

Rainwater harvesting for Hinterland Sanitation Improvement

The objective of this paper is to illustrate the benefits that can be gain in the area of improve sanitation for the hinterland residents through rainwater harvesting.

Abstract

The Guyana Water Incorporate, a semi-autonomous company, an arm of the Ministry of Housing and Water is the only licensed body in the country for the extraction and distribution of potable. The company currently has ninety-eight percent (98%) coverage of the coastline and seventy-one (71%) coverage in the hinterland. This means that 29%, which represent approximately 50,000 residents, according to the 2002 census, are without a reliable source of potable water. This figure can be easily translated into a significant section of the population living without adequate supply of water for household and hygienic purposes. This lack of water for household uses, according to a study conducted by Peter Smith and sponsored by the Pan American Health Organisation, PAHO, is linked to poor hygiene among the hinterland residents and is responsible for the many tropical diseases among the villagers. The Guyana 2002 population census revealed seventy percent of the country's population use either pit latrine or other unhygienic methods of wastewater disposal that threatens the integrity of the aquifer and other fresh water sources in the regions.

The task of providing a reliable supply of potable water in these hinterland regions is a mammoth undertaking for the water company. This is because of the demographic and topology of the regions that are primarily sparely populated forested highlands. According the reports of the 2002 census, some of these regions have a population per kilometer ratio as low as 0.3 which

makes any water distribution plan very difficult and expensive. This paper will propose a solution to the problem through rainwater harvesting, an approach that is very viable considering the regions' consistent rainfall pattern. Rainfall data collected over the last ten (10) years shows that the average annual rainfall in the country ranges between 1778mm (70 inches) and 2800mm (110.2). The average rainfall in these regions is much higher than the country's average, with regions recording average annual rainfalls of 2280 – 2350mm.

The paper will demonstrate the average rainwater that can be harvested per square meter from corrugated zinc roofs, and the related cost saving this approach can have on the water company's annual budgets. More importantly, the paper will present methodologies that can be employed to utilize this harvested rainwater to address the existing sanitation problems in these remote regions. The methodologies will protect the already threaten aquifer and other water sources in the area, thereby improving the health and livelihood of the residents in the regions, whilst provide a cost saving option for the company.

Introduction

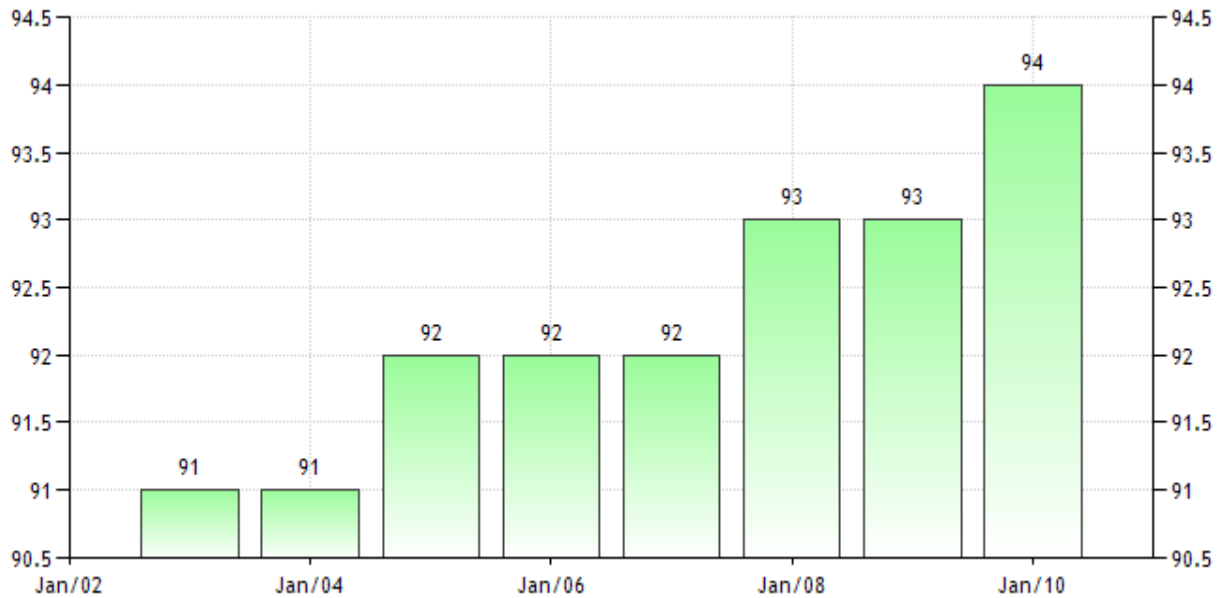
Guyana lies on the north-eastern shoulder of the South American continent between 1°N and 9°N and 56°W and 62°W. The country, a mainland, has a total area of approximately 216,000 km² and a coastline that is about 434 km long and a continental extent of about 724 km. The Guyana water Incorporated is the sole licensed provider of potable water for the country's population of 745,000 citizens (census, 2002). The company has an eighty-five percent (85%) coverage, which represents ninety-eight (98%) percent coverage on the coast and seventy-one (71%) percent coverage in the hinterland. The company in its mission to provide safe and reliable water to all the citizens of the country has, over the last two decades, rolled-out several

multi-million dollar projects that include construction of water treatment plants, installation of transmission and distribution networks, non-revenue water program, etc. Among these projects are several innovative solutions for provision of safe and reliable water supply to the hinterland communities.

The country is divided into four natural regions, whose names describe their locations and geography. These are; low coastal plain, a narrow strip of land (5 -6 km wide) lying along the murky waters of the Atlantic Ocean, and extends some 437km. The hilly sand a clay region an area located 48km above mean sea level, rich with several mineral deposits including bauxite, and iron ore. The interior savannahs – located in the country’s hinterlands and characterized by kilometers of rolling plains approximately 15,000 square kilometers of grassland, and the highland regions, which comprises three of largest of Guyana’s ten administrative regions. This part of the country, in the extreme west, rises steeply to a plateau of over 3000m and is characterized by high mountains ranges, treacherous rapids and dense hardwood forested lands that hold most of the country’s minerals. It is the water and sanitation problems in the two latter regions that this project aims to address.

No Scarcity of fresh water

Guyana is referred to as the “land of many waters” for the country with its high rainfall, many large rivers, streams, lakes and creeks, possesses large volumes of fresh waters. There is therefore no shortage of water for domestic and agricultural uses. In fact according to a World Bank Indicator on water source (% of population with access) Guyana scores very high 94% in 2010 measurement. See figure below – (World Bank Report, 2012).



However, even amidst this large volume of water, the issue of water and sanitation especially in the hinterland region is of major concern. There are several reasons for the concern and the proposal will now look at some of the reasons and how this apparent scarcity is linked to poor sanitation and hygiene in the hinterland regions. As mentioned earlier, within these regions lie much of the country's mineral depositions, such as, gold, diamond, etc. Mining activities for the extraction of these precious stones has resulted in severe contamination of much of the fresh water sources in the regions. This pollution is due to activities such as the stirring of the riverbed through river dredging, poisoning of the water resulting from the use of mercury in the gold mining process and unsafe human waste disposal practices by miners. These practices have forced the villagers, who are predominantly indigenous people know as Amerindians, to be subjected to the use of these contaminated water source since there are not much available options. The geology of the aquifer on the coastlands is relatively simple, two main sand beds overlain clay. In the hinterlands this is entirely different, with hard crystalline "basement" rock.

Extraction therefore is not as easily and is dependant of intercepting cracks and faults and fracture zones in these hard rocks. The water company has employed several methods of water extraction and distribution in these regions. Predominantly the use of shallow wells equipped with hand pumps- and/or small submersible pumps driven by photovoltaic systems. Another method is the use of engine driven and photovoltaic driven submersible pumps in available rivers and creeks. Another major problem is that of water distribution in the region. This is due mainly to the geography of the area and the distribution of the population. As mentioned earlier, the distribution ins some of these areas is a s low is 0.3/km making construction of transmission and distribution systems in these area difficult and expensive. The matter is made even worst in areas that still practice a nomadic culture and where mining activities results in erosions that destroys these transmission mains. With the continued pollution of the waterways and the difficulties in extracting water from the aquifers, especially during dry seasons, and the distribution problems, there therefore, remains a need for a viable solution to the water problem in the region and more importantly the addressing of its link to sanitation hygiene and health.

Waste disposal

According to (census, 2002) over 12, 000 households in these regions dispose of the human waste either through pit-latrines or other unsafe method. As seen in appendix 1, almost 70% of the residents in Guyana dispose of their human waste either via pit-latrines, or another unsafe method. This practice is very prevalent in the regions under considerations. Statistics from a Sanitation report for PAHO by Usuario de Red, 2007 shows that 105, 661 homes utilize pit-latrines for the disposal of their human waste. The report further reveled that more than 50% of these toilets are not built to standards and therefore not appropriate, the situation is further

compound during flooding that cause severe contamination of waterways. The situation is even worse in the hinterland regions with recent statistics showing that there are no septic tanks in the Amerindian communities, whilst only approximately 40% of the households use pit-latrines and the other 60% are without any access to sanitation facility.

Water and Sanitation

There is a definite link between water and sanitation, even with the MDG 7, Target 7c which is to halve by 2015 the proportion of people without sustainable access to safe water and basic sanitation. The conclusion of the WELL's report further shows the relationship between water supply, hygiene promotion and sanitation. As we have seen, thus far in this presentation, there is inadequate access to water in Guyana's hinterlands especially the availability of water at the premises of the residents. This unavailability of sustainable supply of safe water at the household has prevented safe sanitation disposal methods. The statistics shows that in most parts of the region the only available sanitation facility is the pit-latrines. Whilst it is widely utilized as a disposal method in the area, it is not an appropriate solution. This is because most are not built to any standards. There is therefore constant seepage from this facility that often finds its way into the very water that is being used for domestic purposes including drinking. The proposal therefore is to provide other options such as pour-flush latrines and septic tank methods that can only be viable options when a constant supply of water is made available at every household.

Rainwater harvesting

Rainwater harvesting is no new technology, in fact it is widely used all around the world, mainly in areas where there is a scarcity of fresh water such; as in arsenic areas of Bangladesh, parts of

Indonesia where fresh water is become scare and other parts of the world where rainwater harvesting is either the most viable option or an alternative to regular supplies. This practice is most sustaining in parts of the world known for consistent rainfall such as India known for its monsoon rainfall season and the Amazon basin of which Guyana is apart. Rainfall data collected over the last decade shows that in the regions under consideration have an average annual rainfall ranges between 2280mm (90”) – 2350mm (93”).

Rainfall harvesting calculations show that for every inch of water that falls on a catchment area of 1000 square feet, 600 gallons of rainwater, less evaporation, spillage losses and wild effects can be collected. The downpipe however must be sized so as to be capable of carrying peak volume of runoff.

Design of storage tanks

Included in this proposal is a large government intervention in providing the necessary infrastructure for the residents inclusive of the storage tanks that can be either concrete cistern of HDPE (black) tanks. The option is used however, must take the flowing into consideration: algae growth, invasion of insects and vectors. Therefore storage tanks use must be designed to avoid these disadvantages allowing for the safe storage of the harvested rainwater. Regardless of the option chosen care must be taken in determining the required capacity so as to avoid over designing and wastage.

Determining Storage capacity: Design of storage tanks

The volume of the storage tank can be determined by the following factors:

- Number of persons in the household: The greater the number of persons, the greater the storage capacity required to achieve the same efficiency of fewer people under the same roof area.
- Per capita water requirement: This varies from household to household based on habits and also from season to season. Consumption rate has an impact on the storage systems design as well as the duration to which stored rainwater can last.
- Average annual rainfall
- Period of water scarcity: Apart from the total rainfall, the pattern of rainfall -whether evenly distributed through the year or concentrated in certain periods will determine the storage requirement. The more distributed the pattern, the lesser the size.
- Type and size of the catchment: Type of roofing material determines the selection of the runoff coefficient for designs. Size could be assessed by measuring the area covered by the catchment i.e., the length and horizontal width. Larger the catchment, larger the size of the required cistern (tank).

The following formulae can also be used.

$$S = R \times A \times C_r$$

S = mean rainwater supply in m³

R = mean annual rainfall in mm/year

A = surface area of catchment in m²

C_r = Run-off coefficient – accounts for losses due to splashing, evaporation, leakage and overflows and is normally taken as 0.8.

Houses in the hinterland regions are relatively small with corrugated zinc roof top ranging from Using the given formulae and using the average annual rainfalls, families can harvest between 40 – 305 cubic meters of rainwater per year.

Example

$$S = R \times A \times C_r \text{ Therefore } S = 2350 \times 20 \times 0.8 = 38,000 \text{ liters}$$

The country's average water consumption (liter/capita/day) is stated at 243 liters. If we should consider a small family of 4 persons per household then the harvested water use for all domestic purposes should last this family approximately $(38,000/243 \times 4)$ 52 days. However if the water is used primarily for flushing of toilets and washing of hands, then this should at least double the days of use giving the families almost four months of water from hygiene and sanitation uses. Larger families however can have water available for this purpose for $(38,000 / (243 \times 5))$ 233 days if the harvested water is used for all domestic purposes. However if used primarily for flushing of toilets and washing of hands after using the toilet this water can provide large families with 1.3 year's supply of water at their homes.

Estimates cost per small house household

Material	Unit	Unit cost	Quantity	Total cost
Catchment area		Existing	0	0
PVC gutter and piping (\$US)	Length	25	4	100
Cost of tank (1/3 calculated volume)	each	150	15	2250
Other associated cost	sum			500

Total				2850
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This price is quite comparable considering that unit cost to produce 1 cubic meter of water on the coastland is \$US0.25 to produce the same quantity in the hinterland would be much more expensive. Rainwater harvesting is therefore not only a viable option for improved sanitation but can also improve hygiene and health among the communities of the hinterland regions.

Improve Sanitation

Rainwater harvesting puts the water at the homes of the villagers. This eliminates the need for women and children having to travel long distances with heavy containers of water. More importantly it provides opportunities for other more hygienic means of disposal of human waste. As shown the Smith's report and the Census, (2002), the majority of the residents in these villages are without access to adequate sanitation. This project will allow for the installation of wastewater technologies such as Pour-flush latrine, which is an upgrade on the traditional latrine. It is seal with concrete or wooden slab and pipelines and installed to wash the faeces down. Septic tank can also be employed since there is now sufficient water for proper operation. With the large expanse of available land cheap wastewater treatment solution such as wetlands and lagoons can be considered.

Conclusion

Rainwater harvesting is a viable solution in addressing the poor hygienic and sanitation in the country's hinterland. Besides address the core issues, this approach will assist the country in meeting many of its millennium Development goals MDGs, including reduction of child

mortality. This project should be a government of Guyana initiative because of the transformational change in culture that is required. It also requires an initial investment that the villagers may not be willing to make. However once it is implemented sustainability can be the responsibility of the residents through stake holder buy-in. It is cheap solution that will be long term multiple benefits to thousands of residents in the hinterland communities.

GUYANA WATER INC.