Ihemi Village: Community Effort for Implementing a Large-Scale Water Distribution System

Harry Barrett
Justice Harvieux
Libby Kirkeide
Sarah Thole

College of Science and Engineering
University of Minnesota
Minneapolis, MN 55455

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1.0 Contact Details

1.1 University of Minnesota Students

Justice Harvieux
Civil Engineering Student
Phone: 715-781-5376
Email: harvi015@umn.edu

Liberty Kirkeide
Mechanical Engineering Student
Phone: 763-381-7848
Email: kirke022@umn.edu

Harry Barret
Mechanical Engineering Student
Phone: 651-214-2610
Email: barre465@umn.edu

Sarah Thole
Mechanical Engineering Student
Phone: 651-387-9746
Email: thole032@umn.edu

1.2 University of Minnesota Instructors

Dr. Ken Smith
3M Corporation

Dr. Paul Strykowski
University of Minnesota

Steve Grossheim
Hewlett Packard

1.3 St. Paul Partners

Dr. Ken Smith
Vice Chairman

Bo Skillman
Chaiman of St. Paul Partners

1.4 Ihemi Water Committee

Esta Kilasi
Chair (Kiti)

Jonas Ngata
Secretary (Katibu)
Phone: 0765949765

E. P. Nyalusa
Treasurer (Haznia)
Phone: 0764003762

Gafus Bangi
Phone: 0762624871

Patrisia Mjovela
Phone: 0769209935

Maria Mahuvi

Edison Nyalusi

Esterina Kihauzo

1.5 Ihemi Community Members

Aneth Peter Fweni
Pastor
Phone: 0786269044

John Mhekwa
Pastor
Phone: 0752574809

Ezekiel Daniel
Village Chairman
Phone: 0755196160

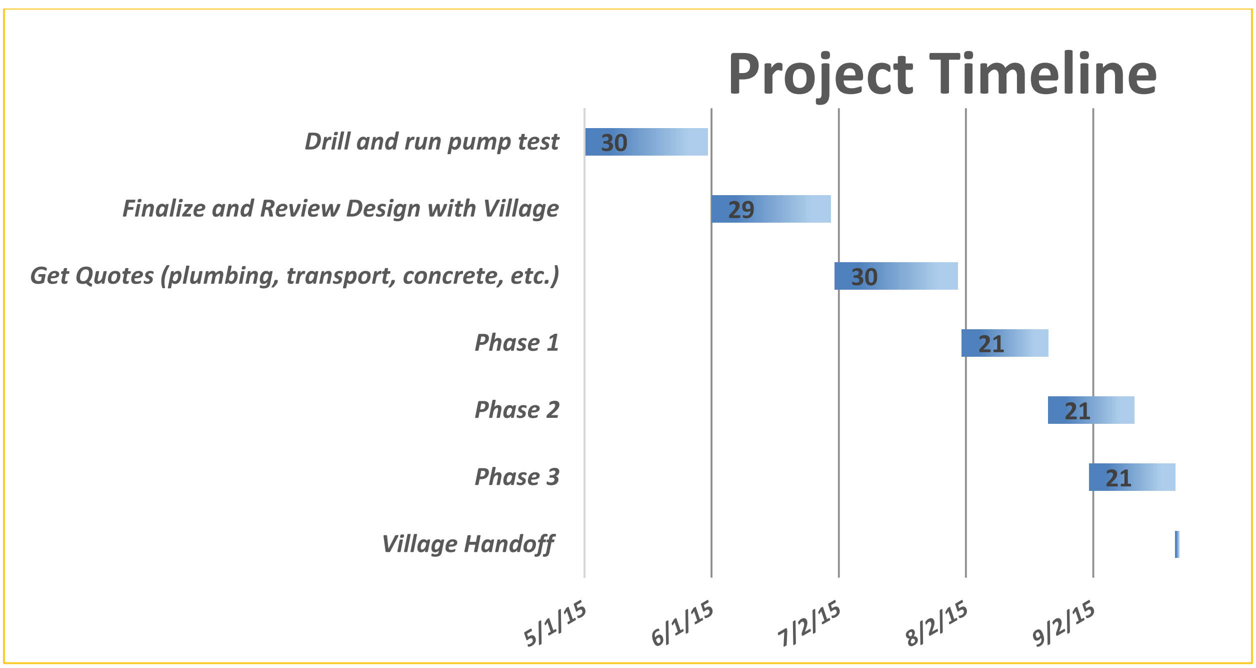
Aloyce Chawala
Phone: 0755685574

2.0 Project Profile

2.1 Project Location

Region: Iringa, Tanzania
District: Iringa Rural Region
Place: Ihemi Village
Climate: Less than one inch of rain for half the year, temperatures reaching 90° F, humid.

2.2 Project Duration



2.3 Project Duration

The project duration is estimated as shown by the schedule in Figure 1.

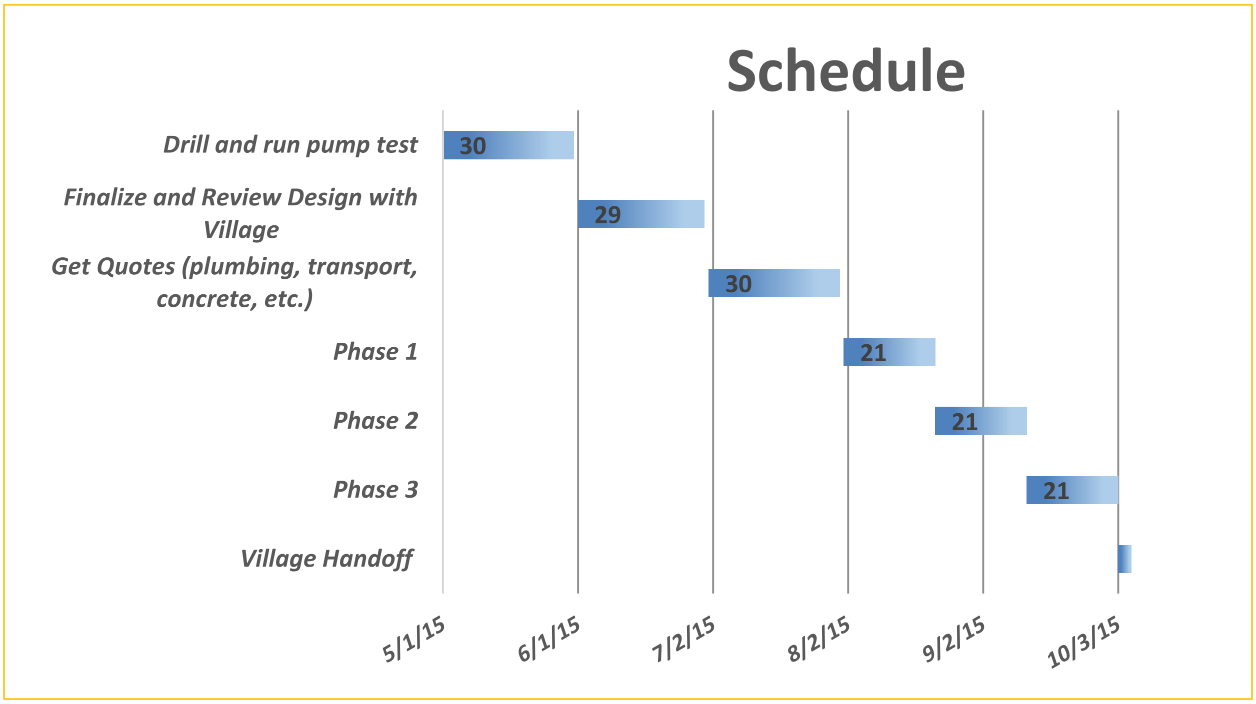


Figure 1: Estimated Project Schedule

2.4 Project Budget

Line	Item	Total Price (TZS)	Total Price (USD)
1	Subtotal Cost	67,974,800	$39,985
2	Total In Kind Contribution	27,380,000	$16,106
3	Subtotal Capital Cost	40,594,800	$23,879
4	Contingency (%10 of Capital Cost)	4,059,480	$2,388
5	St. Paul Partners Overhead	1,700,000	$1,000
6	Total Cost Estimate	46,354,280	**$27,267**

3.0 Executive Summary

The intent of this project is to design a water distribution system that supplies ample potable water to Ihemi village. The existing water system does not provide the capacity or reach to satisfy current water demands. With over 3,000 people living in Ihemi, spread throughout nine sub-villages, it is desired to supply at least 60,000 liters per day to the entire village. Currently, the village is supplied by filling a 5,000 liter storage tank twice a day from a submersible pump in a well. Other water sources in use include three hand pumps and home rain catchment. Both the hand pump water and well water were tested for harmful bacteria and were found to be clean. Due to the long distances women and children have to travel to obtain water, it is desired to have taps installed in densely populated regions. These findings were the beginnings of forming a suitable design.

The leading design choice for this project is a gravity-fed distribution system that is supplied from a borehole well with a submersible pump. Ihemi village is dispersed along a large hill which makes it an ideal candidate for a gravity-fed system. With the span of the proposed distribution requiring almost 7 km of pipe, the design has been divided into three phases to distribute the budget and implementation plan into workable portions. The first phase consists of drilling a new well, building foundation for and installing two 10,000 L SimTanks, and running lines to Killamehewa and Kilimanjaro subvillages. Once the well has been drilled, dynamic water tests can be performed to verify a satisfactory recharge rate, 5,000 L/hr for the implementation of the entire system. If the dynamic test proves successful, phase 2 will be implemented, connecting the newly installed tanks to the current water system and Ihemi 'A' subvillage. The pump used to fill the 5,000 liter tank may be left as a backup or could continue to be used to supply water. Phase 3 will provide water to the secondary school and Kifumbi sub-village. One additional 10,000 L SimTank will be added for both implementation of phase 2 and phase 3.

The people of Ihemi village expressed their willingness to contribute to the implementation of this design. After in-kind contributions from the village have been deducted from gross project cost, the remaining cost estimate is: $27,300. Saint Paul Partner's will work with Ihemi to develop a plan that is best for the village before the design is finalized.

4. Background

4.1 Ihemi Village

Ihemi is located roughly 10 miles southwest of Iringa, Tanzania, along the main highway that runs North-South through Tanzania. Ihemi consists of 3,118 people and 9 subvillages. The subvillages and estimated populations are shown in Table 1. Figure 2 and Figure 3 show the map from Iringa to Ihemi and Ihemi's hand-drawn village map from the village office.

Table 1: Ihemi subvillage populations

Subvillage	Estimated Population
Ihemi "A"	314
Igunga	326
Kifumbi	271
Kilimahewa	541
Kilimanjaro	392
Mfalanyaki	263
Mjimwema	427
Njia Panda	192
Winome	392
Total	3,118

Figure 2: Iringa to Ihemi Map

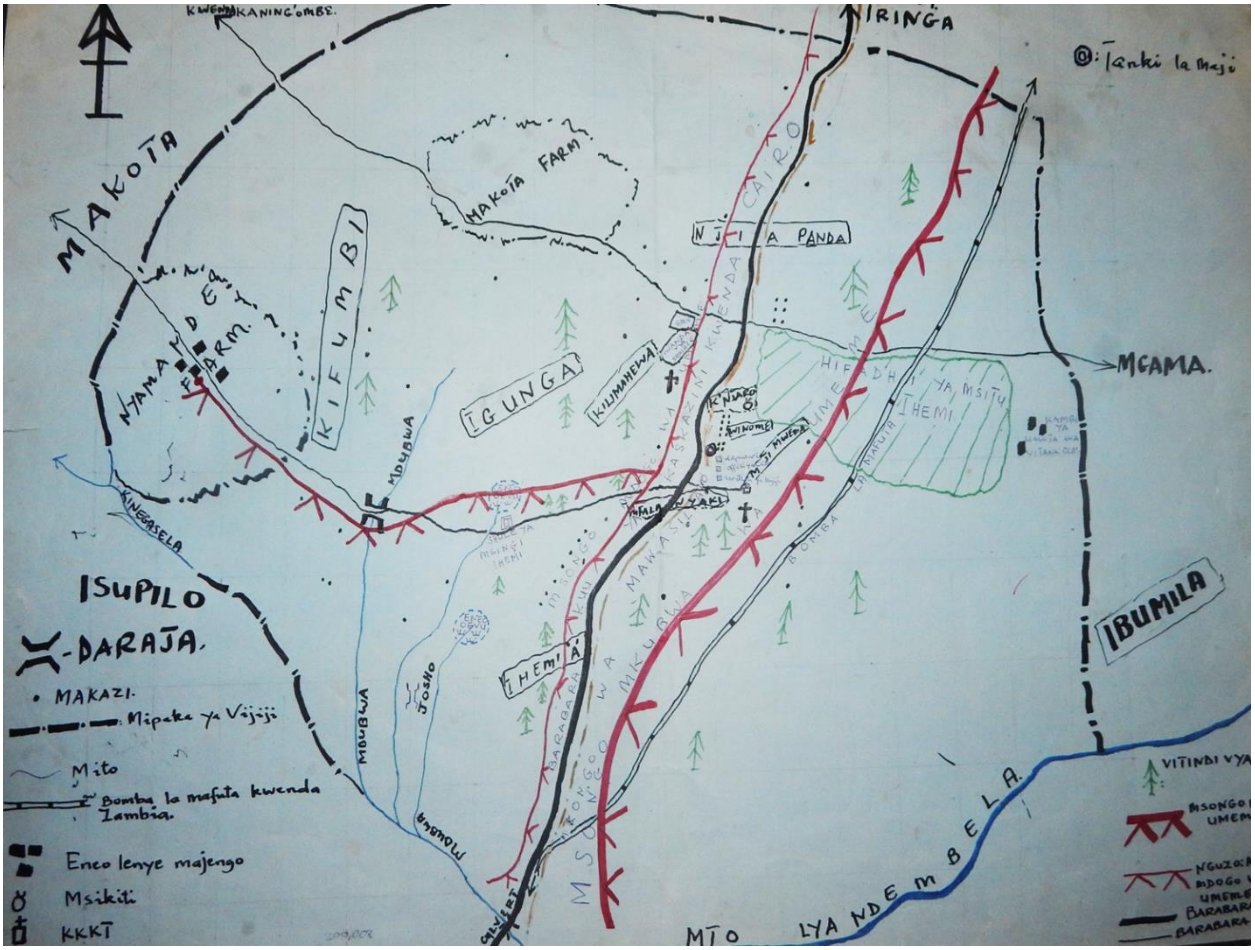


Figure 3: Hand drawn Ihemi village map

Key items to note from the village map (Figure 2) include the main highway shown by the black line running through the center of the map, power lines shown in red, and the approximate locations of the subvillages displayed with boxed labels.

4.2 Existing System

Ihemi currently has an existing water distribution system that supplies water to a portion of the village. The first full day spent in Ihemi village was used to travel to all key water source locations within the village as well as subvillages in need of water. GPS coordinates and elevations were collected at these locations and are shown in Figure 3 below.

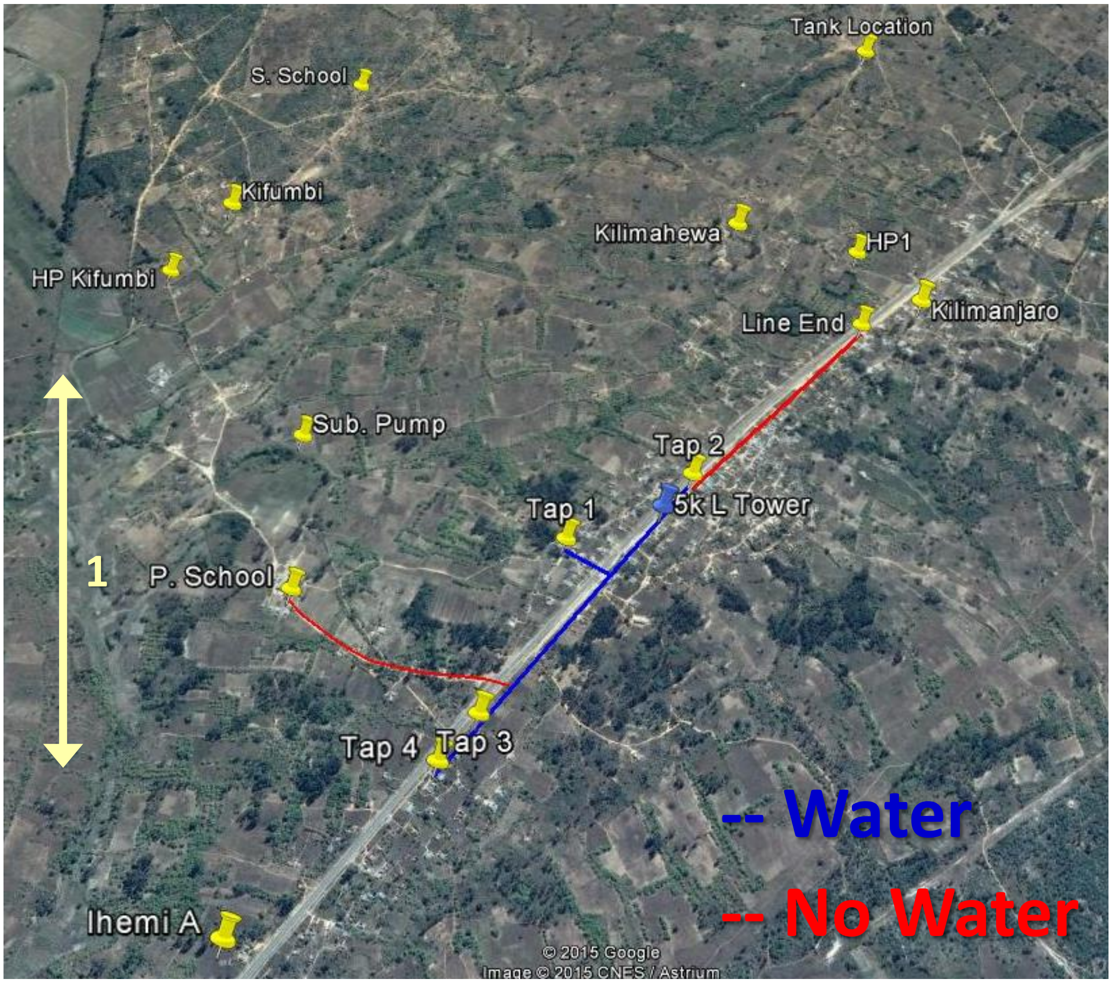


Figure 3: Map of key locations in Ihemi

They used mud rotary drilling to create a well that is used with a submersible pump. This well pumps water up to fill a 5,000 liter polytank two times a day, once in the morning and once in the afternoon. It takes 2.5 hours to fill the 5,000 L tank. This means the distribution system is supplying 10,000 liters per day. Assuming the minimum daily water need is 20 Liters/day/person, and since Ihemi has over 3,000 people, this means only 1/6 or 16% of the total need is met. There are some issues with the current distribution system, however. The 5,000 liter polytank (See Figure 4) had a lid but it was broken at some point and the tank is currently open to the environment on top. This is clearly a hazard for sanitation reasons, as an animal or birds could easily fall into the tank and contaminate the water.

Figure 4: 5,000 L tank on 8 m water tower

They also have a large amount of piping laid underground that is not currently distributing water. In Figure 3, the places where water is being distributed is denoted in blue. Denoted in red is where pipe is laid but not currently distributing water. The pipeline to the primary school no longer supplies water due to a break near the road which happened during road construction. There also is a large amount of pipe laid from the tap in Winome towards Kilimanjaro, however they realized at some point while laying pipe that the system does not have enough head to bring water to this elevation. The submersible pump is 8 years old and is likely to fail within a few years.

Other sources of water include hand pumps, rainwater collection, and hand dug wells. There are three hand pumps in Ihemi placed in Kilimahewa, Kifumbi and at the primary school, however only two of them are working. A village mama kindly stepped in and showed us the right way of operating a hand pump, as shown in Figure 5.


Figure 5: A village mama showing us how to use the hand pump

The hand pump in Kifumbi is either broken or ran dry. They also try to collect rainwater whenever possible. This is not a reliable source of water, however, because there is a dry season that lasts half of the year. Some hand dug wells are used as well, when there is no other option. However, many people get sick from drinking this water because it is not sanitary and there is no way to filter it. These also usually run dry fairly quickly. All of the water samples that we tested from the distribution system and hand pumps came out clean.

Ihemi has successfully managed the current water distribution system. Each spigot of the distribution system has a lock box attached that requires a key to open.


Figure 6: Spigot with lockbox

Each spigot has a designated key keeper who is responsible for opening the spigot two times a day for three hours at a time. They collect money from villages at a rate of 50 TZS per 20 liter bucket. They also record the usage of the tap in a logbook which is then used by the water committee at the end of every month to track money and total usage.

Figure 7: People getting water in the evening under the supervision of the key keeper

4.3 Unmet Needs

During the stay at Ihemi village, the team met with the village water committee and village leaders to discuss the water situation (Figure 8). Questions were asked regarding population distribution of each subvillage as well as what priorities they had.

Figure 8: Meeting with water committee

During the meeting, the water committee stated their priority subvillages as follows:

1. Kilimanjaro
2. Ihemi A
3. Kilimehewa
4. Kifumbi

To determine whether these were realistic priorities, the populations of each subvillage were estimated using the number of registered voters in each subvillage. These population estimates are shown below in Table 2. Assume a minimum of 20 liters/day/person water requirement, the total water need is 62,360 liters per day. And considering the village is only getting 10,000 L from the current distribution system, this equates to approximately 16% of the total water need met.

Table 2: Subvillage population and water need

Subvillage	Estimated population (assume total pop. = 3114)	Design water usage (assume 20 L/d/person)
Ihemi A	314	6280
Mfalanyaki	263	5260
Igunga	326	6520
Mjimwema	427	8540
Kifumbi	271	5420
Kilimanjaro	392	7840
Winome	392	7840
Kilimahewa	541	10820
Njia Panda	192	3840
Total	3118	62360

5.0 Design Criteria

The unmet water needs of Ihemi village motivated the design requirements for this project. From these needs, program objectives were defined to help focus the design process.

1. Increase water system capacity to supply water to 8 of the 9 subvillages of Ihemi.

With only 20% of the village having access to safe drinking water, it is crucial that the proposed design has the capacity to provide more. Ideally the system would provide 20 L/day/person and allow for an efficiency of only 75% (25% of the water is lost). This amounts to 80,000 L/day. The water demand in each subvillage is listed the Table 2. It is not possible to reach Njia Panda with the proposed gravity fed system because of its high elevation.

2. Supply water to the primary and secondary school

Schools in Tanzania are focal points to the village in which they reside. Educational centers promote the well-being of the village and encourage people in surrounding villages to enroll. It is crucial that these locations have ample water to provide for the attending children. Ideally the schools would be supplied with 10 L/student/day for day school and 20 L/student/day for boarding schools.

3. Increase revenue for future infrastructure improvements and/or reduce cost to villagers

Since Ihemi is making a profit on each bucket they sell, by increasing the system capacity six-fold, the village will accrue more revenue which can be allocated to other community projects. With the additional funds, it is expected that the cost of water could halve and still produce enough revenue to maintain the system. Inevitably, financial decisions will be left to the water committee and the people of Ihemi.

4. Build a sustainable design that can serve Ihemi for many years

The current system operating in Ihemi has been in commission for eight years. The well has never run dry and the pump continues to run as expected. It is the vision of this project to mirror the success of this robust system and provide a sustainable water source for many years.

The design will be discussed with Ihemi's community leaders before it is finalized. Compensation or resettlement affected by this project's land use need to be agreed upon. A topographic survey Ihemi will need to be conducted accurately measure distances, to select the pipe route, and to design for washouts and air valves. It is crucial that the current system remain operational during the construction.

6 Proposed Design

6.1 Phases

6.1.1 Phase 1

The goal of the first phase is to supply water to taps in Kilimahewa and Kilmanjaro. These taps will supply water to Kilimahewa, Kilimanjaro, and Igunga (1257 people, 60% of Ihemi). Phase 1 will supply approximately 25,000 L/day. A well will be mud-rotary drilled in Kilimahewa and a pump test will be performed to determine the well's recharge rate. A recharge rate of 5,000 L/h is required to supply 60,000 L/day to the system (all phases). A pump will be chosen based on the dynamic water level and the flow rate required.
Pipe (1.5 in diameter) will be laid from the well to the top of a nearby hill where two 10,000 L sim tanks will be installed. From one tank a line will be laid to Kilimahewa (1 in) and from the other tank a line will go to Kilimanjaro (1.5 in).

6.1.2 Phase 2

The goal for phase 2 is to update the current distribution system to supply water to Ihemi "A" and the primary school and to increase water supply to the 4 current taps. Ihemi "A" has a population of

314 people who do not have access to safe drinking water, and their ideal water demand is 6,280 L per day. The primary school holds 420 students plus teachers and requires 2,000 L of water each day for cooking, cleaning, and drinking. The current distribution system reaches three subvillages containing 1,082 people (35% of Ihemi's population) who require 21,640 L of water each day, but it only supplies 10,000 L of water per day. Figure shows the satellite image of the proposed phase 2.

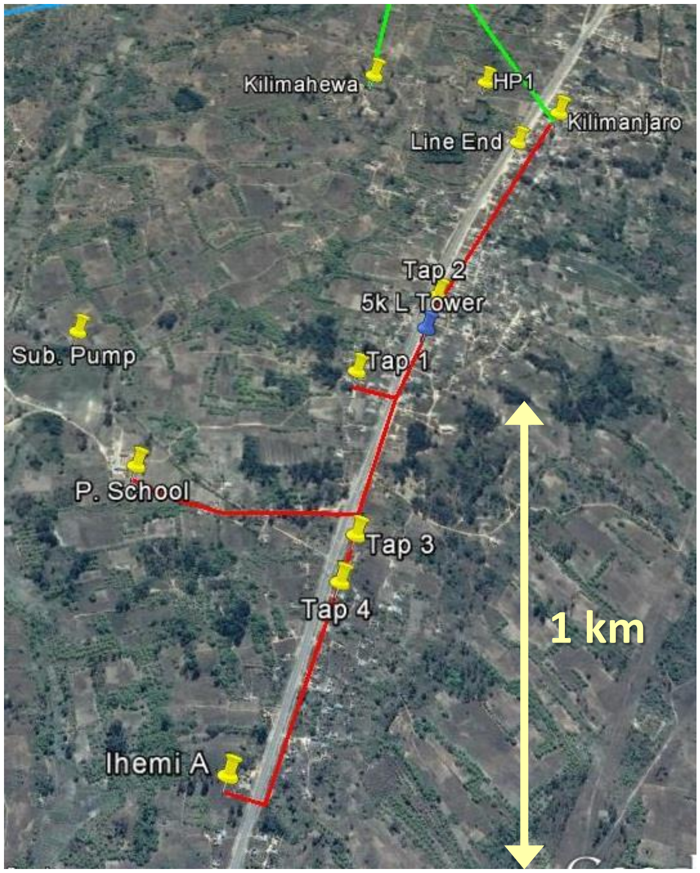


Figure 10: Phase 2 plan

Phase 2 starts with installing the third 10,000 L storage tank at the location of the two previously installed tanks. 950 m of 1.5" HDPE pipe will be used to connect Kilimanjaro to the 5,000 L tank of the existing system. A float valve will need to be installed on the 5,000 L tank so that it does not overflow. The maximum working pressure of this line is 90 psi, which occurs at the base of the 5,000 L tank tower. In order to increase flow from the 5,000 L tank, the existing 1" pipe will need to be replaced with 1.5" pipe from the tower to the start of the primary school line for a total of 560 m. 550 m of 3/4" HDPE pipe is needed to connect Tap 4 to Ihemi "A". Additionally, the 1" pipe to the primary school needs to be fixed where it was severed during construction. The maximum working pressure in this line is 90 psi at Ihemi "A". Another constraint is that the primary school valve should have a minimum K_v value of 300 to insure adequate flows to the other taps when all are open. Table 5 shows the flow rates when all taps are open.

Table 5: Phase 2 minimum tap flow rates

Tap	Q [L/min]
Tap 1	24
Tap 2	15
Tap 3	14
Tap 4	14
Primary School	19
Ihemi "A"	14

6.1.3 Phase 3

The goal for phase 3 is to provide water to the secondary school construction site and the subvillage of Kifumbi. Neither of these locations currently have an easily accessible water source. KIfumbi is a village of roughly 5420 people that currently travel long distances daily to collect water. They had a hand pump as one point but that is now broken or has ran dry. The secondary school has had to pay for transportation of water to the construction. The rate of transporting water to the secondary school construction site is 1300 TZS per 20 Liters of water. This is very expensive and has been the largest obstacle in the construction of the school. A distribution line running to the school would make a huge financial impact on the school's construction as well as the quality of education environment once the school is finished.

Figure 11: Phase 3- water line to secondary school and Kifumbi

Phase 3 begins with the installation of the fourth and final 10,000 L storage tank at the location of the three previously installed tanks.1480 meters of 1'' pipe will run from the tank location to the secondary school with a flow rate of 24 Liters per minute. The minimum flow rate out of the secondary school tap will be 11 liters/minute. Another line of 560 meters and ¾'' pipe will run from the secondary school to the subvillage of Kifumbi. The minimum flow rate out of the tap in Kifumbi will be 13 Liters/minute. One constraint for this phase is that the valve at Kifumbi should have a minimum K_v value of 300 to insure adequate flows to the secondary school when both are open. Table 6 shows the flow rates when both taps are open.

Table 6: Phase 3 minimum tap flow rates

Tap	Q [L/min]
Secondary School	11
Kifumbi	13

6.2 Construction Process and Timeline

The project duration is estimated as shown by the schedule in Figure 4.

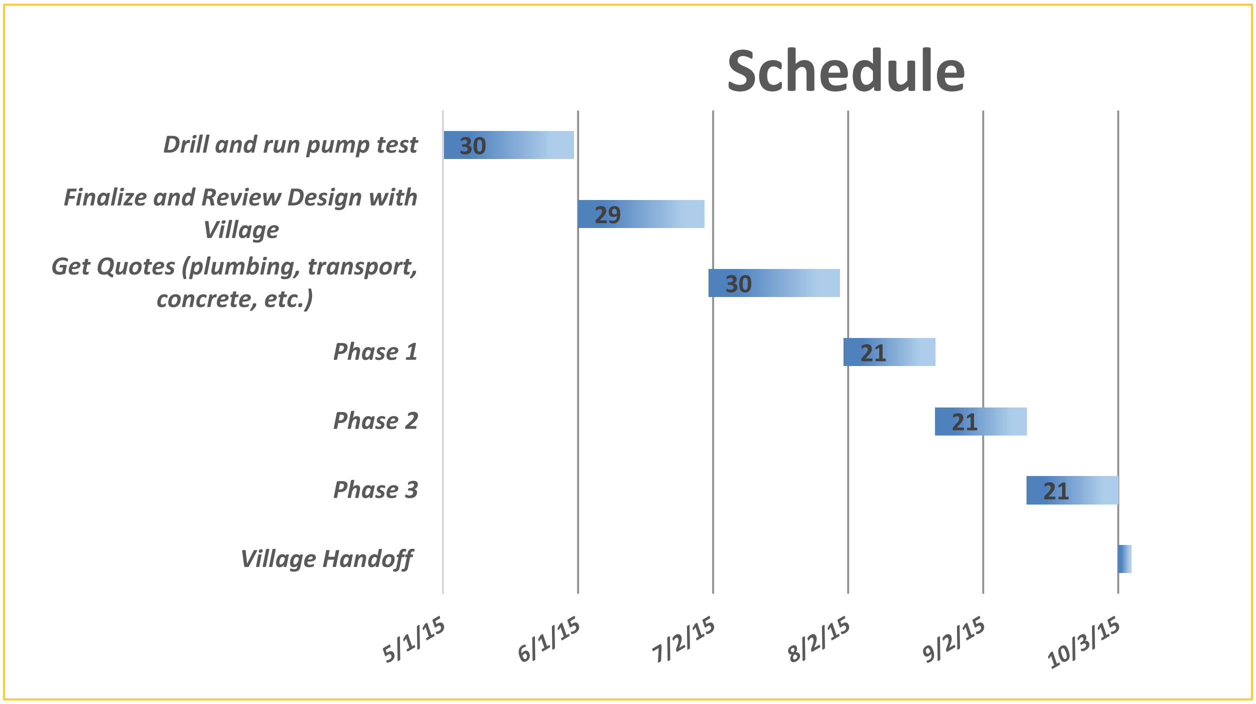


Figure 4: Estimated Project Schedule

A well was drilled in the beginning of May, and pump tests are estimated to be completed by the end of May. Based on the well recharge rate and capacity, a design will be finalized with the village through the month of June. Once the design is finalized, quotes for plumbing, transport, concrete, and all other parts of the project can be requested. Requesting and obtaining quotes is expected to take place in the month of July. Following the quotes, construction can start with Phase 1, move to Phase 2, and end with Phase 3. These phases were estimated to take three weeks each, spanning August and September, and they are described in detail in the following section. It is estimated that the project will be then handed off to the village at the beginning of October.

6.4 Future use of existing system

Much of the existing system will be used in the proposed system. The 5000 liter storage tank and much of the piping are in good condition and can continue being used. As described above in section 6.2, some of the current pipe will need to be replaced with a larger diameter pipe, but can potentially be used in other parts of the village. Not only can the components of the existing continue serving Ihemi village but the system's functionality can as well.

The existing system in Ihemi will continue to operate as a supplemental system for the proposed design. While phase 1 and phase 2 are being implemented, the existing system will continue to provide water to the lower sections of Ihemi. After phase 2 is complete, the existing pump may continue to supply water to the system, if the water committee agrees that having multiple pumps is maintainable. Having an additional water source will alleviate the demand on the new pump. When the older pump fails, it will need to be replaced. While the older well is being serviced, the newly drilled well will supply the village with the desired 60,000 liters.

6.5 Design concerns

Design concerns that must be addressed before starting this project are described in this section. The first design consideration is that minimum K_v values are required to provide sufficient flow to all taps in the worst case scenario (all taps open). The spigots and corresponding minimum K_v values are listed in Table 4.

Table 4: Taps with constrained minimum K_v values

Tap	Minimum K_v [ ]
Tap 2	200
Primary School	300
Kifumbi	300

Another concern is the recharge rate of the well. The pump was estimated for 84 L/min to pump 60,000 L in 12 hours. If the well cannot supply this much flow, alternative designs must be taken into account. This design could be completing phases 1 and/or 3, and not connecting to the existing system. If the new well cannot supply water to all of Ihemi, the current distribution system could be updated as planned in phase 2, but still supplied by the current well. As the pump in the current well is 8 years old, near the end of its lifetime, it may need to be replaced if it is to supply the updated distribution system. Another concern is if there is a transformer on the power line near the proposed well site. If there is, then it would be relatively cheap to extend a cable from the transformer. However, if a transformer needs to be installed, then an additional roughly $4,000 may be required.

7.0 Alternative Designs

Several different designs were investigated in order to refine a suitable final design. All of the options were evaluated based on the program objectives listed below. Due to time constraints, fully developed alternatives were not created. Instead, alternatives were discussed as concepts which were then gauged to determine whether the concepts were worth further development. A brief overview of several design alternatives are provided in this section.

7.1 Hand-pump

Hand-pumps are a common source of water in Tanzania. One key issue involving hand-pump installation is maintenance cost. These pumps use a rubber seal to create suction to pull the water out of the well. Over time, this seal becomes worn and the pump loses becomes less effective. Each hand-pump costs $3500 to install. With a desire to install five tap locations, this would put a reasonable project estimate at $20,000. Ihemi currently has a hand-pump out of commission that they have not taken initiative to fix. When visiting the site of a working hand-pump, villagers stated that they would be willing to pay five times more for water from a tap than water from a hand-pump. This shows that the people of Ihemi value a larger water distribution system over a solution which provides the village with more hand-pumps.

7.2 Rain Catchment

Rain catchment stations can be found around Ihemi village. It was evident that rain water is useful to the villagers, at least during the wet-season. However, a six month long dry-season renders rain catchment stations useless for nearly half the year. Without a reliable source of water during this time period, the village would run dry. As one of the main objectives for this project is to provide a sustainable design for the people of Ihemi, rain catchment stations would not provide the capacity needed to sustain throughout the year.

7.3 Solar Power

Solar power for the submersible pump was considered for the design. There are a few reasons why electricity from the grid was chosen for this project rather than solar electricity. First, the proposed well location is near the main electric line, so tapping a line from the mainline was a possibility. The cost of getting electricity from the grid includes installing the electric cables from the power line to the pump, and then the monthly electric bill. Also, if there is no transformer nearby, there may be additional costs to have the electric company install a transformer. Solar electricity, on the other hand, may not be consistent enough to provide enough power required by the pump. To get the most sunlight, the solar cells should be installed away from obstructions, where they are also visible from the highway. Security would be needed at all times to protect the valuable solar cells. The cost of security, along with the higher up-front cost, does not warrant the use of solar power. For these reasons, electricity from the grid is suggested for the project.

7.4 Cement Storage Tank

One large cement storage tank was considered for the design in place of the four 10k L poly tanks. Quotes for cement tank materials and labor were obtained from two sources, and they were both significantly more costly than installing the equivalent amount of poly tanks on concrete foundations. Poly tanks are simpler to install, easier to clean, and offer redundancy if parts need to be cleaned, fixed, or replaced. Poly tanks have estimated lifetimes of 10-20 years, while cement tanks have estimated lifetimes of 20-50 years. Considering the estimated prices, it could be cheaper to replace poly tanks to extend the lifetime of the system. For these reasons, 10k L poly storage tanks were used in the design.

7.5 Adjustments to proposed design

The most favorable design choice was a large-scale water distribution system. Ihemi village is located on a large hill that is ideal geography for a gravity-fed system. However, the practicality of the proposed design depends on the recharge rate and capacity of the new well. If the well cannot produce enough water to supply 5k L/hr for 12 hours each day, then there are a few design alternatives that can be considered.

The first alternative is to drill another well, and install two submersible pumps in the two new wells. Two smaller pumps could be used to get the required water production instead of one large pump. Drilling another well and purchasing another pump would cost approximately $5,000 USD more, but it would also provide redundancy if one of the pumps would fail.

Another alternative is to continue using the current system's 8 year old pump, and replace it with a new pump if needed. If this option can supply enough water between the new well and the well currently in use, then there would be no need to drill any additional wells. However, replacing the 8 year old submersible pump with a new one may not be as easy as it sounds. It may be required to clean the borehole or possibly replace casing. Further analysis would need to be completed before continuing with this option.

The proposed design includes one spigot at each tap location, but this could cause long wait times at some locations. Depending on wait times, adjustments could be made to the proposed design to include multiple spigots at necessary tap locations. The villagers pointed out that at flow rates of approximately 20 L/min or more, the water splashed out of the bucket and was wasted, so they tended to keep the flow from the taps below this threshold. If the flow rate for the tap line is above this 20 L/min threshold, multiple taps could be installed, which would allow for multiple villagers to obtain water at a comfortable flow rate. When extra taps are to be installed, other taps along the line should be checked simultaneously to make sure that all taps have ample flow rates.

8. Impact of Design

8.1 Social Impact

The new system will supply safe water to a large portion of the village. It will reduce travel time and the hazard of crossing the busy highway. Overall less time will be devoted to water collection which will have a positive impact on the women and children of Ihemi. A reliable and safe source of water will have an immense impact on the health in Ihemi.

8.2 Economic Impact/Operating Cost/Sustainability

The operating cost of the system will be covered by the sale of water. Water from the current distribution system is sold for 50 TZS per 20 L bucket. With the new system in place the cost per bucket will likely be reduced (Table 3). The cost of a replacement pump should be amortized over the lifetime of the pump (8-10 years), to ensure that it can be promptly replaced when it fails.

Table 3: An estimate of the operating cost and revenue generated from the sale of water at 50 TZS per 20 L bucket and 10 TZS per 20 L bucket. The system efficiency is an estimate for the water lost washing buckets at the taps and for the amount of water that is used at the schools, which is not sold per bucket. The calculation assumes a 3 hp pump and an electricity cost of $0.24/k·Wh.

Phase	People	L/d	System efficiency	Money collected/month [USD]	Electricity cost/month	Revenue after elec. and keykeepers/month	Revenue/year
50 TZS/ 20 L bucket							
1	1260	25200	0.7	$778.24	$79.59	$628.78	$7,545.39
2	1394	27880	0.7	$861.00	$88.05	$695.65	$8,347.84
Phase 1+2	2654	53080	0.7	$1,639.24	$167.64	$1,324.44	$15,893.23
3	270	5400	0.7	$166.76	$17.05	$134.74	$1,616.87
Phase 1+2+3	2924	58480	0.7	$1,806.00	$184.69	$1,459.17	$17,510.09
10 TZS/ 20 L bucket							
1	1260	25200	0.7	$155.65	$79.59	$68.45	$821.44
2	1394	27880	0.7	$172.20	$88.05	$75.73	$908.80
Phase 1+2	2654	53080	0.7	$327.85	$167.64	$144.19	$1,730.23
3	270	5400	0.7	$33.35	$17.05	$14.67	$176.02
Phase 1+2+3	2924	58480	0.7	$361.20	$184.69	$158.85	$1,906.25

9.0 Implementation Budget

The budget for each phase is shown in Table 2, Table 3, and Table 4. The entire project budget is shown in Table 5. Most of the prices were estimated from last year's budget. In kind contributions were assumed to be labor of digging trenches, laying pipe, and concrete construction of tank foundations.

Table 2: Phase 1 budget

Line	Item	Unit Price (TZS)	Unit Price (USD)	Unit Amount	Units	Total Price (TZS)	Total Price (USD)
1	Kilolo Star Mud Rotary	5,100,000	$3,000	drilling	1	5,100,000	$3,000
2	~2-3 hp Grundfos Pump	3,400,000	$2,000	pump	1	3,400,000	$2,000
3	Cell phone control	340,000	$200	each	1	340,000	$200
4	Electric cable to pump	6,500	$4	m	200	1,300,000	$765
5	10 kL Polytank	1,940,000	$1,141	tank	2	3,880,000	$2,282
6	Concrete materials	1,000,000	$588	tank foundation	2	2,000,000	$1,176
7	1.5" HDPE pipe Class D (pump to tank)	540,500	$318	150 m roll	6	3,243,000	$1,908
8	1.5" HDPE pipe Class D (tank to K'jaro)	540,500	$318	150 m roll	6	3,243,000	$1,908
9	1" HDPE pipe Class B	119,700	$70	150 m roll	6	718,200	$422
10	1.5" pipe coupling	15,000	$9	each	11	165,000	$97
12	1" pipe coupling	4,500	$3	each	5	22,500	$13
13	Tank fittings	102,000	$60	tank	2	204,000	$120
14	Tap fittings	102,000	$60	tap	2	204,000	$120
15	tanks	300,000	$176	trip	1	300,000	$176
16	concrete materials	300,000	$176	trip	1	300,000	$176
17	pipe	300,000	$176	trip	1	300,000	$176
18	Digging trenches/laying pipe	3,500	$2	m	3530	12,355,000	$7,268
19	Concrete construction	1,000,000	$588	tank foundation	2	2,000,000	$1,176
20	PHASE 1 TOTAL					39,074,700	$22,985
21	PHASE 1 In Kind Contribution					14,355,000	$8,444
22	PHASE 1 Donation estimate					24,719,700	**$14,541**

Table 3: Phase 2 budget

Line	Item	Unit Price (TZS)	Unit Price (USD)	Unit Amount	Units	Total Price (TZS)	Total Price (USD)
1	10 kL Polytank	1,940,000	$1,141	tank	1	1,940,000	$1,141
2	Concrete materials	1,000,000	$588	tank foundation	1	1,000,000	$588
3	1.5" HDPE pipe Class D	540,500	$318	150 m roll	10	5,405,000	$3,179
4	3/4" HDPE pipe Class B	83,000	$49	150 m roll	4	332,000	$195
5	1.5" pipe coupling	15,000	$9	each	9	135,000	$79
6	3/4" pipe coupling	3,500	$2	each	3	10,500	$6
7	Tap Fittings	102,000	$60	tap	1	102,000	$60
8	Tank Fittings	102,000	$60	tank	1	102,000	$60
9	Float valve for 5000 L tank	85,000	$50	each	1	85,000	$50
10	tank	300,000	$176	trip	1	300,000	$176
11	concrete materials	300,000	$176	trip	1	300,000	$176
12	pipe	300,000	$176	trip	1	300,000	$176
13	laying pipe	3,500	$2	m	1110	3,885,000	$2,285
14	concrete construction	1,000,000	$588	tank foundation	1	1,000,000	$588
15	PHASE 2 TOTAL					14,896,500	$8,763
16	PHASE 2 In Kind Contribution					4,885,000	$2,874
17	PHASE 2 Donation estimate					10,011,500	**$5,889**

Table 4: Phase 3 budget

Line	Item	Unit Price (TZS)	Unit Price (USD)	Unit Amount	Units	Total Price (TZS)	Total Price (USD)
1	10 kL Polytank	1,940,000	$1,141	tank	1	1,940,000	$1,141
2	Concrete materials	1,000,000	$588	tank foundation	1	1,000,000	$588
3	1" HDPE pipe Class B	119,700	$70	150 m roll	10	1,197,000	$704
4	3/4" HDPE pipe Class C	117,400	$69	150 m roll	4	469,600	$276
5	1" pipe coupling	4,500	$3	each	9	40,500	$24
6	3/4" pipe coupling	3,500	$2	each	3	10,500	$6
7	Tap Fittings	102,000	$60	tap	2	204,000	$120
8	Tank Fittings	102,000	$60	tank	1	102,000	$60
9	tank	300,000	$176	trip	1	300,000	$176
10	concrete materials	300,000	$176	trip	1	300,000	$176
11	pipe	300,000	$176	trip	1	300,000	$176
12	laying pipe	3,500	$2	m	2040	7,140,000	$4,200
13	concrete construction	1,000,000	$588	tank foundation	1	1,000,000	$588
14	PHASE 3 TOTAL					14,003,600	$8,237
15	PHASE 3 In Kind Contribution					8,140,000	$4,788
16	PHASE 3 Donation estimate					5,863,600	**$3,449**

Table 5: Overall project budget

Line	Item	Total Price (TZS)	Total Price (USD)	Formula
1	Subtotal Cost	67,974,800	$39,985	A
2	Total In Kind Contribution	27,380,000	$16,106	B
3	Subtotal Capital Cost	40,594,800	$23,879	C=A-B
4	Contingency (%10 of Capital Cost)	4,059,480	$2,388	D=0.1*C
5	St. Paul Partners Overhead	1,700,000	$1,000	E
6	Total Donation Estimate	46,354,280	**$27,267**	**C+D+E**

10.0 Summary/Conclusion

Ihemi village has had a successful water distribution system in operation for eight years. With the help of the water committee, Ihemi has managed the system while accruing revenue for paying the electric bill. Their continued success with sustaining the current system shows that Ihemi village is an excellent candidate for implementing a water project. Though their current efforts have proved fruitful, their needs are still not being met. With only 20% of village having access to clean drinking water, it is evident that modifications need to be made. With our proposed design, the added capacity and reach will provide water for 95% of the total village while reaching eight out of nine of the total sub-villages. Ihemi's favorable geography, high water table level, and proven success in managing such a system show that this village has a high chance of success for sustaining this proposition.