Rainwater Collection Saves Water and Energy

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Abstract

With a growing world population, it is becoming more challenging to meet an increasing water demand. Florida gets most of its fresh water from groundwater (6.4 billion gallons/day) but, with a predicted 18% increase in water usage from 2015 to 2035, this will cease to be a sufficient source. Excessive groundwater use has negative environmental impacts such as saltwater intrusion, lowered lake levels and loss of wetlands. Alternative water sources will be essential to meet future demand. This project aims to quantify and understand the potential water and energy savings of using localized rainwater collection to supplement domestic and commercial water use. Local rainwater collection and storage uses water that is already available and reduces the energy expended on extraction and transport. The annual rainfall in Florida is between 40 and 60 inches per year. In Alachua County, depending on the time of year, a 1000 square feet area has the potential to collect 40-160 gallons/day. Although not necessarily suitable for drinking, rainwater could be utilized for flushing toilets and outside uses that are responsible for over 60% of an average American household's water usage. Rainwater utilization, therefore, has a potential to reduce water demand and its related energy consumption.

Introduction

With a growing population and an already stressed water supply, Florida will need to investigate alternative water sources to meet a growing demand, predicted to increase by 18% from 2015 to 2035 [**1**]. A large portion of the public drinking-water supply is currently being used for outdoor irrigation and other purposes that do not require water of this quality. The annual rainfall in Florida is between 40 and 60 inches per year [**2**]. In Alachua County, depending on the time of year, a 1000 square feet area has the potential to collect 40-160 gallons/day [**3**]. Thus, this research aims to quantify the potential water, energy, and monetary savings of supplementing domestic and greenhouse water usage with collected rainwater.

Objectives

- Quantify the water, energy, and monetary savings of using rainwater collection to supplement household and greenhouse water use.
- Evaluate the potential of rainwater to reduce the environmental impact of excessive groundwater usage.

Methods

- Review historical precipitation, water-usage trends, and power requirements for water supplies within Florida and the United States.
- Calculate the water capture capacity, and potential monetary and electrical power savings of different structures.
- Research and evaluate the relevance of reducing groundwater consumption.

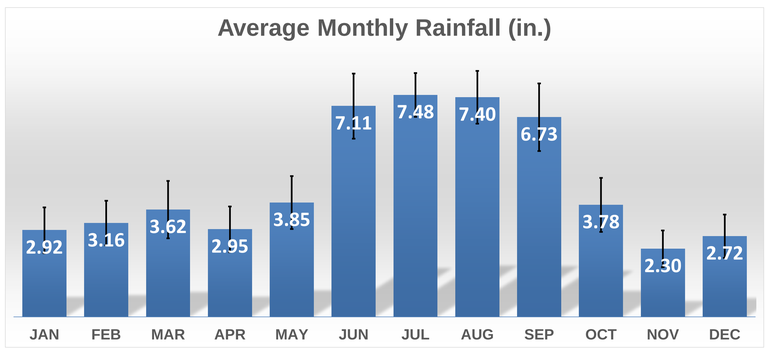

Figure 1. Average rainfall in Florida (1895-2017) [2].

Households

With an average household size of 2.47 [**4**] and an average residential usage of 85 gallons per day [**5**], an average Floridian household would use about 210 gallons per day. Between 30% and 60% of this is outside water usage [**6**] and, from **Table 1**, most houses in Florida would be able to collect enough rainwater to cover these uses. Implementing rainwater collection would thus greatly decrease the domestic water demand and significantly reduce the utility bill of the individual homeowner.

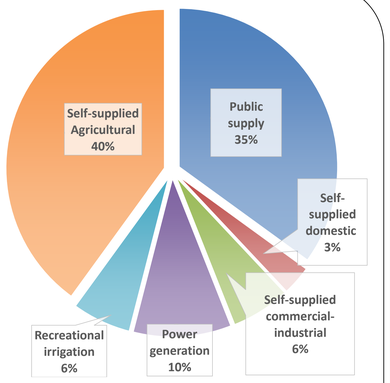

Figure 2. Freshwater withdrawals in Florida, 2010 [7].

Greenhouses

A greenhouse is an isolated environment; thus, it does not benefit from the natural irrigation provided by rain and typically gets all its water from ground and surface water sources. A typical greenhouse requires about 0.3 gallons of water per square foot of growing area per day [**8**]. Florida has a daily average precipitation of between 0.06 and 0.15 gallons [**2**]. As seen in **Figure 1**, precipitation peaks during the summer months. This is also the time when greenhouses require the most irrigation. A greenhouse could thus meet a significant portion of its water demand by rainwater collection.

Figure 3: Commercial Greenhouse

Electrical Energy Savings

Although the electrical energy usage of water suppliers is a major factor in the production cost, it is generally covered by the utility companies and is thus rarely taken into consideration outside the industry. However, with the increasing relevance of global warming and greenhouse gas emissions, it is essential to also consider the potential energy savings of a reduced water consumption. Supplying groundwater requires an estimated 1,824 kWh per million gallons [**9**]. The potential monthly energy savings are shown in **Table 1**.

Table 1. Monthly Savings

Structure	Roof Surface Area (feet^2)	Water Savings (gallons/month)	Monetary Savings ($/month)*	Energy Savings (kWh/month) [9]
Small house	1500	3177 – 4765	12 – 18	5.8 – 8.7
Large house	3000	6353 – 9530	24 – 36	11.6 – 17.4
Small greenhouse	500	1059 – 1588	4 – 6	1.9 – 2.9
Large greenhouse	10000	21178 – 31767	127 – 191	38.6 – 57.9

****The monetary savings are based on GRUs utility prices, and rates vary with size.***

Relevance

While the monetary savings shown in **Table 1** could be appealing for the individual home or greenhouse owners, a reduction in groundwater usage will also be essential to avoid major environmental consequences. Over 90% of residential water use comes from groundwater sources [**10**]. The effects of excessive groundwater extraction can already be seen in increased sink-hole development, the drying of water wells, and an increasing risk of salt water intrusion around the state [**11**].

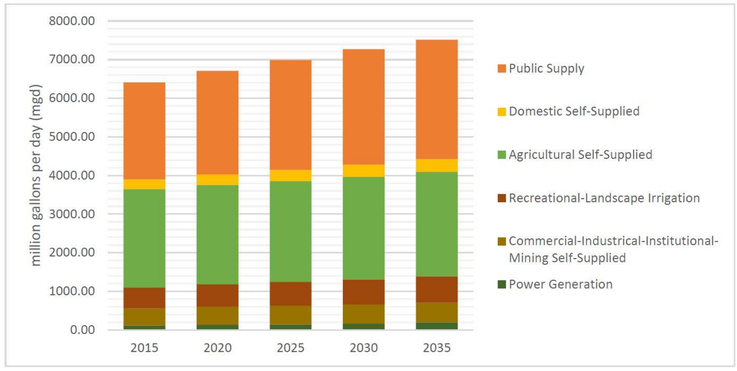

Figure 4. Predicted water usage from 2015 to 2035 [12].

In 2010, public and agricultural water use was responsible for 35% and 40%, respectively, of Florida's total water use. However, by 2035, public water use is predicted to increase by 23% and surpass agricultural use, which would only grow by 8% [**12**]. With these predictions, the adoption of water-saving methods like rainwater collection will be essential to limit the negative environmental impact of over-using the aquifers.

Future Work

- While this project outlines the theoretical savings from rainwater utilization, more research is needed to determine the cost and method for initial implementation and the payback period of the investment.
- Commercial greenhouses are subject to regulations determining what water can be used for irrigation. Further data collection and research on these regulations and the cost of making rainwater conform to these standards is necessary.

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