Performance of Rainwater Harvesting Systems in North Carolina

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Rainwater harvesting has been used for thousands of years to capture rainwater and make it available for use in areas where water supply has been limited by climate or infrastructure. Due to recent concerns over the environmental impact of stormwater runoff and increased water demands, interest in rainwater harvesting systems has developed in humid, well developed regions, such as the southeastern United States. With increased interest in rainwater harvesting, it is important to understand the function and benefit of these systems in this region, since performance may differ from locations where reliable water supplies are not prevalent and rainfall is limited. In order to better understand the anticipated usage and reliability of rainwater harvesting systems in the southeastern United States, a monitoring study was conducted at 3 rainwater harvesting systems in North Carolina, measuring cistern water levels and rainfall. Harvested rainwater was used to flush a toilet at one site, irrigate gardens at another, and wash vehicles at a third location. Results of the monitoring study showed that the rainwater harvesting systems were typically underutilized. Water usage was most consistent at the location where harvested rainwater was used to flush a toilet; however, the water level within the cistern only dropped below 80% of capacity on one occasion during the 30 month monitoring period. Minimal usage of harvested rainwater at the three monitoring locations was attributed to poor estimation of anticipated water usage and public perception of the harvested rainwater. The relatively minimal water usage resulted in frequent cistern overflows during storm events and the systems had little effect on reducing runoff volumes as a result. A computer model was developed to simulate the performance of rainwater harvesting systems based upon historical rainfall data and anticipated usage by evaluating a daily or hourly water balance. Anticipated usage could be established using several methods, including a soil water balance to simulate irrigation demands and custom water usage rates dependent upon month of the year and day of the week. Outputs from the simulation included percentage of runoff volume captured, percentage of water usage replaced, annual water savings, overflow frequency, dry cistern frequency, and percentage of first flush volume captured. Various parameters of the rainwater harvesting system design could be modified and simulations repeated until the user was able to satisfy their water quality, water supply, and system cost goals. The rainwater harvesting model was used to simulate the performance of a 55-gallon (208 liter) rain barrel commonly used by homeowners in this region to meet household gardening demands. A variety of turfgrass irrigation scenarios were examined, varying the size of the irrigated area and contributing rooftop. Simulation results for locations throughout North Carolina showed that the rain barrel was not able to adequately meet irrigation demands. The low volume of water the rain barrel was able to supply for irrigation and the large amount of overflow indicated that the rain barrel was not able to effectively utilize the potential water supply coming from the rooftop and provided minimal runoff volume reduction.