6. Rainwater Harvesting System: Proposal for a pilot rainwater harvesting system installment at Booker Hall.

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Abstract: Fresh water is expected to become increasingly scarce as temperature and sea levels rise due to Global Climate Change. We believe now is the time to start rethinking our behaviors in terms of water use and start conserving water even if it is on a small scale. One of the best ways to conserve water at a university level is to install small scale rainwater harvesting system for irrigation. We propose for the University of Richmond to utilize Booker Hall to collect rainwater using ten 200 gallon rain barrels. The water will be used to irrigate flowerbeds around campus. The project will be relatively low cost, costing the University $2,859.50. Although today the project only saves the University a little under $200 per year, in the future the project will become more economically sustainable since water will become more expensive and possibly less subsidized.

Introduction

Water is a crucial resource for the survival of life on earth. Unfortunately, with the increasing threat of climate change fresh water is expected to become a pressing issue in the future for many countries, including the southeastern region of the United States (EPA 2013), refer to figure 6.1. According to the EPA, water management is likely to become a challenging issue, due to rising temperatures, and demand due to economic and population growth (EPA 2013). Increased temperatures are likely to lead to longer, more intense, and more frequent droughts in the Southeast, putting more stress on water resources (EPA 2013). There is also a concern that saltwater may mix with shallow aquifers of groundwater in coastal areas, due to expected rise in sea level, contaminating the groundwater (EPA 2013). One way to adapt to the changing climate and rain patterns, is to start harvesting rainwater**.**

We as the environmental studies majors believe that it is crucial to conserve and recycle water in light of the future challenges. The University of Richmond understands this principle and is already making the changes required to conserve water, by planting native and drought tolerant species of plants, and irrigating some fields such as the baseball field using greywater from the Westhampton Lake. Other notable water conservation practices include installing water efficient shower heads and the use of drought tolerant landscaping at several LEED certified buildings (Office for Sustainability 2014). We acknowledge the efforts of the University to conserve water, but we also believe there are more opportunities for the University to explore new conservation techniques.

The University of Richmond should expand its water conservation efforts by taking advantage of rainwater and using it to irrigate flowers around campus. In the next pages we outline our rainwater system installation proposal to the University. In short, we think that the

University can learn from the experiences of other colleges, which installed underground rainwater collecting systems, the benefits they enjoy from conserving water such as cost savings and a reputation of an environmentally cautious institutions. However, we do not propose to install expensive underground rainwater collecting facilities, instead we propose an installment of a pilot project with the use of ten 200 gallons barrels to collect rainwater from Booker Hall's gutters. We recommend the implementation of a pilot project to evaluate the risks and the benefits beforepossibly installing the model later on a larger scale.

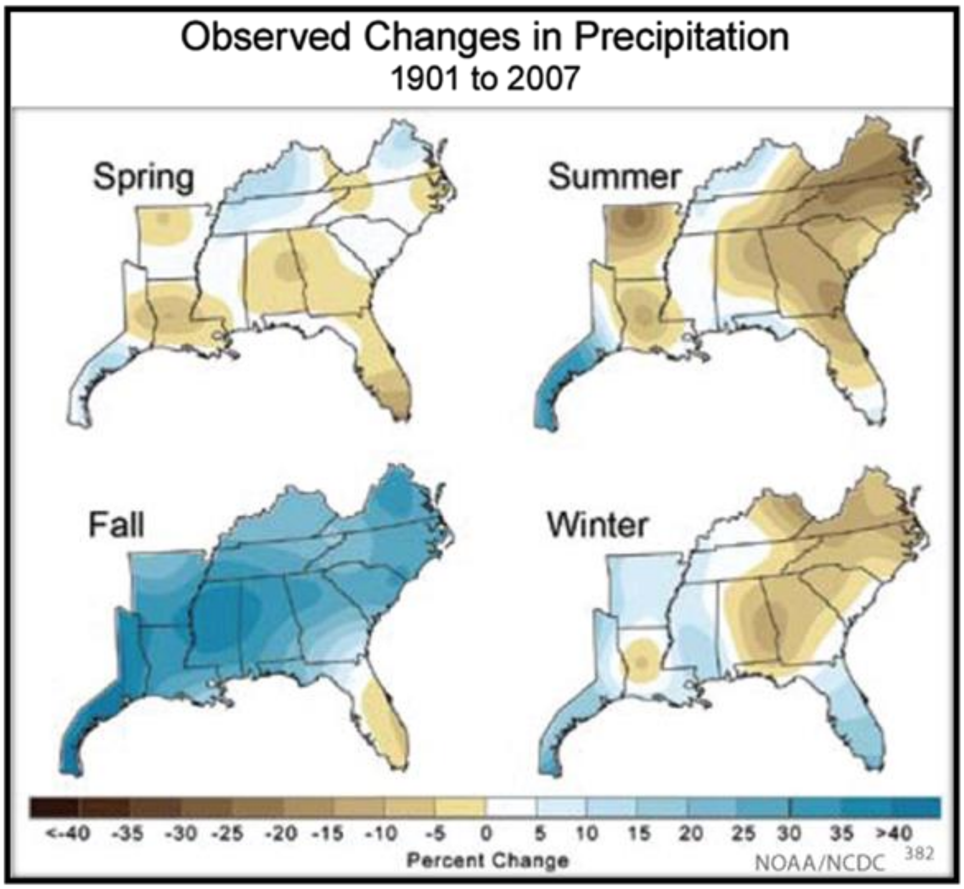

Figure 6.1. The average precipitation in the Southeast has increased, however the summer and winter precipitation has declined by 10 percent. The percentage of areas covered in droughts in the region has also increased (U.S. Global Climate Change Impacts in the United States 2009).

Methods

After a careful analysis of buildings on the University of Richmond Campus, our group determined that Booker Hall was the best building for a rain harvesting system. Booker Hall has a large roof, which provides a large collection area for rainwater. Also, Booker Hall has an accessible and hidden storage area for rain barrels.

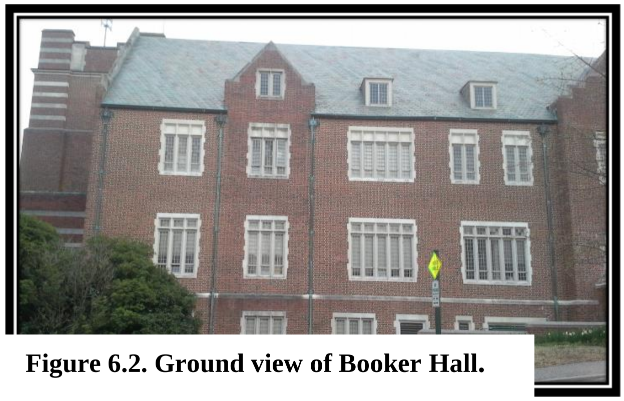

Figure 6.2. Ground view of Booker Hall.

The rain barrels will be set up on a cement floor and connected directly to five gutters coming down from Booker Hall's roof. The storage area is below eye level and hidden by a wall (Glass 2014). The rain barrels will be hidden from any pedestrians walking by Booker Hall. Being able to store the rain barrels in an area where they would not be seen was a critical requirement for our project, as our group did not want the rain barrels to detract from the University of Richmond's aesthetically pleasing campus (figure 6.2).

The storage area is also easily accessible for facilities. They can drive their pickup trucks directly to the storage area where the rain barrels will be placed (figure 6.3), and then can siphon the water from rain barrels into an irrigation tank on the back of their trucks (Glass 2014).

Figure 6.3 Cement floor where the rain barrels will be stored.

For these reasons we are confident that Booker Hall is the best building for a pilot rainwater-harvesting project. Once we determined that Booker Hall was the best building to use, we started calculating the amount of rainwater harvestable by the building. We quickly realized that determining our collection area and calculating the amount of rainwater harvestable by the building was going to be harder than we anticipated.

Booker Hall's roof is a complex structure. From aerial pictures of Booker Hall on Google Maps and ArcGIS we struggled to determine where the rain would drain after falling on the roof, as there are many drainage points. After viewing aerial photographs of Booker, our group realized we would not be able to harvest all the rainwater falling on the roof. We narrowed our collection area and selected two portions of Booker Hall. After narrowing our collection area, we found a new drainage point that connected a portion of the roof to our collection area. However, we were not able to determine how much more rainwater we could harvest from this new section. From aerial photographs we could not determine which way the roof sloped, and where the rainwater would drain. Therefore we took a conservative approach to estimate which roofs would drain to our rain barrels and how much water would be collected from one inch of rain. Our collection area only included two sections and did not include the drainage area that connects to our smaller collection area (figure 6.4).

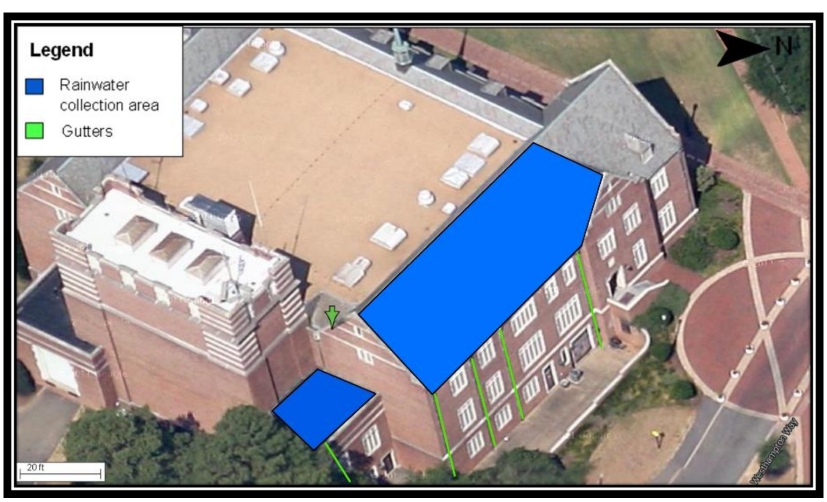

Figure 6.4: Aerial view of Booker Hall. Blue area is our collection area and the green lines are the gutters (Google Maps).

We … estimate our designated sec… …h of rainfall. First we calculated the square feet by using an aerial photograph of Booker Hall from Google Maps. We then uploaded the image to a Geographic Information Systems (GIS) software called ArcMap, and used the ruler tool to measure our dimensions. The dimensions for our collection area are 91.38 feet by 15.76 feet and 15.56 feet by 27.76 feet. After determining the square footage, we plugged the dimensions into a USGS rainwater calculator (Pearlman 2014). The calculator computed the amount of rainfall in gallons that can be collected from one inch of rain on a designated area. After calculating the number of gallons we could harvest from one inch of rain, we were able to calculate how much rainwater could be collected each month. We researched monthly average precipitation levels for Richmond, VA and multiplied this number by 1,113 gallons. After completing our calculations we were able to determine the capacity level and the number of rain barrels the University should purchase.

Our data showed that for six of the twelve months of the year, Booker Hall is capable of filling ten 200-gallon rain barrels twice a month. Our calculations were conservative and we believe Booker Hall is capable of harvesting more than 1,113 gallons from one inch of rain. Due to our conservative calculations, we believe the University of Richmond should purchase ten 200-gallon rain barrels. The 200-gallon rain barrels will allow the University to harvest extra rain which smaller rain barrels holding 100-150 gallons would be unable to capture. Once the rainwater is harvested, facilities will use the water to irrigate flowerbeds around campus.

Why the University Should Do It

Steve Glass, Horticulturist and Landscape Manager at the University of Richmond, graciously had a meeting with our group and informed us that facilities would make use of any rainwater collected. Glass explained how facilities already have irrigation tanks on the back of their pickup trucks, which they use to irrigate flowerbeds around campus (Glass 2014). He believes collected rainwater could replace city water, which is currently being used for irrigation. Mr. Glass also explained how facilities are evaluating ways to work in a more sustainable manner. Our group was excited to hear such a remark, and we believe a rainwater harvesting system used for irrigation would be a great initiative by the University of Richmond to act in a more sustainable manner.

Although our project is starting at a small scale, any steps taken by the University of Richmond towards combating climate change communicates that the University is committed to acting in a more sustainable manner. Our project focuses on ways humans can adapt to the changing climate. By collecting rainwater, the University of Richmond is adapting and protecting itself from expected lower precipitation levels in the future. Looking at figure 6.1, we can clearly see a decrease in precipitation levels for three of the four seasons. Decreases in precipitation levels will likely lead to higher prices for water and water restrictions. Although the focus of our project is the environmental benefit of harvesting rainwater, there is also an economic incentive.

In addition, the University would benefit from the publicity that it will receive by being an eco-friendly campus. We recommend writing articles in the collegian about this project if the University implemented it, and track the benefits of the project through the Office for Sustainability. University tours should also include a brief show of the rain barrels to promote the sustainable image of our campus, and attract an environmentally aware student body.

How the University Should Do It

Based on our estimates we believe that the University of Richmond should invest in ten 200 gallon rain barrels and install them at Booker Hall (figure 6.3). After the rain barrels are installed, the facilities will siphon the water from the rain barrels into barrels on their trucks and use the water to irrigate flowers around campus. Facilities already irrigate flowerbeds using barrels on their trucks, however the barrels are filled with tap water. Therefore, the project will not involve any additional expenses such as transportation or training, since facilities are already accustomed to the processes of using barrels on the back of their trucks.

After researching websites such as Amazon.com, Homedepot.com, and rainharvestingsupplies.com, we found that the latter offers the best barrels in terms of capacity and pricing. Rain barrels that would best fit our project cost $285.95 per 200 gallon barrel on the website (figure 6.5). We were not concerned about the look of the rain barrels since they will be hidden from pedestrians and therefore will not affect the image of our campus. Of course if the rain barrels were placed in places where people will be able to see them, then we would have suggest more visually appealing rain barrels. After deciding on the type of the rain barrels we estimated the cost of our project to be $2859.50, by multiplying the cost of one rain barrel by the number of our rain barrels. We believe that $2859.50 is a justifiable cost for such a project. Our project will be contributing to University's sustainability through the conservation of water resources.

Figure 6.5. Rain Harvesting Tank, holds 200 gallons, priced at $285.95 (Rainharvestingsupplies.com 2012).

Even though, our project is an environmental sustainability project we calculated the payback period to see whether the project can also be economically sustainable. Payback period is an estimate for the amount of years the project is expected to payback its initial cost. The payback period is usually calculated by dividing the initial investment by the cash flows per period. Our initial investment for the project was $2859.50, which is the total cost of the rain barrels. The cash flows per year was a little harder to identify. We decided to calculate how much the project will save the University by switching from using Henrico County water at the rate of $2.73 per one hundred cubic feet (CCF) to free rainwater (Souleret 2014). We calculated the savings for three rainfall scenarios; historical average amounts of rainfall, historical yearly lows, and historical yearly highs (Weatherbase 2014). We multiplied the yearly amount of rainfall in cubic feet for these three different scenarios by the cost of one cubic feet which is 3 cents (Souleret 2014). Our calculations resulted in savings of $177.10 per year for the average rainfall scenario, $21.93 for the low rainfall scenario, and $469.15 for the high rainfall scenario. To calculate these savings we assumed that all of rainwater harvested by our collection area will be captured by the barrels and used for irrigation purposes, as opposed to tap water.

The payback period for average, low, and high rainfall is shown in figure (6.6). The expected payback period is approximately sixteen years. This estimate may seem high since the lower payback period the better, and most of the for-profit projects are usually expected to pay back within 5 years (Litke 2014). However, as mentioned earlier this project is about environmental sustainability more so than economic benefit. In addition, the project may become more economically sustainable in the future when the water will become scarcer.

Average	Low	High
16	130	6

Figure 6.6. Payback period for ten 200 gallon rain barrels is shown for high, low, and average rainfall projections. The payback period is represented in years.

Conclusion

As climate change continues to threaten parts of the world, individuals and organizations must take micro steps to make an impact on the macro level. In order to combat climate change and scarcer rainfall we believe rainwater harvesting is a small but important step to create a greener university and ultimately a greener world. Due to monetary and time constraints our pilot project must start on a small scale. Two small sections of roof from Booker Hall is our only collection area, but as we have shown this can yield relatively significant rainwater capture. Based on our calculations we have determined that collecting water using rain barrels can be effective economically in the future, but most importantly a sustainable way of using water.

The American College and University Presidents Climate Commitment signed by President Ayers in 2007 committed this University to strive for carbon neutrality and increased sustainability (Office for Sustainability 2007). The conservation of water on our campus is just one way we can extend our scope of sustainability. In order to capture the optimal amount of rain in our designated area at Booker Hall we are requesting the purchase and use of ten 200 gallon rain water barrels seen in figure 6.5. Our data indicates that in six of the twelve months the barrels will be filled at least twice to be used for irrigation around campus. This results in a payback period of about sixteen years. In addition, the barrels will be placed out of view so as to ensure the campus remains aesthetically pleasing. Figures 6.2 and 6.3 show the barrels will be hidden by a brick wall as well as the difference of elevation between the observable sidewalk and the actual placement of the barrels.

While rainwater harvesting for irrigation shows promise, we realize this is a pilot project and our calculations are all theoretical. The actual rainfall of each month is impossible to determine, as there could easily be drought periods, or times of intense rainfall. In these circumstances the efficiency of our barrels will be compromised, but based on the average rainfall each month the collection from our barrels should even out and the accuracy of our predictions will be relatively close. Moreover, the successful implementation, maintenance, and management of the barrels will rely on a UR grounds staff that we assume to be skilled, aware, and agile in response to severe rainfall. In addition, we cannot predict the displacement of rainwater as it strikes the roof of Booker Hall. Assuming the rain does not act sporadically then the utilization of the five gutters highlighted in figure 6.4 will be the most effective way to collect the most rainfall we can from our section of Booker Hall. The number one goal of our pilot project is to initiate the conservation of water on campus and to promote sustainability. This type of project has been seen to be effective at other Universities and that the range of use can go well beyond irrigation. We believe rainwater barrels are an excellent starting point, and will hopefully spur further sustainability practices around campus.

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Proposal for Rainwater Harvesting System at the President's House

In addition to implementing a rainwater harvesting system at Booker Hall, we would also like to propose the implementation of an identical system at the house of the President of the University of Richmond. We believe establishing a rainwater collection site at the President Ayers' house would significantly improve our efforts to promote sustainability on campus. We also believe that President Ayers would be inclined to allow this system because he signed the American College and University Presidents Climate Commitment in 2007. Rainwater harvesting would be a great step to continue the climate change commitment of this University.

There are three portions of the President's house that we have studied and would like to use for harvesting rainfall. The first section is the left back portion of the house, which is the roof closest to College Road. This portion of the roof has dimensions of 10.34 feet by 33.18 feet. We calculated how many gallons would be collected on this roof from one inch of rainfall and determined that 206 gallons of water would be collected. The next section of the roof we would like to utilize is the middle back portion of the house. The dimensions of this portion are 17.77 feet by 53.52 feet, which would then yield 595 gallons of rainfall based on one inch of rain. The last section of roof is the back right portion, which has dimensions of 13.3 feet by 20.04 feet. Based on one inch of rain this area will yield 162 gallons of water to be collected. All of these calculations were made using the USGS calculator. In addition to these portions of the roof, there was a front portion of identical size, for the right, left, and middle portion of the house. The front portions of the house mean that there is are additional 162, 206, and 595 gallons to be collected, respectively. That means that the total rainfall that could be collected from the President's house based on one inch of rainfall would be 1,926 gallons of water.

We also researched the amount of rainfall per month and calculated how much rainfall could be collected from the President's house and the least amount was 5,392.80 gallons and the highest amount was 9,052.20. This means that if we purchase ten 200 gallon barrels as we decided for our original project, then the barrels will be filled at least twice every month, and up to four times in one month. This is a significant amount of rainfall that can be collected and is even more than our pilot project at Booker Hall. This water can definitely be used for irrigation, however, unlike the project at Booker Hall this project will not be out of sight, but rather will hopefully draw a lot of attention. We believe the President's house can showcase the rainwater barrels to promote sustainability on campus. The President is a powerful figure at the University and any decision he decides to embrace will more than likely draw attraction to our ultimate goal of creating a greener university and promote sustainability.