SIFUNI MUNGU

Team 09

Project Proposal and Feasibility Study

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Abstract

RCA Global Mission oversees much of the missionary development of parts of East Africa. Because of an ever-growing population, there is a present and future need for growth in educational facilities, as well as safe housing for many communities. Derrick Jones, a director of RCA Global Mission, has recently identified one area for improvement. The village of Alale, in Western Kenya (see Figure 1), is home to a small mission station run jointly by RCA Global Mission and the Africa Inland Church called the AIC Pokot Project. At this mission there is currently a medical clinic, church, primary school, and an unfinished girls’ secondary school and dormitory. Leaders of this mission have expressed a desire for a boys’ secondary school, a boys’ dormitory, and drinking water storage.

![Figure 1: (left to right) Africa, Kenya, and West Pokot Region](image)

Sifuni Mungu can be loosely translated from Swahili to “I Praise God” or “LORD of All”. It is a common phrase spoken by the people of Kenya and the surrounding area in worship settings. Specifically, the inspiration for Team 9’s name came from the choral piece, *O Sifuni Mungu (All Creatures of our God and King)*, by First Call, which was performed by the Calvin College Capella on their Spring 2010 tour. The phrase applies to Calvin’s senior design program because Christians are called to praise the LORD in all situations and in everything they do.

To fulfill the needs of the AIC Pokot Project, Sifuni Mungu will develop a design of the boys’ secondary school, dormitory, and water management system. The secondary school will initially have 4 teachers and about 100 students. The dormitory will accommodate up to 100 students, with availability for an addition to house up to 200 students. There is currently a 124-acre plot of land that is largely rural and rugged. Neighboring cities and towns are available for commercialized products in the construction of this school. The mission has also expressed a great need for the design of a water management system (including collection, filtration, storage, and wastewater treatment) for the complex using a clean water source.

Sifuni Mungu’s design of these facilities will incorporate the culture of the Kenyan people, the resources available, and methods and materials common to both the mission and the surrounding village. Designs will be developed using information and suggestions acquired from staff at the mission and representatives from RCA Global Mission who are familiar with the AIC Pokot Project.
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1. Introduction

1.1. Project Statement

The goal of Team Sifuni Mungu’s project is to develop a comprehensive plan for a boys’ high school in the West Pokot District of Kenya which is only a few miles from the Ugandan border. Reformed Church of America (RCA) Global Mission oversees a mission there along with the African Inland Church and they currently have a girls’ high school under construction and would like to complement the girls’ school with a boys’ school. The plan includes the design of two structures, a school building and dormitory, and water management systems. The water management systems include potable water treatment and storage and also wastewater treatment of effluent from the site. Local design methods and materials will be considered in the designs. The site plans also include using appropriate technology and an inexpensive budget.

1.2. Team Description

*Sifuni Mungu* can be loosely translated from Swahili to “I Praise God” or “LORD of All”. It is a common phrase spoken by the people of Kenya and the surrounding area in worship settings. Specifically, the inspiration for Team 9’s name came from the choral piece, *O Sifuni Mungu (All Creatures of our God and King)*, by First Call, which was performed by the Calvin College Capella on their Spring 2010. The phrase applies to Calvin’s senior design program because Christians are called to praise the LORD in all situations and in everything they do.

Charles Blum is a senior from Issaquah, WA, a suburb of Seattle. He is currently pursuing a Bachelors of Science in Engineering with an International Civil Concentration and a Minor in Mathematics. Charles achieved the International Designation by studying in Bremen, Germany in the summer of 2008 and taking the “Dutch Landscapes” Interim course January 2009. He looks forward to either finding a job in the field of Civil Engineering or pursuing Graduate Level studies in Water Resources Management. In his free time Charles enjoys playing ultimate frisbee with the club team at Calvin.

Brandon Van Dyk is a senior from Elmhurst, Illinois, where he attended Timothy Christian Schools. He will be graduating with a Bachelor of Science in Engineering with an International Designation in the Civil/Environmental Concentration and a Mathematics Minor. During the summer in 2008, he spent some time in Bremen, Germany, studying statics and dynamics and German language and culture. Brandon worked for the City of Holland, Michigan in the Streets and Engineering Department during the summer of 2010. At Calvin, he sings as a member of The Capella and the Oratorio Society. Upon graduating, he plans to pursue Graduate Level studies.
Ben Dykema is a senior from Oak Brook, Illinois, where he attended Timothy Christian Schools. He will be graduating in May with a Bachelor of Science in Engineering degree with an emphasis on the Civil/Environmental Concentration. He has spent many summers working for a family owned Landfill in Ottawa County and just recently started working for the Kent County Department of Public Works as an intern surveyor at their South Kent landfill. At Calvin, he is a member of Varsity Track running middle distance races. Upon graduating, Ben plans to pursue a career in environmental studies and applications.

Steven Kranenborg is a senior from Lombard, Illinois, where he attended Timothy Christian Schools. He is currently pursuing a Bachelor of Science in Engineering degree with a concentration in Civil and Environmental Engineering. The Last two summers he had an internship with the Illinois Department of Transportation in the bureau of construction. In his free time he plays ultimate frisbee with a club team at Calvin. After graduation he is getting married and plans to pursue a career in civil engineering.

Marcus VanderBrug is a senior graduating with a Bachelor of Science in Engineering with Civil/Environmental concentration. He grew up in Elmhurst, Illinois where he attended Timothy Christian School. Marcus is looking forward to finding a job, if possible, near his hometown. In the free time he has he enjoys playing tennis and roller hockey.

2. Background

2.1. Mission Agencies

Sifuni Mungu is partnering with the Reformed Church in America (RCA) Global Mission. “RCA Global Mission serves Jesus Christ through the Reformed Church in America, an evangelical and ecumenical church committed to sharing and receiving the gospel of Jesus Christ through word and deed.”¹ A significant portion of the RCA Global Mission’s focus is on Africa, where the agency is active in Ethiopia, Kenya, Malawi, Mozambique, Niger, South Africa, and the Sudan. “Since 1948, the RCA has sent scores of missionaries and volunteers to serve alongside African church partners to bring the good news of Jesus Christ to this promising but needy land.”¹ The RCA also consistently funds projects and invites African church leaders to join in completing various operations throughout the African continent. The RCA’s work in Kenya began when some of its missionaries serving in Ethiopia were forced to evacuate because of communist rule. The RCA’s partner church in Kenya is the Africa Inland Church.

The Africa Inland Church (AIC) was formed in 1943 from individual church plants. Most of these plants are projects of the Africa Inland Mission (AIM), which was established in 1895.

¹ http://www.rca.org
by Peter Cameron Scott. AIM, whose stated mission is “to declare the Glory of God to Africa and beyond”\(^2\), originated with a mostly failed attempt at a mission station in the coastal Mombasa, Kenya. Out of the second attempt in Nzawi came the first member of what would become the Africa Inland Church. AIM has since planted hundreds of churches in Kenya and surrounding nations, many of which have joined the AIC. The Africa Inland Church, although independent of it, works closely with the Africa Inland Mission and has a major emphasis on evangelism. Because of this focus, AIC has grown to include more than 1,000,000 members in this gospel-hungry region of the world.

One of the joint AIC-RCA projects is the Pokot Project among the people of Alale. While the main focus of this project is on evangelism, it also favors improvements to health, water development, and education. Its strong mission program has led to increased direction of the indigenous peoples. In 2002, the last western RCA mission staff person handed over the project to nationals. Amos Limo Liang’or, the director of the medical clinic, is Sifuni Mungu’s on-site contact.

2.2. **Site Information**

The site on which Sifuni Mungu will be designing is located on the mission campus in Alale, Kenya. It is a 25-acre (10-hectare) plot of land. The terrain in the area is rough with many rocks and shrubberies. The land will first be cleared by local residents before construction can begin. The location of the school and dormitory building on the plot of land will depend on ease of construction and accessibility. The rest of the land may be used for outdoor school activities. Figure 1 shows the country and location of the village.

2.3. **Geography**

The country of Kenya is located on the Eastern coast of Africa. It is bordered by Tanzania to the South, Uganda to the West, Ethiopia to the North, and both Somalia and the Indian Ocean to the East. Alale is located on the Western side of the country in the Kenyan Rift Valley, close to the Ugandan border. Figure 2 shows the country of Kenya and the location of the village.

\(^2\) [http://www.aimint.org/usa/about.html](http://www.aimint.org/usa/about.html)
2.4. **Rainfall**

The weather tends to be tropical in this region with temperatures ranging from 9° to 29°C (48° to 84°F) in January and 7° to 26°C (45° to 79°F) in July. Alale receives about 32-36 inches of rain each year with a wet season from March through the end of June.

2.5. **Culture**

Historically, The Pokot tribe has lived on the Western border of Kenya in both the rainy highlands and dry plains. In the highlands, natives have grown crops and herded cattle for a living, while in the dry plains more cattle were herded. The wealth of a native was measured by how many head of cattle he owned. A cow was used for barter, exchange, and as payment to a family for a daughter’s hand in marriage. The value placed on a cow led to many tribal wars. Raids for cattle occurred often and led to death and destruction. Most recently, missionaries have settled with the Pokot people in the village of Alale and have begun to set up a small mission station within the village. This village started with two tin shacks, which included a shop and missionary living quarters. Today, there are multiple buildings within the mission compound, including a church, a medical clinic, and a primary school. **Figures 3 and 4** are examples of the Pokot people and their dwellings.
3. Design Requirements

3.1. School

- Structure designed to accommodate 100 students with the potential for expansion to 200 students
- Includes four classrooms, administrative offices, library, and two laboratories
• Use resources that are readily available to the region, minimizing needs for transporting material from other cities

3.2. Dormitory

• Two structures designed to house 100 students with the potential for expansion to 200 students
• Include kitchen with stove and seating area
• Use resources that are readily available to the region

3.3. Water

3.3.1. Stormwater Management

• Overall site drainage plan
• Mitigate water infiltration next to building foundations to keep soils stable
• Create a catchment system to collect rainfall from structures

3.3.2. Drinking Water Treatment

• All water that will be used for drinking needs to be properly treated as shown in Table 1

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Removal level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryptosporidium</td>
<td>Log-3</td>
</tr>
<tr>
<td>Giardia Lamblia</td>
<td>Log-3</td>
</tr>
<tr>
<td>Viruses</td>
<td>Log-4</td>
</tr>
<tr>
<td>Turbidity Level</td>
<td>&lt;1 NTU</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trihalomethanes (THMs)</th>
<th>(in mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHBrCl₂</td>
<td>0</td>
</tr>
<tr>
<td>CHBr₃</td>
<td>0</td>
</tr>
<tr>
<td>CHBr₂Cl</td>
<td>0.06</td>
</tr>
<tr>
<td>CHCl₃</td>
<td>0.07</td>
</tr>
</tbody>
</table>

3.3.3. Drinking Water Reclamation and Storage

• Demand for drinking water will be approximately 45 Liters/Capita/Day. Table 2 shows the breakdown of water demands

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Demand (L/Cap/Day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drinking</td>
<td>5</td>
</tr>
<tr>
<td>Sanitation</td>
<td>15</td>
</tr>
<tr>
<td>Bathing</td>
<td>15</td>
</tr>
<tr>
<td>Food Preparation</td>
<td>10</td>
</tr>
</tbody>
</table>

• Drinking water must to be stored properly so it is not contaminated
Find a supplemental water source

3.3.4. Wastewater Management

- Wastewater must be treated so it can be discharged to a nearby body of water or used for irrigation and/or fertilization.
- The standard wastewater will be treated to are World Health Organization (WHO) guidelines for safe use of excreta and greywater.

4. Objectives

4.1. Scope

The leaders of the AIC Pokot Project have a vision for extensive expansion in the near future. As the church in Alale continues to grow, the mission compound requires additional facilities to accommodate the ever-increasing needs of the Pokot people. Currently, the station is comprised of a church, medical clinic, airstrip, primary school, and unfinished girls’ secondary school and dormitory. Ultimately, the AIC Pokot Project committee would like to add a boys’ secondary school and dormitory, teacher’s housing, guest housing, hardware store, medical clinic addition, expanded drinking water capabilities (including acquisition and storage), wastewater treatment system, social hall, dining hall, and an appropriate fence structure.

Sifuni Mungu is excited for the opportunity to design the boys’ secondary school and dormitory, as well as a water management system, including stormwater management, drinking water reclamation and storage, and wastewater management.

4.2. Design Norms

During this project, Sifuni Mungu will be concentrating on three design norms: cultural appropriateness, transparency, and justice. Cultural appropriateness is very important and will be a main focus for this project. All aspects of the design must complement the culture and customs of the Pokot people. The design and materials used in this project must fit traditional building styles and practices. The design will also incorporate a high level of transparency. Clear communication between Sifuni Mungu and the customer leads to a better overall design. The design must be user friendly and intuitive. The final plan for the school must be easy to read and understand. The people in the village must be able to carry out the design without the aid of skilled labor. Justice is also a very important goal because the design must take into consideration all the people that this design will be affecting. The school must be designed to incorporate the needs of the community and not just the needs of the students. Also, the site must accommodate the needs of students of different ages and physical abilities.

3 “WHO Guidelines for the Safe Use of Wastewater, Excreta, and Greywater”
5. Alternative Solutions

5.1. School

The principle requirements for the school are that it must be inexpensive to build and easy to maintain. Operating costs must also be kept to a minimum. Because of a limited amount of electrical capacity the building must be designed such that the amount of electrical components is minimized. A majority of the lighting for the building must come from the sun and the building must be designed for maximum ventilation.

There are two general solutions to designing the school. The first alternative is designing the school so that the each room has at least two outside walls, as shown in Figure 5. Designing the layout this way allows for more sunlight to enter the room and increases ventilation. Doors to the building are located in the inner courtyard. The down side to this solution is it requires a greater amount of space but, it will have a lower operating cost.

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**Figure 5: School Building Layout, Alternative 1**
A second solution is to design the school with electrical lighting. Currently the amount of electricity is limited so additional electrical capacity will be required. This can be achieved by attaching solar panels to the roof of the school or adding diesel generators. Electrical lighting allows for a more compact layout and thus fewer building materials. An example of this layout can be seen in Figure 6.

5.2. **Dormitory**

The requirements for the dormitory are similar to the school. It must have low cost and maintenance as well as windows for sunlight. The amount of electricity that is used must be kept as low as possible because only solar panels and generators as a power source. It must also be designed for maximum ventilation because the only means of natural ventilation is wind.

There are two primary design solutions for the dormitory. In both solutions, the doors are on the exterior of the building. The first design dictates that each room must have at least two windows. The dorms will be designed using four identical modules. Each module will have six rooms, a common bathroom, and a common area or lobby. Each room will house four students so a single module will house 24 students. Figure 7 shows the layout of a single module.
A disadvantage to this design is the amount of space that it requires. The second design incorporates an electrical system so that more rooms can be placed side by side, resulting in less windows per room. The rooms still hold four students, but the bathroom for each module is increased in size to accommodate 48 students. Figure 8 shows a layout of this alternative. The advantage of this design is less space is required, however, the drawback is the increased cost of electricity due to lack of natural light.

The first alternative is the better option because space is not necessarily a concern and it has a lower operating cost than the second alternative.

5.3. Water Management

5.3.1. Stormwater Management

There are two general solutions to manage rainfall near the buildings. The first is to collect the rainfall in some manner and then store it to supplement water demands. Water collection could be accomplished by designing the roof so that water flows easily across it to a single point or to a system of gutters as shown in Figure 9. The gutter system would convey the water to either a tank for storage or to a treatment system to treat the water to drinking standards. The second alternative is to collect the rainfall and then allow it to infiltrate into the ground away from the two structures. A similar gutter system would be used but instead of the water being conveyed to a storage tank, the water would be conveyed to an infiltration basin away from the structures. At this point the first option seems to be the best option because rainfall collection provides a seasonal supplement of relatively clean water compared to that of the stream. Clean water in any developing area is crucial to further development.
5.3.2. **Drinking Water Treatment**

There are two main alternatives for treating raw water. The first is to convey water to a slow-sand filter to treat the water and then convey it to a storage tank for everyday use. The process for this alternative is shown in **Figure 10**.

![Diagram of single step treatment process](image1)

**Figure 10: Process Flow Diagram for Single Step Treatment Process**

The second alternative is to place a storage tank between the source(s) of raw water and the slow-sand filter. The raw water is then drawn from the storage tank to be treated by the sand filter. **Figure 11** shows this two step process.

![Diagram of two step treatment process](image2)

**Figure 11: Process Flow Diagram for Two Step Treatment Process**

The second alternative (the two step process) is the better option because it allows for equalization of inflows of water from the stream and randomly occurring rainfall events.

5.3.3. **Drinking Water Reclamation and Storage**

The water source that the mission is currently using is a mountain stream. Recently, the Kenyan military constructed a base upstream of Alale and the water flow and quality has diminished along. The mission is growing and water requirement is going to increase in the coming years. To meet these increasing needs, a couple of solutions are analyzed.
These range from finding a supplementary water source to abandoning the stream altogether in favor of another source such as another stream or digging a well.

Water also needs to be stored. It can be stored in two different states: potable and non-potable. Potable water storage would require a vessel which can maintain the integrity of the water over long periods of time. The vessel can be above ground or below. The vessel could be built out of several materials, such as molded plastics or concrete. If the water is stored in a non-potable state, then it would require treatment before drinking; but storage requirements would not be as strict. A tank or basin could be used which is open to the atmosphere.

The water will have to be treated regardless of its source. The level of treatment required, however, depends on its origin. If the source is surface water then some method of filtration should be used to remove turbidity and larger sediment, followed by some form of disinfection. If the water is coming from a well then it will most likely only have to be disinfected. At this point, alternatives are still being considered.

5.3.4. Wastewater Management

There are two predominant options for treatment of solid waste and wastewater. The first is using a septic system with a leach field. A basic schematic of a septic system is shown in Figure 12.

![Figure 12: General Septic System Layout](image)

Treated effluent from this system could be used in crop irrigation. The second option would be a composting latrine. A composting latrine system would not require as much space as a septic/leach field and would not produce any liquid effluent. A section view of a composting latrine is shown in Figure 13.

The better alternative is the composting latrine because it does not require an extra demand on the stream and the waste is converted to compost which can then be land-applied.
6. Feasibility Study

6.1. School and Dormitory

AIC Pokot Project’s primary request is the design for a boys’ secondary school. The school must include four classrooms to hold about 100 students and four teachers, as well as two laboratories, administrative offices, faculty offices, a faculty lounge, a library, and a cafeteria, and bathrooms. Included with the design of the school is the design of a boys’ dormitory. The dormitory will be designed to house 100 students with the potential to expand to approximately 200 students. Also, the dormitory must include bathrooms and possibly a kitchen area.

The challenge is to design both of these buildings similarly to the way that buildings are designed locally. This eliminates the requirements of many engineering codes that are used in the United States. Therefore, engineering judgment and the appropriate U.S. building codes must be used.

6.2. Water Management

A second major component of this project is water management. Aspects of water management include stormwater management, drinking water reclamation and storage, and wastewater treatment.
Stormwater can be managed two different ways. The first is to store it as drinking water when the stream does not provide sufficient volumes. The second is to convey the stormwater to an area where it can infiltrate into the ground.

Since the drinking water volume and quality has diminished due to the construction of the military base, there is a need for a supplementary source or an entirely new source. The possible supplementary source is the collection and treatment of rainfall. Therefore, there must be a gutter system on the roofs so that the rainfall is guided towards a collection basin, and subsequently to a treatment system. Rainfall runoff quality is usually better quality than surface water (like a stream or river), so treatment of rainfall is not as involved as treating surface water. If the water is not treated before storage, the collection basin would not have to meet any strict standards because the water is not yet treated. However, once the water is treated, the storage container must be clean so it does not contaminate the water.

The wastewater is also strictly constrained. Wastewater needs to be treated before discharge to a body of water so the water body would not be contaminated. Contaminated water causes adverse effects to the environment and surrounding wildlife. Wastewater treatment usually involves settling of large particles and either discharge to a receiving water or infiltration. Irrigation of treated wastewater is an alternative to discharging treated wastewater.

6.3. Feasibility

Sifuni Mungu’s site plan for a boys’ high school is feasible for many reasons. Firstly, multiple alternatives exist for each part of the design (structural design of a boys’ secondary school and dormitory and principle design of water management systems). Sifuni Mungu’s project is also feasible due to the available local building materials which have created and can create a safe structure. For instance, there are buildings already built and in the construction phase (the girls’ secondary school), so constructing another building on the mission station is reasonable. Finally, RCA Global Mission has received grants and other funding from the Kenyan Government and Worldwide Christian Schools.

7. Basis of Design

7.1. Soil Types

Alale is located in a hilly area on the foothills of the Karasuk Hills, a low mountain range that runs north and south along the Kenya/Uganda border. The soil in this area is mostly rocky with pockets of sand scattered throughout. Some valleys contain a heavy clay as well. A sketch of the Pokot region and various soil types as well as their properties can be seen in the appendix. Table 3 shows four main soils near the village of Alale, which are denoted with the symbols MU1, MU2, HU, and UmU.
Table 3: Soil Types in the Region near Alale

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Local Name</th>
<th>Soil Depth</th>
<th>Color</th>
<th>Rockiness, Stoniness</th>
<th>Texture</th>
<th>Surface Infiltration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MU1</td>
<td>Chiroi</td>
<td>Mod. deep</td>
<td>Various, Dark</td>
<td>Rocky, stony</td>
<td>Sandy loam</td>
<td>High-mod.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Clay loam</td>
<td></td>
</tr>
<tr>
<td>MU2</td>
<td>Chiroi</td>
<td>Shallow-deep</td>
<td>Various</td>
<td>Extremely rocky, stony</td>
<td>Sandy loam</td>
<td>Low, various</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sandy/clay loam</td>
<td></td>
</tr>
<tr>
<td>HU</td>
<td>Chiroi</td>
<td>Shallow</td>
<td>Various</td>
<td>Rocky, stony</td>
<td>Sandy clay loam</td>
<td>Low, various</td>
</tr>
<tr>
<td>UmU</td>
<td>Sutowon</td>
<td>Shallow-deep</td>
<td>Red-brown</td>
<td>Rocky, stony</td>
<td>Sandy loam</td>
<td>Low-mod.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sandy clay loam</td>
<td></td>
</tr>
</tbody>
</table>

7.2. Construction Material and Method

Construction materials of the buildings were chosen based on availability, cost, and construction capability. Since several buildings exist in Alale already, the materials chosen are those that have already been used in the previously constructed buildings. Both the foundations and walls of the buildings are to be designed using a concrete mixture. To create the concrete mixture, cement will be brought in from the neighboring village of Kitale. Next, small stones and rocks will be gathered and combined until a fine, gravel mixture is created. The cement, gravel, and water are mixed to create the concrete. To construct the foundation, the concrete will be poured into slabs and reinforced with a 6-in square wire mesh. 6-in x 9-in x 18-in solid cement blocks will be made in forms and used to construct the walls. Trusses will be made using 2-in x 2-in square iron bars for the upper and lower chords and 1.5-in x 1.5-in square iron bars for the web. The roofing will be made with Mabeti metal sheets.

7.3. School

The design of the school building will include four classrooms, two laboratories, four administrative offices, faculty offices, a staff room, a cafeteria, bathrooms, and a library. One lab will be designed as a science lab and the other designed as a computer lab. The offices and staff room will be designed to accommodate 20 faculty and staff members. The material for construction will be selected based on a variety of design norms, with an emphasis on those that apply to safety, availability, and economics. For simplicity of construction methods, the building will be designed as a single story facility. The dimensions for each room can be seen in Table 4.

Table 4: Room Dimensions for School Building

<table>
<thead>
<tr>
<th>Room</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>25’ x 30’</td>
</tr>
<tr>
<td>Laboratory</td>
<td>25’ x 45’</td>
</tr>
<tr>
<td>Library</td>
<td>25’ x 45’</td>
</tr>
<tr>
<td>Front Office</td>
<td>25’ x 15’</td>
</tr>
<tr>
<td>Faculty Office</td>
<td>10’ x 12.5’</td>
</tr>
<tr>
<td>Faculty Lounge</td>
<td>25’ x 30’</td>
</tr>
<tr>
<td>Cafeteria</td>
<td>30’ x 90’</td>
</tr>
<tr>
<td>Kitchen</td>
<td>30’ x 25’</td>
</tr>
</tbody>
</table>
7.4. Dormitories

The client requests designs for two dormitory buildings to house a total of 100 students. Because only limited site data is available, four identical dormitory modules are designed to create building placement flexibility. The module system will allow for simple expansion by adding additional wings to a dorm. Figure 14 shows a possible expansion for the dorms.

![Figure 14: Possible Dorm Expansion Layout](image)

Each dormitory module includes six dormitory rooms housing four students each with a closet space for each room. At the center of the module is a community bathroom with space for three bathroom stalls, urinals, sinks, counters, and a showering area. The module is arranged with the dormitory rooms aligned in a row to create a layout where natural light is more prevalent. The dimensions of each room are shown in Table 5.

<table>
<thead>
<tr>
<th>Room</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormitory Room</td>
<td>20’x12’</td>
</tr>
<tr>
<td>Closet</td>
<td>10’x2.5’</td>
</tr>
<tr>
<td>Bathroom</td>
<td>20’x20’</td>
</tr>
</tbody>
</table>

Table 5: Room Dimensions for Dormitories
7.5. **Water Management**

Two separate water systems will be included in the designs of the buildings. One system will be design for drinking water and a second for wastewater treatment.

### 7.5.1. Potable Water Management

The potable water system must accomplish the following tasks:

- Treated water must be treated to standards listed in **Table 1** in Section 3.3.2.
- Treated water must be stored so that it will not become contaminated.

The potable water system will be designed using two subsystems. The first subsystem will catch rainfall and convey it to a storage tank. The second system will draw water from the storage tank and pass it through the slow-sand filter. The process flow diagram for both sub-systems is shown in **Figure 11**. The intermediate storage tank allows for equalization of inflows so the slow-sand filter receives a more steady flow. The storage tank size will be based on the flow rate of the stream and the volume of rainfall runoff from the building roofs for a 25-year storm event. Assumptions will be made about the raw water quality because detailed information is not yet available.

### 7.5.2. Wastewater Management

The wastewater system must accomplish the following tasks:

- Land apply treated waste or discharge to receiving water.
- The standard wastewater will be treated to are World Health Organization (WHO) guidelines

The wastewater system will also be designed using two sub-systems. The first is subsystem will collect wastewater from sinks and drains in the buildings. The wastewater will not include an excrement stream so the BOD levels will be reduced. The waste flow will then be transported to a septic system where it will be treated to meet WHO standards. A process flow diagram is shown in **Figure 15**.

![Figure 15: Process Flow Diagram of Septic System](image-url)
The second subsystem treats excrement waste. This will be accomplished by using several composting latrines. This waste stream will have a very high BOD concentration. The waste stream will be completely contained in the bin below the toilet. Once the waste has been converted to compost via aerobic digestion the compost is manually removed via a hatch using a shovel. A side view of a composting latrine is shown in Figure 13, located in Section 5.3.4. The process flow diagram for a composting latrine subsystem is shown in Figure 16.

![Figure 16: Process Flow Diagram for Composting Latrines](image)

### 7.6. Project Obstacles

#### 7.6.1. Culture

In the design of the boys’ secondary school, many cultural differences must be considered. The day-to-day life of someone living in the Pokot region is much different than someone living in the United States. Communality (system of thought that incorporates how all can benefit) is an enormous part of Pokot culture. The facility must be designed so not only the students benefit from it, but the entire community. The pace of life in Kenya differs from that of the United States, mostly because priorities of the African people differ greatly from those of Americans. These differences in culture give Sifuni Mungu the opportunity to learn about another part of the world and provide better self-examination of the American lifestyle.

Not only is the way of life different in Kenya, but the practices used to construct a building differ greatly from those in the United States. Buildings are most often built with locally-acquired materials and unskilled labor. Therefore, the materials used are usually the most inexpensive and easy to obtain.

#### 7.6.2. Distance

Since Alale is located in rural Africa communication is often difficult and slow. When trying to prepare detailed designs it is difficult to relay technical information quickly and accurately. Acquiring site-specific data is the biggest challenge that arises with distance. Currently, none of Sifuni Mungu’s team members can travel to the village of Alale to collect site data. Therefore, site data must be collected by people in the village and then relayed to Sifuni Mungu in the United States. The only method of communication
between Sifuni Mungu and the people in Alale is e-mail, tends to be slower than communicating in person or by phone.

8. Method of Approach

8.1. School

In designing the school building, the first items to be determined are the loads and the maximum load case. The walls will be made of concrete block and the roof framing plan can be determined once the final layout of the building is complete. The roof will be designed using iron trusses and local roofing material. When the walls and roof plans are finalized the foundation can be designed with the added loads. The final building will be modeled in a computer-modeling program such as Revit or AutoCAD. A small scale model of the building will be constructed when the final design is complete.

8.2. Dormitories

In approaching the design of these buildings, the focus will be on creating a space that the students can use to optimize their studies and live comfortably. The layout of the buildings must be designed for maximum ventilation and sun light. Once the loads and layout are determined the roof plan and foundation can be designed. The final buildings will be modeled in a computer-modeling program such as Revit or AutoCAD. A small scale model of the buildings will be constructed when the final design is complete.

8.3. Water collection and treatment

The method of approach for water collection requires per capita water demands. This demand gives a basis for how large water storage and treatment systems must be to meet the needs of the school and dormitories. The constraint for the raw water treatment system, a slow-sand filter, will be the plan view area. The constraint for the storage tank is simply the size of the tank. Waste treatment systems like composting latrines and septic systems will be constrained a little differently. Constraints for the composting latrines are the required size the composting portion of the system and the number of latrines needed. The septic system will be sized based on the flows and loads of the waste being generated. Calculations to size the various systems will be done using a computerized mathematics package like MathCAD and dimensioned drawings of the designs will be done using AutoCAD. A scale model of the systems will be constructed when the final design is complete.

9. Business Plan

The boys’ secondary school will be designed so that it can be used as a model for other developing regions. Sifuni Mungu’s model will not be able to be put into mass production because it is designed to be site specific. Because the plan is designed to be affordable and use locally available materials, Sifuni Mungu hopes that this model will be able to be used for future development in other regions. The business plan is to aid as many communities as possible in multiple settings by making our plans available to them. Once the final plans have been completed they will be available on Sifuni Mungu’s web page.
10. Conclusion

The village of Alale is still in the developing stages for a community, and is in need of boys’ secondary school. Sifuni Mungu’s designs will include a master plan of the school’s campus, including the school building and two dormitories. We will also include plans for treating rainfall using sand filtration so that it can be used as drinking water, as well as plans for treating wastewater to produce biogas. Since resources are limited, the buildings will be designed to accommodate what is available in the region. Research and data collection of the area and the specific site will be a continuous process throughout the project. Each team member is assigned a certain portion of the entire design. The project will be completed in May, in which case the designs will be handed over to RCA Global Mission for implementation.

11. Acknowledgements

Emery Blanksma, RCA and CRWRC Missionary
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Roger Lamer, Industrial Consultant
Amos Limo Liang’or, On-site Contact; AIC/RCA Project Manager
Larry McAuley, RCA and CRWRC Missionary
Glenn Remelts, Director of Hekman Library
Professor David Wunder, Advisor
12. References


13. Appendix

Figure 17: Soil Type Map, West Pokot District
Table 6: Soil Types

<table>
<thead>
<tr>
<th>MAP UNIT SYMBOL</th>
<th>LOCAL SOIL NAME (Pokot)</th>
<th>DRAINAGE CLASS</th>
<th>SOIL DEPTH</th>
<th>COLOUR</th>
<th>SALINITY, SOLUBILITY, CALCAREOUS-NESS</th>
<th>ROCKINESS, STONEINESS</th>
<th>TEXTURE</th>
<th>WEATHERING CAPACITY OF THE SURFACE SOIL</th>
<th>WATER HOLDING CAPACITY</th>
<th>RELATIVE SOIL CHEMICAL FERTILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M14</td>
<td>WELL</td>
<td>MOD. DEEP - DEEP</td>
<td>VARIOUS, WITH DARK TOP SOIL</td>
<td>NONE</td>
<td>LOCALLY ROCKY, STONY</td>
<td>SANDY LOAM-CLAY LOAM</td>
<td>HIGH - MODERATE</td>
<td>HIGH</td>
<td>MODERATE - HIGH</td>
</tr>
<tr>
<td>2</td>
<td>M14</td>
<td>WELL</td>
<td>VERY SHALLOW - MOD. DEEP</td>
<td>VARIOUS</td>
<td>NONE</td>
<td>EXTREMELY ROCKY STONY, GRAVELLY</td>
<td>SANDY LOAM-SANDY CLAY LOAM</td>
<td>LOW; VARIOUS</td>
<td>VARIOUS; LOW</td>
<td>MODERATE - HIGH</td>
</tr>
<tr>
<td>3</td>
<td>H1</td>
<td>WELL</td>
<td>SHALLOW</td>
<td>VARIOUS</td>
<td>NONE</td>
<td>ROCKY AND STONY</td>
<td>SANDY CLAY LOAM</td>
<td>LOW; VARIOUS</td>
<td>VARIOUS</td>
<td>MODERATE - HIGH</td>
</tr>
<tr>
<td>4</td>
<td>U1</td>
<td>AGRICULTURALLY USED LAND</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>M13</td>
<td>COMPLEX OF MAPPING UNITS</td>
<td>1: M14 AND 4: U1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>M14</td>
<td>WELL</td>
<td>SHALLOW - MOD. DEEP</td>
<td>DARK BROWN - DARK RED</td>
<td>NONE</td>
<td>ROCKY AND STONY</td>
<td>SANDY LOAM-CLAY LOAM</td>
<td>LOW - MODERATE</td>
<td>LOW</td>
<td>MODERATE</td>
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<tr>
<td>7</td>
<td>U1</td>
<td>WELL</td>
<td>SHALLOW - MOD. DEEP</td>
<td>DARK REDISH BROWN - DARK RED</td>
<td>NONE</td>
<td>LOCALLY STONY</td>
<td>SANDY CLAY LOAM - SANDY CLAY</td>
<td>MODERATE - HIGH</td>
<td>LOW</td>
<td>MODERATE - HIGH</td>
</tr>
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<td>WELL</td>
<td>SHALLOW - MOD. DEEP</td>
<td>VARIOUS</td>
<td>NONE</td>
<td>STONY</td>
<td>SANDY LOAM - SANDY CLAY LOAM</td>
<td>LOW - MODERATE</td>
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<td>MODERATE</td>
</tr>
<tr>
<td>9</td>
<td>F1</td>
<td>WELL</td>
<td>VERY DEEP</td>
<td>DARK REDISH BROWN</td>
<td>NONE</td>
<td>NIL</td>
<td>SANDY CLAY LOAM</td>
<td>LOW</td>
<td>MODERATE - HIGH</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>E1</td>
<td>WELL</td>
<td>VERY DEEP</td>
<td>BROWN</td>
<td>NONE</td>
<td>NIL</td>
<td>SANDY, SANDY LOAM - SANDY CLAY</td>
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<td>MODERATE</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>F1</td>
<td>WELL</td>
<td>VERY DEEP, IF NOT ERODED</td>
<td>VARIOUS, MOSTLY DARK BROWN</td>
<td>NONE</td>
<td>LOCALLY GRAVELLY; ROCKY</td>
<td>VARIOUS</td>
<td>HIGH, IF NOT ERODED</td>
<td>HIGH, IF NOT ERODED</td>
<td>MODERATE - HIGH</td>
</tr>
<tr>
<td>12</td>
<td>M13</td>
<td>WELL</td>
<td>MOD. WELL</td>
<td>VERY DEEP</td>
<td>VELLOWSH BROWN TO BROWN</td>
<td>CALS, SALINE IN NODULAR SURFS</td>
<td>NONE</td>
<td>SANDY STRATIFIED OR SANDY CLAY</td>
<td>MODERATE AND HIGH</td>
<td>HIGH</td>
</tr>
<tr>
<td>13</td>
<td>M14</td>
<td>WELL</td>
<td>VERY SHALLOW - MOD. DEEP</td>
<td>VELLOWSH BROWN - DARK BROWN</td>
<td>NONE</td>
<td>LOCALLY SELAZING</td>
<td>GRVELY, NODULAR, LOCALY ROCKY</td>
<td>MODERATE - LOW</td>
<td>LOW</td>
<td>MODERATE - HIGH</td>
</tr>
<tr>
<td>14</td>
<td>P13</td>
<td>WELL</td>
<td>VERY SHALLOW</td>
<td>VARIOUS</td>
<td>NONE</td>
<td>LOCALLY GRAVELLY AND ROCKY</td>
<td>SANDY LOAM - SANDY CLAY LOAM</td>
<td>LOW- VERY LOW</td>
<td>LOW- VERY LOW</td>
<td>LOW</td>
</tr>
<tr>
<td>15</td>
<td>P12</td>
<td>WELL</td>
<td>MOD. SHALLOW</td>
<td>DARK BROWN - DARK REDISH BROWN</td>
<td>NONE</td>
<td>LOCALLY ROCKY</td>
<td>SANDY LOAM-CLAY LOAM</td>
<td>LOW</td>
<td>MODERATE - LOW-MODERATE</td>
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</tr>
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<td>P12</td>
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<td>14: P12 AND 15: P12</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>P13</td>
<td>WELL</td>
<td>IMPERFECT - POOR</td>
<td>VERY DEEP</td>
<td>LIGHT TO VERY DARK BROWN</td>
<td>SALT ; CALC - REOUS</td>
<td>NONE</td>
<td>VARIOUS; STRATIFIED OR SANDY CLAY</td>
<td>HIGH</td>
<td>VERY HIGH</td>
</tr>
<tr>
<td>18</td>
<td>M14</td>
<td>WELL</td>
<td>IMPERFECT - POOR</td>
<td>VERY DEEP</td>
<td>VERY DARK BROWN</td>
<td>SALT ; CALC - REOUS</td>
<td>NONE</td>
<td>LOCALLY GRAVELLY</td>
<td>HIGH</td>
<td>HIGH</td>
</tr>
</tbody>
</table>
Figure 18: Topography of Location, 50,000:1 Scale, 33.3% zoom
Figure 19: Satellite View of Alale, Kenya