CRP 5798

Ghana Sustainable Change

Rainwater Harvesting

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Executive Summary

In the past, Ghana Sustainable Change participants have focused on water quality and water access but have strictly taken measurements and recorded conditions rather than implementing a project. Their findings indicate there is an issue of access to water, and especially clean water. Many people have to travel to retrieve their water and the water they are getting is contaminated with bacteria. Another issue noted by other participants is the road conditions. Many roads are dirt, which is washed away and eroded by rainwater during the rainy season. As a country that receives so much annual rainfall, Ghana has a huge potential to harvest that and take advantage of it. This project aimed to begin the process of rainwater collection and to start using this resource naturally given to them.

Introduction

Program Objectives

Working hand-in-hand with the Offinso North District community, the Ghana Sustainable Change program focuses on locally-expressed critical needs, supports interdisciplinary service-learning and builds on a strong planning and development foundation for a sustainable and resilient future. Issues addressed include rapid urbanization, growing informal settlements, and the need for services such as clean water, sanitation, and sustainable energy production just to name a few. Once the district expresses community priorities for development, the program develops and implements projects to address the concerns. Past topics have included housing, site development, community planning, renewable energy, public health, water, sanitation, agriculture, education, governance, economic development, and public outreach and engagement. Focusing on these areas will improve the quality of life and increase opportunity for the growing number of new residents relocating to the District.

Course Objectives

The course goals align with the goals of the Ghana Sustainable Change program, outlining its overarching purpose, goals, and needs. Students work towards these goals by integrating the strategic plan items into projects that will be implemented in country. Additionally, they develop knowledge of the issues and methods involved in developing countries and address issues of project management, including evaluation of efforts, appropriate technologies, and community-based participation in planning.

Project Statement

Ghana presents challenges in many different areas. The area we felt most passionate about and chose to focus on is public health. While the other potential projects would be meaningful, we put the ability to live first and wanted to work on projects that improve quality of life and address basic human needs that are not being met. After speaking with and hearing from Roger Dzwonczyk and his engineering group, our initial plans because more concrete. We looked through the assessment report created for Ghana and highlighted the following public health issues: stream water treament plant/chamber, waste treatment to convert organic waste to fertilizer, design of engineering drain to check the devastating effect of stormwater, schematic diagram of borehole pumps with related components prior to its construction. All of these issues were prioritized by the residents of Ghana. After learning what their concerns were, I chose to focus on water access and treatment. Past projects focusing on water quality have included rain water harvesting, biosand filtration, and mapping of water sources. I want to focus efforts on filtration methods and the potential incorporation of these methods into a rainwater collection project. Proper educational tools will be distributed in country to increase the likelihood that the project will be successful and be used and maintained upon our departure from country.

Background Information

Ghana

Ghana is a country in West Africa that spans 238,535 sq km in area: 227,533 sq km being land , 11,000 sq km being water, and 539 km being coastline. The climate is tropical with the eastern coastal belt being warm and comparatively dry, the southwest corner being hot and humid, and the north being hot and dry. The country experiences two distinct rainy seasons in the south; between May and June and August and September. In the north, the rainy seasons tend to merge. In the coastal zone, the average rainfall is 83 cm. The manmade Lake Volta is the world's largest artificial lake by surface area (8,482 sq km), extending from the Akosombo Dam in southeastern Ghana to Yapei, 520 km to the north. The lake generates electricity, provides inland transportation, and is a potentially valuable resource for irrigation and fish farming. Freshwater withdrawal totaled 0.98 cu km/yr in 2000; one-fourth was for domestic use, ten percent was for industrial use, and two-thirds was for agricultural purposes. Current environmental issues in Ghana include recurring drought, soil erosion, water pollution, and inadequate supplies of potable water.

While only 64 percent of the population had access to an improved water source in 2001, a majority of the population was reported as having access to safe water in 2010: with a total of 86 percent of the population having access, 80 percent of rural and 91 percent of urban populations. In 2012, 87.2 percent of the population had access to improved water source- 81.3 percent of rural and 92.5 percent of urban populations.

While those numbers seem high, it still leaves about 3 million people lacking access to an improved water source. Additionally, only about 14 percent of the country had access to an improved sanitation facility in 2012, with rural having 8.4 percent and urban populations having 19.9 percent; this leaves nearly 86 percent of the country without access to improved sanitation.

These poor water and sanitation conditions lead to health problems. The risk of infectious diseases is very high in Ghana: specifically, food or waterborne diseases such as bacterial and protozoal diarrhea, hepatitis A, and typhoid fever, and the water contact disease schistosomiasis. Unsafe water and poor sanitation cause 80 percent of all diseases in Ghana. In the three northern regions, one in ten children die before their fifth birthday as a result of these conditions; annually, over 3,000 children under five lose their life. Water, sanitation, and hygiene education projects are carried out in six of the ten regions in the country. Community-led solutions and systems are put in place to help empower local communities and people.

The Offinso North District is located in the semi-equatorial climatic zone and experiences a double maxima rainfall regime. It receives rainfall from April-June and September-October. That puts the annual rainfall between 125cm-180cm. It also means that between November and March is the dry season. Because many Ghanaians in rural areas collect water from open sources filled by rainwater, these sources do not provide throughout the entire dry season. Inadequate supply aside, these sources are also incredibly unsanitary and present many health problems, including death-especially in young children. Additionally, these sources tend to be a sizable walk away. When the area receives so much rainfall each year, the residents could benefit significantly from rainwater collection. They would be able to have a more reliable water source that would be right outside their house or in their village. Being able to protect and filter the water will also present a higher quality of drinking water for the residents. Lastly, it will also reduce the damaging effects of flooding from water runoff from buildings.

The Water Crisis

Currently, 780 million people live without access clean drinking water. Specifically, more than one-third of Africa's population, or 358 million, lack access. Additionally, residents of SubSaharan Africa use only 2-5 gallons of water per day; but each day, women and children spend 140 million work hours collectively retrieving this water for their families. Even after all this time is spent collecting the water, it's still not ideal for drinking. Many times, the same source is used by wild animals (which presents danger as well as contamination), is stagnant, and experiences pollution runoff. Additionally, 90 percent of wastewater produced in underdeveloped countries is discharged untreated into local waters. Consuming this water leads to dehydration, diarrhea, and death. The World Health Organization has found that 80 percent of all sickness and disease worldwide is related to contaminated water. These conditions have led to half of the world's hospital beds being occupied by people with easily preventable waterborne diseases. Children are especially effected, with dirty water killing more children than war, malaria, HIV/AIDS, and traffic accidents combined. Particularly, diarrhea has killed more children in the last decade than all armed conflicts since World War II. These numbers average out to a child under the age of 5 dying every 20 seconds from waterborne illnesses. All these lives translate to $260 billion in estimated annual economic loss from poor water and sanitation conditions. If one-third of what the world spends on bottled water in one year was put toward water projects, it would provide water to everyone in need. Additionally, a half-liter water bottle can be refilled 1,740 times with tap water for the equivalent cost of a 99 cent water bottle at a convenience store. Water use has grown at more than twice the rate of population increase in the last century. By 2025, two-thirds of the world's population is projected to face water scarcity. Additionally, the percentage of the Earth's land area stricken with serious drought more than doubled between the 1970s and 2005; by 2050, five times as much land as today is likely to be under "extreme drought" conditions.

Rainwater Collection

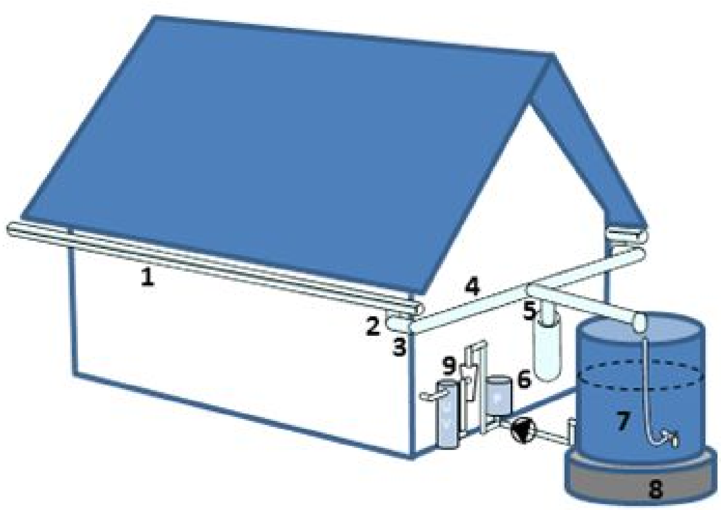
As mentioned in the background information on Ghana, the country receives a significant amount of rainfall each year. Despite this rainfall, people are still collecting water from open sources, boreholes, and sometimes wells. These sources have been known to be contaminated and unsafe to drink but for most people it is their only option. For a country receiving so much rainfall, it's difficult to imagine that its people do not have access to clean water. In general, rainwater is one of the cleanest forms of water that exist and is safe to drink if harvested correctly. If more villages implemented rainwater collection, it would increase the access to clean water, decrease the amount of time spent on collecting water, and decrease the soil erosion and flooding during the rainy season.

The main components of most rainwater collection systems include a gutter system to catch the water coming off of the roof, and a piping system to connect the gutters to a collection tank. Within the collection tank, it is possible to incorporate a filtration method so the water will be safe to drink. Storing the water is especially important due to the long season of no precipitation. There are a few initiatives in Ghana already trying to incorporate rainwater collection. An article published by Christina Benjaminsen of Gemini.no shares some of the current research being done in Ghana. They focus on the middle class that would be able to finance the water systems by themselves. Their systems include gutters, a downpipe with a self-cleaning grate, pipe bend and pipe connecting downpipe and tank, t-pieces to connect pipes, first flush diverter, tank with level-gauge, cast foundation, and a pressure-pump, cartridge filter, and UV disinfection unit. This system is the most advanced and allows water to be drank directly from the tap. They also offer two other versions. The second system has a pump, distribution unit, and filtration unit, but requires chlorination to provide water that can be drank. The most basic version consists of a simple collection system and a storage tank available in different sizes. This water has to boiled or purified before drinking.

Materials and Methods

Design

The design for these systems varies based on the shape of the roof and the collection method being used. The system implemented in country was based on the system featured in the gemini.no article. It was a more basic system, only composed of the gutters to capture the water and a barrel to collect and store the water. While it did not have additional purification components, a metal sieve was incorporated into the barrel.



1. Gutters are installed with a downward gradient of 2 degrees towards the downpipe

2. Downpipe with self-cleaning grate that removes leaves and debris

3. Pipe bend which transports water around corners

4. Pipe from downpipe to tank, sloping so as to prevent standing water

5. T-pieces connecting pipes from other parts of the house and which connect to the First Flush Diverter

6. The First Flush Diverter that diverts the initial volumes of rainwater and ensures that the roof is clean before water is harvested for storage

7. Tank with level-gauge, calibrated to the size of the tank

8. Installed tank with cast foundation

9. Onward distribution with pressure-pump, cartridge filter and UV disinfection unit that automatically maintains a constant pressure in the supply pipes

Materials

Like the design, materials can also vary based on what is available and what is preferred. Once in country, it was relatively easy to find the materials needed to assemble the system. The final system was composed of gutters made from PVC pipe, brackets made from galvanized sheet metal, connector PVC elbows and T-piece, PVC end caps, a galvanized sheet metal sieve, and a plastic barrel. The materials are that of the most basic collection system, modeled off of the system mentioned above. Every component of the system implemented can be altered to fit the needs of the community or to even make a more efficient system.

Budget

Item	*GHC (3.65GHC=1US)*	*US (1US=3.65GHC)*
PVC pipe, 40 ft	*100 GHC*	*$27.40*
PVC elbows, 4	*80 GHC*	*$21.92*
PVC T-piece, 2	*60 GHC*	*$16.44*
PVC end caps, 3	*60 GHC*	*$16.44*
Galvanized Sheet Metal, 534 sq ft	*80 GHC*	*$21.92*
Concrete Nails, 1 lb	*10 GHC*	*$2.74*
2 in screws, 30	*10 GHC*	*$2.74*
Hacksaw	*15 GHC*	*$4.11*
Plastic Barrel	*75 GHC*	*$20.55*
Tape Measurer	*5 GHC*	*$1.37*
PVC Cement	*N/A*	*$7.50*
Hammer	*N/A*	*N/A*

Power Drill	*N/A*	*N/A*
Drill Bits	*N/A*	*N/A*
Ladder	*N/A*	*N/A*
Total	*495 GHC*	*$143.13*

All of the above supplies were purchased for the project- everything was purchased in Ghana except for the PVC Cement, the hammer, the power drill, drill bits, and a ladder. The hammer, drill, and bits were borrowed from a fellow student and the ladder was borrowed from ONDA in Ghana. Some items were also purchased and not used: one end cap, one t-piece was not used, some sheet metal, and screws. The power drill and drill bits were not helpful, but not required.

Going in, there was no planned budget. As a group, the budget was 2,555 GHC ($700) in country for all projects. The rainwater collection project cost almost 500 GHC, as shown above. While some items bought were not used in the final product, some items may also be replaced with different material and items such as a hammer and ladder may need to be purchased in the future.

Implementation

Day	*Planned*	*Accomplished*
Monday, March 14	*Get materials, Examine existing systems, Explain the system, Choose area for barrel platform*	*Meet with Augustine, Gather materials, Help Jill with her project*
Tuesday, March 15	*Compose the barrel- clean, spigot, cover, overflow valve, sieve Build platform for the barrel*	*Get more supplies, Cut gutters in half, Look at biosand filter, Go to welder with Jill*
Wednesday, March 16	*Attach gutters to the each other and to the*	*Get more supplies, Look at biogas*

	roof, *Connect gutters to the barrel,* *Attach first flush diverter*	*digester,* *Make brackets,* *Attempt to hang up brackets*
Thursday, March 17	*Finishing touches,* *Potentially add a second barrel*	*Get more supplies,* *Hang up brackets,* *Cut gutters,* *Attach gutters to elbows,* *Attempt to attach gutters to each other,* *Place gutters in brackets,* *Make metal sieve for barrel*

The original plan was to attach gutters to all sides of a house or building where it would be monitored and maintained. Upon arrival, a site was chosen by ONDA and supplies were gathered. Because it was a work in progress, a trip to the market happened every morning to gather more materials. The overall plan did not change very much other than what was individually accomplished each day.

Originally, the plan was to first examine existing systems if possible and to explain the proposed system as well as choose a location. Then, the barrel and its platform would be composed. Next, the gutters would be attached to the roof and and connected to the barrel. Once in country, the timeline and being able to get everything done was brought into question. For that reason, the priority became attaching the gutters.

Once given a site, it could be surveyed. The roof was larger than anticipated and did not have an ideal way of attaching gutters to the ends of the building. Due to constraints of time, materials, and attachment, gutters were only chosen to go on one side of the house. The side of the house chosen was the one alongside dirt, rather than grass, and where an existing rainwater cistern was in place. The existing cistern was designed to collect water from one part of the house, but not the part this project would go on. The cistern also served as a platform for the collection barrel, saving time and materials that would have went into creating one.

Once the design was chosen, the gutters were purchased as well as some end caps, elbows, and t-pieces. Throughout the week the design became concrete and the exact amounts needed became apparent. Some local workers assisted in cutting the gutters in half. Once cut, the gutters were measured and cut again to fit along the roof of the house.

The next step was to be able to support them against the house. This step involved getting material to form brackets and connecting the brackets to the house. Originally, it was assumed that screws and the power drill would be able to attach the brackets. When attempted, the two inch screws were too large to fit into the house and the power drill could not drill that far into it either. Additionally, the ladder used did not reach high enough to comfortably use a power drill.

After talking to members of ONDA, it was suggested that one inch concrete nails be used instead of screws. Once purchased, holes were put into the brackets using the nails and a hammer and then holes were put into the side of the house. Generally, one bracket for every three feet is enough support but due to the length of the gutter pieces and where they overlapped, that distance varied from bracket to bracket. In addition, the brackets also sloped down, with each one about ½ inch lower than the previous one.

Once all the brackets were attached to the house, the gutters were put into place- with the end cap being attached using PVC cement at one end and an elbow being attached using PVC cement at the other end. The elbow directed the water off of the house to more PVC piping, which attached to another elbow that directed it towards the wall of the house, more piping to carry it, another elbow to direct it towards the ground, and more piping to carry it. That piping connected to a t-piece, where some pipe continued toward the ground and contained another end cap (not cemented so it is removable), and the other pipe lead it outward toward the barrel, where it ended with an elbow and more pipe directing it into the barrel. The piping between the t-piece and the ground acts as a first flush system, where the first water coming off of the roof would be contained. This water is full of the dirt from the roof and needs to be collected separately from the clean water. The end cap is removable so the water can be emptied between rainfalls. All elbows were attached using PVC cement.

While the PVC cement worked well for connecting elbows to pipe, it did not work when trying to connect pipe to pipe. For this reason, the gutters were put up without being one continuous piece. However, they were overlapped at each intersection and supported by brackets. Once water is flowing, the overlap and slope of the gutter carry it down toward the barrel. While some water will escape because the gutters are not sealed to each other, some water is also going to still be collection.

The barrel itself was originally planned to contain a spigot for dispensing the water as well as a removable screen to keep large debris out. Once in country, the barrel was not a priority and was not even going to be purchased or included. After realizing there was room in the budget, the barrel was purchased and one with a removable lid was chosen over attaching a spigot. The removable lid also allowed for a metal sieve to be inserted between the lid and the barrel. The sieve was created using galvanized sheet metal and, at first, the drill and drill bit to create holes. The drill lost battery during the process and nails and a hammer were used to finish creating the holes. The sieve would catch any large debris that was carried from the roof and prevent it from entering the collected water.

After the system was finished, a very small test run was performed, where a few bottles of water were poured into the gutters. Some water escaped where the gutters were not connected, but some water did make it to the downspout as well. The system may behave differently with a more rapid flow of water.

Maintenance

The maintenance for the system is minimal. Like any gutter system, it will become clogged with debris- mostly leaves- and need to be cleaned. However, this process only needs to occur once every few months, more or less as needed. Additionally, the sieve for the barrel can be removed to be cleaned as needed. Mostly, like the gutters, large debris would simply need to be removed. Lastly, the water contained in the first flush downspout would need to be emptied between each rainfall to ensure that there is no standing water in the system and that it is performing its purpose of collecting the first water that is cleaning that roof.

Improvements

As the first rainwater collection system the Ghana Sustainable Change Program has implemented, there are several areas to improve upon. One major issue that arose was not being able to connect the gutters to the house or to each other. Luckily, the concrete nails were able to hold the brackets in place but especially on the end of the house where the downspout is, it was difficult to nail into the building. The brackets themselves are not very sturdy, as it was possible to bend them using only your hands. Given the intense nature of the rainy season, they may not withstand the weight of the rainfall. Incorporating a stronger material (that can still be shaped into an “L”) would increase the durability of the system. The gutters also need to be connected to each other. One immediate solution is to change the material used for the gutters. PVC pipe was used in this project because it was readily available, but there are also other options in Ghana that may be easier to connect to each other, such as aluminum. Incorporating rivets rather than nails or cement is also another option for connection.

The downspout of the system is not long enough, and part of that was using whatever piping we had left for it as well as not being given a site until arriving in country. The size of the roof determines how big the downspout needs to be to effectively clean the roof and not contaminate the water. Calculating that out is important to have a clean water source.

The barrel could have a spigot or further filtration/purification systems incorporated as well as connections to other barrels for more storage. The removable lid seems to be a good short term solution but there can be more efficient methods of storage as well as more efficient methods of filtration.

Recommendations

After being in country and experiencing first-hand the lack of water available, I strongly recommend that groups continue water projects in the future. Because rainwater is so prevalent in Ghana, it makes sense to continue rainwater collection because it is possible and it is relatively cheap to implement. Implementing a system in a more rural area that does not have access to a borehole, bottled water, or running water, would also be more beneficial to those receiving the system.

As mentioned above, choosing more reliable materials should be incorporated for future projects, as they are available in Ghana. It would also be helpful to reach out to those you will be working with early on and to gather feedback from them on what will work and what will be the best options.

The system itself is relatively simple to assemble once all the materials are gathered. It takes a few people involved but is not difficult work, especially for Ghanaians. Implementing it in an area where others can see and providing them information on how to create it themselves would be beneficial because it’s something they can take advantage of and is affordable.

When encouraging people to implement these systems, it is important to emphasize the ease of assembly and maintenance, how it is going to save time and money on water use, and how it is as safe as if not safer than their current water source.

Sustainability

Rainwater collection projects generate access to a reliable water source. They also decrease water dependence from a public source, including importing water. The water collected from rainwater is also cheaper and safer than that brought in from outside sources. These rainwater collection systems have the potential to change the main source of water for many Ghanaians as well as create an investment system and source of income and jobs. Having people invest in the system will create a sense of ownership and increase commitment to maintaining the system. Leaving instructional material will also aid in the sustainability of implemented systems.

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Class Syllabus

2015 Water Purification and Filtration Report