Potable Water Supply for Kising'a Village

Kathryn Klarich
Mark Dierauer
Jessica Malone
Maria Crandall

College of Science & Engineering
University of Minnesota
Minneapolis, Minnesota 55455

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Gravity-Fed Potable Water System Proposed for Kising'a Village Kilolo District, Tanzania

Proposed Project Period:
September 2014 -October 2014

Street scene in Kibaoni Hamlet of Kising'a

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1.0. Contact details

1.1. St. Paul Partners/Tanzania Water Development Partners

Mrs. Heute Andrew
Country Program Manager
Contacts: 011 255 716 626164/011 255 764 435252
Email: sppwater@gmail.com

Ms. Hanael Gadwe
Country Business Manager
Contacts: 011 255 658 006100
Email: hannahgadwe@gmail.com

Peter Simon
Country Driver
Contacts: 011 075 549 8610
Email: simon29@gmail.com

1.2. University of Minnesota Engineering Students

Mark Dierauer
Major: Mechanical Engineer
Contact: 612-219-6491
Email: dier0127@umn.edu

Maria Crandall
Major: Biomedical Engineering
Contact: 612-558-3117
Email: crand101@umn.edu

Kathryn Klarich
Major: Civil Engineering
Contact: 507-272-3954
Email: klar0030@umn.edu

Jessica Malone
Major: Mechanical Engineering
Contact: 320-291-6430
Email: malon256@umn.edu

1.3. University of Minnesota Technical Advisors

Paul Strykowski
Professor of Mechanical Engineering
Contact: 612-626-2008
Email: pstry@umn.edu

Dr. Ken Smith
Senior Engineer
3M Corporation
Contact: 651-336-7273
Email: klsmith@mmm.com

2.0 Project Profile:

Project Profile:

A. **Project Title**: Potable Water Supply for Kising'a Village

B. **Project Type**:
The existing gravity-fed water system, which is in disrepair and incapable of efficiently capturing the available water supply, will be replaced. A recently discovered fresh water source is located approximately 1.6 km east of the Kibaoni hamlet of Kising'a's village. Due to the mountainous terrain the present delivery pipeline cannot withstand system pressures leading to ruptured pipeline and connection challenges. The proposed system is designed to withstand the high hydrostatic pressures and provide a safe and convenient source of clean drinking water. A new water committee formed in Kising'a's will bear primary responsibility for approval of this proposal as well as regular upkeep; the village will also be responsible for upfront cost and in-kind construction.

C. **Project Implementing Organizations**:

Organization:	St. Paul Partners
Function:	Project oversight
Primary Contact:	Heute Andrew
Email:	sppwater@gmail.com
Phone:	011 255 716 626164

D. **Project Location**:

Region:	Iringa, Tanzania
District:	Kilolo Rural
Village:	Kising'a
Sub-village:	Kibaoni
GPS:	-7.916 latitude, 35.985 longitude

E. **Beneficiary Information**:
This project will supply clean drinking water for the entirety of the Kibaoni hamlet of Kising'a including its primary school – presently no consistent supply of clean water is available. While the Kibaoni hamlet is the main target of this proposal due to its proximity to the fresh water source, other villagers in Kising's, in particular those in the Kidumka hamlet, will benefit.

Beneficiaries based on January 2014 demographic statistics:
Direct: Kibaoni Hamlet population: 537
Indirect: Total Population of Kising'a: 3302 (1465 men, 1837 women)

F. **Proposed Project Duration**:
Start Date: September 2014
End Date: October 2014

G. **Project Budget**:
Implementation of this project will cost a total of $7,630. We propose that 20% of the total project costs would be borne by the village of Kising'a ($1,526). Furthermore, we expect the village water committee to raise $120 annually to cover ongoing maintenance expenses: funds raised should be held in an account explicitly for this purpose.

3.0 Executive Summary

In January 2014, students and faculty from the University of Minnesota traveled to the village of Kising'a in the Kilolo District (elevation ~ 5300 ft) to evaluate the feasibility of providing clean drinking water to the community. Figure 1 shows where Kising'a is located relative to Tanzania as a whole, in what is known as the south central highlands region. Kising'a can be difficult to get to, particularly in the rainy season, as it requires travel on treacherous dirt/clay roads; similar conditions exist in the village and surroundings.

Figure 1: This is the location of Kising'a in Tanzania. This remote village is only accessible via a modestly maintained, two-lane dirt road.

The 45 km, two-hour journey from Iringa to Kising'a is outlined in Figure 2. The buildings in Kising'a are either mud or red-clay brick structures. The village is situated in a beautiful valley surrounded by rolling hills – the villagers are very adept at farming, though runoff from the fields drains into the local rivers making them unsuitable/unsafe for drinking without first boiling the water. Kising'a is not on the electricity grid, although some homes do have one or two lights supported by small rooftop solar collectors.

Figure 2: The blue line denotes the road between Iringa and Kising'a.

Kising'a is made up of several hamlets including Kidumka and Kibaoni as seen in Figure 3, which have populations of 537 and 428, respectively. The distance between the two hamlets is approximately 4 km following the main village road – shorter routes could be taken but would require passage over rather rough and steep terrain. Kibaoni is dominated by individual family homes, has a dispensary, several churches, and some small businesses including corn milling using diesel generators.

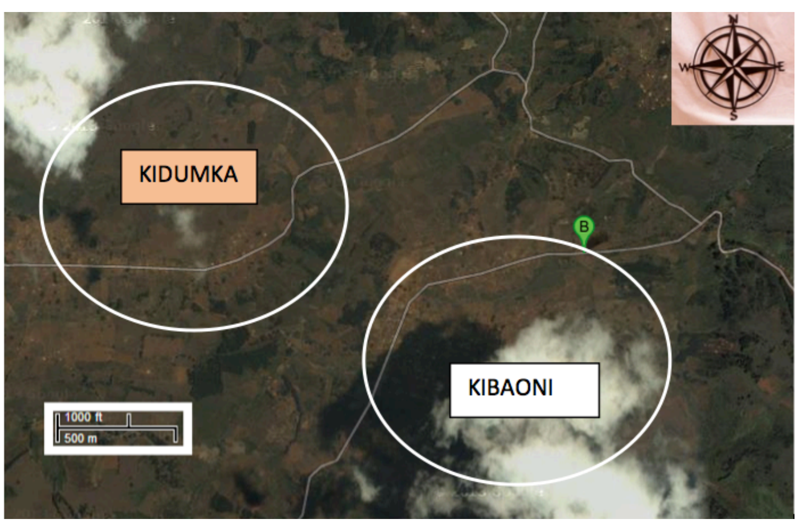


Figure 3: Kidumka and Kibaoni hamlets of Kising'a

Figure 4 illustrates several key locations within the vicinity of Kibaoni. The pastor's home is located on the main road and within a half of a kilometer of the primary school. There are two water sources currently available to the villagers in this area, labeled 2 and 3, in Figure 4. The open pool (2) is contaminated and (3), while tested to be relatively clean, provides a very low flow rate of water, making wait times considerable for the women and young children who fetch water. An inoperable hand pump is also located in Kibaoni as identified by (4) in Figure 4.

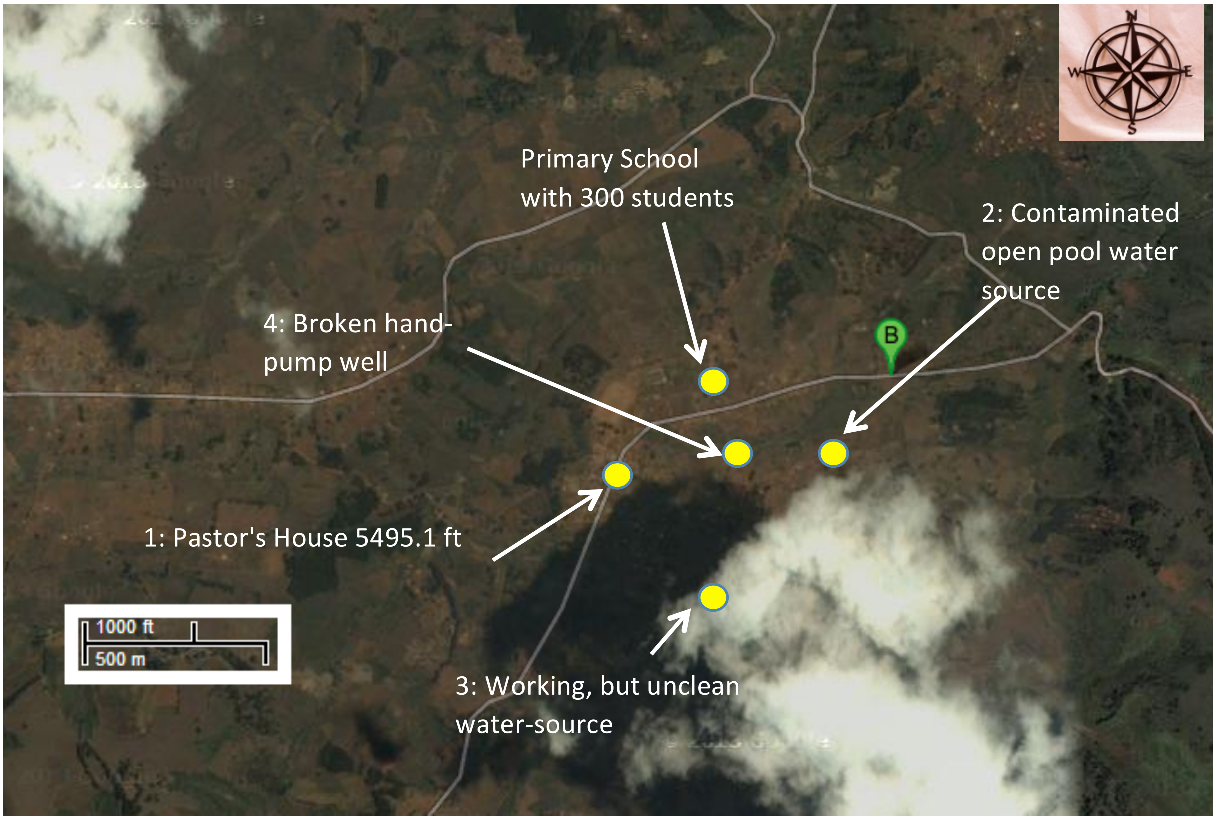


Figure 4: Kibaoni is home to many students during the school year who use the contaminated open pool (see Fig. 7) for water. Several hand pumps (e.g. see Fig. 9) were inoperable.

The University of Minnesota students and advisors stayed with Pastor Cornelius and his family. The Pastor was gracious and his home provided a wonderful opportunity for the team to experience living in Kising'a village. (A picture of the group is shown in Figure 5 in front of the Pastor's home.) Pastor Cornelius was clearly a respected member of the community and welcomed many villagers, including village leaders, into his home during our visit to share their perspectives on life in Kising'a. The Pastor and other residents of Kising'a were adamant about the hardships caused by a lack of a clean and reliable water supply. Women in the village carry the lion share of water back to their homes from far away sources and over rough terrain every day. Consequently women devote a significant portion of their day to fetching and boiling water leaving precious little time for other chores that fall on their shoulders including cooking and cleaning. As a result, many of the women said they have little time for sleep, much less for creative endeavors.

Figure 5: University of Minnesota group on the steps of Pastor Cornelius's home in Kising'a. Refer to Figure 4, location (1).

Although drinking water is scarce, Kising'a is a good place for agriculture and forestry. Views in the village, for example Figure 6, revealed corn, potatoes, tomatoes, carrots, sunflower, avocado, banana, squash and wheat; timber (pine) is also grown as a cash crop. The New Forest Company in Kising'a offers well-paying jobs to villagers willing to work in the timber industry. Villagers told us that New Forest Company workers make about 5,000 TSH a day. While that is only approximately $3 a day, it exceeds the daily average wage of $1/day.

Figure 6: The village of Kibaoni; the view from the pastor's house looking north.

As mentioned earlier in this report, the village of Kising'a is located in the rolling hills of Kilolo district and as of January 2014 had 3302 residents (56% women). At present, the village does not have a supply of safe and reliable drinking water. As an example, the open source water used by the villagers [location (2) in Figure 4] is shown in Figure 7. Testing this water for bacteria (both E. coli and coliform) reinforced initial assumptions that this water was not safe for human consumption without first being boiled yet many students consume this water without purification due to its proximity to the primary school.

Figure 7: A surface water source in Kibaoni. Adjacent agricultural field runoff and livestock waste run into the pool, making it unsafe for drinking.

Assuming a minimum water requirement of 20 liters/person per day, present demand for the village is approximately 66,000 liters/day. Currently, residents of the village use water from a variety of small streams, rivers, natural pits, and hand-dug wells. The sources visited on the assessment trip (largely in the Kibaoni hamlet) were mostly in low-lying areas surrounded by agricultural land. As such, these sources are deemed to be unsafe; measurements supported the visual assessment. Furthermore, due to the scarce nature of water, long waiting lines were commonly observed at water sources. For example, when the UMN group was visiting one of the cleaner water sources [location (3) in Fig. 4], there were about 30 women and children waiting in line to fill buckets (the time measured to fill a 20 L bucket from this source was approximately 5 minutes). A photograph of this water source is shown in Figure 8. It should also be noted that there are five existing shallow wells (6-8 m deep) with hand pumps in the village. However, none of the pumps were working at the time of the assessment trip (January 10-12, 2014). The lack of water may have been due to poor maintenance or that the well had gone dry: one of the dry wells visited is shown in Figure 9.

Figure 8: This source is relatively clean; however, it only produces 4 L/min. There were about 30 people waiting in line at the source to fill buckets. The need to deliver a new and reliable source is evident. Refer to Figure 4, area # 3 for the location.

As a rough estimate of the time needed to haul water in Kibaoni, we took a representative walking distance from the center of the hamlet to the current sources shown in Figure 8. At a total distance of 6 km and a walking pace of approximately 4 km/hour – recognizing that the women travel very slowly on the return trip with 40 pounds of water on their heads – it takes a woman 1.5 hours to haul 20 liters of water. Villager families with two or more children, cattle/chicken, and small gardens, require approximately 200 liters/day. Hence 15 hours per day is spent hauling water if the work is done by the sole female in the household: many small children help, which will alleviate this burden somewhat, but the toll is considerable.

Figures 9: This hand dug well in the village of Kising'a is about 8 m deep and is no longer in working condition. This well was originally intended to serve the primary school [see location (4) in Figure 4].

While in Kising'a, the UMN group observed that the village is running critically short of potable water. Currently, the village is able to get by using a variety of small, unsafe sources. It is likely that the water situation becomes increasingly dire during the dry months of the year as many of the sources run dry. Although the unclean water can be boiled prior to consumption, this is labor intensive and brings about further public health issues associated with unventilated stoves used throughout the village.

Project Site

A villager named Sajeni discovered a new fresh water source in 2011. The source will be discussed hereinafter as the 'Sajeni' source. The Sajeni source is located approximately 1.6 km east of the population center of Kibaoni. Working alone, Sajeni spent 3 months digging a trench to lay the pipe that follows the path as seen in Figure 10. The polyethylene pipe (32-mm outer diameter and minimum wall thickness of 1.9 mm*) carries the water from the Sajeni spring on the side of the mountain to a low point in the Kibaoni valley. The pipe is thin walled and may be

* Based on information from DPI Simba Ltd., this pipe is Class B with an estimated burst pressure of 99 psig.

of poor quality as is suggested by frequent bursting. During the UMN group's three-day stay in the village, the pipe was leaking to various degrees most of the time.

Although this source is not capable of meeting the demand needs of the entire village, it could make a difference for the 537 villagers of Kibaoni, particularly the drinking water requirements, since existing village water sources can provide the additional water for cleaning and agricultural needs. During the UMN visit the Sajeni system provided approximately 8.5 liters/min or 12,240 liters/day, as measured directly from the system outlet. Assuming a minimum water requirement of 20 liters/person per day, this source could provide enough clean water for 625 people, namely more than the population of Kibaoni. Note that the water was tested using basic bacterial testing equipment and did show evidence of coliform, so a more comprehensive test is recommended to validate the water quality.

Employing the Sajeni source is deemed to be the most affordable of those evaluated by the UMN group and was therefore selected for further examination in this report (see the budget in Section 5 for a cost estimate). It is proposed to position a storage tank near the current Sajeni outlet with multiple taps in order to collect water when people are not filling buckets and alleviate waiting time when multiple people are present.

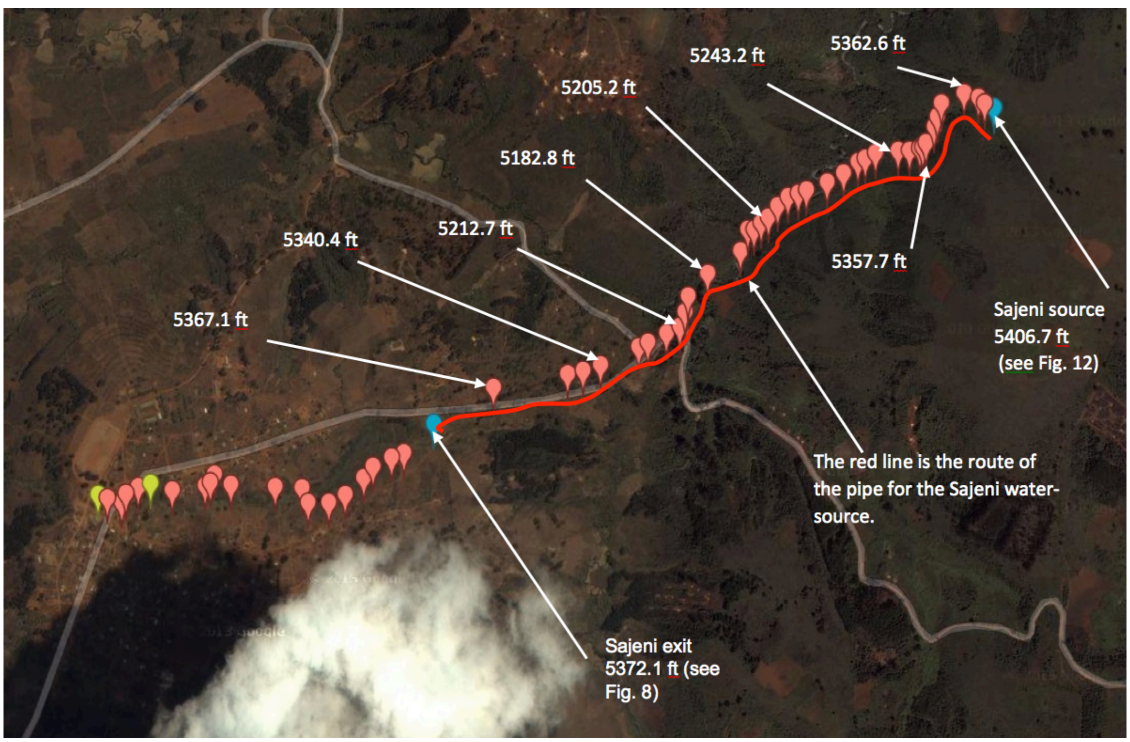


Figure 10: The route of the existing Sajeni line is highlighted in red. From the source of the spring at 5,407ft to the outlet at 5372 feet, there is a 35-ft elevation drop. The outlet would serve the people of Kibaoni.

It should be noted that the current Sajeni outlet site is located well below the elevation at which most of the population lives. Women and children fetching water will still need to walk over difficult terrain to fetch water. However, due to the small elevation difference between the source and the outlet, this location is one of the only options for outlet placement. Note that while the net elevation change from source to outlet is only -35 feet, the pipe elevation drops to a minimum in the intervening valley that is approximately 240 feet below the source, as shown in the contour diagram of Fig. 11, leading to significant water pressure in the system.

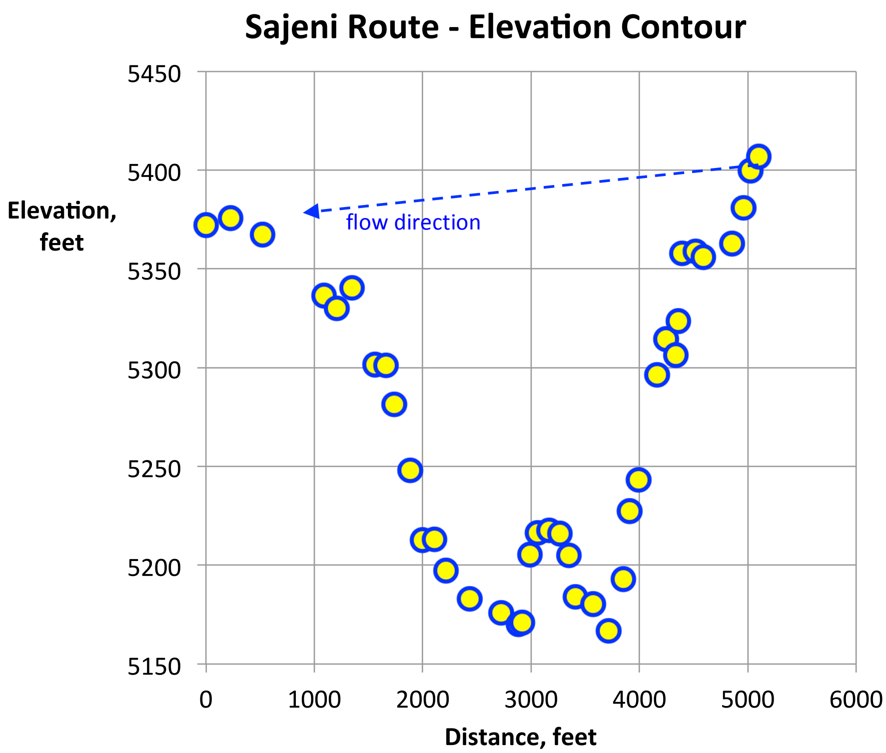


Figure 11: Location '0' corresponds to the Sajeni exit and location '5100' corresponds to the source.

While the University of Minnesota Group was visiting Kising'a, the village successfully formed a water committee. A list of the committee members can be found in Appendix B. It is recommended that this committee raise 20% of the funds for this project. Additionally, the committee will be held responsible for regular maintenance and upkeep of the system.

Technical Overview of Potential Solutions

Several options exist to increase the supply of potable water to Kising'a, which include at least the following: (1) fixing existing wells and/or drilling new wells, (2) building a more reliable piping and storage system for the Sajeni source, and (3) reexamining the Preliminary Design Report of Eng. A.M.S. Byemerwa conducted in 2008, which tapped a more distant source at a projected cost of 313.9 million tsh or the equivalent of approximately $200,000 in 2008.

All of these solutions have drawbacks. Existing wells in Kising'a are only 6-8 m in depth and are prone to drying out during the summer months. A successful well project would require air hammer drilling since it is reported that bedrock is only 8-10 meters below the surface. We were informed that there may be reliable sources 8-10 m below the surface in this region, but it would be hard to pinpoint the fissure in the bedrock where the water is located. Pursuing the Byemerwa approach was deemed too expensive to pursue at this time.

Option number (2) was explored since the Sajeni source could supply clean drinking water to the population center of Kibaoni at a relatively low cost. The exit of the current Sajeni pipeline as seen in January 2014 is shown in Fig. 12. When water is not collected in buckets it continuously flows onto the surrounding ground, saturating it in the process and making access to the outlet difficult if not dangerous for walking. Downstream of the source the pipeline traverses over a river through the black polyethylene pipe as shown in Figure 13; this location corresponds to the minimum elevation observed in Figure 11.

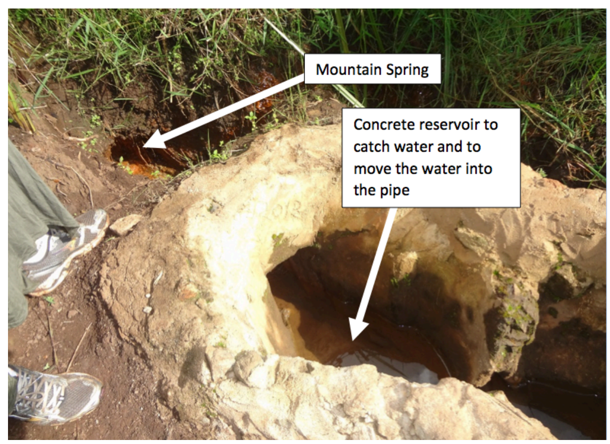
Figures 12: Photographs of the outlet of the Sajeni pipeline in January 2014.

Figures 13: Pastor Cornelius hops over the river. The white arrow points to the pipe.

The fittings used to connect sections of pipe (see Fig. 14) as well as the thin wall of the pipe make this source unreliable and susceptible to rupture. Sajeni spends a substantial amount of time fixing this system for which he is not reimbursed. During the UMN visit leaks were observed in the valley portion of the pipeline traverse where the substantial changes in elevation lead to very significant water pressures. It is also likely that sections of the pipeline that are exposed to traffic are damaged by local residents or livestock.

The natural spring source discovered by Sajeni is located on a rock face at an elevation of 5407 feet and 1.6 km east of Kibaoni. The water emanates from a crack and flows into a manmade concrete basin as shown in Fig. 15. It was difficult to determine whether all of the available water exiting the source was captured by the basin. It was also difficult to make direct measurements of the water flow rate from the source. *Careful flow measurements are needed to fully assess the capacity of this source.* As mentioned elsewhere in this report, water flow from the outlet was measured to be approximately 8.5 liters per minute in January 2014; Sajeni indicated that water flows from the source year round. Given that the UMN team visited the Sajeni source in the early stages of the wet season, the new system was designed to handle a larger capacity than that measured during the January 2014 visit.

Figures 14: photograph of exposed pipe connection on Sajeni line



Figures 15: concrete basin used to collect water exiting the mountain source

3.1. Organization background information

3.2. St. Paul Partners

St. Paul Partners (SPP) was established in 2002 and serves the Iringa region. Their goal is to provide safe, reliable water to communities in the Iringa region. SPP will meet with leaders in Kising'a before and after the project to form water committees and to see if the system has proper maintenance. While SPP is there to help, it is the village's responsibility to stand up and take ownership of the project. SPP facilitates community involvement.

3.3. Program Objectives

The objective of this project is to harness the entirety of a water source for consumption in the village of Kising'a. This plan will increase the quantity, quality and reliability of water in the village. In order to accomplish this objective, we plan to install a pipeline and storage tank system. The pipeline will carry water from the Sajeni source to a low point in the population center of Kibaoni.

The project will entail:

- Assessment of the community needs (present and future)
- Construction of a detailed map of the pipe route
- Determination of the available water supply capability
- Design and cost of the supply system
- Recommendations for system improvements

3.4. Program Deliverables

There are several steps in the development of a functioning water supply system. Upon the UMN group's visit to the village, the villagers structured a water committee. St Paul Partners and the UMN group will work closely with the village government leaders, religious leaders, and water committee to secure approval and buy-in from the village. In order to create community ownership it will be requested that the village supply 20% of the funding for the project. The village will also be expected to make contributions of in-kind labor and maintenance.

Additional funding for the projects will be raised through St Paul Partners or other outside sources. Detailed construction plans and costs will be provided from the UMN group. Finally, a maintenance plan will be developed and agreed upon between St Paul Partners, the village and the water committee. This plan must include a way to maintain funds to repair the system as needed.

3.5. Impact goals

The goal of this project is to improve quality of life through the delivery of clean and reliable drinking water. It is expected that the Sajeni source can deliver up to 13,540 liters of water per day of water at a rate of 9.4 liters/min.[1] Assuming a need of 20 liters per person per day, this source can provide water for 680 people per day. As the source outlet would be located near a primary school (approximately 1.1 km), this plan would greatly benefit the students who currently do not have a safe water supply. The population of Kibaoni is 537 people; therefore, the proposed system could serve a large portion of the population center. The proposed source will provide water, which is safe for drinking. However, there are other sources in the nearby vicinity, which can be used for cleaning, cooking and livestock.

Water Storage

The water supply from the proposed source is currently unable to be used to its maximum capacity. A large amount of water is wasted when people are not filling buckets of water at the

[1] These numbers are based on the flow of water observed at the Sajeni outlet in January 2014. The measured flow rate of 8.5 liters/min was increased by 10% to account for water escaping through leaks in the pipe or not captured by the source basin. The actual measurement: 20 liters of water over 140 seconds.

source outlet. Furthermore water is lost to leaks and burst pipe, and at the basin. The proposal is to harness the entire flow and store excess water (when people are not at the outlet, particularly in the evening) in a 10,000 L storage tank.

Sajeni Water Source

A man named Sajeni discovered the Sajeni source in 2011. This source is located approximately one mile away from the population center of Kibaoni. The source exits the ground at the top of the mountain and as such is thought to be clean. Basic biological tests were performed on the sample, but the results were inconclusive. Therefore, laboratory testing of the water is recommended. According to the villagers, bacteria does not appear to grow in the water from this source even if allowed to sit for a long period of time. As such, the villagers also believe the water to be clean. Initial evaluation of this source was conducted with endorsement from the village government and local church leaders.

State of the Current Supply System at the Sajeni Source

Presently, this source is captured in an intake basin at the source. It is carried to a low-point in the Kibaoni valley by 32mm outer diameter pipe. The pipe used to construct the current delivery system is partially buried six to twelve inches below ground level. The pipe bursts and disconnects frequently and is therefore highly unreliable. The system may be underutilized by the villagers due to its unreliable nature. The pipe is likely undersized and of low quality (Class B) as is suggested by the frequent bursting. Water is wasted when people are not there to collect it, particularly during the evening hours.

Project Objective

The objective of the proposed project is to increase the supply, storage capacity, and reliability of the system in a cost-effective manner. It is thought that improving the reliability of the system will increase its utilization. Increasing the storage capacity will increase the amount of water available for use by the villagers. The proposed system will also reduce the time spent filling and waiting to fill water buckets, as the storage tank will have taps for multiple people to fill buckets at one time.

3.6. Implementation Plan

The proposal is to replace the existing pipe network with 50-mm outer diameter Class E pipe at least one-half meter underground. A Class E 50-mm pipe has an inner diameter of 40.8 mm, and will be able to capture the entire water flow at the source. A new intake basin will be constructed at the source along with a fence to prevent animals from entering the water catchment area.

The system being designed is gravity fed, eliminating the need for pumps and/or an external power supply. Water will be delivered to a relatively low point in the Kibaoni population center. A primary school, secondary school and dispensary may be served by the proposed system as they are in the near vicinity of the source outlet.

The 50-mm Class E pipe was chosen to increase the amount of water harnessed from the source. The inner diameter of the current piping is 28.2 mm and carries a capacity of approximately 8.5 liters/min. Increasing the inner diameter will increase the flow up to a theoretical maximum of 23 liters/min, though flows at this level are not expected.

Using class E pipe will guard against pipe bursting at low elevations, because this class of pipe can withstand up to 160 psig. The maximum pressure in the pipe will reach up to 736.4 kPa (106.8 psi) at the lowest point of the route from the inlet to the outlet (see Table 1 and Figure 16).

Table 1: Displays maximum pressures within the pipe and the location of the maximum pressure. The maximum pressures are similar but decrease slightly with pipe diameter.

Pipe Diameter	Maximum Pressure	Elevation	Horizontal Distance from Source
1.0"	742 kPa (107.6 psi)	5170 ft	1391 ft
1.6"	737 kPa (106.8 psi)	5170 ft	1391 ft
2.0"	733 kPa (106.3 psi)	5170 ft	1391 ft

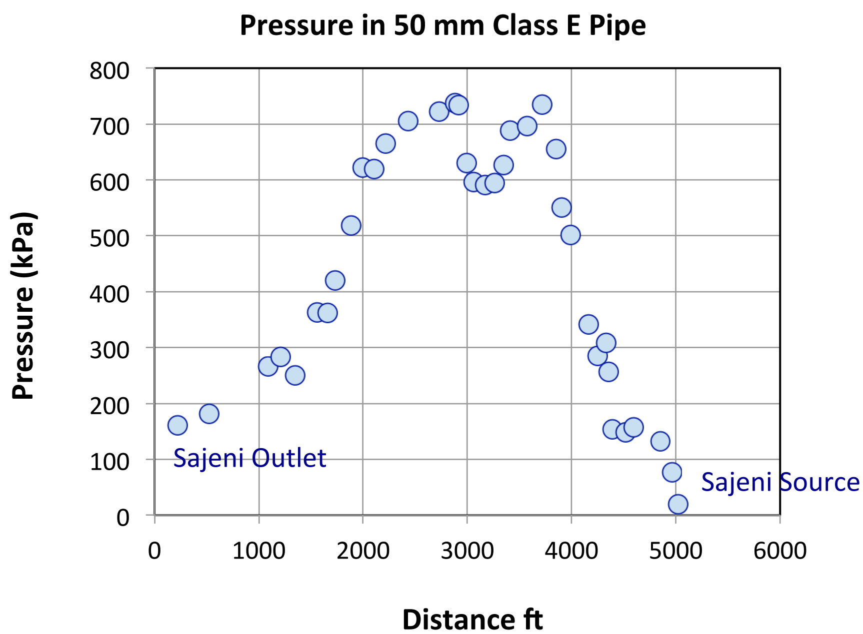


Figure 16: This figure compares the changes in pressure to changes in elevation on the route from the water outlet to the source. These pressure changes are caused by changes in elevation. Notice that at low elevations on the route, pressure increases.

The outlet of the system will be kept in its current location in Kibaoni (-7.915262 latitude, 35.991515 longitude) which is 35 ft below the source. The outlet will be connected to a 10,000 L storage tank. The tank will be fitted with 5 taps to allow multiple individuals to fill buckets concurrently. A two-tiered concrete pad will be constructed underneath the tank with adequate space to fill buckets on the lower tier (see figure 17). A roof will be constructed over the storage tank to minimize sun damage.

The calculations for pressure and flow were made using EES, a program that allows the user to solve the governing equations. A snapshot of the EES program can be seen in Appendix A. The calculations were based on the energy equation, written for our purposes as follows:

$$\frac{P_2-P_1}{\rho g}+\frac{\bar{V}_2^2-\bar{V}_1^2}{2g}+Z_2-Z_1=\frac{\dot{W}_{in}}{\dot{m}g}-\frac{\overline{V\cdot V}}{2g}\left(\frac{fl}{d}+\sum K_L\right) \qquad \text{Equation 1}$$

P_2 is the downstream pressure, P_1 is the upstream pressure, ρ is the density of the fluid, g is the gravitational acceleration, V_2 is flow velocity at the outlet, V_1 is the flow velocity at the inlet, Z_2 is the downstream elevation, Z_1 is the upstream elevation, $\dot{W}_{in}$ is the input work (in our case the input work is zero), $\dot{m}$ is the mass flow rate of water, $\bar{V}$ is the average velocity in the pipe, f is the friction factor, l is the length of the pipe, d is the inner diameter of the pipe, and $\sum K_L$ is the sum of the losses due to bends and elbows in the pipeline system.

Source:
- Intake basin made of concrete
- Latched basin cover
- Fence to protect source from animals
- Fine mesh to protect pipe inlet

Pipe:
- 1.6 km of 50 mm Class E pipe (40.8 mm inner diameter) from source to outlet

Outlet:
- Concrete pad at outlet
- Approximately 0.9 m tower for water storage tank (concrete slab and concrete block)
- 10,000-liter storage tank
- 5 valve-spigots for tank
- Straw Roof over tank for sun protection

Trenches will need to be dug for the pipes, and this will be done by in kind labor from members of the village. Sajeni had stated that it took him three months to dig and lay the pipes for the current system. It was estimated that he worked five days a week for four hours a day over these three months and hence it would have taken him a total of 240 hours to complete. If ten men are helping to dig and lay the pipes, it would take them each around 24 hours or six, 4-hour days to complete. The cost estimate for this would be $3/person per day or a total of $180 worth of in-kind labor.

Future Suggestions

At the village meeting, citizens explained that women and children suffer the most from the water situation as they are responsible for retrieving water. Women told us they spend the majority of their day carrying water over long distances. This leaves them little time for anything else. Sexual assault is a concern as women must go to water sources during the night and early morning hours. Adding additional water supply may worsen these issues as women may make more trips for water. In order to ease this burden, a water distribution business model could be developed. This distribution business could use trucks or bikes to pick up water from the source and deliver water to households. Since the water source will not be located next to a road, employees would need to carry water the short distance to the road. Residents who utilize the service would pay a small fee for the quantity of water delivered.

Another suggestion for the village is to use the river (which runs through the valley in Kibaoni) for cleaning, cooking and livestock. A small solar pump, or possibly the hydrostatic force of the river, could be used to pump the water to a tank near the outlet of the Sajeni source. One tank could be used for drinking, and the other tank could be used for other purposes. This would require proper labeling and educating the community. However, this system could easily supply as much water as is desired by the community.

These improvements could alleviate major problems in the community, and perhaps provide jobs for villagers. However, these ideas would only be successful with complete endorsement and adoption from the community.

3.7 Project Sites

The proposed project will primarily follow the path and location in Figure 10. The Sajeni source at 5,407 feet elevation will include sealing the intake basin, a latched basin cover, a fence, and fine mesh. Currently, water is leaking out of the basin before it enters the pipe. The basin must be sealed. The basin is also open to the air. A basin cover will reduce potential contamination. Additionally, the fence will keep animals out of the catchment area. Fine mesh on the pipe inlet will be the last measure used to prevent debris from entering the pipe. The second site is the pipeline itself; buried pipe will follow the current route as shown in Figure 10. We asked the water committee if the current outlet location was acceptable. They were very supportive of keeping the outlet in its current location. As a result, the third site, called the Sajeni exit, will be the outlet for the gravity fed system at 5,372 ft. This site will consist of a concrete pad, the 10,000 liter storage tank, water taps, and a straw roof.

Table 2: Displays projects, village names, elevation and coordinates.

Project Site	Village Name	Sub-village	Elevation	GPS N	GPS E
Sajeni Source	Kising'a	Kibaoni	5,407 ft	-7.909314	36.00319
Pipeline	Kising'a	Kibaoni	Figure 11		
Sajeni Exit	Kising'a	Kibaoni	5,372 ft	-7.915262	35.991515

4.0 Concrete Pad Construction Process

The concrete will be purchased from Mbeya Cement for 10.00 dollars per 50 kg bag. The design in Figure 17 includes a 10,000 liter water tank, a concrete block tower in the shape of a cross, and a foundation. The foundation is thick where the water tank is; however, it is thin where the people will stand. This design will save concrete while meeting American Concrete Institute code. The code says that the foundation should have less than 1000 pounds per square foot (psf). Our design will have only 384 psf acting on the .3 meter foundation (see the equation below).

$$Soil\ Bearing = \frac{20{,}000lb}{52squarefeet} = 384psf \qquad \text{Equation 2}$$

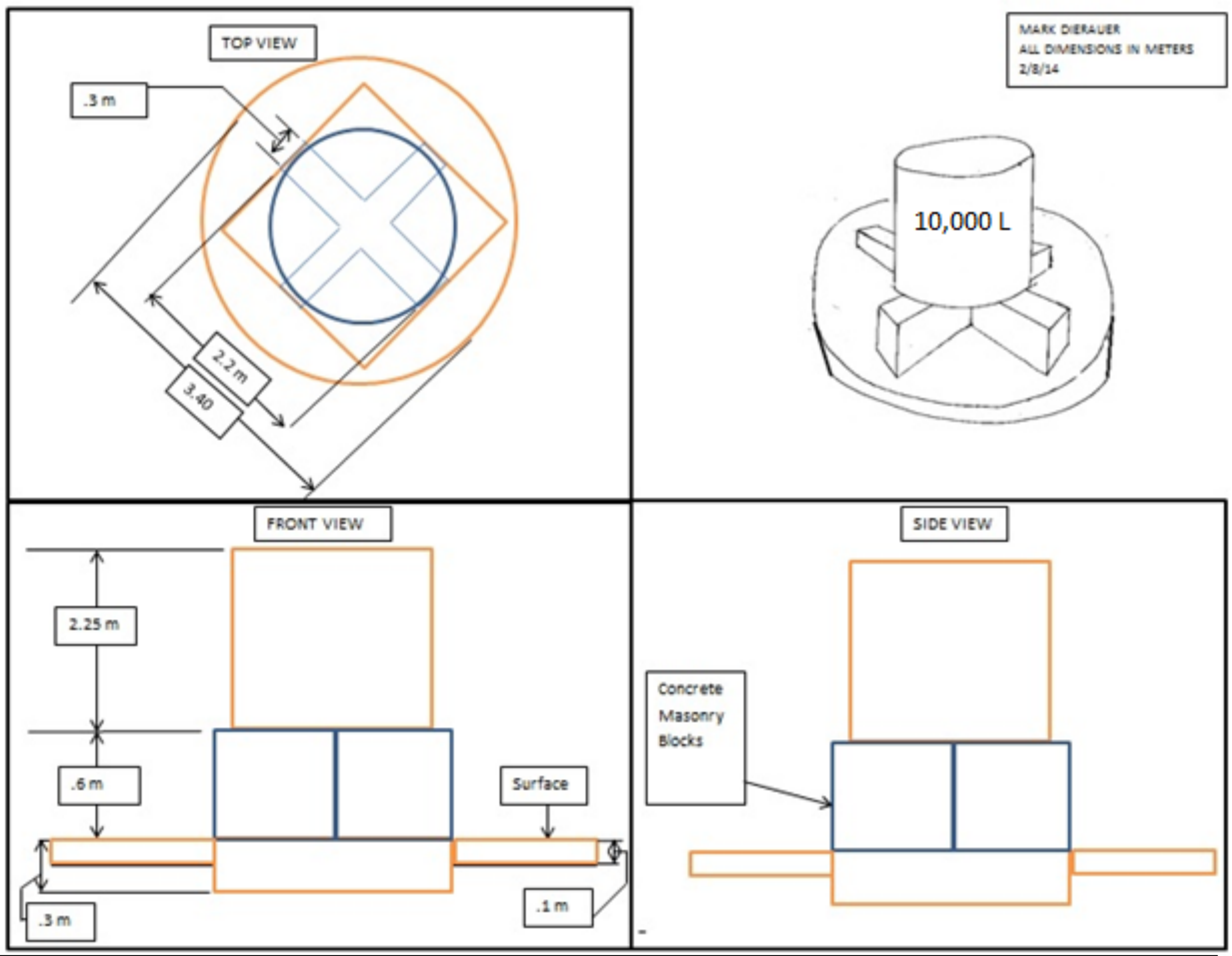


Figure 17: Schematic of concrete pad for a 10,000L water tank.

The concrete foundation design will need 4,000 kg of concrete to be built. This will require 80 bags of cement at 50 kilograms a bag. After the foundation hardens, 51 concrete blocks would be stacked in the shape of an “x” with 3 levels at 17 blocks a level. By raising the tank up above the ground, people can put their buckets under the spigot for easy access.

4.1 Project Sustainability

In order to keep the water system in working order for years to come, the community members must feel personally invested in this project. In order to foster a feeling of personal investment, we suggest that the community provide the labor for digging the trenches for the new piping. Additionally, it is suggested that the village provides 20% of the total project cost.

The water committee will be expected to maintain the water system after the initial construction. Although the responsibility will fall primarily on their shoulders, Saint Paul Partners will be available if serious problems arise. Although the gravity-fed system is not expected to require much maintenance, the water committee members must be educated on how to properly maintain the system and how to distinguish if something has malfunctioned. $120 will be collected every year to pay for any needed repairs.

5.0 Project Budget

S/N	Descriptions	Unit Cost ($)	Unit	Quantity	Total Cost ($)
1	10,000 L storage tank	$1,235	n	1	$1,235
2	Spigots	$50	n	5	$250
3	HDPE 50mm Class E Pipe	$266	150 m	11	$2,926
4	Concrete mix before water	$10	50 kg	80	$800
5	Concrete bricks	$125	lorry	1	$125
6	SPP Oversight and Training	$500	day	2	$1,000
7	Pipe Fittings	$20	n	10	$200
8	Freight				$400
9	10% Contingency Fund				$693
	Subtotal				$7,630
10	20% Support by Kising'a				-$1,526
*11	Labor (IN KIND VILLAGE CONTRIBUTION)	$3	per person per day	60	$180
	Total Requested Donor Contribution				$6,104

*This is not included in the requested total because it is expected that the village will do this work in kind.

The sources for these supplies are shown in Appendix C.

Appendix A: EES Program

Modeling the Sajeni Source: EES Flow Calculating Program

```
{Calculates the flow rate of water using the energy equation}

d = 0.0381  {m}    {1.5-inch pipe inner diameter }
A = pi*d^2/4    {m^2} {Cross sectional area of pipe}
Q = V_bar*A   {m^3/sec} {Flow rate}
Q_LPM = Q*1000*60   {volume of water in liters/minute}
Q_GPM = {Q_LPM/3.8} Q*15850 {volume of water in gal/minute}
k_L = 500 {estimation with "losses" associate with water flow through bends and etc.}
L = 5100 / 3.281  {m} {Pipe length}
z_1  =  5407            /3.281  {m} {Elevation at Sajeni source}
z_2  =  (5372)       /3.281   {m} {Elevation at Sajeni outlet}

rho = 1000   {kg/m^3}
g = 9.81      {m/s^2}
nu = 0.000001   {m^2/s}
Re=4*Q/(pi*nu*d) {Reynold's number}

{friction factor calculations}
ed = 0.2/1000
AA = -2 * log10(ed/3.7 + 12/Re)
B = -2 * log10(ed/3.7 + 2.51*AA/Re)
C = -2 * log10(ed/3.7 + 2.51*B/Re)
f = 1 / (   AA - (B-AA)^2/(C - 2*B + AA)   )^2
{----------------------------------}

{Energy equation assuming P_1=P_2 and negligible change in average velocity}
z_2 - z_1   =   -V_bar^2 * (f*L/d + k_L) / (2*g)
```

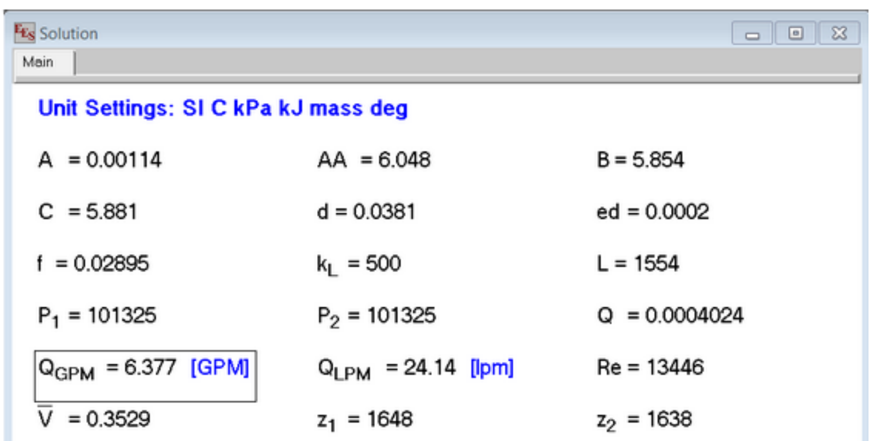


Figure 18: Shows the results obtained from EES for the maximum possible flow using a 1.5"inner diameter pipe.

Modeling the Sajeni Source: EES Pressure vs. Location Calculating Program

```
{Inputs: distance x (in feet) from source, and elevation y (in feet) at distance x from source. P_2 is
calculated using these values and the Energy Equation}

d = 0.0381  {m}    {1.5-inch pipe inner diameter }
A = pi*d^2/4    {m^2} {Cross sectional area of pipe}

Q = V_bar*A   {m^3/sec} {flow rate}
Q = 0.0004024
Q_LPM = Q*1000*60   {volume flow of water in liters/minute}
Q_GPM = {Q_LPM/3.8} Q*15850 {flow of water in gal/min}

k_L = 500 {estimation with "losses" associate with water flow through bends and etc.}

L = x / 3.28  {m} {Length of pipe depending on distance x (ft) from Sajeni source}

z_2  =  y          /3.28  {m} {Elevation of point y (ft) corresponding to distance x (ft) from the source}
z_1 =  5407       /3.28   {m} {Elevation of Sajeni Source}


P_1=101325  {Pa, N/m^2} {Pressure at Sajeni Source}

{Energy Equation}
(P_2 - P_1)/(rho*g) + z_2 - z_1 = -V_bar^2/(2 * g) * ( k_L + (f * L)/d )

rho = 1000   {kg/m^3}
g = 9.81      {m/s^2}
nu = 0.000001   {m^2/s}

Re=4*Q/(pi*nu*d) {Reynold's number}

{friction factor calculations}
ed = 0.2/1000

AA = -2 * log10(ed/3.7 + 12/Re)
B = -2 * log10(ed/3.7 + 2.51*AA/Re)
C = -2 * log10(ed/3.7 + 2.51*B/Re)
f = 1 / (   AA - (B-AA)^2/(C - 2*B + AA)   )^2
{---------------------------------}
```

Appendix B: Water Committee

KISING'A VILLAGE 11/01/2014
WATER RESOURCES COMMITTEE.

NO:	NAME	GENDER	TITTLE	STREET.
1.	MESHACK KIVAMBA	M	CHAIRMAN	KIBAONI
2.	ENEA SWAI	F	BURSAR	KIBAONI
3	SAJENI MTENGEIA	M	SECRETARY	MABALALA
4	NELIA KASENEGALA	F	MEMBER	MABALALA (A)
5	ALEX KADINDE	M	MEMBER	KIDUMUKA
6	AGNETA KIBIKIMUNU	F	MEMBER	MADASI
7.	ANTONI LULENGA	M	MEMBER	LUHAPO
8	SUZANA MNYALAPE	F.	MEMBER	MABALALA
9.	ALANZUSA MUOHAMWENDE	F	MEMBER	KIDUMUKA
10	NEHEMIA LUHWAGO	M	MEMBER	MABALALA
11	DEUSI LULENGA	M	MEMBER	MABALALA.
12	DEVOTA MWILONGO	F	MEMBER	MADISI

These are the names of the water resources Committee in Kising'a Village.
Thank you!! AFISA MTENDAJI WA KIJIJI CHA KISING'A S.L.P. KILOLO

Appendix C: Material Suppliers

S/N	Descriptions	Supplier/source
1	10,000 L Sim Tank	Kilolo Star Supplier
2	Spigots	Mtera Proposal
3	HDPE 50mm Class E Pipe	DPI SIMBA Ltd
4	Concrete mix before water	Mbeya Cement
5	Concrete bricks	Lukani Proposal
6	SPP Oversight and Training	Kiponzero Proposal
7	Pipe Fittings	N/A
8	Freight	Local Estimate
9	10% Contingency Fund	N/A
10	20% Support by Kising'a	N/A
11	Labor (IN KIND VILLAGE CONTRIBUTION)	N/A