Report on the

Rainwater harvesting project

Mwoyoweshumba Primary School

Mutasa District, Zimbabwe

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Contents

Executive summary

In October 2018 Sustainable OneWorld Technologies C.I.C. (SOWTech) supplied a pilot-sized Interseasonal Rainwater Harvesting (IRH) system to Africa Trust who then installed it at school in Zimbabwe. The system comprises gutters to collect the rain off corrugated rooftops and a storage tank of 50m³ which was of sufficient size to hold enough water to be of significant use during the dry season.

The system has performed as anticipated and collected an estimated 28m³ during the rainy season. It has proved to be robust, withstanding the impact of a cyclone and has provided water through the dry season to the school.

Some of the impacts that the availability of water has had on the school are:

- The school has retained more teachers in the dry season than in previous years
- The number of pupils enrolling at the school has increased
- Improved education as the pupils do not have to spend time collecting water
- Improved hygiene and sanitation as water is available for toilets and washing

Feedback has been obtained from the school and this will be used to improve that design of the system.

SOWTech are now working with a partner organisation, Bolsan, with the aim to supply and install IRH systems from within Zimbabwe reducing problems with importing goods and improving service to clients.

Introduction

There are two seasons in Zimbabwe, the rainy season and the dry season. During the rainy season the rain falls in heavy cloudbursts for about one hour when up to 12mm of rain can fall. In the dry season there is little or no rain which leads to water shortages and inability to irrigate crops which often leads to food scarcity. The rain that falls in the rainy season is seldom collected and, when it is, it is only collected in small quantities.

In October 2018 Zimbabwe Africa Trust took delivery of a pilot scheme Interseasonal Rainwater Harvesting system (IRH) designed by Sustainable OneWorld Technologies C.I.C. (SOWTech). The aim of this pilot project was to demonstrate that it is feasible and practical to collect the rainwater falling onto classroom roofs during all seasons and store it for use when needed in the dry season.

Partners involved

There are four partners involved in the pilot project, Africa Trust, Bolsan, Mwoyoweshumba School and SOWTech.

Africa Trust is a UK charity that works in eight countries in Africa including Zimbabwe with the aim of providing sustainable solutions to poverty in Africa. They provided and organised the location for the project and funded it.

Bolsan is a social enterprise company based in Zimbabwe who are looking to provide employment through sustainable products. They have visited the project to obtain feedback from it and are planning to be the manufacturers and distributors of the system going forward. Their findings and comments have contributed to this report.

Mwoyoweshumba School is a primary school in the Mutasa district of Zimbabwe where the pilot project is located. See the Project location section for more details of the school.

SOWTech are a UK Community Interest Company looking to provide sustainable innovative products to alleviate water, sanitation and climate change challenges predominantly in Africa. They designed and manufactured the IRH system.

Project overview

Background

The initial project was conceived when talking to a farmer in Uganda who was saying that his wife had to go to the river in the valley to collect all the water. At the time it was raining and the the rain was running off the roofs of the buildings and being lost into the ground. SOWTech felt that this was a loss of a valuable natural resource and started to develop a way of collecting the water.

There were a number of issues that had to be overcome. Firstly western style gutters cannot be used as the roofs are normally corrugated and overhang the edge of the buildings. This lead to the development of the wrap-around gutters. Another issue was that in the wet season when it rains there are sudden, very heavy downpours. That can easily overwhelm conventional gutters and down pipes unless they are large bore and therefore expensive. The solution devised by SOWTech was to use buffer tanks located close to the gutters. The buffer tanks were sized to hold the rain from a single downpour. The water could then leave to tank more slowly in smaller bore pipework over a period of hours. This minimises the amount of large bore, and more expensive, pipework needed. A third issue was the size of the storage tank. To hold all the rain it had to be large. The expected volume of rain per season was calculated using local official rainfall statistics and the roof area available. An innovative tank was developed that was laid in a trench and could be easily assembled and installed.

Once these innovations had been developed SOWTech then approached Africa Trust about siting a pilot project at one of their schools.

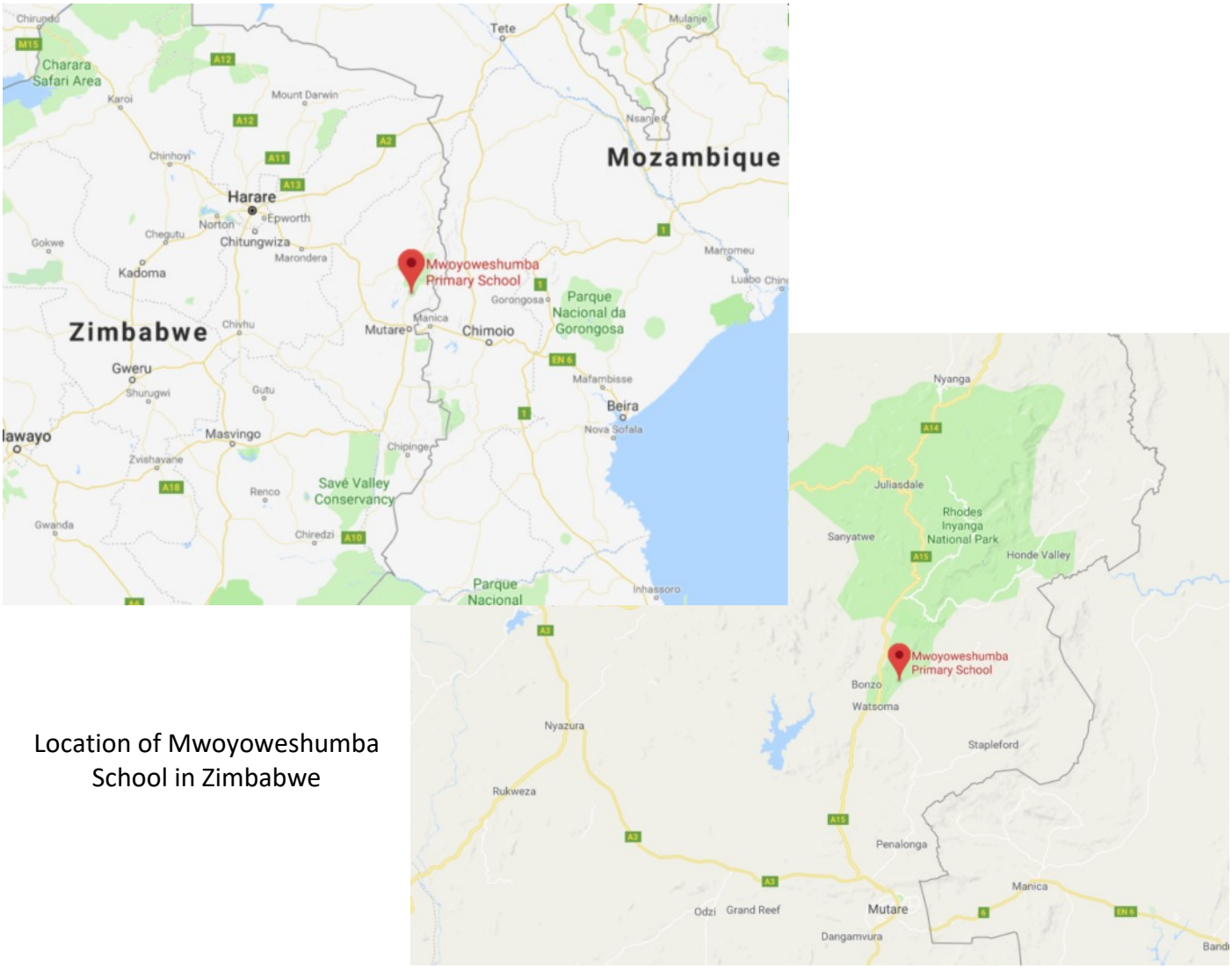
The pilot project was to install guttering to the roof of a classroom (or portion of a classroom building) to collect the rain falling on the roof and direct it to buffer tanks. From the buffer tanks it will be allowed to run slowly, through a series of pipes, to a rainwater storage tank sized to hold 50m³ of water. This water would then be stored in the tank until it was needed in the dry season.

Project location

The location of the pilot project is the Mwoyoweshumba Primary School in Mutasa District, Zimbabwe. Mutasa District is one of seven districts in the Manicaland province of Zimbabwe. Mutasa district is located 30 km from Mutare and stretches up to the Honde Valley, which is about 100 km northeast of Mutare.

The school had been struggling with water-access dating back to 1973 when it was established. The only natural water source is the River Nyamuchiri which is some distance from the school. This is not suitable not only because of the distance from the school but there have also been multiple reported incidents of students slipping on the rocks at the river and subsequently plunging to their death in the river. Therefore other means of water-access where sought.

In 2015 the Coke Cola Africa Foundation and RAIN was sponsored a water-pump at the school. This unfortunately has been reported as having stopped working in 2017 due to the falling water table. Again, students and teachers reverted to walking 6 km away to collect water, this time at the Nyamuchiri river and Mwoyoyeshumba Secondary School.



Location of Mwoyoweshumba School in Zimbabwe

Description of pilot project

The school has a number of different buildings including classrooms and and an administration building. The buildings contain more than one classroom and are therefore too long to be used as a pilot project. It was therefore decided to use one end of a classroom building roof to demonstrate the system.

Approximate lengths of school buildings shown

Wrap-round gutters made from polyethylene (PE) were attached to the edge of the roof. These were to collect the rain it falls and runs down the roof. They then direct the rainwater to each end of each gutter where the water is directed into buffer tanks through large bore pipes to remove the water quickly from the roof area.

The buffer tanks were locally-sourced and are mounted on raised platforms so that the water can leave the buffer tanks under gravity without the need for pumps. The buffer tanks have a volume of around 0.5m³ to accommodate the rain from a single downpour during the rainy season.

The outlets from the buffer tanks are connected to a smaller plastic water pipe, again bought locally, which lead to the rainwater storage reservoir.

For the pilot scheme a storage tank with a capacity of 50m³ was supplied. The storage tank is 3.75m wide, 2m deep and 7 m long. This gives an additional water collection area of approximately 24m² on the top of the reservoir.

The tank is located in a trench in the ground, dug using local labour to fit the specification of the tank.

Why that size

Using rainfall figures from a weather station in Mutare it was calculated that the annual rainfall is around 790mm, the majority of which falls in the months of October to March. Calculating the amount of rain predicted to fall in the rainy season on a classroom roof of size 12m x 10m gives a figure of 85m³. This gives a mean daily rainfall of about 15mm. As each storm lasts about 1 hour the assumption was made that 15mm of rain will fall in one hour. Using the above assumptions each gutter will collect 0.9m³ of water per day. The buffer tanks were therefore sized to accommodate this amount of rainwater.

As well as the classroom roofs, the top of the Rainwater Reservoir can also be used to collect rainwater.

The Rainwater Reservoir has therefore been designed to hold both rainfall from the classroom roof and the top of the reservoir.

The classroom has a footprint of 10 x 12 m, this gives an area of 120m² onto which the rain will fall and can be collected from. With a gutter front and back and over a 12 month period, assuming that all rain landing on the classroom roof was collected, there is the potential to collect around 100m³ of rain of a single roof. It is unrealistic to expect all the rain to be collected and therefore the storage reservoir tank was sized to accommodate half of this amount, ie 50m³. However the classrooms at Mwoyoweshumba are not single buildings but a long building with a number of classrooms in it. The guttering was therefore put along one side of the building over twice the length.

Installation of the system

The IRH system was installed by Zimbabwe Africa Trust in November 2018, in time for the wet season. The trench was dug and the IRH tank was installed into it. Specialist cable ties had been provided to lift and hold the tank in place. These proved to be problematic and modifications were made using rope and plastic washer type reinforcements behind the rope.

The gutters were attached to the roofs with no problems reported. The only modification was that the gutters were only attached to one side of the roof. Collection vessels were improvised from plastic bottles to join the gutters to the down pipes. The downpipes fed into plastic barrels as the buffer tanks.

The installation guide supplied with the system specified that narrow bore hosepipe or water pipe was used as the water outlet from the tank. These pipes were then to be joined together at a manifold which then led to a single inlet at one corner of the tank. The reasons for this were threefold. Firstly to ensure that the water left the tank more slowly than it entered to allow time for any heavies to sink to the bottom. Secondly there would be only one access point where there is already a way into the tank, leaving the geotextile on the top of the tank intact to prevent insects and debris entering the tank. This was not done as specified. The pipes were fed into the tank at intervals along the tank causing the top to be perforated.

Functionality of the system

The system was in place before the rainy season. In the months between December and March, when most rains fell in the region, 28,000 L of water were collected. The school authorities confirmed that this amount was more than 90 % collection efficiency based on the amount of rain that fell. The school was hit by Cyclone Idai in March 2019 but the IRH system proved to be robust and sustained no significant damage.

Of the water that had been collected approximately 80 % of it has been used in the dry season between April and October 2019.

Uses of the water

The water in the tank is used for the following:

1. washing toilets and hands
2. for cooking and washing eating utensils (this cooking is because of a governmental feeding program that the school conducts and the water has enabled the school to implement it)
3. bathing and washing clothes
4. Drinking (this is not recommended without further treatment).

Impact

Bolsan have been to visit Mwoyoweshumba Primary School twice to obtain feedback about the system. The first time was in September when the members of District Water and Sanitation Coordination Committee (DWSCC), Zimbabwe Africa Trust and other dignitaries were present too. They spoke to the Head teacher, other teachers and students to get their feedback on how the system was working, what the benefits were and any problems or issues that they had. They also visited in October when they obtained further feedback and clarification on some of the aspects discussed in September.

Overall opinions

With the installation of the IRH the Headmaster has reported that a number of positive changes have been noticed at the school. First, and most importantly, the school has managed to retain its teachers and students. Previously many of them would transfer elsewhere because of the water problems faced. Teachers are reported to not have stayed at the school for more than three years in one stretch. The headmaster of the school reports that in 2017-2018 the student enrolment was around 400 and this number rose by 35% to 542 students enrolled in 2019. He has stated that he believes this increase stems from the availability of water at the school.

The water in the IRH tank can be used by using buckets or manual well pumps to lift the water out for use. However the school has opted for a water pump to be installed to retrieve the water from the tank. This was connected directly to a tap. As the water is coming from an in-ground black body and not stored in the sun before use, the water from the tap was cold which a teacher commented that it made it more pleasant to drink than that stored above ground before being used.

Benefits

The school's headmaster has said that the IRH system has brought many benefits to the school. It has enabled both students and teachers to focus on education without worrying about water-access. Students no longer need to travel more than 5km to the nearest water source, hence do not miss out on class room activities or generally lose focus and suffer from tiredness from the long walks.

In addition to the primary outcome of water provision to the school there are other secondary achievements of this tank:

1. increase in quality of education because of more time spent in the classroom and teachers readily available to tutor students.
2. peace of mind and focus for both students and teachers (psychological welfare).
3. a bigger advantage to girls because of societal expectations that girls need to fetch water whilst the boy child continues to learn in the classroom.
4. improved sanitation and hygiene as water is available to wash hands and to adequately clean toilets.

Aspects to be reviewed for future projects

As this was a pilot project it is expected that there would be modifications and improvements to be made to subsequent installations. These issues are discussed below.

Tank installation

The button cable ties supplied for the holding up of the tank tank when in the trench were unsuitable for the purpose. The people installing the tank had devised a method using rope loops with plastic washers behind. This has proved to be successful and will be refined and incorporated into future designs.

Covering of the tank

The supplied tank was in a geotextile "sock". The tank itself had small slits in the top to allow rain landing on the tank to go into the tank. If the rain was allowed to sit on the top the weight of the water could cause the tank to cave in. There were no slits in the geotextile to prevent insects and debris entering. The plan was to have the water input and output pipes go into the ends of the tank where the lid was not sealed. When the tank was installed slits were put into the geotextile and the input pipes pushed through. This increased the size of the holes and can allow debris and insects to enter the tank.

One way of preventing that happening would be to cover the top of the tank with a sloping impermeable layer to prevent rain falling onto the tank. Having a sloping roof would allow the rain landing on this roof to also be collected in gutters and fed into the tank.

There is also a perceived risk that children could fall onto the tank resulting in injury to the child and/or damage to the tank. The fencing off of the IRH tank would prevent this happening accidentally but also, if there was a roof on the tank this would also be a preventative measure.

Suggestions for coverings of the tanks included tin roofing material, a mesh screen such as that used for surrounding the tank compound and sheets of plastic.

Each material has its pros and cons. Roofing material is easy to acquire but would get hot in the sun. It could also be difficult to handle should it need to be removed for maintenance or repair of the tank. The mesh screen would allow the rain water though, so guttering would not be needed and it would prevent debris landing on the roof of the tank and being washed into it. However it would not prevent insects and dust entering the tank and would probably be the most expensive option. Plastic sheeting would be easier to handle due to its light weight and would not get hot in the sun. However it would need to be anchored down firmly to prevent it being blown away when windy.

A roof in sections is proposed so that it is easier to handle and the whole roof doesn't have to be removed to access one part of the tank. The choice of materials to use could be site specific.

Input and output pipes

The tank was designed to have the input and output water pipes inserted at the ends of the tank. However due to having increased the number of buffer tanks which were located at a number of positions alongside the tank rather than a single one at the end of the roof it was deemed more cost effective to connect the buffer tanks to the storage tank with the shortest run of pipework.

This is an issue that needs further work to be done especially if longer tanks are installed. The roofing of the storage tank may be a solution.

It has also been suggested that a hole needs to be cut to allow the insertion of a pump to extract the water from the tank. This would reduce the integrity of the roof of the water tank further and SOWTech believe that the opening at the end of the tank should suffice. Clearer instructions and explanations are required to explain how and why to do this.

Building roofs

There are two types of materials commonly used for corrugated roofs. One is corrugated iron and the other is asbestos.

This system when holes have to be made in the roof to attach the gutters is not suitable for asbestos roofs. Asbestos is not harmful as long as it is not disturbed. If holes are cut to attach the gutters this is when the asbestos dust could be inhaled and cause respiratory problems either now or in the future.

Rain collected from roofs is generally considered to be some of the cleanest water available, especially in rural areas with no air-bourne pollution. However the water could become contaminated if the roof has lead flashings or is covered with lead-based paints, bitumen and tar or treated timbers.

Use of water

Currently the water is been taken directly from the tank for a number of uses. These include drinking, toilets, bathing and watering plants. The water has been connected to a tap so it can be easily accessed. Whilst it is really good that the water is being used there is concern that it is being used as drinking water without further treatment. Whilst it is obviously cleaner than that taken from a river it cannot be guaranteed to be free from contaminants and disease. It therefore needs to undergo a treatment process before being drunk. SOWTech and Bolsan are looking into options for water purification that can be offered as part of the system.

Future work

Overall, the IRH pilot project was a success and Bolson and SOWTech would like to rolled out to other schools and the farming community in Zimbabwe.

The feedback obtained by Bolsan from Zimbabwe Africa Trust and staff at Mwoyoweshumba Primary School will be used by SOWTech to make modifications to the design of the IRH to make it more robust and to improve the installation and functionality of the tanks. These include improving the method of holding up the tank in the trench, ways of putting the water pipes into and out of the storage tank and covering the tanks to improve Health & Safety.

The need for a troubleshooting guide was mentioned. There is little to go wrong with the system apart from the infrastructure being damaged by human, animal or natural causes. Some maintenance guidelines to prevent damage and to ensure the smooth running of the system were deemed to be useful.

A number of questions were raised by Zimbabwe Africa Trust and local community interest groups regarding the quality of the water in the tank and the integrity of the materials used. SOWTech have always made it clear in all literature about the IRS system that the water collected should not be used as human drinking water without further treatment. There is no control of the cleanliness of the water running off the roofs where it could pick up debris and contaminants. However, rainwater harvested from rooftops is considered one of the purest water sources and so it will be largely free from harmful contaminants. This is especially true at Mwoyoweshumba as it is a rural school away from toxic industrial gases. Concerns were raised over carbon dioxide levels in the water. Dissolved carbon dioxide forms a weak acid (carbonic acid) that is easily broken down by the body and is exhaled as carbon dioxide and is therefore not listed in the WHO guidelines as a contaminant.

Nevertheless, even with rainwater, over the years, organic matter and debris can find a way into the IRH tank and can form a sludge layer at the bottom. The use of the buffer tanks will help to remove physical contaminants as heavy materials will fall to the bottom of the buffer tanks and light material will float. If the water is not taken from the very bottom of the buffer tanks these should not go into the storage tanks.

The material used to build the gutters and the storage tanks has been used for many years to store liquids. SOWTech will prepare a technical note on the properties of the materials used.

Bolsan and SOWTech are looking to become partners in a supported local manufacturing project to begin to build IRH systems in Zimbabwe. Zimbabwe Africa Trust have indicated that they have 51 more schools that could be interested in the system. There is also the possibility of extending the installation of these tanks to support small scale farmers in Zimbabwe. A market analysis has been carried out on this consumer group and it has shown an appetite to acquire such a water resource. Bolsan and SOWTech are continuing to pursue this new business enterprise.

Appendix 1 - Maintenance

Feedback obtained has indicated that there is need for guidance on the maintenance of the IRH system. We have therefore included these this appendix containing the maintenance tasks that we advocate for the system.

Gutters and roofs

The roof and gutters should be inspected every 2-3 months and cleaned as necessary to remove any debris. Any holes in the guttering should be patched or the gutter replaces to avoid water not flowwing into the buffer tanks.

Any tree branches hanging over the roof should be pruned. This reduces possible contamination from plants and animals who might climb and scamper across the catchment area.

Care should be taken to avoid roofs with lead flashings, covered with lead-based paints, bitumen and tar or treated timbers. All these elements can contaminate water supply.

Avoid collecting rainwater from parts of roofs with chimney pipes from wood burners.

Buffer tanks

The buffer tanks should be cleaned out regularly especially after the rainy season to remove any materials in the bottom to prevent them becoming an anaerobic slime and also before the start of the rainy season. This will remove anything that has fallen in during the dry season that will contaminate the water collected.

The tanks should also be checked for leaks so that no water is lost.

Pipework

Regular inspection will ensure that the pipes do not be come blocked.

Storage tank

The inside of the IRH tank should be inspected every 2-3 years for sediment build-up. This sediment build-up is normally comprised of organic matter such as leaves which turns into a slimy biofilm layer at the bottom of the tank called sludge.

The tank should also be inspected regularly for signs of damage which may cause the tank to leak.

To prevent the water in the storage tank becoming stale it should all be used over the dry season and not stored until the next year.