Cambodian Field of Dreams

Team 16
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Executive Summary

Project Summary

World Renew is a non-profit organization active all around the globe. The organization responds to the needs of people around the world who are suffering from poverty, hunger, disaster and injustice. The mission of this organization is to “engage God's people in redeeming resources and developing gifts in collaborative activities of love, mercy, justice, and compassion”. Cambodia, a country where World Renew has a strong presence, is heavily reliant on its agricultural industry but their seasonal yields have been far surpassed by those of their neighbors. World Renew conducted a study and proposed a cover crop as the solution to this problem. A cover crop is a biological fertilizer that, instead of being harvested after it grows, is tilled into the malnourished soil to reintroduces nutrients. In order to do this, Calvin College received the task of designing a piece of equipment capable of inserting the cover crop, in this case legumes, into untilled soil. The planting must be done in such a manner as to foster the best possible growth, so the surrounding soil must be broken up for the roots to be able to spread. The entire process of planting the legumes must be very simple, intuitive, and able to be done without exerting too much energy. The figure below shows a CAD model of the chosen design.

Figure 1. Final Design
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1. Introduction

1.1 The Team

Brittainy Claire Phillippi

Brittainy Claire Phillippi likes to be called Claire. She will graduate from Calvin College in Grand Rapids, MI in May 2014. Claire has always had a passion for engineering. As a child, a screwdriver helped her to take apart everything in her parents’ house. She has had three internships in the last 3 years. The first in 2010 at Rapid-line, a small furniture manufacturer in Grand Rapids, MI. The second in 2012 at Woodward, a jet engine nozzle manufacturer in Zeeland, MI. The latest in 2013 at Steelcase, a world leader in office furniture in Grand Rapids, MI. Claire enjoys riding and fixing her motorcycle, and any outdoor activity. She hopes to work as an engineer for a few years then go back to school for Masters and PhD.

Joshua Vanderkamp

Josh is a local Grand Rapidian in his senior year at Calvin College. He is finishing his degree in Engineering with a Mechanical Concentration. Josh spent the summer of 2013 in Germany interning with TRW Automotive and thoroughly enjoyed the cultural experience as well as the work. In his free time Josh enjoys playing sports, reading, a classic video game or two, and camping with friends or family. He is pursuing an engineering job for after graduation, or possibly taking a year to serve with a missions organization abroad. True to an interest in missions and engineering, Josh is excited for all this senior design project holds as the group partners with World Renew to bring about a more sustainable life for Cambodia.

Schieffer Kwong

Schieffer is an international student from Hong Kong with a US citizenship currently pursuing a Bachelor of Science in Engineering, Mechanical Concentration with International Designation. In his time at Calvin, he was a three year member of the Student Martial Arts Club (Kicks for Christ Federation) studying Tang Soo Do Kyohoe Kwan. He has taken four belt tests and passed all of them. During the summer of 2013, Schieffer worked as an intern in TRW Automotive in Koblenz, Germany in the department of Actuation. He developed vacuum consumption theory and designed a ball screw tolerance test rig. When he graduates, he plans to work in the American industry as a Mechanical Engineer, hopefully in the field of aviation.
1.2 The Project
Cambodian Field of Dreams is trying to help farming communities in partnership with World Renew. The soil nutrition and yearly rainfall in Cambodia is quite poor. The main rice season usually yields a harvest of 1.5 tons per hectare, whereas the surrounding countries with similar conditions produce yields of up to 5 tons per hectare. Members of World Renew have researched techniques to improve on the agricultural output of Cambodia. Assisted by a Dr. Roland Bunch, a leading agroecologist and Director of Agriculture and Food Safety at World Vision International, it was decided that a biological fertilizer would significantly increase the Cambodians’ rice yield to possibly 3 tons per hectare. Doubling the food in this manner would be fantastic for the farmers’ livelihoods. It will be CFD’s responsibility to produce the equipment capable of planting these biological fertilizers in untilled and dry ground prior to the main planting season.

1.3 The Partners

1.3.1 World Renew
The project was proposed by World Renew, a relief and development organization of the Christian Reform Church. The organization responds to the needs of people around the world who are suffering from poverty, hunger, disaster and injustice. The mission of this organization is to engage God's people in redeeming resources and developing gifts in collaborative activities of love, mercy, justice, and compassion.

1.3.2 Cambodian Community
Cambodia is a country in Southeast Asia with a population size of about 15 million people. It is bordered by Thailand, Laos, and Vietnam. The government is a Unitary Parliamentary Constitutional Monarchy, meaning there is shared power between a king and a senate. The official religion is a type of Buddhism, which is practiced by about 95% of the populace. Civil war ravaged the country during the early 1970’s, followed by Vietnamese occupation from 1978 to 1993. It wasn’t until the turn of the century that reconstruction had finally begun to improve the country. This project will involve the people living in this culture.

Figure 2. Map of Cambodia
2. **Problem Statement**

2.1 **Requirements**

The goal of this project is to plant legume seeds in dry, un-tilled clay at a specified depth of 5 to 10 cm with the equivalent of plowed soil underneath it for another 5 to 10 cm. The figure below illustrates the ideal end product.

![Figure 3. Diagram of Project Purpose](image)

The process should be very repeatable and consistent over an entire rice field. Each seed should be roughly 15 cm apart, with spacing between rows around 90 cm.

![Figure 4. Rice PaddyDiagram](image)

Equipment will be built to produce these results. It will be durable, light, fast, intuitive, and affordable. These variables, among others, played a part in the decision matrix discussed later. The purpose of this equipment is to plant the cover crop that will fertilize the rice fields and, according to extensive research (discussed later), increase rice yields.
2.2 Project Sustainability
A member of the team, Claire Phillippi, visited Cambodia in January of 2012. She was able to view the land and the culture and interact with the people. Cambodians in the smaller agriculturally-focused communities are very hard working, hospitable and generous. But they are fairly set in their ways and not prone to swift change. With their very limited average income of $750 per year (worldrenew.net) they can’t afford to waste resources. This mind set saves them from foolish decisions, but can also prevent productive and innovative ideas from helping too. World Renew has been working in these communities to improve the harsh living conditions. It is important in such development situations to “help people help themselves.” A cover crop could greatly improve the standard of living for farmers if it is successful in increasing yields, and it is the responsibility of World Renew, and by association, this team, to work with the Cambodians. One of the largest challenges and most important factors is that the people support and get involved with this project. If they do not than it is very meaningless and will not be successful.
3. Background

3.1 Current Labor Conditions
The focus of our project targets female workers who help the household by doing agricultural work besides their daily main job. To understand their everyday life, one must understand Cambodia’s economic lifeline. The following table shows 2007 economic data of Cambodia (Economic Institute of Cambodia 1 - 30).

Table 1. GDP, Employment and Output ($2007)

<table>
<thead>
<tr>
<th>Sector</th>
<th>GDP</th>
<th>Employment</th>
<th>Output/worker(US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>31.9%</td>
<td>58.1%</td>
<td>511</td>
</tr>
<tr>
<td>Industry</td>
<td>26.8%</td>
<td>14.7%</td>
<td>1,691</td>
</tr>
<tr>
<td>Service</td>
<td>41.3%</td>
<td>27.2%</td>
<td>1,417</td>
</tr>
<tr>
<td>Total</td>
<td>100.0%</td>
<td>100.0%</td>
<td>931</td>
</tr>
</tbody>
</table>

Source: Data compiled from NIS and CSES 2007

From this table, one can see that the agriculture sector has the most employment, however it has the lowest wage in US$ per worker. Cambodia’s economy is also dependent on her industry, particularly garment production, and service, particularly tourism (Economic Institute of Cambodia 1 - 30).

Table 2. Cambodia's GDP Growth (% using 2009 prices)

<table>
<thead>
<tr>
<th>Sector</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>-1.0%</td>
<td>15.5%</td>
<td>5.5%</td>
<td>5.1%</td>
</tr>
<tr>
<td>Paddy</td>
<td>-12.2%</td>
<td>43.7%</td>
<td>4.3%</td>
<td>7.5%</td>
</tr>
<tr>
<td>Industry</td>
<td>17.0%</td>
<td>12.9%</td>
<td>18.4%</td>
<td>8.4%</td>
</tr>
<tr>
<td>Garments</td>
<td>24.9%</td>
<td>9.2%</td>
<td>20.4%</td>
<td>10.0%</td>
</tr>
<tr>
<td>Services</td>
<td>13.2%</td>
<td>13.1%</td>
<td>10.1%</td>
<td>10.2%</td>
</tr>
<tr>
<td>Tourism</td>
<td>23.4%</td>
<td>22.3%</td>
<td>13.7%</td>
<td>10.3%</td>
</tr>
<tr>
<td>Total GDP</td>
<td>10.3%</td>
<td>13.3%</td>
<td>10.8%</td>
<td>10.2%</td>
</tr>
</tbody>
</table>

Source: Data compiled from Cambodia Economic Watch

3.2 Soil Nutrition
Cropping in Cambodia revolves around three seasons: early wet season from April to July; main wet season from July to October; and dry season from November to March (Nesbitt, 1997). Rice is the dominant crop in Cambodia, in which ~90% of her agricultural land are used for (Nesbitt, 1997). Some
rice are harvested in sandy soils, however, the dominant rice ecosystem in Cambodia is rain-fed lowlands (Wade et al. 1999). Within a single farm, the upper terraces maybe classified as a drought-prone sub-ecosystem, and the lower terraces may belong to submergence-prone sub-ecosystem. In other words, 1) fields in upper terraces lose large amount of water, especially after heavy rainfall, through subsurface lateral water movement and surface runoff, while; 2) lower terraces would intercept and absorb water flows from the upper terraces. (Fukai et al. 2000). Such classification is mostly in part due to the erratic rainfall, topography and the dominance of sandy textures in the rice crop’s root zone.

“Drought, waterlogging and inundation are significant water-related hazards that influence the growing of field crops in lowland soils. In addition, soil fertility constraints in the early wet season and dry season will likely differ from those encountered by rice due in part to the different soil water regime they encounter. In particular soil acidity, low nutrient status, hardsetting and shallow rooting depth have been identified as significant constraints for field crops.” (Seng, R.W., P.F., N., S., and W. 42 - 48)

Figure 5. Generalized geology map of Cambodia. Source: Mekong River Commission

World Renew has been working in Cambodia for several years. They exclusively work with communities. Their goal is to help Cambodian communities with problems that they identify. World Renew worked with a different organization to figure out that a pre-season of legumes would be worth it. The problem is that it is very difficult to dig holes and put seeds in the ground when the only older women are around. We are going to make this task easier with our machine. World Renew helped identify the problem, and as a team, we would like to provide a solution to it.
4. **Project Schedule**

This project has been divided into several segments. There are priority portions which *must* be completed over the course of the 2013-2014 academic year, and there are additional extensions to the project which will be completed if time allows. The list below indicates a short summary of what has been done, and the timeline for what is to come.

*First Semester*

1. Research phase: Completed
   
   Extensive research was done concerning the country of Cambodia itself, present farming techniques as well as basic farming techniques used here in the US, equipment used, industry profile, and soil characteristics.

2. Design Alternatives Phase: Completed
   
   Based on the research gathered about farming techniques in Cambodia and elsewhere, several design alternatives were sketched. Some were built to test ideas or theories.

3. Final Design Phase: Completed
   
   Ultimately one design was chosen based on several variables (discussed later in this report). This design was modeled in CAD and calculations were completed concerning its basic force required for use to ensure it was feasible.

*Interim*

1. Prototype Phase: in progress
   
   During interim a prototype of the final design will be built using materials easily accessible. This is to make the ideas more tangible and problems more evident.

2. Material Selection Phase: in progress
   
   As the prototype is being built, the team will consider what materials are being used and how they are put together and compare those to what is available in Cambodia itself. There will be several possible options for each component of the model. As a result the seeder will be easily constructible regarding the resources available. This will also assist with replacing parts if they break in the future.
Second Semester

1. Final Design Construction Phase
Based on the materials chosen for the design, a final model will be built. This is what will be shipped to World Renew in Cambodia for use.

2. Trouble Shooting Documentation Phase
When the prototype and final model are being constructed, all possible problems will be documented and solutions for them will be recorded as well. This is to be sent with the model to Cambodia so that whatever problems arise, the customer will be able to fix them using this guide. It will be translated to Khmer, the official language, by World Renew language specialists.

3. Full Report Documentation Phase: On-going
A complete report of the year-long project will be compiled.

4. Mechanized Design Phase
If time, a motor will be added to the final model. This is to further speed up the process. It will be designed to run off of renewable energy, possibly a solar panel.

5. Tractor Compatible Design Phase
Also if time, a theoretical design will be generated that could be pulled by a tractor and do multiple rows at once. This would be the fastest possible way of planting a cover crop.
5. **Design Norms**

As this project progresses it is important to keep the goal in mind and the manner in which that goal will be accomplished. In order to avoid making design trade-offs detrimental to the end customer, it is important to have moral and ethical principles to guide decision making and shape the end result as well. Team CFD chose to focus on the following three design norms because they best fit the situation and provide an appropriate framework for what this project hopes to accomplish.

5.1.1 **Cultural Appropriateness**

Cultural Appropriateness is one of our design norms because all the time while doing this design we are keeping the communities we are helping in mind. We are making our machine to fit the women who will be doing this labor. We are making the tractor design to fit the tractors that most Cambodian farmers already use.

5.1.2 **Stewardship**

Stewardship is also our design norm because we are trying to be good stewards of the environment. We are trying to help World Renew not use chemical fertilizers which deteriorate the soil.

5.1.3 **Trust**

Trust is our design norm because we are trying to gain trust of our customers. Currently our customers do not believe that planting this extra season will increase yield enough to be worth the amount of time spent to plant it in the first place.
6. Design Alternatives

Several alternative solutions were drawn up and analyzed. This section shows each one and its pros and cons. Section 7 then discusses the design which was finally chosen to be built.

6.1 Injection Hand Seeder

This design was the simplest solution to the presented problem. A hollow shaft connects the seed storage at the top to a pointed bottom component capable of opening upon contact with the ground.

There are several pros to this design. There are only 3 main components – the seed container, body (or shaft), and injection end – so the cost to produce it would be very low. It was estimated around $23 to produce, not including labor or machining costs. It is also very simple to use. This straightforward design is very user-friendly and intuitive. Because of this, maintenance is also very simple, there are few components to replace and replacing them is easy. It is also very durable.

Some of the cons to this design is the amount of effort it takes to heft the device and bring it down with force into the ground. That was an important requirement: that it doesn’t cause back problems or other related injuries with repeated use. This was the main reason why this design was not selected.

Figure 6. Injection Hand Seeder, Top View

Figure 7. Injection Hand Seeder, Side View
6.2 Auger Hand Seeder

The auger hand tool was another somewhat simple solution, with a hollow shaft connecting to an auger and a seed container at the top. The auger is inserted into the ground and rotated until it is 15 cm deep, it is then pulled out and hovers over the hole while a lever is flipped and several seeds fall down the shaft and into the hole.

One of the most important benefits of the auger design is that it really breaks up the soil and provides a perfect situation for the seed to grow. It is dropped directly on this churned soil. Its cost is also low, as with the injection hand seeder. The main difference is the $20 premade auger which makes it slightly more expensive, but more durable too. It is also simple to use and requires less force.

Lifting and carrying this device is still a concern. Again, that was one of the most important criteria and was the biggest factor as to why this design was not selected.

Figure 8. Hand Auger Side View

Figure 9. Hand Auger Top View
6.3 Industrial Push Seeder

This push seeder is the most common seeder used for smaller-scale situations. The team visited a local organic farm in Zeeland to see firsthand how it worked. A simple hoe creates a furrow in soft ground and directly behind this, seeds are dropped in. A gear is located inside the seed container and as the wheels of the device turn, they turn this gear too. At each turn several seeds are captured and deposited. A chain or rigid piece of metal drags behind the device by a few centimeters to pull the displaced soil back over the seeds. A modification was designed for the front hoe, because the soil in Cambodia is far denser than the lush dirt in Zeeland, MI. The proposed front was either a more sturdy hoe device or two rotary discs overlapping one another.

A pro of this device is that it is one simple motion: push the device in a straight line. The speed of the device would be good because it is one continuous motion and not broken up at each hole. The posture of the user would be healthy due to the motion, no unnatural bending of the back.

The cost of this device would be higher.

Table 3. Industrial Push Seeder Production Costs

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>$25.00</td>
</tr>
<tr>
<td>Steel Pipes</td>
<td>$7.00</td>
</tr>
<tr>
<td>Steel Angle</td>
<td>$4.90</td>
</tr>
<tr>
<td>Seed Container</td>
<td>$5.00</td>
</tr>
<tr>
<td>Spring</td>
<td>$5.00</td>
</tr>
<tr>
<td>Seed Device</td>
<td>$20.00</td>
</tr>
<tr>
<td>Labor</td>
<td>$100.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$166.90</strong></td>
</tr>
</tbody>
</table>

Also because of the component used to break up the soil, there would be significant force required by the user. Also there is little or no filler soil underneath the seed. This would hinder the entire ideology behind the project of growing these legumes.

This was a good design and was expected to score highly on the decision matrix, however it wasn’t the best choice based on all the variables.
6.4 Plow Push Seeder

The plow push seeder combines the idea of the industrial push seeder and an old fashioned plow. Using the shear weight of a solid metal plow to break down the soil, a furrow would be created. The components following would be similar to those of the industrial seeder for the seed dropping and furrow filling. There would be only one wheel and it would be located on the front with long handles coming straight back to the pusher. Dragging behind this would be the plow.

This would be a simple process of pushing something across a field without worrying about process which is good. It is very durable and cost effective because the front is simply a heavy piece of welded steel.

One of the biggest problems is again the lack of filled in soil underneath the seed. This equipment would also require a great deal of force to drag such a heavy object across a field.

Figure 11. Wheel Push Seeder
6.5 Wheel Push Seeder

The wheel push seeder is a design already on the market but not widely used. It is a wheel with two handle bars protruding straight back for the user to push. Seeds are stored inside the wheel and there are injection “beaks” along the outside which open when planted in the ground. There are levers which trail the beaks, and as the beaks are in the ground, the lever then comes into contact with the ground with the rotating wheel. The lever is engaged by contact with the ground.

This is a sturdy, simple to use device which requires little force.

The parts would be more difficult to access due to its compact nature. And the cost would be higher as a result of the more intricate parts. Again, there would be no filler soil at all. The image below is the product from the competitor discussed later.

![Wheel Push Seeder](image)

Figure 12. Wheel Push Seeder
7. Final Design

7.1 Decision Matrix

**Speed**
The length of time it takes for the seed to get into the ground and covered with dirt was denoted by speed in the decision matrix. This was rated as a good speed or a bad speed if it was faster than hand digging each hole with a shovel and planting the seed.

**Ergonomics**
The user should also be comfortable when using this machine which is denoted by ergonomics. The user should not be bending down or standing at odd angles to operate the machine. A good design was one that allowed the user to use the machine at their own designated height.

**Cost**
The cost of production and cost to the user was covered by cost in the decision matrix. A good cost would be a low production cost and a low cost to the consumer. All of the designs met the production cost and customer cost. This meant that designs were compared to themselves.

**Simple Use**
The use of the machine must be simple for the end user. Some machines require more than pushing a planter so these were compared to the easiest system. A machine was given a good rating if it was as simple as pushing a planter across a field.

**Replaceable**
The machine should be easily fixed when broken. The designs were judged if they could be fixed with pieces that are found in Cambodia. If the entire machine had to be replaced than this would mean the design is not a replaceable machine. A high rated machine would have parts in Cambodia to replace if they were broken.

**Filler soil**
A criteria given to us from the customer was to have soil in the hole before the seed was planted so the seed would root well. This also describes if a design put the dirt in the soil after the seed was placed. A design received a good rating if the hole was dug and half-filled in before the seed was placed.

**Simple Maintenance**
The machine should be so simple that it should be very easy to understand how the machine works. This will help the user fix something if it broke on the machine. The machines were given a good rating if they had a simple mechanism.
**Force Used**

A machine should be able to be moved across the field with as little force as possible. The proper force should not be so difficult that our user becomes very tired while using it. This part of our criteria was denoted by the force used.

**Durability**

Machines should be durable enough to last ten years. If a design did not meet this criteria then it was given a low rating. To receive a high rating the machine just had to last the ten years. This criteria was denoted by durability.

<table>
<thead>
<tr>
<th>Table 3: Decision Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision Variable</td>
</tr>
<tr>
<td>Speed</td>
</tr>
<tr>
<td>Ergonomics</td>
</tr>
<tr>
<td>Cost</td>
</tr>
<tr>
<td>Simple Use</td>
</tr>
<tr>
<td>Replaceable</td>
</tr>
<tr>
<td>Filler Soil</td>
</tr>
<tr>
<td>Simple Maintenance</td>
</tr>
<tr>
<td>Force Used</td>
</tr>
<tr>
<td>Durability</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

**7.2 Design Description**

The auger push seeder was chosen from the team’s decision matrix. This design consists of an auger which is hand cranked and a wheel for the push seeder. To make the pushing of the seeder easier a cam was designed to raise and lower the auger as the machine moves along the ground. This way as the person cranks the auger the auger will push itself into the ground and back out again. Then when finished with the hole and the wheel is moved the optimal three inches from the hole a seed will be dropped into the hole. A preliminary CAD design is shown below in figure x. This is the rough design for the frame that will hold the seeder device.
For the seed delivery system the team will be using market idea of a plate with a hole in it that turns as the push seeder is moved. When the push seeder is moved it turns the plate which grabs a seed and drops it into a hole. This method is proven to be very effective. With this method the team should not have to do much testing for the effective seed dropping method.

Calculations have been done for optimal angle of entry into the soil with a soil mechanics book. Which proved that it will take very little effort for the auger to dig the hole necessary to put the seed into the hole. The key to this design is that as the auger comes out of the hole some dirt falls back into the hole so the seed will not have to root into hard un-tilled soil, but instead in the soft dirt that has been dug by the auger.

7.3 Soil Mechanics
To optimize our design the teams has begun research into soil mechanics to better understand how the soil interacts with our tool. To begin with there is a reaction to the force applied to the soil. To calculate this force equation 1 is used.

\[
q_{ult} = 1.2cN_c + \gamma D_f N_q + 0.6 \gamma RN_y
\]  

(1)

This equation has some very interesting properties (Meier, 2009). Soil Cohesion is the c in equation 1. A general coefficient for internal soil cohesion is given by the term \(N_c\). This term can be defined when the internal soil friction angle is found using Table 8.

Table 4: Internal Friction Angles Determined by Classification of Soil
Then the other $N_q$ and $N_c$ can be calculated using Table 5. Now another term in the equation above is $\gamma$. This term is in reference to the bulk soil density which is weight per cubic foot. Now the only term that remains is the radius $r$ which for this equation is 8 cm. Using this equation to solve in an overall force calculation to tell the amount of force an auger would exert on the ground.
Using the following equation 2 gave us a force that will be used on the auger to dig into the soil.

\[ P_c = (\gamma \cdot 9.807 \text{ [m/s}^2\text{]} \cdot d_m \cdot N_{\gamma} + c \cdot N_c + q \cdot N_q) \cdot d \cdot w \]  

(2)

The force ended up being 10 kg which should be exerted by the entire mechanism and will allow the auger to bore itself down into the soil. The weight of the mechanism should help with this. Further EES source code can be found in the Appendix.
8. **Maintenance**

There is always a possibility with any project that problems will arise during production or it may break down several years into its use. The first product used will have been built here and shipped overseas. If problems arise with this model our senior design team will make ourselves available to help fix them from our current location. A local member of World Renew will be trained in how this product is built and how to fix it as well. As prototypes are constructed and the eventual final design is finished, testing will be done to determine probable problems and several solutions will be documented on how to go about fixing them with materials available.
9. **Costs**

9.1 **Cost Estimate**
This is an estimate of total costs for the project now, and what it may cost to produce it in the future.

9.1.1 Development
The development of this product will involve prototype costs as well as costs for the final design model.

<table>
<thead>
<tr>
<th>Component</th>
<th>Details</th>
<th>Quantity</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold-rolled Steel Sheeting</td>
<td>18 gage, 4'x10'</td>
<td>2</td>
<td>$148.00</td>
</tr>
<tr>
<td>Steel Angle</td>
<td>1/2&quot;x1/2&quot;x1/8&quot;, 20' long</td>
<td>2</td>
<td>$39.20</td>
</tr>
<tr>
<td>Weatherproof spray</td>
<td></td>
<td>1</td>
<td>$8.00</td>
</tr>
<tr>
<td>Steel Pipe</td>
<td>1&quot; diameter, .133&quot; thick, 21' long</td>
<td>1</td>
<td>$35.91</td>
</tr>
<tr>
<td>Bike Tire</td>
<td>20&quot; diameter</td>
<td>4</td>
<td>$70.00</td>
</tr>
<tr>
<td>Nuts/Bolts</td>
<td>various types/sizes</td>
<td>bulk</td>
<td>$20.00</td>
</tr>
<tr>
<td>Springs</td>
<td>various types/sizes</td>
<td>bulk</td>
<td>$10.00</td>
</tr>
<tr>
<td>Steel Rod</td>
<td>4' long</td>
<td>1</td>
<td>$10.00</td>
</tr>
<tr>
<td>Gears</td>
<td>various types/sizes</td>
<td>bulk</td>
<td>$40.00</td>
</tr>
<tr>
<td>Seed Container</td>
<td>2</td>
<td>$10.00</td>
<td></td>
</tr>
<tr>
<td>Steel Auger</td>
<td>3&quot; blade</td>
<td>2</td>
<td>$80.00</td>
</tr>
<tr>
<td>Motor</td>
<td>found on ebay</td>
<td>1</td>
<td>$20.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>$491.11</strong></td>
</tr>
</tbody>
</table>

9.1.2 Production
The production costs represent current estimates what it would take for someone to reproduce our model in the future.

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost</th>
</tr>
</thead>
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<tr>
<td>Auger</td>
<td>$40.00</td>
</tr>
<tr>
<td>Seed Container</td>
<td>$5.00</td>
</tr>
<tr>
<td>sprng</td>
<td>$2.00</td>
</tr>
<tr>
<td>Gears</td>
<td>$5.00</td>
</tr>
<tr>
<td>Tube</td>
<td>$5.00</td>
</tr>
<tr>
<td>Labor</td>
<td>$100.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$157.00</strong></td>
</tr>
</tbody>
</table>
10. Marketing

10.1 Industrial Profile

10.1.1 Industry
Cambodia is a country in Southeast Asia with a population size of about 15 million people. Farming and agriculture accounts for over a third of the country’s GDP, and the main crop within this industry is rice. Cambodia is bordered by Thailand, Laos, and Vietnam, all of whom have higher rice yields, at about 5 tons/hectare, compared to the national average for Cambodia of 2.6 and furthermore the average self-employed, rural farmer who produces only 1.5 (Inserey). The soil nutrition in Cambodia is quite poor, even when compared to these neighboring countries who share similar seasonal weather patterns. Cambodia itself has many agricultural equipment manufacturers to supply this market, however, they do not extend into the seeder niche very well (discussed later in the report). Farming is a major part of Cambodian life and it is this industry that the company will attempt to break into.

10.1.2 Customer
The target customer will be rural farming villages, beginning with the immediate vicinity of Phnom Penh. Word Renew has a strong presence in this area and throughout Cambodia. Using this resource, business will expand throughout the country. World Renew and many other non-profit organizations work with farmers around to world to increase crop yields, in the future it is hoped that products can be supplied to any of them and their surrounding region.

10.1.3 Barriers to Market Entry
The biggest barrier to entry for this market niche is the cultural attitude towards the idea of a cover crop. The demographic being marketed to has an annual income of $750 per year (worldrenew.net), so there is little room in their budget for experimenting with new farming techniques when they can barely scrape by in general. If the seeder can be made cheaply enough and marketed positively by local World Renew representatives and native farmers it would be possible to overcome this caution.

10.2 Business Strategy

10.2.1 Market Image and Position
This company hopes to form an image of trust and cultural appropriateness within the industry and populace in general. Partnering with an organization like World Renew helps to build this image. Because this is a new idea to most of Cambodia, this company will be a leader and innovator, not only in the theory itself, but also in simple and effective equipment design.

10.2.2 SWOT Analysis
A SWOT analysis was conducted to evaluate this project. The various elements are given in Table 1 below.
Table 7. SWOT Analysis

<table>
<thead>
<tr>
<th>Internal</th>
<th>Helpful</th>
<th>Harmful</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Strengths</strong></td>
<td><strong>Weaknesses</strong></td>
</tr>
<tr>
<td></td>
<td>Guaranteed initial market</td>
<td>Difficult to understand local terrain, soil texture</td>
</tr>
<tr>
<td></td>
<td>Small, well-defined niche with little (cheap, no-till)</td>
<td>Unable to test product onsite with customer</td>
</tr>
<tr>
<td></td>
<td>Simple project scope. Able to do it well.</td>
<td>Difficult communication with end user, rural Cambodian farmers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>External</th>
<th>Helpful</th>
<th>Harmful</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Opportunities</strong></td>
<td><strong>Threats</strong></td>
</tr>
<tr>
<td></td>
<td>Potential worldwide NGO interest</td>
<td>Chemical fertilizers used instead of biological fertilizers</td>
</tr>
<tr>
<td></td>
<td>Great resource for information and funds in World Renew</td>
<td>Lack of community interest and investment</td>
</tr>
<tr>
<td></td>
<td>Able to help people help themselves</td>
<td></td>
</tr>
</tbody>
</table>

10.2.3 Competitive Strategy
The competitive strategy of choice will be mainly cost with some differentiation. Companies within the niche agricultural hand seeders are either very expensive, or not fit for no-till situations, when the soil is hard and dry. Team Cambodian Field of Dreams plans to provide a cheap alternative (price discussed more in depth later) and one that works optimally under the described circumstances.

10.3 Marketing Strategy

10.3.1 Problem
“Compared to neighboring countries with similar weather and soil conditions, Cambodia’s paddy rice yield remains relatively low. In 2006, the average yield was 2.6 tons per hectare, while Thailand, Laos, and Vietnam achieved 2.8 tones, 3.5 tons, and 4.9 tons, respectively” (Inserey). Because using chemical fertilizer is culturally unacceptable, another way to increase paddy rice yield is to use bio-fertilizers. The company’s product provides a fast, easy and relatively effortless way to plant seeds into the ground, which, when matured, would serve as bio-fertilizers.

10.3.2 Target Market and Demographic Profile
The company’s target market is Cambodian villagers that are willing to try cover cropping. The company aims to better the nutrition value of the soil and ultimately increase the rice yield. The company’s product should be designed in such a way that race, social class and gender will not be a limit. However, the product is limited by age and location. The company’s product is not suitable for children below the age of 12. Because of the design, the product should refrain from being used in locations that has harder soil than that of Cambodia’s dry season rice paddies. The company would initially aim to sell specifically to females, as they are more available for implementing new and unproven ideas than the men in their culture.
10.3.3 Product Appeal and Promotion
The company will partner with World Renew to spread the cover crop concept. Once the concept is out, the company aims to convince some of the farmers by giving them free trials of the seeder. Because of the cover crop strategy, the rice yield for that planting season should increase. With initial farmers convinced and feedback taken, the company hopes to advertise the product along with testimonies from local farmers. The advertisement strategy relies heavily on these customers testimonials.

The advertising and promotion of this product will be mainly through World Renew. The company would like to use local resources and other NGOs to reach out to farmers. The message would mainly focus on advertising and purposed to spreading knowledge of cover cropping. The initial budget for advertisement does not exist because the company will be partnering with World Renew for advertisement, which the NGO will fund.

10.3.4 Market size and trends
There are an estimated 200,000 villages within Cambodia that the company would hope to sell the seeder to. The company hopes to increase the production after initial feedbacks and extensive, specific local village research. Through this research, the company hopes to have several alternative designs of the initial seeder. The target of selling to 200,000 villages should be reached within 5 years.

10.3.5 Pricing
The company would like to be seen as a leader in no till farming solutions. We wish to put our product in the hands of every Cambodian village so that they may be able to increase soil fertility. We wish to be trusted to supply a quality product that takes copious abuse before it will break.

The no till seeder we are proposing is $50, which is $100 cheaper than our closest competitor. We can sell it this cheap because of our non-profit status. We are not trying to make money. We are trying to help our customer get the product that they need to have a thriving farm.

The Gross profit margin on this product ranges from 20% to 25%. This is achieved by our very low overhead because we will be manufacturing in Cambodia. This gross profit margin will be going back to the company’s investors so the company can be self-sufficient and help the farmers with new projects.
10.4 Competitive Analysis

There are companies, two in particular, who pose a competitive counterpart to this project. In order to be successful, it is not only necessary to overcome *them*, but also the unawareness and doubt of the potential users towards the idea of a cover crop. Because in the end that is what is keeping the people from buying similar products from other existing companies. The previously mentioned competition takes the form of an immediate market competitor, and a potential one.

10.4.1 Immediate Competitor
Zhengzhou AIX Machinery Equipment Co., Ltd. is a Chinese company that sells three different no till hand seeders. However they are all priced between $150 and $200 which is out of the price range of the average. The scope of our team is creating a model which costs $50, we would attempt to overcome this competitor with a lower price. A strength of their company is that they have a very solid design and can mass manufacture it. There are two problems with these designs. One design doesn’t till the earth at all, it merely inserts seeds into the ground a certain depth. This harms the seed’s ability to grow because the roots can’t expand well into the packed soil. The design does till the earth but relies on the user’s pure force to till a furrow in the earth. Our target user will be the women of rural Cambodia, and with how dense the soil is and the amount of push force the average woman can exert, this design is not favorable.

10.4.2 Potential Competitor
MekongAT is an Agricultural Machinery company who builds seeders. These do not work in no till applications and so, would require some design modifications before they are an applicable competitor. The potential is still there to redesign one of their present machines, but as of now they do not have a design for our particular niche.
11. Conclusion

Upon reviewing the problem, chosen solution, probable costs, and the given time constraint, Team CFD has decided this project is feasible.

When World Renew proposed this project it was very appealing because a majority of our group is interested in mission work and this fits that scope incredibly well. World Missions is a great organization to work for. Claire Phillippi has had interactions with them in the past and had great things to say about the experience. The proposed project combines creativity in machine design and agricultural techniques to become a fascinating topic.

Researching possible designs, visiting local farms, and building prototypes have provided a fairly clear vision of what it will take to design the equipment. It is also believed that this can be done within the monetary limits provided by the Calvin College Engineering Department for materials, and through World Renew grants for travel.
12. Acknowledgements

Partnering with CRWRC for implementation:
Rick Degraaf (rickdegraaf@worldrenew.net)
Rachel Brink (rbrink@worldrenew.net)
Kathleen Lauder (klauder@worldrenew.net)

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Rachel Brink for helping us with grant writing
Kathleen Lauder for being our World Renew contact
Ned Nielsen, our team’s advisor and counselor
Phil Jaspers for helping brainstorm ideas, build our prototypes, and find our way around the metal shop.
And of course, Michelle Krul for all the organizational help she provides for the class.
13. References


# Appendix

## Table 6. EES Force Calculations

"Soil mechanics for Cambodia for different tool widths and tool angles"
"Cutting force using cohesion"
"d=cutting depth"
"w=tool width"
"c=cohesion coefficient of soil"
"Based on soil classification"

<table>
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<th>Value</th>
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</thead>
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</tr>
<tr>
<td>( d )</td>
<td>30 ([\text{cm}])</td>
</tr>
<tr>
<td>( D_f )</td>
<td>30 ([\text{cm}])</td>
</tr>
<tr>
<td>( w )</td>
<td>10 ([\text{cm}])</td>
</tr>
<tr>
<td>( R )</td>
<td>3 ([\text{in}])</td>
</tr>
<tr>
<td>( c )</td>
<td>1.5</td>
</tr>
<tr>
<td>( \theta )</td>
<td>30</td>
</tr>
<tr>
<td>( q )</td>
<td>1.2 (c^<em>N_c+\gamma</em>D_f<em>m^<em>N_q+0.6^</em>\gamma</em>R_m^*N_{\gamma}\gamma)</td>
</tr>
<tr>
<td>( N_c )</td>
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<tr>
<td>( N_q )</td>
<td>18.4</td>
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<tr>
<td>( N_{\gamma}\gamma)</td>
<td>22.4</td>
</tr>
</tbody>
</table>

\[w_m=w*\text{Convert(cm,m)}\]
\[d_m=d*\text{Convert(cm,m)}\]
\[D_f_m=D_f*\text{Convert(cm,m)}\]
\[R_m=R*\text{Convert(in,m)}\]
\[P_c=(\gamma*gf^*d_m^*N_{\gamma}\gamma+c^*N_c+q^*N_q)^*d^*w\]

"\(P_{\text{wedge}}=(\sin(BETA+PHI))/((\sin(alpha+BETA+delta+PHI))*c^*d^*w)\)"

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
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<td>( c )</td>
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<tr>
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