construction process and some tips that our team used to make the build day easier. We also will discuss maintenance and future repairs that may need to be taken into account.

## 3.1 Sketching and Designs

1. Discuss with your team the different options for your rainwater harvesting system
2. Make a pros and cons list of each design

   Things to consider:
   - Support
   - Cost
   - Difficulty to assemble
   - Weight
3. Reconvene with your team and choose the top 2 designs
4. Sketch out the designs on pen and paper or using the free software: SketchUp (Click Here for the Free SketchUp User Guide) or Canva Include specific dimensions, labels, and color coordinate materials. Make multiple drafts if needed.
5. Decide with your team which design is best

## EXAMPLE: Finca Escuela Project

Here are two design concepts that were created. One uses simply pen and paper, and the second is more in-depth (drawn to scale) in Canva.

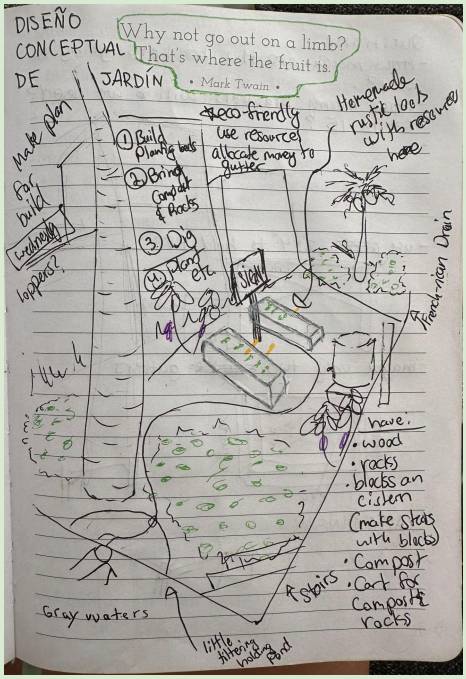


*Figure 7: Rough design*

*Figure 8: Canva garden design*

## 3.2 Equipment and Tools

Next it is necessary to list out all materials (both what you already have and those needed). Either an Excel (or Google Sheets) or pen and paper table can be created.
The table should include materials both ones that are needed and ones you already have.

Example:

- Gutter
- Safety tools
- Screws
- Brackets
- Saw/other cutting device
- Drill

Another column to include are 2 or more price options and the corresponding purchase locations. Then, it is easy to visualize and decide which material is best given the price and the quality.

### EXAMPLE: Finca Escuela Project

One easy way to make an expense report is using Google Sheets. For the Finca Escuela project, a lot of the materials were already purchased but there was still a lot needed (seen in red in Figure 9). This color coordination is a useful technique to clearly show what is needed vs already bought. A highlighter or different color pen is an easy alternative and can be adopted by anyone.

| EXPENSE REPORT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| EXPENSE CATEGORY | | | | | | | | Category Total |
| Gutter Parts | Home Depot | Walmart | | | | | | |
| Insect Screen for Cistern | $17.48 | | | | | | | |
| PVC Parts | $5.00 | | | | | | | |
| Metal Brackets | $150.00 | | | | | | | |
| 2 x 4 Treated Pine | $94.40 | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| GUTTER TOTAL | $266.88 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $266.88 |
| Safety | Home Depot | Walmart | | | | | | |
| Gloves | $24.00 | | | | | | | |
| Hard Hat | $70.79 | | | | | | | |
| Tape Measure | | $23.54 | | | | | | |
| Bottled Water | | $9.28 | | | | | | |
| First Aid Kit | | $18.43 | | | | | | |
| | | | | | | | | |
| SAFETY TOTAL | $94.79 | $51.25 | $0.00 | $0.00 | $0.00 | $0.00 | $0.00 | $146.04 |

*Figure 9: Expense spreadsheet*

## 3.2 Construction Steps

### 3.3.1 Getting Help to Assemble

The build day is one of the most important days in this process. For smaller communities, it's best to get a lot of residents involved to not only get the extra hands but also to make it a communal educational workshop. Making flyers, posters, or social media posts are some of the best ways to get the word out about what you're doing.

The build day must be organized and well-planned. A prepared schedule made in advance, along with any notes, are both helpful things to have ahead of time.

EXAMPLE: Finca Escuela Project

Construction and gutter building is not something that everyone knows how to put together. For La Perla specifically, this was something that hardly any residents knew, so it was important to make this project a community teaching event. The goal for build day was to include as many people as possible and organize a workshop teaching residents how the build process went and other tips. To get the word out, the students created a flyer (Figure 10) that would be shared via Facebook, and community social media groups, and printed to be visible near Libros Libres.


*Figure 10: Spanish Version of Build Day Flyer*

Both a Spanish and English version of the flyer was created and advertised. It's best to cater to your audience and choose images and words that would target residents. The students used photos of a before and projected after to show residents what the space would transform into and the benefits of it. In addition to a flyer advertising the build day event, the students also made a brochure (Figure 11) to be handed out at the event. This brochure aims to be informative and educational about the importance of rainwater harvesting so that community members understand the purpose behind all of the work. Again, both an English and Spanish version were made.


*Figure 11: Spanish Version of Informative Brochure*

Some important things the group included were information about themselves, how the community would be helping, and the benefits of harvesting rainwater.

### 3.3.2 Construction Day

**Tips and Tricks:**

*Skilled Workers:*

These individuals would be helpful to have on build day to ensure a smooth construction process.

- Welder - for connecting the metal joist brackets to a metal support post, welding is the preferred technique
- Carpenter - a skilled individual who works often with power tools and understands the basics about construction
- Extra community members - people who are willing to help monitor and ensure safety and be extra hands during construction

*Types of Tools:*

- Drills - two or more drills are ideal. A drill bit that can go into metal and has enough power is needed
    - Make sure there are extra batteries and that they're charged
- Screws - there are different types of screws that are used for certain sections
    - Teks - these are a great brand of screws and hold wood structures together very well. They also make metal-to-metal screws that are ideal.
    - Roofing Screws - these are metal screws that have a rubber washer on the end that make it easier to screw into the gutter from the roof
    - Metal to Metal Screws - we used these for connecting the metal bracket to the metal support (can also be welded together instead)
- Additional Tools: Hammer, screwdriver, metal cutters, saw, tape measure, level, circular saw, pliers

When completing this project, we did not have access to a full toolkit which made it difficult to complete certain parts of the project, so a basic starter kit would be ideal.

*Safety:*

- Scaffolding - if working on a high roof, scaffolding was a need to ensure safety and to get the proper angles for screwing
- Ladders - a ladder higher than the roof itself as well as an A-frame ladder are both great tools to have. Multiple ladders can be used as a substitute for scaffolding if in a safe and level location.
- Hard hats - when working on elevated surfaces, hard hats are necessary especially when under a roof (metal or not)
- Safety goggles - these protect your eyes from any possible risks and also prevent dirt and other sawdust from irritating your eyes.
- Other - water and food are nice to have on-site. Also being able to take breaks throughout the day in the shade and cool off is necessary.

## 3.3 Maintenance and Repairs

### 3.4.1 Minor Repairs

- Clogged Gutters
    - Like any other gutter, this rainwater harvesting system will need to be routinely cleaned and taken care of. In this situation, a ladder will need to be stabilized on the roof, and with the use of a rake or similar tool, a person should safely climb up and rake out all the leaves to ensure smooth water flow. A hard hat should be worn as well as having an additional person to stabilize the ladder throughout this process.
- Reapplication of silicone
    - Because a lot of seals are solidified with silicone, a reapplication may be needed. In any place where there are screws, silicone should be used to keep the gutter leakproof, but over time the silicone hold can weaken and may need to be reapplied.
- Any leaks
    - If there are any other leaks, additional screws can be placed and sealed with silicone.

### 3.4.3. Major repairs

- Gutter falling
    - If there is a major issue such as the gutter falling, additional support will be needed. One idea to add extra support is to use wood along the posts to connect to the gutter and provide more support.
    - The option to completely remove the gutter is also one and replacing it with a lighter one, such as PVC, would help reduce the need for extra support.

## *Section 3 Key Lessons*

- Make organized lists and schedules of building materials and build day
- Sketch multiple designs and discuss a final choice
    - Use pros and cons lists to weigh out the options
- Create flyers to educate residents and get help on build day
- Monitor the gutter regularly to ensure its stability and repair as needed.

# Key Lessons Summary

### Section 1

- Rainwater harvesting comes with many benefits
    - Can increase planting and other gardens
- Rainfall is high in San Juan and capturing rainwater is an easy solution to water shortages

### Section 2

- Choose a lightweight gutter (PVC or galvanized steel)
- Support with brackets frequently
- Slope the gutter down towards your cistern

### Section 3

- Make organized lists and schedules of building materials and build day
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    - Use pros and cons lists to weigh out the options
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**Figure 2:**
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**Figure 4:**
https://www.nationalstoragetank.com/wp-content/uploads/2020/06/the-different-types-of-above-ground-water-storage-tanks-image-01.jpg

**Figure 6:**
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