Site-Specific Design for Rainwater Harvesting Systems and Applications

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Abstract

Availability of clean fresh water is directly related to quality of life. In the developing world, access to clean fresh water is limited and drilling wells is an expensive solution that is not feasible for most poor communities without external resources. Rainwater, like groundwater, is typically cleaner than surface water, and harvesting rainwater can be a sustainable solution for water scarcity. Local rainfall data along with planned usage can be incorporated to design a harvester for optimal storage and water usage. An independent stand-alone rainwater harvester was designed and constructed to serve as an irrigation supply system for a 2000-square foot garden growing seasonal vegetables. The surface collection area is 100 square feet, and the system was designed with approximately 300 gallons of intermediate storage. Typical rainfall patterns in Gainesville, Florida indicate that 2,948 gallons of water will be generated per year which is sufficient for the proposed agricultural land use as long as strategic, intermittent water distribution is applied during dry periods. Other potentially beneficial uses of this system, particularly for areas with limited resources, include a hygiene station or water supply for a communal latrine.

Introduction

Sustainable Cycle:

Drawing down the aquifers through excessive pumping is not a sustainable approach for water conservation, particularly for agricultural use. The more traditional methods of water security that included rainwater harvesting (RWH) have been overshadowed and replaced for the sake of convenience. However, groundwater usage for agriculture is becoming increasingly unsustainable, especially since potable water supplies are becoming more limited as a result of climate change. RWH technology may be a relatively inexpensive way to mitigate ground water dependence.

Public Health Service:

A lack of clean water, sanitation, and hygiene can be directly correlated to increased disease. In sub-Sahara Africa, people are 10 times more likely to contract diarrheal diseases than they are in the United States[1]. Despite efforts motivated by the United Nations Millennium Development Goals, there are still over two billion people world wide that lack adequate water, sanitation and hygiene. Water quality issues are often worse in rural areas due to a lack of sanitation services resulting in contaminated surface waters.

Stand-alone rainwater harvester at the Bioenergy and Sustainable Technology Laboratory

Objective

To design and construct a rainwater harvesting system that will adequately irrigate a 2,000-square foot vegetable garden during dry periods in Gainesville, Florida.

Methods

Estimate Annual Precipitation:

- Gather monthly precipitation averages reported by the National Weather Service for the Gainesville Regional Airport Station
- Calculate the estimated annual rainfall in the Gainesville region

Estimate irrigation requirements for a 2000-square foot vegetable garden:

- To cover a variety of seasonal vegetables, assume row crops will be situated every 36-inches and plants will be spaced 1 to 2 feet apart.
- Evaluate soil type to determine estimated water retention

Design Appropriate Rainwater Collection Area and Storage:

- Determine roof collection surface area based on estimated irrigation needs and rainfall data.
- Provide adequate storage for at least two weeks of drought period.

Rain falling into gutter system during 0.25-inch rain event

2000-square foot garden area

100-gallon storage capacity integrated within the infrastructure of the RWH

Table 1. Monthly Rainfall Averages (Inches) from 1981-2010 at Gainesville Regional Airport

Jan	Feb	Mar	Apr	May	Jun
3.31	3.20	4.33	2.67	2.48	7.12
Jul	Aug	Sep	Oct	Nov	Dec
6.07	6.39	4.22	2.88	2.06	2.48

Average Annual Rainfall Total = 47.2 inches

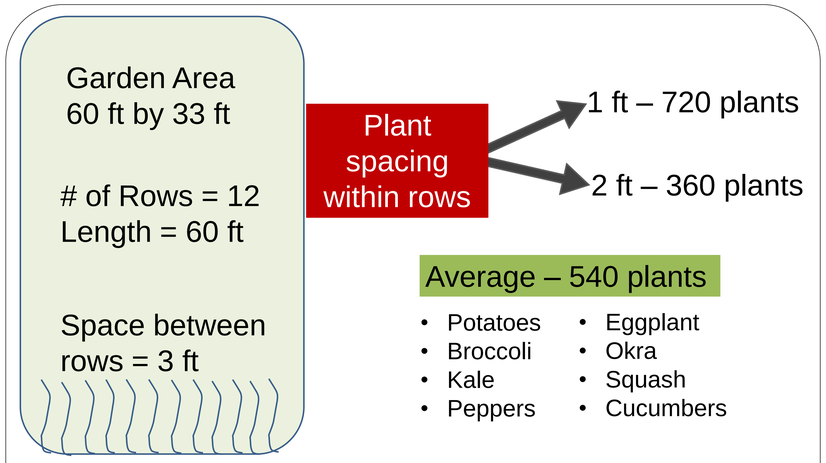

Figure 1. Garden Area Layout and Estimated Number of Plants

Irrigation Requirements:

- Sandy soil – 0.75 inch/ft is available water holding capacity and thus approximately 78 gallons per irrigation event (1700 gal/ac determined for current plantings) are recommended for a 1-foot wetting depth [2]
- Number of irrigation events is dependent on monthly evapotranspiration rate (Eto) divided by application efficiency (60 to 80% for overhead sprinklers) [2]

Example: March ETo = (2715 gal/ac/day)/70% = 3879 gal/ac/day, which results in 2 to 3 irrigation events/day

Recommended Irrigation = 150-230 gallons/day

Rainwater Collection Design: 100 sq. ft.

Table 2. Monthly Rainfall Collection Volumes (Gallons)

Jan	Feb	Mar	Apr	May	Jun
206	200	270	166	155	444
Jul	Aug	Sep	Oct	Nov	Dec
378	398	263	180	128	155

Annual Rainfall Collection Volume = 2943 gal/yr

References

1. Lewin, S., Norman, R., et al. (2007). Estimating the burden of disease attributable to unsafe water and lack of sanitation and hygiene in South Africa in 2000. SAMJ 97(7). 75-762
2. Zotarelli, L., Dukes, M.D., et al. (2016). Chapter 3. Principles and Practices of Irrigation Management for Vegetables. In: Dittmar, P. J., *Vegetable Production Handbook*. EDIS publication # CV297.

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