Rainwater Harvesting for Irrigation

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Abstract. *Many are looking for an affordable alternative water source for landscape irrigation. For the average landscape, the most cost effective option is a rainwater collection system. Water use greatly increases during the irrigation season. Water utilities must have supply, treatment capability, and infrastructure to supply this increase in water use. As large urban areas grow in population and development, the cost of supply, treatment and infrastructure increases therefore the water cost to customers increase.*
For every square foot of imperious surface, a one inch rainfall will collect 0.623 gallons of water. So a 2,000 square foot building can collect 1200 gallons every one inch rain. A 10,000 square foot office building or parking lot can collect 6,000 gallons from every one inch rain. Rainwater in the most areas is salt free and slightly acidic. Plants benefit from slightly acid water.

Rainwater Harvesting for Irrigation
Capturing rainwater in above ground or below ground cisterns is an ancient practice many homeowners, businesses and municipalities are adopting to use for irrigation, topping ponds and pools, greenhouse water, livestock, wildlife, firefighting and potable water. Some cities and states are encouraging rainwater capture particularly for summer irrigation when water use increases anywhere from 25 to 60%. This increase is attributed to irrigation. As population growth and development continues to strain water resources, landscape water conservation is not just an issue but a necessity. Future landscapes must conserve water to be sustainable. In urban areas, harvesting rainwater for irrigation will take the strain off municipal water supplies, delay building expensive new water treatment plants, and reduce flooding, erosion and stormwater contamination. In rural areas, rainwater harvesting is an optional supply for potable water when no other source is available and as a water supply for firefighting, livestock and wildlife.

Large-scale rainwater harvesting is an option for landscapes in parks, schools, commercial sites, parking lots, apartment complexes and greenhouse operations. Smaller rainwater harvesting systems are an option to supply irrigation water in residential landscapes.

A rainwater harvesting system consists of a method to collect, divert, store, filter and distribute water into the landscape. Systems are designed to collect the amount of water required landscape irrigation minus rainfall or if not enough collection surface is available to supplement with municipal water or groundwater. Of course using an efficient irrigation method and resource efficient plants will greatly reduce the amount of irrigation required.

Roof and other hard impervious surfaces are the best collection sites although collecting runoff from landscaped areas is another option particularly on a slope. Gutter and downspouts or a roof valley can direct rainwater into a rain barrel or a large tank/cistern. Drip irrigation tubing can deliver the water into the landscape. One inch of rain will provide 0.6 gallons per 1 square foot of roof. So an average 2,000 square foot home can collect 1,200 gallons during a 1 inch rain event. Where the average rainfall is 36 inches a year, a 2,000 square house will collect 43,000 gallons, more than enough for irrigation for a small landscape using water conserving plants and turf.

A rain catchment system cost as little as $0.50 a gallon for a do-it-yourself rain barrel to as much as $10.00 a gallon for a large underground cistern.

<u>Calculate Supply</u> (Amount of Rainwater Collected off all or part of Roof)

Supply In gallons	=	Rainfall In inches	X	0.623	X	Catchment Square feet	X	Runoff Coefficient

<u>Calculate Demand</u> (Water Required for Irrigation)

Demand In gallons	=	Evapotranspiration	X	Plant Coefficient	X	0.623	X	Irrigated Area Square feet

Every site generates unique supply and demand. For some sites, rainwater harvesting systems will provide enough water to meet irrigation demands, while for others, harvesting will only partially satisfy demand. Remember that supply fluctuates from year to year, depending on the weather (when and how much it rains). Demand can increase/decrease with plant water requirement, warmer-than-normal weather, as the landscape ages, irrigation issues, mulch layer maintained and with establishment of new plantings in the landscape.

Rainfall Harvesting Supply Worksheet						
	A	B	C	D	E	F
Follow the lettered instructions for each month	Enter the rainfall amount in inches for each month	Multiply "A" by 0.623 to convert inches to gallons per square foot	Enter the square footage of the catchment surface	Multiply "B" by "C" to yield the gross gallons of rainfall per month.	Enter the runoff coefficient for your catchment surface	Multiply "D" by "E" to obtain the total monthly yield of harvested water in gallons
January	0.53	0.33	1625	536	0.9	**483**
February	0.58	0.36	1625	585	0.9	**526**
March	0.42	0.26	1625	425	0.9	**383**

April	0.73	0.45	1625	793	0.9	**665**
May	1.79	1.11	1625	1812	0.9	**1631**
June	1.71	1.06	1625	1731	0.9	**1558**
July	1.89	1.13	1625	1842	0.9	**1658**
August	1.77	1.10	1625	1725	0.9	**1553**
September	2.31	1.39	1625	2259	0.9	**2033**
October	1.77	1.10	1625	1725	0.9	**1553**
November	0.65	0.39	1625	633	0.9	**570**
December	0.65	0.39	1625	633	0.9	**570**
Annual	14.80					**12518**

Plant water requirement is based on evapotranspiration and plant coefficient.

Rainfall Harvesting Demand Worksheet						
	A	**B**	**C**	**D**	**E**	**F**
Follow the lettered instructions for each month	Enter the ET amount in inches for each month	Enter the appropriate plant water use coefficient	Multiply “A” by “B” to obtain plant water needs in inches	Multiply “C” by 0.623 to convert inches to gallons per square foot	Enter the total square footage of landscaping	Multiply “E” by “D” to obtain total landscaping water demand in gallons
January	1.30	0.75	0.96	0.61	1200	729
February	1.70	0.75	1.27	0.76	1200	918
March	4.20	0.75	3.15	1.89	1200	2268

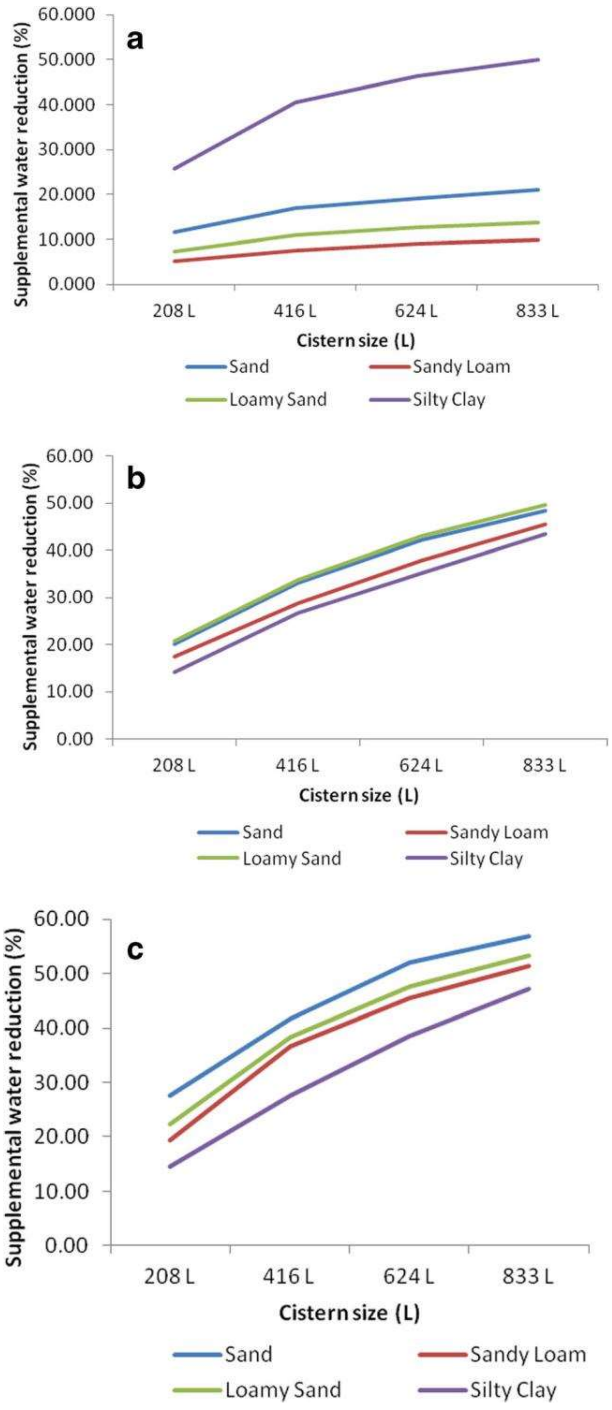
April	5.60	0.75	4.2	2.52	1200	3024
May	8.60	0.75	6.45	3.87	1200	4644
June	9.23	0.75	6.92	4.15	1200	4984
July	9.10	0.75	6.82	4.09	1200	4914
August	8.35	0.75	6.26	3.75	1200	4509
September	7.60	0.75	5.70	3.42	1200	4104
October	5.20	0.75	3.90	2.34	1200	2808
November	2.00	0.75	1.50	0.90	1200	1080
December	1.10	0.75	0.82	0.49	1200	594
Annual	64.98					25488

Plant Coefficients

Plant Water Use Coefficients	
Plant Type	Percentage
Low Water Use (Blue Grama, Buffalo, Zoysia, Desert Willow)	0.20
Medium Water Use (Bermudagrass, Spiraea)	0.50
High Water Use (St. Augustine, Fescue, Magnolia)	0.75

The plant water use coefficient represents the water requirements of a particular plant relative to rates of reference evapotranspiration (Et_o). Thus, a low-water-use plant requires only 20 percent to ET_o, but a high-water-use plant requires 75 percent of ET_o. New plantings of all types require more water. Supplemental water must be supplied when a plant's water use requirement (demand) exceeds the amount of water available from precipitation (supply).[2]

Research show rainwater harvesting is a feasible source for irrigation water.



Supplemental water reduction percentage for different cistern sizes, different irrigation scheduling methods **A** time-based; **B** soil moisture-based, and **C** ET-based as compared to NO RWH system for each irrigation scheduling method[3]

Connection to Irrigation
For a new irrigation system, the main line water source is the water from the cistern. For existing irrigation systems, disconnect the main line from the potable water source and connect the main line to the cistern.

Filtration
Clean water is essential for irrigation efficiency. Rainwater requires filtration before storage and distribution to remove any particles and debris. Debris off a roof will accumulate in the cistern, damage pump and clog nozzles. Debris of roof include roofing material, leaves, catkins and other flowers and fruit/nuts off trees and bird and animal droppings.
Keep gutters free of leaves and other debris. Clean gutters at least twice a year. Once in the fall after all the leaves have finished falling and again in spring after all the flowers fall. Or add gutter device to exclude debris.
Filter stormwater before entering the cistern and again before the water enters pump and irrigation system. For a small system use a first flush diverter. Larger systems, there are many types of filters for large systems. Consult with a Rainwater Harvesting Professional about the many selections, sizing the filter and maintenance. Filter water going into pump and irrigation system using an drip irrigation filter.

Pump
The pump size is determined by knowing the pressure required to run the irrigation system properly. Too high or too low a pressure will create unsatisfactory irrigation.

The "head" required of the pump is determined by calculating the total dynamic head of the system.

Equation 1. Total Dynamic Head (TDH)

$TDH = h_p + h_e + h_f$

TDH = total dynamic head (ft)

h_p = operating head (pressure) required by fixture (ft)

$h_e = h_2 - h_1$ = elevation difference between pump and fixture (ft)

h_f = friction loss in system (ft)[4]

Once the required flow and total dynamic head are determined, consult a pump vendor for information on specific pumps that are best suited for system demand. On-Demand, Irrigation, transfer, sallow well pump and submergible pumps all have different features. Select one that works best for the site, system and customer. A pressure tank is required for some systems.

Back-Up Water
If the catchment area is not large enough to collect enough water for irrigation, a supplemental water resource is required. Supplemental water or Back-up water is from another water source, municipal or groundwater. Cross contamination with potable water must be avoided using a

backflow prevention device. Attached the supplemental water near the top of the cistern with a six inch air gap between the opening for the back-up water to the top of the overflow pipe. Check with the city to see if they also require a backflow prevention device in the potable water line.

There are several companies with devices to automate back-up water so the entire cistern will not fill up with potable water. Check with a Rainwater Harvesting Professional for selection of these different devices.

Maintaining Your Rainwater Harvesting System

Inspect water harvesting systems monthly to assure the system operating properly.

Use this maintenance checklist to keep your system in top condition:

- Develop a maintenance checklist
- Develop and use a schedule for maintaining system
- Keep a Diary of maintenance –and Usage
- Trim tree branches away from roof
- Keep debris out of gutters and downspouts
- Clean filters/screens going into and out of cistern
- Inspect tanks, lines and connections for leaks. Repair any leaks
- Empty First Flush after each rainfall or install an automatic or semiautomatic drain
- In colder climates, empty first flush before a freeze and protect pipes from freezing temperatures
- Flush debris from cisterns if necessary
- Clean and maintain filters, especially those on drip irrigation systems
- Lower level in system before each rainfall
- Lower level in cistern to allow for freeze expansion in cold climates

Rainwater Harvesting for Irrigators

Rainwater harvesting is an option irrigators, landscape management companies, and property managers should offer commercial and residential clients. Familiarize yourself with all options for rainwater collection systems and the calculations. Contact rainwater collection professionals to design and install rainwater collection systems. The American Rainwater Catchment System Association (ARCSA) and Texas A&M AgriLife Extension is the education and certifying organization for rainwater professionals. Their web site is http://www.arcsa.org/. Visit this web site for a list of professionals. Many states have rainwater collection state associations that umbrella under ARCSA, so check for state associations. Texas Rainwater Catchment Association is at http://www.texrca.org/. Texas A&M University AgriLife Extension Rainwater Harvesting Team is a leader in education about rainwater harvesting. This team has created a web site with information including pictures, videos and many fact sheets and publications. Visit this informative site as http://rainwaterharvesting.tamu.edu. Check these web sites often because new technology for rainwater harvesting is developing daily as the demand for systems increase through the county and the world.

‘**Conclusion**

A RWH model based on mass-balance method for solving the complex storage-use dynamics of RWH system and investigating the effectiveness of RWH system as a SCM was developed and evaluated in this study. There were two standards for determining the effectiveness of the system: reduction of the total volumes of potable water used for irrigation and, reduction of the total runoff from an irrigated turfgrass plot. The evaluation was done for four soil types, comparing three irrigation scheduling methods, and four cistern sizes. A series of simulations showed that all cistern sizes were efficient in reducing total runoff and potable water used for irrigation as compared to a NO RWH system. When moving from coarse soil texture such as sandy soil to fine soil texture such as Silty Clay soil the total water runoff predicted increased and total supplemental water predicted decreased. While RWH cistern provided adequate storage for irrigation demand for the studied area and contributed to reducing potable water used for irrigation, it overflowed frequently during stormwater events and especially when water was not released for irrigation purposes. A controlled release program based on predicted rainfall amounts from upcoming storms would improve the efficiency of RWH as an SCM. Predictive equations were developed to assist users in selecting an appropriate cistern size to save water and/or reduce runoff from their residence. Decentralizing the urban stormwater runoff problem to be on a household scale by implementing RWH system could result in financial savings as well as enhance both human and environment quality.’[5]

Rainwater harvesting is one of many landscape water conservation practices to consider. Landscape design, plant selection, soil preparation, mulch, irrigation efficiency and proper maintenance are also essential.

1, 3, 5 Shannak, Sa’d A.; Jaber, Fouad H.; Lesikar, Bruce J. 2014. Modeling the Effect of Cistern Size, Soil Type, and Irrigation Scheduling on Rainwater Harvesting as a Stormwater Control Measure. Water Resources Management 28:4219-4235.

2 Persyn, Russell A., Porter, Dana O. and Silvy, Valeen A. 2010. Rainwater Harvesting. Texas A&M AgriLife Extension publication B-6153.

4 Hunt, William, F. and Jones, Matthew, P. 2006. Choosing a Pump for Rainwater Harvesting. North Carolina State University Cooperative Extension