Title of Proposal: Rainwater Harvesting as a Stormwater Best Management Practice
Focus Category: a) FLOODS b) IRRIGATION c) WATER USE
Keywords: Rainwater Harvesting, BMPs, Urban Runoff, Stormwater, Flood Control, and Irrigation
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Principal Investigator (graduate student). Sa'd Shannak, Texas A&M University,Water Management &Hydrology Science, G7, Saedshannak2002@gmail.com, 979-862-9134 301 Ball Street. Apt 1046, College Station, TX 77840
Co-Principal Investigator (faculty advisor). Dr. Bruce Lesikar, P.E., *Professor, Extension Specialist, Associate Department Head & Extension Program Leader,* 301E Scoates, (979) 845-7453, b-lesikar@tamu.edu

Congressional District(s) where project will occur: Urban Solutions Center - Texas AgriLife Research and Extension- Dallas, TX
Statement of Critical Regional Water Problems: How does the irrigation schedule and Rainwater Harvesting System size impact the effectiveness of RWH system for stormwater management at a plot scale and on a watershed scale?

Abstract
As a result of population and economic development, Texas, as most other states in the U.S continues to experience high escalation in urban growth. With urban growth, impervious land coverage usually increases due to the growth in the number of rooftops, parking lots, roads, and sidewalks and can be the cause of drastic effects on water quality and watershed ecosystems. As a result, infiltration and base flows will be reduced and urban runoff, the frequency of flooding and peak runoff flow rates will increase. The consequences of urbanization will be reflected not only on the hydrological cycle and infrastructures, but also on human health. Urban runoff has a significant role in transporting pollutants such as chemicals, sediments, pesticides, fertilizers, and oils, then depositing it in water bodies, where they harmfully affect water quality.

Best management practices (BMPs) aim at negating the effect of urbanization on stormwater by reducing the runoff volume and peak flows as well as improving the water quality. BMPs can be costly and form a burden for municipalities and states. Thus, selecting a proper, cost effective solution is crucial. While rain water harvesting (RWH) has been extensively used as an alternative source of water, it has not been studied as a stormwater BMP. RWH can reduce stormwater runoff volumes, and delay and decrease peak runoff flow rates. Collected water can be used later for irrigation systems or filtered and reused for household activities such as toilet flushing.

This research aims to demonstrate the effectiveness of RWH as a stormwater BMP in urban areas, specifically in Dallas, Texas. Different irrigation management methods combined with RWH and a control site without RWH are going to setup to determine the effect of RWH as a BMP on a single-family housing scale. The effects of each irrigation method on peak runoff rates and volumes as well as water quality are going to be compared. Results of this study will provide information on the required tank sizing, and water use method that will improve the performance of RWH as a stormwater BMP.

Introduction
Although rainwater harvesting is commonly mentioned in literature as a stormwater BMP, most research concentrates on the water savings and the necessary treatment for different water uses, not on stormwater. The effectiveness of Rain Water Harvesting (RWH) system as a stormwater BMP may be significantly impacted by the use of the harvested water at plot scale and on the sizing of the storage containers. The proposed research will provide a basis for evaluating the efficiency of RWH system to achieve the goals of stormwater BMPs by addressing the following question:
How does the irrigation schedule and RWH system size impact the effectiveness of RWH system for stormwater management at a plot scale and on a watershed scale?

This study will conduct a field experiment to provide data on RWH system-irrigation systems as stormwater BMPs.

Problem statement

Although different policies requiring the use of RWH as a BMP are already in place, little research has addressed the effectiveness of implementing RWH system as a BMP. Therefore, investigating possible runoff reductions and effectiveness of RWH system on a household and watershed scales is an important research question and will potentially become increasingly so in the coming future. Moreover, type of irrigation scheduling plays a significant role in determining the effectiveness of RWH as a stormwater BMP. For instance, most of the irrigation practices involved over watering which in turn results in increasing water runoff and all the negative effects associated with it, such as: increasing pollution, decreasing groundwater recharge, increasing flush floods, and streams deterioration. As a result, this study will involve three different management irrigation methods with RWH system and a control site without RWH. A comparison between each irrigation method will be conducted based on reducing stormwater runoff. Those irrigation methods include: time-based irrigation scheduling, evapotranspiration-based scheduling, and soil moisture-based scheduling.

Significance of the study

There is a limited amount of research available in literature focusing on the effectiveness of RWH system in controlling urban runoff-. A limited number of RWH system as BMP research are conducted in the United States and no research has been done in Texas, or the Southeastern United States. The results of this study will provide guidelines for developing stormwater management policies in a cost effective way. Also, this work will provide insight into how RWH system can be both a public need in terms of stormwater management and erosion control, and a private pleasure by savings (saving water bills on a household level as well as saving power on a national level). This study will also provide a better understanding of the complex storage-use dynamics of RWH system. Data on water use of and water quality coming from various irrigation systems will also be generated.

Objectives

The aim of this research is to present a procedure that can be used to verify the effectiveness of RWH system as a BMP for different stormwater events. This is going to be attained by studying the impact of irrigation schedule and RWH system size on the effectiveness of the system.

The overall goals of the field research are as follows:

1. Providing stormwater management developers with new options for on-site stormwater control and peak discharge reduction;
2. This work will also provide a model that can be used to size a cistern with the best irrigation method to control stormwater runoff based on a desired efficiency;
3. Enriching literatures with real data related to RWH system as a BMP based on field experiment;
4. Estimating the stormwater-reduction volume by the RWH-Irrigation system and, therefore, flood peak reduction.
5. Comparing the 4 small scale roofs according to: runoff volume, peak discharge, hydrograph kurtosis, runoff coefficient, and runoff threshold.
6. Comparing the stormwater load reduction of Nitrogen and Phosphorus from the various irrigation methods

Description of the Experiment

An 18-month study will be conducted at the Urban Solutions Center of Texas A&M University located in Dallas, TX. The experiment will consist of four small scale roofs and lawn areas to emulate urban residential units. The ratio of roof to lawn area will be designed to reflect the Dallas area lawn to roof ratio average. The four plots will represent three different irrigation management methods with RWH system and a control site without RWH system. The three irrigation methods will represent 1) time-

based irrigation scheduling; 2) evapotranspiration (ET)-based scheduling; and 3) soil-moisture-based irrigation scheduling. Time-based irrigation scheduling, commonly used in urban areas, will also be used in the control plot. The RWH system will consist of a catchment area built from a common roof material, a gutter with leaf guard and a downspout, a first flush diverter and a water collection barrel.

Monitoring and Evaluation

A monitoring system to collect and store continuous data, quantifying the components of the water balance, will be designed and installed in each of the plots. These data will include weather data, water yield in the rain barrels, irrigation volume applied, soil moisture, and total runoff. Rainfall, irrigation and runoff data will be collected on event-basis, while the remaining weather data will be collected from an on-site weather station. The total rainfall volume collected and the total runoff volume flowing from each irrigation method plot will be used to assess the overall water conservation as well as the effectiveness of RWH system as a BMP.

Experimental Design

Each setup would be a small scale representation of an average house in the Dallas Fort Worth area. An average house has a floor footprint of 2000 square feet and a yard of 5000 square feet. It will be assumed for this experiment that homeowners will install a 1500 gallons tank. A tank of that size would be sufficient to irrigate half the yard with minimal additional water, i.e. 2500 sq. ft. If the tank is represented by two 55 gallons tank connected to each other, the representative roof should be 150 square feet and the irrigated yard would be 190 square feet.

The representative roof should be 15ft x 10 ft. It needs to be higher that the height of a 55 gallons barrel, which is approximately 40". So 48" long 4" diameter posts at the corners and 1 in between each corner of the roof are needed (8 in total). The roof material needed would be corrugated metal. Two sheets of 15'x5' would be needed. Lumber (2" x 6") would be needed to build the base where the metal roof will sit. Eight 10' foot pieces would be needed and six 15' pieces. Distance between lumber pieces would be 5'. Two sections of 15' x 5' roof sections can be joined together sloping towards the center. Gutters will be installed at the edge of the roof structure to collect the rainfall into a downspout. Four of these structures would be needed for this study.

Equipment	1 Setup	# of Setups	Total
4" diameter x 48" long posts	9	4	36
2"x6" 10' lumber	8	4	32
2"x6" 15' lumber	6	4	24
5'x15' corrugated sheet metal	2	4	8
55 gallons barrels	2	4	8
5' gutters	2	4	8
14' gutter	1	4	4

The runoff plots would be on the edge of a terrace and runoff will be collected using gutters at the downside end of the plot to direct runoff into a measuring tank.

The treatments require soil moisture sensors, data loggers and irrigation controllers. A drip system will be used to irrigate the plots (to minimize water spilling outside the plots). Level loggers (Level Troll) will be used to continuously monitor water levels in the barrels.

Expected Results

The expected results of this research study will be attained by studying the following parameters:
1) Quality and quantity of water runoff from the roofs
2) Water runoff and overflow from the barrel
3) Amount of rainwater captured and used for irrigation
4) Water runoff in terms of quantity and quality coming out of plots