Project Proposal Feasibility Study

Team 6:
Case for Cambodia
Calvin College Senior Design
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Abstract:

As Cambodia continues to develop, there is a need for education within the agricultural community. Cambodia’s tragic recent history has resulted in a young and less educated population. A Cambodian couple Navy Chann-Chhay and Li Chhay have helped aid in a solution to this problem. The Genesis Community of Transformation (GCT), a Non-Governmental Organization founded by Navy, focuses on community development such as building relationships with the church and church members. The Eden School of Agriculture (ESA) is one of the programs of GCT. It is a vocational training school and research farm for the local Cambodian community of farmers. ESA is located in Sre Ambel, Cambodia just off the coast of the Gulf of Thailand.

Case for Cambodia’s project goal is to develop a master plan for the Eden School of Agriculture. Approaching this project, Case for Cambodia will focus on culturally appropriate methods and materials used by the common Cambodian along with transparency of communication in our design. The master plan will include a common building for classes and dormitories, a water distribution system to supply the sanitary facilities and for irrigation of the crops. It will also include a bridge and renewable energy source. Designs will include information gathered from sources and educated assumptions until the site can be properly surveyed.
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1. Introduction

1.1. Project Statement:

The goal of team Case for Cambodia’s project is to develop a master plan for the Eden School of Agriculture (ESA). The master plan will include steps to develop ESA’s farmland into a center of education for the Cambodian farmer and groups visiting the farm. Our team objective is to design the structures and develop the site, along with a promotional package and timeline for implementation. The master plan will include a design of a common building, water distribution system, renewable energy source, bridge, and sanitary facilities. Local building techniques and materials will be used to design a durable facility. Case for Cambodia will design a system that is affordable (considering the average Cambodian only makes around $500/yr). This plan will integrate the components together and have a staged construction plan as funds become available.

The common two-story building is intended for group meetings, training sessions, and shelter during the rainy season. Water sources on the farm include a 140 ft well and 2 streams that run down off the nearby mountains. The well water will be used for the sanitary facilities, drinking water, and irrigation of the farm. Water pressure needed for the sanitary facilities and irrigation will be supplied with a renewable source such as a merry-go-round pump or windmill to an elevated storage tank. Site development includes a bridge across the stream to the farm site. The sanitary facilities will include toilets, sinks, and showers. An electricity system may include solar panels, hydro-electric power, or wind, which will be used in the buildings and for communication purposes.

1.2. Team Description:

Elizabeth Smit is a senior from Seattle, WA. She is currently pursuing a Bachelors of Science in Engineering degree with a concentration in Civil Engineering. The past two summers she has had internships at structural engineering firms and hopes to either get a job or attend graduate school for structural engineering after graduation. She also runs for Calvin’s cross country and track and field teams.

Aaron Goodman is a senior from Milwaukee, Wisconsin where he attended Milwaukee Lutheran. At Calvin, Aaron is working towards a degree in Civil / Environmental engineering. Aaron is also a member of the Calvin Cross Country and Track and Field Teams. After graduation he plans on pursuing a career in the field of engineering.
Jordan Johnston is a senior from Ypsilanti, Michigan where he attended Plymouth Christian Academy. At Calvin Jordan is pursuing a Bachelors of Science in Engineering degree with a concentration in Civil Engineering. Last summer Jordan worked in the accounting department for Johnston Lithograph helping with the accounts payable and receivable. In the spring of 2008 he had an internship at Wade Trim in Grand Rapids, MI working in the traffic engineering department. After graduation he hopes to get a job in structural engineering.

Lisa Andela is a senior from Richfield Springs, NY. She is currently pursuing a Bachelors of Science in Engineering degree with a concentration in Civil and Environmental Engineering. Last summer she had an internship with the Soil and Water Conservation District in Walton, NY working on stream restoration projects in the New York City watershed. For summers before that, Lisa was involved in setting up her own artisan cheese making business with her father on their small dairy goat farm. Lisa is planning on getting married summer of 2010 and will look forward to combining farming and engineering in her future careers.

Eric Immerfall is a senior from Plymouth, Michigan where he attended Plymouth Christian Academy. At Calvin Eric is pursuing a Bachelors of Science in Engineering degree with a concentration in Civil Engineering. Last summer Eric worked for Ibach Enterprises as a property manager. After graduation he is getting married and plans to pursue a career in engineering.

2. Requirements

2.1. Water Distribution System:
- Use a combination elevated tanks and detention pond to feed both the irrigation system and sanitary facilities
- Tank large enough for irrigation of up to 12 acres and daily water usage

2.2. Sanitary Facility:
- Structure attached to common building
- Includes 2 toilets, 2 showers, 2 sinks
2.3. Common Building:

- Use resources that are readily available in Cambodia and are transportable to the site which is 3 hours out of the Phnom Penh (capital city of Cambodia)
- Approximately 8m (26ft) x 15m (50ft)
- Two story with lower floor having a large open space and upper floor enclosed with dorm rooms

2.4. Bridge:

- Span a distance of ~12 meter (~40') in the wet season
- Support the load of a small vehicle
- Simple design out of concrete, timber, or both
- Possibly built with a culvert and land bridge design

2.5. Renewable Energy Source:

- Renewable energy source large enough to supply the needs of the common building and the existing structures

3. Background

3.1. Site Information:

The ESA site is located in Sre Ambel, Cambodia. ESA is located on a 12-acre (5 hectare) plot within a 70-acre plot of land owned by Ly Chhay and his wife Navy Chann-Chhay. The rest of the farm used to grow Sour sop trees, which will be harvested and used as a revenue source for ESA. Figure 1 shows the country and location of the ESA site.
3.2. Climate and Culture:

Cambodia is a small country in Southeast Asia. It borders Thailand to the north and west, Laos to the northeast, and Vietnam to the east and southeast. It has a 443-kilometer (275 mi) coastline along the Gulf of Thailand. Some dominate features of Cambodia include a large lake centrally located called the Tonle Sap, the Bassac River Systems, and the Mekong River, which crosses the country from North to South. It also contains a few mountainous regions but about three quarters of the country lies at elevations less than 100 meters above sea level. Its weather is quite tropical with a dry season from November-May, with about 80% of the annual rainfall occurring during the wet season in June-October. Cambodia has moderate to high temperatures ranging from 69° F to 95° F approximately.

The culture is such that “most Cambodians consider themselves to be Khmers, descendants of the Angkor Empire that extended over much of Southeast Asia and reached its zenith between the 10th and 13th centuries.” (World Factbook) Cambodia was occupied under the protection of France until after the Japanese occupation in World War II where Cambodia gained its full independence in 1953. In the 1970’s, the Khmer Rouge, a communist party lead by Pol Pot rose to power, executing more than 1.5 million Cambodians. “A December 1978 Vietnamese invasion drove the Khmer Rouge into the countryside, began a 10-year Vietnamese occupation, and touched off almost 13 years of civil war.” (World Factbook) In 1999, the remaining Khmer Rouge surrendered and recent elections have been relatively peaceful. At the present there is quite a bit of government corruption slowing the revival of Cambodia. The road of development will be challenging because over half of the population is less than 21 years old. The youth has little education and productive skills due to the lack of basic infrastructure, especially in the countryside where more than three-quarters of the Cambodian labor force is agricultural.

3.3. Community:

The communities surrounding ESA include many relatives of Ly, which have come back to their “home land” after the Khmer Rouge invasion and civil war. These villages are the focus of the agricultural school.
4. Project Objectives

4.1. Project Scope:

4.1.1. Water System:

The water distribution system will use the combination of a pair of elevated tanks and detention pond to gravity feed both the irrigation system and sanitary facilities.

4.1.2. Sanitary Facility:

A structure attached to the common building including a water storage tank and 2 of each toilets, showers, and sinks. Water supplied to the sanitary facility from an elevated tank near the well to its own water storage tank on top of the facility.

4.1.3. Common Building:

The common building will be approximately 20’ x 40’, two stories with the lower floor having a large open space and upper floor enclosed with 10-12 dorm rooms. Use resources that are readily available in Cambodia and are transportable to the site.

4.1.4. Energy:

A renewable energy source will be large enough to supply to meet the needs of the common building and the existing house.

4.1.5. Bridge:

The bridge will span a distance of ~12m (~40ft) and support the load of a small vehicle.

4.2. Design Timeline:

The Project Proposal Feasibility Study (PPFS) will be completed December 11, 2009. Final Design and table model will be completed end of May. For a more detailed task breakdown, refer to Appendix A.

4.3. Reliability and Safety:

4.3.1. Water Distribution:

Water distribution is an important part of developing the ESA site. There will be storage tanks that will need to be elevated in a safe and sturdy way such that it will not fall and cause injury. Considering some of the water will be used for drinking, it is important to transport the water without contamination.
4.3.2. **Sanitary Facility:**

The sanitary facility design must have a long life and must have easily accessible pieces that can be replaced for little to no cost if something was to fail. The sanitary facilities must work consistently without having any problems. Because of weathering concerns, sturdy piping will be used.

Safety is the whole purpose of the design of the sanitary facilities. Being able to remove waste in a safe way will help prevent sickness. The showers will also provide a place for increased hygiene. The sanitary facilities will promote healthier lifestyles to the community of farmers at the ESA.

4.3.3. **Common Building:**

A structure must be built in a fashion so that it can be trusted not to fail and hurt or kill the inhabitants. Deflection is also a concern that needs to be designed for so that the residents trust the structure. In order for the structure to be good for the health of the people it must withstand the climate. In Cambodia there are several months in which the weather is perpetually wet. Wood becomes permeated and can begin to rot and mildew which is not good for personal health or the life of the structure itself. The building will become obsolete much quicker if the main columns rot away.

4.3.4. **Bridge:**

In bridge design, safety and reliability are the most important aspects of the design. The bridge must be able to support a small vehicle without breaking under its weight. One small error in the design of bridge could end up causing serious injury or worse. Since there is also a large difference in water elevation during the rainy season the bridge must also be able to hold up against strong flows and possible flooding.

4.3.5. **Renewable Energy Source:**

Reliability is always an issue in regards to renewable energy sources. These sources are directly dependant on environmental conditions that cannot be controlled. Because the hours of operation are not always constant, interruptions of the energy production are inevitable. However, this does not necessarily rule them out of the equation. The system must have the capability to store energy for a few days in less than ideal conditions. The reliability of a micro-hydro system is a little different. Because the flow of the stream will be continuous storage becomes less of an issue. Rather, the chief determination in the reliability of the design is whether the system can hold up season to season. The system must be able to handle the deviation between the dry and rainy seasons.
The design of the energy source must allow for maximum safety. Electricity can become dangerous when harnessed in an inappropriate manner. While Case for Cambodia will not be directly constructing the system, adequate guidelines can be developed to ensure safety on the site.

4.4. Cost Analysis of Team Funds:

Case for Cambodia would like to test the instrumentation and application of a renewable energy system. Because the solar energy system is currently the most prominent option, the model budget is derived from it. The model system could either be comprised of a generic solar hookup or it could be modified so that more than one solar panel or battery is being used. Investigation in to a multiple battery system would be most applicable in designing a battery bank for the energy storage of the proposed system. Table 1 provides cost estimation for a small scale model system. The cost of the actual system would be significantly more. Here 5-6 panels and 10-12 batteries are required. Furthermore, each component would need to handle a much higher load. In the test 30-50 W panels will be tested; whereas at the site 100-200 W panels would be preferred.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Panels</td>
<td>$200</td>
</tr>
<tr>
<td>Charge Controller</td>
<td>$50</td>
</tr>
<tr>
<td>Batteries</td>
<td>$70</td>
</tr>
<tr>
<td>Wiring</td>
<td>$15</td>
</tr>
<tr>
<td>Inverter</td>
<td>$75</td>
</tr>
<tr>
<td>Materials for Bench Scale Model</td>
<td>$100</td>
</tr>
<tr>
<td>Experimental Water Filter</td>
<td>$50</td>
</tr>
<tr>
<td>Total</td>
<td>$560</td>
</tr>
</tbody>
</table>

Additional cost may be incurred to construct a scale model of the ESA Site. Likewise, a small-scale version of the water tank and irrigation system may be desired.

Because Case for Cambodia was awarded with a $300 grant from Innotech the budget maximum is currently around $600. Case for Cambodia should be able to stay within the reaches of this budget. However, when the expenditures do become clearer, an element of unforeseen costs will be factored in (5% of budget).
5. Alternative Solutions

5.1. Water Distribution:

A water distribution system needs to provide water to the sanitary facilities and irrigation of the fields. There are many different irrigation methods. Methods range from basic watering with a bucket to highly sophisticated sprinkler systems. The most efficient method is a trickle irrigation system. When watering plants with a bucket, often water is applied rapidly and much of the water runs off or evaporates, rather than soaking into the soil. Sprinkler systems are not very efficient either, because it requires energy and much of the water evaporates before it reaches the soil. Trickle irrigation systems apply water slowly and directly to the root system, so the plant always has moist soil and can develop strong root systems with little, to no, soil and nutrient runoff. Figure 2 shows an example of a small trickle irrigation system.

![Figure 2: Trickle Irrigation System](http://www.dripirrigation.com/drip_irrigation_help.php?pgv=Gravity)

There are two possible sources for the water distribution system. These sources include water pumped from the well or water channeled from the streams into a detention pond. The groundwater level during the dry season will depend on how much can be pumped out of the well. A detention pond would be replenished during the wet season when the level of the stream is high. The bottom of the detention pond would have to be lined with a clay type soil or plastic lining to reduce infiltration of the water during the dry season, keeping in mind that there will be a lot of evaporation of this water.
5.2. Sanitary Facilities:

When designing a sanitary facility in a developing country, it is important to take into account the available resources and the alternative options that best suit the Cambodian people.

The first options to examine are whether the sanitary facility should be connected to the common building, or if it should be separate structure. The client requested that the sanitary facilities be connected to the building. This way, it will be located at an easy access location. Alternatives for the gravity flow system from the elevated storage tank and waste disposal will also be considered. Also, the waste removal method is a big choice with several alternatives. Currently, pit latrines, stabilization ponds, oxidation dikes, and other alternatives are being researched and examined to find what the best solution to remove the waste is.

5.3. Common Building:

The common building will be used for group meetings, classes, housing visiting groups and general shelter in the rainy season. One alternative is to construct the building entirely out of concrete, because of its strength and water-resistance. A concrete building could be modeled after the NIBC center, which is an existing school and Christian center in Cambodia.

However, one of the goals of this project is to respect the culturally different style of architecture, and a concrete building would not fit into the building style of the villagers. A house in Cambodia is typically built of wood and rests on stilts about three or four feet off the ground and is built strictly out of local materials such as bamboo with a thatch roof. Concrete is a good material to use, but a large concrete building would seem very out of place in rural Cambodia. So, a second option is to construct the school building in the local style using only wood.

Another option is to compromise between the two. The bottom floor could be composed of a concrete patio, while the top floor will be supported either by concrete columns and enclosed by local materials. Using a concrete foundation and base rather than wood, increases the life and integrity of the building. The layout plan is shown in Error! Reference source not found..
Other smaller decisions need to be made once the main building type is selected such as: Do we fully enclose the classrooms? Are the bathrooms inside the structure or just attached to the side? And how is the second floor attached and supported?

5.4. Bridge:

There are many different design solutions to building a bridge that can span a minor creek. The first solution to the problem would be to build a slab bridge. A slab bridge could be done in two ways. The first would have a concrete foundation on each side of the stream and then would have a slab to cross the stream resting on top of the foundations. This solution would be the simplest bridge design and would probably be the easiest bridge to build in Cambodia. The second design for the slab bridge would be to pour the whole bridge as one unit with a foundation underneath. This bridge could be more difficult to build since it must be all done at once and has less room for error. The second alternative would be to build a truss bridge. A truss bridge would be very similar to the first slab bridge design in that it would have foundations on each side of the stream. The difference in this type of bridge is that it would have some form of truss running along both sides of the bridge that would help distribute the loads. This bridge would use less concrete and more timber probably making it a cheaper design. The problem with this is that it would be much harder to build than the slab bridge and would probably take longer as well. These two designs can be seen in Error! Reference source not found.
A third solution would be to put in a culvert of sorts and then fill in land over top creating a land bridge. This design would be the easiest to build since all they would need is some sort of culvert that would need to be large enough to handle the flows during the wet season. After they purchased this culvert they would fill in the land over top and then either go with just the land as the bridge or put in some form of roadway overtop.

5.5. Renewable Energy Source:

Currently, there are three major alternatives for the production of energy at the ESA. Solar, hydroelectric, and wind power all appear to be viable options. All options have the potential to produce sustainable energy to areas which power is not easily accessible.

6. Feasibility Study

6.1. Water Distribution:

Water to the sanitary facilities will be supplied directly from the well source. It is important to have enough pressure to get the water down the pipes properly in a gravity-fed trickle irrigation system. The water pressure will depend on the change in elevation of the elevated storage tanks at the well sanitary facilities. There is a well that exists on the ESA site that will be used for this distribution system. Currently there is a diesel pump that is drawing the water from the well, but a renewable energy source is being looked into for drawing the water. It is known that the well is at a higher elevation than the location of the ESA site. This will help when gravity transferring water from the well to the sanitary facilities. We also know that the ESA site is between two streams. This will be useful when extra water is needed for irrigation. During the rainy season there is a
considerable amount of water that flows through the streams, which could be harnessed to fill a detention pond for extra irrigation water capacity.

6.2. Sanitary Facilities:

The sanitary facility was one of the first things requested by one of the contacts for this project, S.K. Lee. There is no doubt that sanitary facilities can be constructed using the materials available locally. Because less than 25% of the population of Cambodia has access to proper sanitation, there may be challenges and obstacles in properly designing a cost effective and efficient sanitary facility. It has been proven though that there are feasible solutions to provide sanitary facilities in developing countries. Latrine pits have been proven effective in many different countries and the idea of a septic tank could be implemented if the funds could be provided for. Not only are sanitary facilities feasible, they are part of a movement through developing countries to greatly improve the quality of life for the people.

6.3. Common Building:

Building in Cambodia is a much different and simplified process than in the United States. A design that would be efficient in the States may have no relevance in Cambodia. To be a feasible design the building must be built using materials that are easily accessible and affordable. Some of these material choices affect other decisions; for example, clay tiles are a common building material, but they are much heavier than other roofing materials driving up the strength requirements of the rest of the structure. Cedar and eucalyptus are the most available types of lumber in Sre Ambel and will be used in the design of the roof and second floor. The client requested that the building resemble the local style of architecture. A house in Cambodia is typically built of wood and rests on stilts about three or four feet off the ground; this style of building needs to be tweaked in order for it to meet the purposes of the building. While still keeping to the generally type of building, the second floor will need to be elevated to make room for classrooms and meeting space on the ground floor. The ground floor even may need to be slightly elevated to keep dry during the rainy season and will be constructed from concrete. Using concrete will lengthen the life of the structure because concrete is water resistant as opposed to wood which takes on water and rots.

On the second floor 10-12 dorm rooms have been requested which is going to increase the overall size of the structure from the original 6m x 12m (20’x40’). Space is not much of a constraint for the building, but as the size goes up the cost will also increase. Without a set source of funding for this project increased cost may delay the construction of the structure. Without a set of building codes in Cambodia, it is up to engineering judgment, and U.S. building codes where applicable, to make sure that the building is
safe to occupy. Sanitary facilities are incorporated into the design of the building, but may be attached to the outside so that in the case of an additional water tank the support will come from separate columns rather than affecting the entire structure.

6.4. Bridge:

While building a bridge to span approximately 12 meters is difficult anywhere heavy machinery is not available it is still feasible. The main resources that will be used to build this bridge are concrete and/or wood, which are both readily available in Cambodia. Much of the wood could be harvested from the site, or from neighboring areas, and concrete could be purchased and brought in. Since the resources are available all that is needed is a design and workers who are able to build the design. If the culvert design is chosen the only problem that could arise is difficulty finding the culvert in Cambodia. As long as there are culverts available in Cambodia that design would take very little time and could be built by just about anyone. Overall, with a few workers this job is very feasible and should be no problem to complete after the plans are drawn up.

6.5. Renewable Energy Source:

There are numerous concerns to acknowledge when discussing the feasibility of energy production for ESA. One of the biggest factors is the site location; because the site is located three hours travel from a major city, proper precautions must be taken. First of all, the system should be relatively easy to deliver and assemble. Likewise, the integrity of the system must be able to hold up. A product that requires frequent specialty maintenance is not feasible. The system should provide sufficient power so that energy for 1-3 days can be stored in less than ideal conditions (i.e. a cloudy day for solar power). Further redundancy could be considered that in the case of partial system failure sufficient electricity will still be provided to the school.

Cost is another issue for feasibility of renewable energy sources. In the past, cost has been a primary opponent to the advancement and application of renewable energy. Such sources of energy tend to have a relatively high capital cost. However, over recent years, with the assistance of newer technologies and research, costs are becoming more competitive.

The primary work for the energy system has been research. Investigation has been primarily focused on the development, cost, and feasibility of the different alternatives. For the design selection, a pros and cons list has been developed. Contact with a Cambodian solar company Kamworks has provided the team with information regarding the solar irradiation in Phnom Penh. Solar irradiation is the amount of energy emitted by the all of the sun’s wavelengths in 1 second to an area of 1 square meter. This data can be viewed in Error! Reference source not found..
Because the irradiation does not fluctuate to a large degree, and the fact that the value never drops below 4.5 KWh/m^2 shows that solar power is a feasible option. Further information from Kamworks informed the team that wind power is not a feasible option. There simply is not enough wind to operate a turbine on a consistent basis. Further data from The World Bank Asia Alternative Energy Program provides wind charts of the area. It shows that the location of EAS has poor wind velocities throughout the year. For the majority of the year wind speeds are less than 2 meters per second. The remaining alternative is the hydro-power which remains less than ideal due to the low elevation difference in area. Without sufficient hydraulic head efficiency of a turbine would be significantly less.

7. Detailed Task Specification

7.1. Water Distribution:
- Research the maximum amount of water that will be used
- Determine the area used by the trickle irrigation system
- Determine the amount of time between fillings of the elevated storage tanks
- Determine how much water could be stored in a detention pond to use for irrigation
- Calculate pressure needed for a gravity-fed trickle irrigation system
- Determine the height of the reservoirs to get the desired pressures for both the sanitary facilities and trickle irrigation system
- Survey the land
- Determine how the water is going to be transferred from the well to the reservoir
- Design the elevated tanks, detention pond, and piping configuration

7.2. Sanitary Facilities:
- Research waste management and removal in developing countries
- Calculate pressure requirements for required water pressure in shower, toilet, and sink
- Determine the location and size of a water reservoir upstairs in the sanitary facility to provide additional pressure
- Design shape and structure of facility

7.3. Common Building:
- Research material strength, ideal materials—research strength of cedar, eucalyptus, concrete, clay tiles, types of soil, etc
- Foundation design, concrete piles vs. mat foundation
- Column design, weight of structure supporting
- Layout and floor framing plan
- Details—how is floor framed into columns
- Truss design

7.4. Bridge:
- Find out the maximum load that the bridge will need to support
- Consider different bridge design types with maximum load in mind
- Calculate the forces that the bridge supports will need to be able to hold
- Find most feasible materials to support the calculated forces
- Draw up plans with dimensions for future building of the bridge

7.5. Renewable Energy Source:
- Assess demands
- Survey stream (Hydraulic head, soil, cross sections, rain fluctuations)
- Wind pattern analysis
- Solar analysis
- Develop system
- Develop storage
- Test system—model version

8. Preliminary Design

8.1. Water Distribution:

The preliminary design consists of an electric pump, preferably powered by a renewable source, which moves water from the well to an elevated tank. The pump may be driven by a wind turbine or merry-go-round, but currently a diesel pump is used. From the elevated tank, the water will gravity feed from that reservoir in an underground pipe to a
reservoir on top of the sanitary facilities. The reservoir on the sanitary facilities will provide pressure for the toilets, showers, and sinks as well as the irrigation system. An alternative water source for the irrigation system is a detention pond, which will be filled in the rainy season from the stream. The irrigation system will consist of a water main and branches off to the main line to the rows of plants, with small holes punched in the pipes.

8.2. Sanitary Facilities:

The design of the sanitary facility will rely on the shape and structure of the common building. Most likely the bathrooms and showers will be connected on the side of the building where it will be closest to the water supply. Different ideas are being explored at how to get water for the showers and toilets using only gravity. Another issue faced is how the waste will be safely removed. Pit latrines are a popular method that is cheap, but has several disadvantages. Using a septic tank with a leeching field is also a better option, but more costly. There will be an elevated water tank on top of the bathrooms to give additional water pressure and storage to make the system more efficient.

8.3. Common Building:

As part of the school’s facilities, the common building will accomplish several purposes: house groups of visiting students, provide classroom space, allow for large gathering space and shelter in inclement weather. The building will be two stories tall with the second story reserved for 10-12 dorm rooms. The second story will be supported by a set of concrete columns and fully enclosed with natural materials (bamboo, cedar, etc.). Underneath the second story there will be a large, unenclosed, multipurpose open space. At one end, the building will contain one or two classrooms. The ground floor will also host the sanitary facilities. The floor will consist of either concrete or clay tiles, along with clay tiles on the second story floor. Stairs will run along the end of the building up to the middle of the second story connecting to a hallway with the dorm rooms on either side.

8.4. Bridge:

At this point in time the preliminary design for the bridge is coming down to one of the three options described above. All three options will need to span a distance of ~12m (~40ft) and will have to be able to withstand the added flow of the wet season. The slab bridge will have one of two types of foundations that will hold the bridge above the ground. The only difference in the foundation is that one is poured with the bridge and the other the bridge slab sits on top of the foundation. The truss bridge on the other hand would most likely be built to sit on top of the foundation much like the first foundation.
option for the slab bridge. These two types of foundations can be seen in Reference source not found.

![Foundation Designs](image)

The third option would require some sort of culvert. If culverts are readily available in Cambodia this option would be the easiest to build and design.

8.5. Renewable Energy Source:

8.5.1. Solar Power

Solar power allows for great flexibility in the production and expandability of the system. Multiple panels can be introduced into the system to account for the necessary demands. However they do have a few disadvantages. The biggest disadvantage is that sunlight is not always prevalent and therefore charge must be stored. Furthermore, because the charge is not always continuous, the flow into the battery must be controlled in order to maintain the battery’s longevity.

A potential system would be comprised of the following elements:

- **Solar Panels:** The photovoltaic cells within these panels collect the suns energy and convert it into DC electricity. Probably will be designed using 175W model that Kamworks carries. Six to ten panels will most likely be necessary.

- **Mounting Rack:** The rack holds the panel in the optimal position of sunlight.

- **Batteries:** Linking batteries together forms a collection system for the charge accumulated throughout the day. Specialty solar batteries are sold and are suggested, but car batteries have shown to be effective as well. The company Kamworks tends to use the solar batteries which are maintenance free.

- **Charge Controller:** The controller is essential for regulating the battery. Without it, the life of the battery will drastically be reduced.
- Wiring: Various wires and connection devices will be required to adequately tie the system together.

- Inverter: An inverter is required in order for the electricity of the system to be converted into AC power.

8.5.2. Micro-Hydro Power

Micro-hydro power systems have the ability to supply energy ranging from 200 W to 300kW in secluded areas. Such turbines have the potential to drive machinery as well as generate electricity. Likewise, micro-hydro systems are easily assembled and are often devised of supplemental material.

Within the design of a micro-hydro system there are two major types. The first type generally diverts stream water into a separate channel using a weir. This channel then utilizes an elevation difference to provide the necessary hydraulic head to drive the turbine. This type is simple to develop and cost effective. However, diversion channels usually require significant elevation differences. The second type is a storage scheme. This option dams off a section, backing up water. Disadvantages include a higher cost and susceptibility to clogging from silt from the river. Advantages to both systems in comparison to the other alternatives is that hydro power would provide more of a constant energy flow, requiring less electrical storage capabilities.

There are two potential streams that run through the property. Flows through the one stream were measured to be approximately 700 L/min by Jon Cooper. According to Cooper, the flows in the two streams were relatively similar. Likewise, the flow is expected to be much larger during the rainy season. Further investigation of the site is necessary to fully determine the feasibility and logistics of a micro-hydro power system design.

8.5.3. Wind Power

The third alternative is using a wind turbine to provide power to the ESA. This method is also suitable for off-gird applications and has been proven rather reliable. The biggest issue with wind turbines is locating a site that is subjected to optimal wind velocities on a regular basis. Based on data from a wind study of Southeast Asia by True Wind Solutions, the site may provide moderate to poor energy production (Wind Energy Resource Atlas). Our contact at Kamworks, Arjen, said wind would not be a practical option. Another downfall is that typical wind turbines are sized at a height of at least 30m. Such a height may not be feasible for the site design at the school.

A basic system would require the following:
- **Blades**: The Blades must be sized to specification of the energy demands and the height they are placed above the ground.

- **Shaft and Turbine**: The turbine generates the DC power from the rotation of the shaft.

- **Base Components**: The base must be able to support the system and designates the height of the system.

- **Battery System**: This system would most likely be very similar to that of the solar power alternative.

### 9. Method of Approach

#### 9.1. Water Distribution:

A reservoir on top of the sanitary facility will provide pressure for toilets and showers as well as pressure for the irrigation systems. A gravity fed irrigation system needs to have a minimum pressure 10-30psi to operate efficiently. This pressure will be supplied by the difference in elevation from the reservoir by the well to the reservoir on the sanitary facility. The size of the reservoirs will depend on the amount of water used each day by the sanitary facilities as well as the area of proposed irrigation. To design a gravity fed water distribution system, pressure calculations need to be done. This will decide the height of the reservoirs as well and the capacity of the reservoir. The demand at both the sanitary facility and the irrigation system will decide the needed capacity of the reservoirs.

#### 9.2. Sanitary Facilities:

In approaching this design, the focus must initially be on making the design simple and effective for the Cambodian people. The design will include two of each, toilets, showers, and sinks. Concrete is a possible option for material use in the main common building and will also be the material of choice for the bathrooms and showers. Other available materials will be further examined to determine their feasibility. It will also be important seeing the water demand in the village compared to what output will come from the elevated water tank.

#### 9.3. Common Building:

First, the loads need to be determined and the maximum load case figured out. The roof trusses can be designed using local types of wood and roofing materials. Then the concrete columns and foundation can be designed with the added roofing and flooring.
loads considered and the layout decided on. Detailing should be done throughout the process to make sure all the components fit together properly and cohesively. Finally it will be modeled in a computer-modeling program such as AutoCAD or Revit for further design or construction purposes. A scale model will be constructed when the final design is completed.

9.4. Bridge:

The method of design for the bridge will include using computer modeling of the bridge along with hand calculations to figure out the load that each bridge support will have to support. After the loads have been calculated, materials will be researched to find which type of material will best support the loads for the environmental conditions they will encounter. Once the bridge has been designed to hold the maximum loads it will be modeled in AutoCAD to give exact dimensions and multiple views for the builders. This model will also show which materials will be used in the bridge.

9.5. Renewable Energy Source:

The energy system must be able to meet the demand of both the common building and house. Once this load is determined it will be multiplied by a scaling factor allowing excess charge to be stored for incremental situations. Likewise, efficiencies must be determined for all steps of the process. This will determine the number and rating of the solar panels used. Storage capabilities will also be dependent on these inefficiencies.

10. Business Plan

10.1. Master Plan

The Eden School of Agriculture master plan will be designed so that it can be used as a model for other similar sites. While there is no real way to put our plan into “Full Scale Production” on a regular basis, Case for Cambodia hope that it will be used for future developments in the area. Because the plan will be designed affordably and use local natural resources that could be easily acquired in many different countries it could be used as a model for sites in other developing countries. The business plan is to make the project available for the assistance of as many people as possible in as many different settings as possible. After completion of the site plan, files will be available on the Case for Cambodia home webpage and will be open for developmental usage. The full business plan is found in the Appendix B.

11. Project Obstacles
11.1. Distance:

Since Cambodia is on the other side of the world distance can be a major problem when detailed designs are being prepared. Finding the site specifics is one of the biggest challenges that arise with distance. Since no one from the group can make the trip to Cambodia the site specifics must be found through a third party. This means that most of the design will be planned around other people’s data. During interim Rachel Koopman has volunteered to acquire needed site data.

Communication is another obstacle. The only way to communicate with the site is through emailing which can take extra time compared to being able to communicate in person or by the phone.

11.2. Cultural Differences:

There are many cultural differences that need to be accounted for when designing the master plan for ESA. Cambodians standard building practices are very different from what Americans are used to. Also, the materials used in Cambodia are usually dependant on what materials are available on-site or the least expensive.

Cultural differences go beyond building practices. Cambodians have different ways of communicating and often have a slower pace of life, which Americas are not used to. They are very hospitable and will go out of their way to try to answer questions. Noticing cultural differences creates a unique opportunity to understand a totally different way of life and learn from the joy Cambodians have from so much less.

11.3. Financial Support:

The master plan for ESA will have to include plans for financial support because an average yearly salary is about $500. The need for financial support will also be a deciding factor in design including materials and methods of construction. The design will be as cost efficient and effective as possible.

12. Design Norms

12.1. Cultural Appropriateness:

Cultural appropriateness is an important goal of Case for Cambodia. The design, materials, and construction methods of this project should reflect the culture and customs of the Cambodian people. Common and available materials will be used and incorporated without compromising performance. Likewise, the design should fit traditional building
techniques. Supplies and machinery will not be as accessible as they are in the United States.

12.2. Transparency:

The design will also incorporate a high level of transparency. Clear communication results in a greater reliability and performance. Similarly, the different components will be arranged so that they are easy to use. The master plan will be designed in a way that common people should be able to carry out the tasks, not just a skilled laborer.

12.3. Integrity:

Throughout the design, Case for Cambodia hopes to provide a high level of integrity. This master plan should facilitate a relationship between the people of Cambodia and their land. Similarly, this design should exemplify the best efforts of Case for Cambodia. The designs should be effective, cost effective, and reliable through a reasonable lifetime.

12.4. Integration of Faith:

A Christian approach is necessary to give Eden School of Agriculture the best design possible. Incorporation design norms will help the master plan be simple, efficient, and helpful to this educational facility. Every aspect of the master design plan is created to improve the quality of life. Case for Cambodia will be working with a community of learning that is centered on the church and Christian principles. As Christians we are called to provide for those in need. In 1 Peter 4 it says, “Be generous with the different things God gave you, passing them around so all get in on it.” We must shine the light of Christ so that others will know Him based on who we are.

13. Conclusion

Our project consists of a master plan for the Eden School of Agriculture in Cambodia proposed by Navy Chann-Chhay. The master plan includes a water distribution system to irrigate experimental rice fields and daily use, sanitary facilities and a common building, a bridge spanning a small river, and a renewable energy source enough to power the facilities. As funding is difficult to rise, the final project will include a plan for phased installation. The next steps of our project are to begin the design phase. Each alternative will be considered and eventually the best one chosen. Each group member has been assigned a part of the project in order to break it down and each part will be broken into individual tasks with specific deadlines. Research is an ongoing task that will be a large portion of our time. The project will be completed by May including site drawings, building plans, and a full report submitted to the client.
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Appendicies

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