Mission Statement:

HESE students have been prototyping greenhouses for the people of sub-Saharan African farmers as well as any lower class consumer looking to grow crops. Though they have made great progress, they are still looking for a longer duration of a minimum 5 years, lower cost, and the greenhouse to withstand high-speed winds, tremendous rainfall, and extreme temperatures within the greenhouse. With no additional materials other than leaves, which are green and are easily found, we will be able to smooth out the joints making for a better resting place for the glazing. Our prototype provides a new layout for the greenhouse to last longer and allow the farmers to grow their crops efficiently. This project will benefit a range of people including: the user, retailer, HESE students, farmers, and greenhouse workers.

Concept Development Summary:

Before designing for the improvements to the greenhouse, it is important that we look at what we’re dealing with in Sierra Leone. This is a very poor country that is still dealing with the aftermath of the civil war that ended in 2002 and a corrupt government that is still holding them back. The aftermath of the civil war left the country’s healthcare system in a critical state. With little money to receive proper medical supplies, people were not able to afford it. Other countries assisted and created free healthcare for pregnant women and children under five. Another casualty from the war was its effect on education. Over one thousand primary schools were destroyed, which left over 60% of children with a variety of ages with no education.

As a result of the war’s disruption of education, that a significant portion of the population is uneducated, therefore the prototype that we design must be easy to use. Although the education is lacking, “Sierra Leone spends 14% of its national budget on education, out of which approximately 50% goes to primary education.” (Sierra Leone). The primary language of the people is Krio, which is English based, so communicating on how things work won’t be difficult. Also, the greenhouse does not go against their religion in the region.

We also have to design something that is very durable. Sierra Leone has two distinct seasons, which consists of a dry season, going from December to April, and a hot and humid season from May to December (Central Intelligence Agency). During the dry season, there is very little rain, which minimizes their access to water, and sand storms do occur when the wind blows sand from the desert. During the wet season, there is a lot of heavy rainfall, which could easily damage the greenhouse glazing process. The heaviest rainfall occurs closer to the coast, so selecting locations near the coast is probably a poor decision.

Sierra Leone is slightly smaller than South Carolina, but it population is larger. Sierra Leone is among the poorest countries in the world, which means the material we use has to be very inexpensive. The per capita income is only $340 and the exchange rate is an atrocious 4,320 Leones per US dollar. Also, the poverty rate in Sierra Leone is 66%.
Another issue that must be addressed is the outbreak of disease in Sierra Leone. Anyone travelling to Sierra Leone should be aware of the Ebola outbreak as well as the risk of malaria and other diseases. There is no cure for the Ebola virus, and Sierra Leone has had over 10,000 total cases, which is the most of any country. This means that it would be best to make sure that Ebola is taken care of before traveling to Sierra Leone.

Iron, titanium, and cocoa beans are Sierra Leone’s biggest exports. For their imports, they mostly receive rice, refined petroleum, and medications. With such an abundance of forestry, their local resources primarily consist of wood and charcoal. Also, there is no use of power tools in Sierra Leone due to the lack of electricity needed to use these tools.

### Test Report Summary for Prototype #1

<table>
<thead>
<tr>
<th>Requirements for Prototype</th>
<th>Observations</th>
<th>Pass?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using $8 or less</td>
<td>The materials we used were sandpaper, screws, and superglue. In total, this roughly cost a little over $4 from <a href="http://www.homedepot.com">www.homedepot.com</a>.</td>
<td>Yes</td>
</tr>
<tr>
<td>Build within 10 minutes</td>
<td>It took roughly a total of 15 minutes to make our prototype.</td>
<td>No</td>
</tr>
<tr>
<td>Sustaining wind pressure up to 25 m.p.h.</td>
<td>Sam moved one joint piece in a rough, swaying motion to attempt to imitate the wind. Linnie moved the glazing side to side before we attached it to the joints, and the glaz did not tear.</td>
<td>Yes</td>
</tr>
<tr>
<td>Sustaining temperature of 70 degrees Celsius</td>
<td>Willie used the hairdryer and faced it towards the prototype for 3 minutes to a maximum temperature roughly 160-165 degrees Fahrenheit or 70 degrees Celsius. This did not tear the glazing.</td>
<td>Yes</td>
</tr>
<tr>
<td>Sustaining waterfall of 25 inches a day</td>
<td>We put the prototype in the sink while Sam poured water from a water bottle for duration of 2 minutes. This did not tear the glazing.</td>
<td>Yes</td>
</tr>
<tr>
<td>Duration of 5 years</td>
<td>Since the prototype held up on the wind pressure, temperature, and waterfall tests, we assume it can have duration of approximately 5 years.</td>
<td>Yes</td>
</tr>
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### Test Results Summary:

We chose a spending limit of $8 for our prototype. People in Africa are poor and cannot afford to spend too much money on their greenhouses. By using additional materials under our budget, people of Sub-Saharan Africa will no longer have to invest so much money into a greenhouse project. We determined that the joint would have to be built in 10 minutes of less. This goal is intended to make the overall build time of the greenhouse faster than before. Sierra Leone has a “wet season” where the land receives an abundance of water and wind. With the waterfall test, we needed to make sure that the waterfall during the “wet season” would not tear the glazing and essentially destroy the greenhouse. The wind test was to make sure the wind would not be a factor in the
downfall of the greenhouse. We also tested our prototype against temperature, mimicking heat with a hairdryer to see how the prototype would sustain. Our final requirement was we would like it to last for at least five years. Being there will be plenty of storms in that time period, all the climate tests will help determine if our prototype would be suitable for Sierra Leone.

**Observation Summary:**
From the tests we conducted, we noticed that our design is a stable and durable structure. Due to the simplicity of our design, there is not much that could break off and repairs will be limited. However, the main problem we faced was building the joints within the ten-minute limit we decided on. In addition, another problem we faced when building our initial design was finding the optimum position for the third piece of wood to cross and connect the joints together. These difficulties lead us to break the top piece into a shorter piece, which allowed us to connect the ends between both the joints. The tests performed assured the team that we have a sturdy, durable structure, though we need to adjust the top of the joint and use a hammer and nails instead of a screw in attempt to reduce our time consumption. The only thing the team was uneasy about was the location of the final piece of wood, which is laid across the intersection of the two joints. However, this placement was just a misunderstanding of the design and what we wanted and will be addressed in the second prototype.

**Re-design Ideas/ Thoughts for Prototype #2:**
Our ideas for improvement include using nails rather than using screws, which will significantly decrease the time consumption, since a large part of our time was spent finding the correct screw size, drilling the hole, then screwing it in the wood. With a long nail, we can just hammer it in which will take significantly less time. The other thing that we plan to address with an improvement is to make the pieces to the joint smaller and nail them right on the long piece on top, then sand down the top piece. We believe that the tests we conducted are perfect for this project so they will remain the same. These prototype testing helped us learn about our design’s weaknesses. This will allow us to make a better prototype for our second one.

**Figure 1:** Sam is performing the wind test, as he applies force to one joint reenacting wind against it.

**Figure 2:** Sam and Linnie are gluing the two joints together with super glue, finishing the first prototype.
Concept Refinement Summary:

After the completion of prototype 1, our group was extremely satisfied with the design. We felt that with a couple of adjustments it would be a very efficient, easy to build, and cost effective design. As a team we were not satisfied with the way we assembled the joints. The initial joint build consisted of a long piece of wood crossing a shorter piece creating a joint with then a third piece glued to the side of the joint to make the roof shape. We noticed the design looked awkward and was subject to more possible failures than the design should have. Taking that into account, we decided to make the crossing piece that connects all the joints the peak of the roof and nail two equal length pieces to make a symmetrical right angle.

Test Report Summary for Prototype #2

<table>
<thead>
<tr>
<th>Requirements for Prototype</th>
<th>Observations</th>
<th>Pass?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using $8 or Less</td>
<td>The materials we used were wood sandpaper and 2 in. nails. This cost was roughly about $7 from <a href="http://www.homedepot.com">www.homedepot.com</a>.</td>
<td>Yes</td>
</tr>
<tr>
<td>Build within 10 minutes</td>
<td>If the builders know what they are doing, have the tools ready, and follow the directions in a timely manner, it can be accomplished in under 10 minutes.</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Sustaining wind pressure up to 25 m.p.h. | Willie pulled on the prototype and moved it in a rough swaying motion to simulate the wind. Brad moved the glazing side to side before we attached it to the joints and the glazing did not tear. | Yes

Sustaining temperature of 70 degrees Celsius | Brad put a hair dryer next to the prototype at full power. The hairdryer was very warm, at a temperature of roughly 160-165 degrees Fahrenheit or 70 degrees Celsius and was held next to the prototype. It did not tear the glazing. | Yes

Sustaining waterfall of 25 inches a day | The prototype was put in the sink while Willie poured a large water bottle fully onto the prototype and the glazing did not tear. | Yes

Duration of 5 years | Since the prototype held up on the wind pressure, temperature, and waterfall tests, we assume it can have duration of approximately 5 years. | Yes

We chose to pull at the joints and rub the glazing against the wood to simulate the harsh winds in Sub-Saharan Africa because we know that the winds will put pressure on the joints and the glazing will be grinding on the wood. By doing the tests we did, we were able to conclude that the design is sturdy enough to sustain the pressure that comes from the wind in addition to having a design that minimizes the tearing on the glazing that would usually happen when it is rubbed against sharp corners of a piece of wood.

Figure 1: Willie pulls at the prototype to make sure that the design can withstand wind pressure.
Figure 2: Brad puts a blowdryer up to the prototype to test if the design will hold up against the high temperatures inside and outside of the greenhouse.
Figure 3: Willie pours a bottle of water on the prototype. This is the rainfall test.
**Cost Analysis:**

Our second prototype met the price goal of under $2.00 per joint in materials. Our estimated price of our final prototype is $3.50, which includes “Wood sandpaper” from [www.homedepot.com](http://www.homedepot.com). Our prototype consists of only 2 joints, so if a greenhouse used our idea, it would only cost them $7, which is well below the price restriction. If 250 greenhouses were manufactured per year, the total additional cost would roughly come to $1,750.

**User Guide:**

**Figure 5:** First, you sand down the top of the beam to create a smooth and rounded edge.

**Figure 2:** This is the result of sanding the beam down.

**Figure 3:** Next, you nail the side beams to the top beam at an angle to connect the joint.

**Figure 4:** This is the result of nailing down the side beams to create the joint.

**Figure 4 Lay the glazing evenly on the top. Then nail it down.**
Re-design ideas/thoughts:

We generally got solid feedback from the HESE students about our design. They liked the concept of a simple design, the fact that there are not any parts that could be damaged, and the low cost. The main problem they had was the time to sandpaper all the large pieces of wood. Also, they were concerned about how there is likely not going to be any sandpaper in Sub Sahara Africa, but they agreed that it shouldn’t be a big deal to ship the sandpaper over.

In order to cut the time for these large pieces of wood, I would suggest that they try to cut a part off the top so that there is a smaller angle for them to sand it down. I would also say that the curve does not have to be as smooth as it was in our design, because the main objective with our prototype is to just get rid of the sharp edges that are usually going to tear apart the glazing. Our goal here is not to make it look pretty, which is what we were aiming for in our prototypes. Our goal is to make it work and increase the life of HESE greenhouses.
Works Cited


www.homedepot.com 5 Mar. 2015