Final Report

2011 Civil Engineering and International Development Summer Internship

The University of Western Ontario
In Partnership with The Ministry of Agriculture of The Gambia and GAM-Solar Energy & Engineering Co.

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Executive Summary

This report describes the work undertaken by the UWO student interns during their time in The Gambia. The students who participated in the internship were Daniel Hyland, John Iezzi and Yena Ahadzie. They arrived in the country on May 5th, 2011 and departed on August 6th, 2011. The students worked with Soil and Water Management Services (SWMS) of the Ministry of Agriculture, as well as GAM-Solar Energy & Engineering Co. Ltd.

During the time with SWMS, the students observed many of the functions of the organisation and participated in checking existing structures and construction sites to ensure that they were properly built. Many of the structures observed and worked on include: dike/spillway systems, bunds and causeways, bridges, and tidal irrigation systems. Many suggestions were also made. While the students believe their suggestions should be given serious consideration, they also recognize that there may be factors that they are unaware of preventing the suggested improvements from becoming realities.

As the students worked with GAM-Solar, they developed a strong understanding of the potential uses of solar power in The Gambia as well as solar water pumping. Much was learned about how these systems are designed and maintained, as well as the challenges that are often encountered as well as the benefits. The use of solar water pumps in gardens was also observed.

During the time with GALDEP (Gambia Lowland Development Project), much was learned about how these projects are planned, designed and implemented. The students also observed many of the issues facing Gambian farmers and what GALDEP is doing to combat these problems. Some of the practical steps being taken include fencing to protect from animals destroying the crops, an improved irrigation source and the capacity to preserve and process excess food. Recommendations were also made, such as using a drip line system, and increased preservation and processing of food.

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Introduction

As part of the requirements for the Civil and International Development program at the University of Western Ontario, three students undertook a summer internship in developing countries in Africa. The students: John Iezzi, Daniel Hyland and Danielle Yena Ahadzie spent three months in the summer working with the Ministry of Agriculture's Soil and Water Management Services in Yundum, The Gambia.

This report details what the three interns in the Gambia spent their time doing and the knowledge they acquired throughout the internship. Due to uncontrollable administrative and financial set-backs, the students shared their time between two different companies: the Soil and Water Management Services and GAM-Solar Energy & Engineering Co. Ltd. As part of the internship, the students also undertook a community development course with the West African Community Development Training Centre (WACD-TC) for the first three weeks in May, where they interacted and learned alongside their Gambian peers how to effectively utilise community development training. Details of this time can be found in the student's forthcoming feedback report. The following report deals with the more technical aspects of working in the Gambia.

Background

Geography, Climate and Population

The Gambia is the smallest country in mainland Africa with a surface area of approximately 11,300 square kilometres (Njie, 2009). It is located in the western tip of Africa and stretches about 440 kilometres from east to west (Manka, 2010). The Gambia is bordered on the North, South and East by Senegal and on the West by the Atlantic Ocean, which also acts as the outlet for the River Gambia. The river also divides the country into the North and South banks which extend 12-15km on either side of the river, resulting in a width from 24km at the tip to 50km at the mouth of the Atlantic Ocean. There are seven administrative regions in the Gambia: two municipalities (Kanifing Municipality and City of Banjul) and five provincial regions: Upper River Region, Lower River Region, Central River Region, West Coast Region and North Bank Region (Manka, 2010).

According to the 2005 National Population and Housing Census, the population of the Gambia is about 1.6 million and growing at a rate of 2.8% per year (FAO, 2008). 74% of the population is believed to be rural (NIB, 2008), and with a density of 128 people/km^2- the Gambia is believed to be one of the most densely populated countries in Africa (Camara, 2006). Statistics indicate that 60% of the population is under 25 years old (FAO, 2008) and the male-female ratio is approximately 49.2 to 50.8 percent respectively (Manka, 2010).

Majority of the Gambia lies in the Sudano-Sahelian zone resulting in a typically Sahelian seasonal climate: a long dry season (November to May) followed by a shorter rainy season (June to October) which lasts on average three months. Average annual rainfall is about 1000 mm however this figure ranges from 850mm - 1597mm depending on the agro-ecological zone (NIB, 2008). An estimated 80% or higher of the total annual rainfall occurs in the three months of the rainy season leading to short agricultural production systems (Njie, 2009) and a high dependency on rain-fed practices during those months. Spatial and annual variation in rainfall distribution also affects agricultural practices either through uneven rainfall patterns in certain areas of the country which may hinder crop cultivation or the unpredictable occurrences of droughts which affect the seasonal crop production severely.

Economy, Agriculture and Food Security

In 2007, the estimated GDP of the Gambia was USD 643million per year with a GDP per capita of USD 377 per year (NIB, 2008). After tourism, agriculture is the next largest sector of the Gambian economy and accounts for 22-28% of the GDP and 85% of export earnings. Statistics indicate that two-thirds of household incomes are attributed to agriculture related activities and 77% of the country's economically active labour force is also employed in the agriculture sector (NIB, 2008). However, despite the high level of local involvement, agricultural productivity in the Gambia remains low. This can be partially attributed to the rain-dependent and small-scale subsistence farming techniques that are used. Traditional agricultural practices are based on extensive land use, intensive but rudimentary manual labour and little technological or agricultural inputs (Njie, 2009). This combined with erratic or unreliable rainfall patterns, extended periods of drought and possible soil infertility leads to an agricultural system that is extremely vulnerable to climate variations.

According to the National Investment Brief paper presented at a high-level conference on Water for Agriculture and Energy in Africa (NIB, 2008), only 250,000ha of farmland in the Gambia are currently cultivated out of a total of 558,000ha of total available cultivable land. Crop production is the major agricultural activity and on average 120,000 ha of the upland area is allocated annually for coarse grains such as early millet, late millet, maize and sorghum. The main cash crop, groundnut, occupies 45% of the cultivable upland while in the lowland under rain-fed and irrigation conditions the staple food, rice, takes on average up to about 120,000ha. Domestic food production satisfies only 50% of the country's demand and consequently the difference between food production and consumption is filled by imports, especially of rice. Imports of rice are currently estimated to be about USD 40million (NIB, 2008). Therefore to help increase productivity of the farmlands and to improve the country’s food self-sufficiency, the Ministry of Agriculture in conjunction with the Government of Gambia and foreign donors implemented projects concerned with developing the countries lowland and upland agricultural fields as well as implementing an integrated water resource management unit (PIWAMP).

Other

The livestock and fishing sectors also contribute partially to the Gambian economy. Livestock production provides employment for 12% of households and food security for more than 60%. Composed mainly of cattle, donkeys, small ruminants, poultry and swine, the livestock also serve as a source of additional manual power on farms and are essential for the transportation and production of crops. Fishing is an important activity for people living close to the river and its tributaries and reportedly contributes up to 8% of the country's GDP. Fish also provides a relatively cheap and nutritious source of animal protein to local diets (SWMS, unpublished report, year unknown).

The Gambia ranks 155 out of 177 countries in the 2007 UN Human Development Index (HDI) Report (NIB, 2008) with a value of 0.39 (FAO 2009). The UN HDI measures the social and economic development of a country based on three major factors: health, education and living standards (UNDP, 2010). With a low GDP per capita and a relatively low HDI value, the Gambia may be considered one of the less developed countries in Africa. However the country’s most recent Poverty Reduction Strategy Papers (PRSP II 2006) indicate an increase in the Gini Coefficient 0.466 to 0.483 which indicates a slight reduction in the equality of distribution of wealth. Unfortunately when this value is paired with the low GDP per capita- it most likely shows a non-uniform poverty distribution related to a need for better education and training. A potential strategy to address this discrepancy may involve an increase in income generation strategies aimed at specific sectors. (Keenan, 2011)

PIWAMP and SWMS Background

PIWAMP

The Participatory Integrated Watershed Management Project (PIWAMP) was initiated in 2006, and has a lifespan of 8 years. It aims to build on its predecessor which focused on lowland areas, the Lowland Agricultural Development Project (LADEP, 1997-2003), and expand to the rest of the country. The goal of PIWAMP is to reduce rural poverty by increasing food productivity through better soil and water management techniques. The project is funded by the African Development Bank and International Fund for Agricultural Development, with a total budget of 17 million USD. The Gambian government also contributes a portion of the funds, and the local communities contribute in the form of labour and simple tools.

The project uses a demand-driven, participatory approach. The first step is for villagers to apply using a simple Request for Assistance form. The villages are then selected based on the feasibility of the villagers’ request, which may depend on the tasks that the villagers are requesting as well as the amount of involvement and interest that they show. Usually about 25 villages are selected each year, and the villages that aren’t selected can reapply the following year. The next step is preparation and planning, which involves community development workers leading a participatory rural appraisal and the formation of a Village Farmer Association. Needs can further be assessed and a watershed management plan can be developed as well as a community action plan. After that, the project is implemented with joint efforts from the villagers and SWMS. After completion, the Village Farmers Association is responsible for ensuring the structures are maintained, and may need to collect small fees from the villagers in order to do this. Further and bigger projects may also occur if the villagers have shown they can handle the smaller ones.

SWMS

SWMS is the main implementing body for PIWAMP. They are part of the Ministry of Agriculture, and the PIWAMP activities which they do are listed and described below.

Dikes and Spillways

The primary purpose of the dike and spillway systems constructed by SWMS is to sustain and improve rice cultivation. The spillway is 35cm high, which ensures the 35cm of water (necessary for rice cultivation) is trapped and the excess water can continue to move downstream. Depending on characteristics of the land such as elevation change, more dikes/spillways may be constructed downstream in order to achieve a relatively consistent 35cm depth of water. The result can be described as a "cascade effect". When the dike intersects a road or pathway, it can be reinforced with concrete to ensure it keeps functioning as planned, while allowing people and vehicles to pass over it without eroding the structure. The road can be raised and a gentle slope can be added to ensure vehicles such as donkey carts can pass over it. Another option is to use the dikes as a pathway, and by adding a concrete slab at the spillway crossings people will be able to walk along the length of the dike.

Figure 1 - Dike and Spillway recently constructed at Sohm

Sluice gate and salt water flushing

A large portion of the River Gambia is salty, and when the tide rises and floods the adjacent lands, salt can be deposited on the land, making it unsuitable for any kind of agriculture. These lands will remain unsuitable for farming unless the salt is removed. The method SWMS uses to reclaim the salted land is to build a dike and a spillway with a sluice gate between the river and the farmland. When the river floods, the dike will prevent the salt water from intruding into the farmland, and once it rains, freshwater will accumulate on the farmland side of the dike. The freshwater will dissolve some of the salt so that when the tide of the river has receded, the sluice gates can be opened, releasing the freshwater and taking a portion of the salt with it. SWMS estimates that after 3 years the field will be suitable for rice cultivation once again.

Bridges and Causeways

This aspect of SWMS's work is crucial as it gives farmers access to fields and markets that otherwise would have been impossible, or near impossible, for them to access. Bridges and stable roads are constructed over swampy areas making rice fields accessible to the local farmers. Farmers will also be able to access new markets where they can sell their produce.

Figure 2 - Bridge/Causeway at Kalim Valley

Field Reclamation from Acidity

Many of the farmlands are prone to becoming acidic due to specific soil characteristics (depending on past uses of the land and molecular composition) as well as the constant addition of fertilizer. When the land is tilled, oxidation occurs resulting in a decrease in the soil's pH. In order to make the fields suitable for rice production once again, lime is distributed over that land surface in order to bring the pH back up to acceptable levels, which is between 5.5 and 6.5 for rice.

Figure 3 - Faraba Banta - Reclamation using lime (the white particles)

Tidal Irrigation

This process takes advantage of the river's changing levels in the freshwater portion of the river. Canals are dug, which fill with water when the river's level rises. Once the tide subsides, the water in the canals is trapped by the gates. A system of canals and gates can be constructed in order to control the amount of water in different parts of the rice fields. Tidal Irrigation has a high initial cost (US$4,500-7,000/ha), as much excavation of canals and construction of gates is required. However, maintenance and running costs are low as no fuel is required for pumping. The only work that must be done is cleaning and de-silting of the canals once a year and any repairs that may be required.

Figure 4 - Tidal Irrigation at Sapu

Bunds and Diversion Channels

Bunds are structures that are placed throughout farmers' fields in order to collect overland runoff to prevent erosion and loss of fertile soil. The number of bunds on a field depends on various factors such as the slope and size of the field. The bunds transport the runoff to a main diversion channel which collects the water then carries it to either a main water body, or the lowlands where it can contribute to the irrigation of rice fields. When a bund intersects a road or pathway, concrete is used to reinforce the bund to ensure both the bund and the road can still function properly. While on a site visit, bunds that were eroded around the concrete road section were observed. This was caused by vehicles, such as donkey carts, attempting to go around the concrete bump. This jeopardizes the function of the bund, allowing water to pass through, and suggestions to fix this problem will be made in this report.

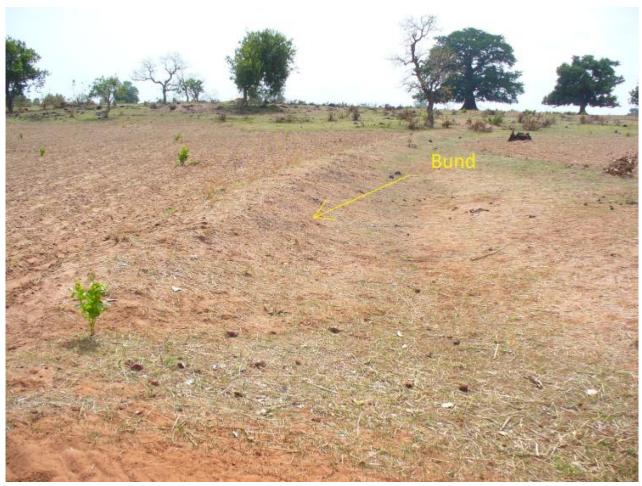


Figure 5 - Bund in Kachong

Recommendations:

Bunds

Problem – Erosion at the intersection point of the bund and a road. Concrete was added and made to be the same shape and height as the bund in order to ensure the performance of the bund. The concrete portion was also the same width as the road. However, it was found that donkey carts and other vehicles would put one tire on the concrete and one just next to it on the bund, attempting to have a less bumpy ride. This resulted in the erosion of the bund right next to the concrete portion, on either side.
Solution – Our first suggestion here was to simply widen the concrete portion in order to discourage vehicles from eroding the bund. However, this may not be adequate. It was therefore deemed necessary to add a post on either side of the concrete, which would prevent vehicles from eroding the bund. As long as there was enough space between the posts to allow a truck to pass through, it would be wide enough. There is very little traffic on these roads and in the event that two vehicles arrive at the point at the same time, one could wait for a few seconds to allow the other to pass. The posts could be made out of wood, or perhaps concrete. Reflectors should also be added to it for night time safety. The posts

should also be strong enough to ensure they cannot be removed. While SWMS continually attempts to educate farmers and villagers about maintaining the bunds, in some cases villagers seem to not understand the importance of the bunds so this may be a better option for ensuring the bunds function properly. This solution would involve little extra cost to the project as one bag of cement costs D 195 (roughly 7 USD), which would produce more than enough concrete for one intersection point (in addition to the existing concrete).

Another option would be to make the concrete bump longer and more gradual, thereby reducing vehicles likelihood of trying to avoid it. However if two vehicles were approaching the intersection from opposite directions on the single lane pathway, this design would do nothing to prevent them from both driving onto the bund in order to avoid each other and share the road.

Figure 6 - Erosion beside the intersection **Figure 7 - Example of the bund being eroded**

Vetiver Grass

While it is good that SWMS has been using Vetiver grass to stabilize many of its dikes and bunds, many of its structures still have not been stabilized by the grass. While on site visits, of all the structures observed, the students noticed only one dike that was stabilized by the grass. SWMS has been attempting to continue adding Vetiver grass to more of its structures during the rainy season (it is not possible to transplant the grass during the dry season), however, it has been difficult because of administrative and funding issues. For example, it was difficult to get fuel in order to transport the grass from the nurseries to the sites. Also, at one time funds were not getting to the nurseries, which meant the work needed to grow the Vetiver grass was not being done by the staff. It is our hope that SWMS will continue to stabilize their new structures, as well as structures that have already been built, by adding Vetiver grass to them. This will increase the lifespan and reduce the required maintenance of the structures in the long run.

Village Farmers Association (VFA)

Throughout a project's construction phase, villagers contribute labour and basic tools, which is a positive way of instilling a sense of ownership into the project. Once the construction is complete, the entire system is handed over to the VFA for them to operate and maintain. This is a good way to ensure that the project is successful and sustainable. Since the villagers own and directly benefit from the project, they will see the importance of maintaining and caring for it. However, while this is the case in most villages, there are some cases where the villagers neglect to carry out essential maintenance operations. One case observed was the Kalim Valley Access Bridge. It was the villagers' responsibility to paint the metal portions of the bridge to protect it from corrosion, however at the time of the visit it was apparent that the bridge had not been painted in a long time and that corrosion was taking place. Long term maintenance issues, such as corrosion, may seem less important to villagers than other more obvious issues, such as a leak in a dike. More education on how corrosion works and prevention may be needed. It may also be beneficial to assess the VFA of a particular village to see if it is functioning properly and if all members are contributing. This could be a possibility for future student interns. The student(s) could live in one or more villages for a short period where a VFA exists, in order to observe how it functions, what seems to work and what doesn't seem to work, and to help it function more effectively.

Another example was in the Tidal Irrigation rice fields at Jahaly. Each individual rice field is fed by an appropriate canal. In one situation, it was found that a farmer had cut through the road in order to take water from another canal. This may have been because his specified canal was not producing enough water. However, ideally he should have gone to the VFA to try to get them to fix the issue before taking it into his own hands (they could use their excavator to clean the canals leading to his lot, for example). The local VFA may need to be more active in order to keep the farmers satisfied. Of course, there may be other issues that we are unaware of that are affecting this situation, therefore our suggestion is based only on the information we had at hand and shouldn't be considered the only option.

Tidal Irrigation

As suggested by Mr. K. Manka of the SWMS, while constructing a Tidal Irrigation system, it would be beneficial to save the excavated topsoil, and use the subsoil for road construction, instead of the other way round. This way the fertile topsoil could be used on the fields, and would result in a better crop output as well as less fertilizer consumption. The one drawback to this suggestion is that it would be more time consuming and therefore more costly to do this. Even though it would have long term benefits for the farmers, this method does not generally happen because of the cost.

GAM-Solar

The Company

GAM-Solar Energy and Engineering Co. Ltd. is a Gambian-based solar energy company which was registered in the Gambia in 1998. It focuses its activities in five main energy related areas: photo voltaic (PV) solar electricity systems, solar water pumping and irrigation systems, solar water heating systems, maintenance and repair of solar systems and energy efficient and LED lights.

About 80 villages and over 250,000 villagers are currently benefiting from access to clean potable water from solar pumping stations installed by GAM-Solar. In addition to plans to provide and sustain rural water supply, GAM-Solar has teamed up with numerous NGOs, community-based organisations and the Gambian Government to build an extensive local network to implement its projects. The company recently signed a contract with the Ministry of Agriculture to fully equip 20 horticultural gardens with boreholes, fencing, reservoirs and solar pumping systems (The GALDEP Project). It also works with private companies and individuals to provide customised design and installation services for schools, clinics, offices and homes.

The company aims to play a key role in the three areas it considers vital to development: *electricity, water and food* through the design, installation and promotion of sustainable alternative energy technologies.

Solar energy

The concept behind solar energy is the use of photovoltaic (PV) cells which convert light into electric power. An array of PV modules (commonly known as panels) are arranged to produce the voltage or power necessary to meet the required energy or pumping needs. This array is connected to an inverter which is an electronic device that converts low voltage direct current (DC; from PV panels and storage batteries) to high voltage alternating current (AC; the standard form of electrical supplied by a country's utility grid which varies).

During the course of the time spent with GAM-Solar, the students had the opportunity visit the village of N'jawara on the North Bank of the Gambia to observe how the company assesse a village's energy needs, discuss the implementation of solar panel systems with the villagers and parties concerned, and subsequently provide a cost/installation quotation to the village and any sponsors involved.

The initial cost of any solar project is known to be quite high as the equipment used is quite costly. Depending on the energy needs of the individual or society, a complete solar energy package may include the panels or modules, a back-up or storage battery pack and an inverter. A solar tracker (which is a mounted array of solar panels that automatically tilts to follow the path of the sun thus producing more energy), may also be installed and has been installed in two locations in the Gambia, the largest and best-known being located at the Bwiam Hospital in the Central River Region of the country. GAM-

Solar installed this system in 2008 and it reportedly has 92 panels of approximately 24 volts or 130watts.

Figure 8 - Bwiam Hospital Solar Panel array with mounted tracking systems

Due to the high cost associated with both installation and maintenance solar energy equipment, GAM-Solar devised a long-term financial initiative to help maintain and sustain the solar systems in villages. The scheme requires villagers to pay a small fee for every metred 1000 litres of water used based on a contract between the company and community. The funds are collected every three months and used mainly for maintenance costs, however a fraction of the fee collected contributes to a Maintenance Fund for future repairs after the standard five-year warranty period offered by the company.

Solar water pumping

As mentioned earlier, GAM-Solar provides solar water pumping services. This usually takes on the form of boreholes being drilled, a solar-powered pump being installed and a storage tank or distribution reservoirs being made available for use. The main device used in this scenario is the pump controller which monitors the functions of the pump. The controller can be modified to perform many functions including stopping and starting the pump, DC-to-AC or voltage conversion, low water and full water tank shutoff via a float-switch mechanism (i.e. the controller pumps less or more water depending on how high or low the water level or floating device in the tank is.)

We observed borehole testing and drilling during our work with GAM-Solar and learnt the basics required to drill a borehole. Before water is pumped from a borehole or drilled well, a few important parameters must be considered:

- *Recovery rate*: the rate at which groundwater refills the plastic or steel casing of the well after the water level is drawn down by pumping. This is used to determine/decide the production rate of the well i.e. how much water can be pumped without detrimental effects to the ground water table.

- *Drawdown and drawdown level*: the lowering of the water level in a well due to pumping and the depth to the water surface from in a well when it is being pumped.
- *Static water level*: the depth measured from the surface to the water in the well under static conditions. This level may be subject to seasonal variations or depletion.
- *Head/vertical lift*: the vertical/upward distance that the water is pumped (minus the losses due to friction in the pipes). This parameter is an important factor in determining what size of pump to use.
- *Distance to aquifer/GWT*: vertical depth of the water tables which dictates the depth to which the borehole must be drilled to access the clean water source. Also important to note would be the presence of any nearby potential polluting sources which could contaminate the water being pumped since filters or water treatment is not incorporated after well drilling.

(Lorentz, 2010)

Future projects

As solar energy grows in popularity as an alternative energy source, the rise in local businesses offering cheap and non-durable panels becomes a concern. GAM-Solar is planning a program in collaboration with the Gambian Technical Training Institute (GTTI) to educate young technicians on the advantages and disadvantages of solar power as well as train them in identification of the pitfalls to be avoided that would impair the efficiency of the technology, such as imitation goods with wrongly-labelled specifications and wrong installation of the panels leading to high repair costs.

Another potential project in the making is in collaboration with ASNAPP an agri-business based in Accra, Ghana which promotes sustainable and income-generating local-based agricultural practices. GAM-Solar's involvement in this project will be to provide the PV modules and tracking systems, while working to use new agricultural technologies such as drip-lines, greenhouses and hydroponics (Noteboom, 2010). The project is promised to be partially funded by the GEF/UNIDO and requires a few other sponsorship partners to proceed.

Recommendations:

One issue to consider with the rise in acceptance of solar energy as a viable and technologically appropriate power source in developing nations (where there are six or more hours of intense sunshine daily) is whether or not solar power is in fact the ideal solution for all energy needs. It is necessary to exercise caution and objectivity in prescribing solar systems for villages and villagers who without the help of external monetary aid probably would not be able to afford installing the systems. The appropriateness of the technology should be continually assessed on a case-by-case basis especially since repair of malfunctioning or broken equipment is extremely costly and usually requires outside input. An option to combat this and encourage human resource development/capacity building would be to train the locals in maintenance and repair of the systems in case of breakdown. This will help further instil a sense of ownership by the community towards the system and decrease the chances of vandalism and disinterest in the system.

It may also be beneficial to have an in-depth assessment done on the strength of the maintenance fund. If all the villages that have solar water systems are paying into the fund, theoretically it should be strong enough financially to cover any future repairs that may be needed for all the villages. However, oftentimes villages may sign the maintenance contract (which stipulates that for a fee GAM-Solar will maintain their pumping system during the specified time frame), but after some time be unable to make their payments to the fund. There have been some cases where the village has made no payments at all. This can pose a problem for the fund since it is a collective fund and relies on all villages to make payments in order for there to be enough funds for repairs to be made. It may be worthwhile for future UWO interns in The Gambia to explore the option of investigating why some villages cannot make the payments and any ways to ensure the sustainability of the maintenance fund, either by ensuring villages make their payments or otherwise.

In the future, it may also be possible that carbon credits will be given to developing countries that are choosing to invest in alternative forms of energy. The idea is that developed countries producing large amounts of carbon emissions will be taxed, and the tax will then be given to developing countries and invested in the renewable energy sector. This will greatly benefit companies like GAM-Solar since it can strengthen the sustainability of the PVPs throughout the country and help them to be more effective as a development partner. This could be another potential area for research for future UWO interns.

The GALDEP Project

The Gambia Lowland Development Project (GALDEP) is a 5 year project established in 2006 and is expected to conclude in early 2012. The objective of the project is to improve food security and alleviate poverty by enhancing the production and productivity of rice and other cereals, vegetables and fruits in the Western Region of the Gambia through the improvements of lowland, soil and water management and developing irrigation in the upland. To do this, the GALDEP project has been split into two sections; Rural Infrastructure, and Borehole drilling and Irrigated Land Development.

Rural Infrastructure

The rural infrastructure portion of the project utilizes many of the operations that are undertaken by the Ministry of Agriculture with the PIWAMP project. This project consists of implementing 600ha of water control and retention structures, rehabilitating 400ha of existing deteriorated structures and the reclamation of 400ha of land lost due to salt water intrusion. All of these processes are outlined above, in the ‘PIWAMP and SWMS Background’ section of the report.

Borehole drilling and Irrigated Land Development

The irrigated land development section is the largest part of the GALDEP project. It consists of providing 20 villages in the Western Region of Gambian with gardens. Each garden will be enclosed by a fence and contain a drilled borehole with pump system, a distribution network of pipes, 20 small ground reservoirs and one large elevated reservoir. As the project stands now, 10 of these villages have been selected to also have a storage facility on the site which will be used to preserve the yield until market. These 10 villages were chosen based on the community's display of commitment and enthusiasm towards the project. Of the 100 ha of gardens (5ha per village), 70ha are allotted for vegetable growth, while 30ha are for orchards; the expected flow rates have been calculated based on this demand (Manka, K. 2009)

Fencing

A large issue that farmers in the Gambia face is how to eliminate losses due to animals feeding on their crops. To alleviate this issue, GALDEP has proposed the solution of enclosing each garden with a 2m barbed wire fence. The height of the fence is sufficient to restrict access from unwanted cattle and the barbed wire, angled to both the inside and out, will greatly reduce the amount of monkeys that are able to infiltrate the garden and spoil the farmer's yield.

Figure 9 - Fence enclosure

Bore hole and Pump/Solar Panel System

A borehole is dug at each site down to the location of the aquifer. The bore hole will be 8" in diameter and dug using compressed air with a 210mm drill bit. Upon completion, the water will be pumped constantly for 6 hours and then a recovery test will be performed to ensure the site can handle the pumping. Using this data, a safe yield for the site will be identified. Water samples are then taken and analysed for quality at the laboratory of the Department of Water Resources.

Figure 10 - Water Quality testing, shortly after borehole was dug

Each site has been analyzed and a specific pump had been selected based on the sites required head. From here, the necessary amount of panels were selected and sized to handle the load.

Elevated Storage Tank

The main storage unit for the water at each site is an $80m^3$ elevated concrete tank. The pump will feed this tank directly via a 110mm PVC pipe. The tank will be elevated to a height of 6.6m, providing sufficient head for the transport of water to each of the individual ground reservoirs.

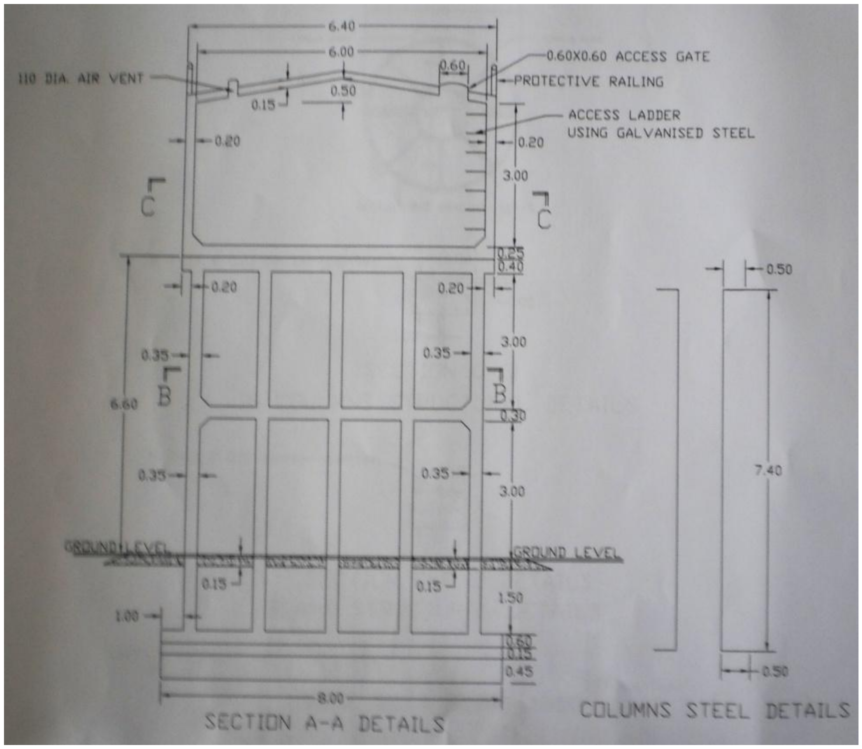


Figure 11 - AutoCAD drawing of the Elevated Reservoir

Ground Reservoirs

There are 24 small, 5m^3 (2.5x2x1) ground reservoirs on each garden site. The reservoirs are placed evenly throughout the garden, splitting it up into 24 plots and creating an equal walking distance for each area's gardener. The reservoirs are constructed using 6 inch cement blocks which are capped and coated with concrete. This design is sufficient enough to withstand the hydraulic pressures of the water at full capacity and is much cheaper than a completely concrete design. As the women will be fetching water from these reservoirs, a 25cm concrete matting around the parameter of the reservoirs is included in order to reduce erosion of the surrounding soil.

Figure 12 - Concrete Block Reservoirs, before matting was placed

Crop Preservation Room

As the Gambia is located in a semi-arid climate region (Manka, K. 2010) and refrigeration is not always sufficient, many of the crops spoil before they can be sold in market. To improve this problem, the project has planned the build of crop preservation storage facilities on 10 selected sites. These facilities, to be shared by the locals who use the garden, are to be used for temporary storage of produce. The solar panels that power the borehole pump will also be used to supply the power required to refrigerate these facilities.

Pipe Distribution Network

For the transport of water in the project, PVC pressure piping was chosen. From the borehole to the main elevated reservoir and from the reservoir straight down the middle of the garden, 110mm piping will be used. Secondary piping of 50mm will then branch off to split the garden into the 24 plots. The tertiary piping will be 25mm and connect from the secondary to the smaller ground reservoirs. The schematic is show below in **Figure 13.** As it would be detrimental to grow crops over the piping, the area above the main distribution line will be used as an access road, and above the secondary supply lines will be used as a footpath. This procedure should ensure minimal damage to the network over time.

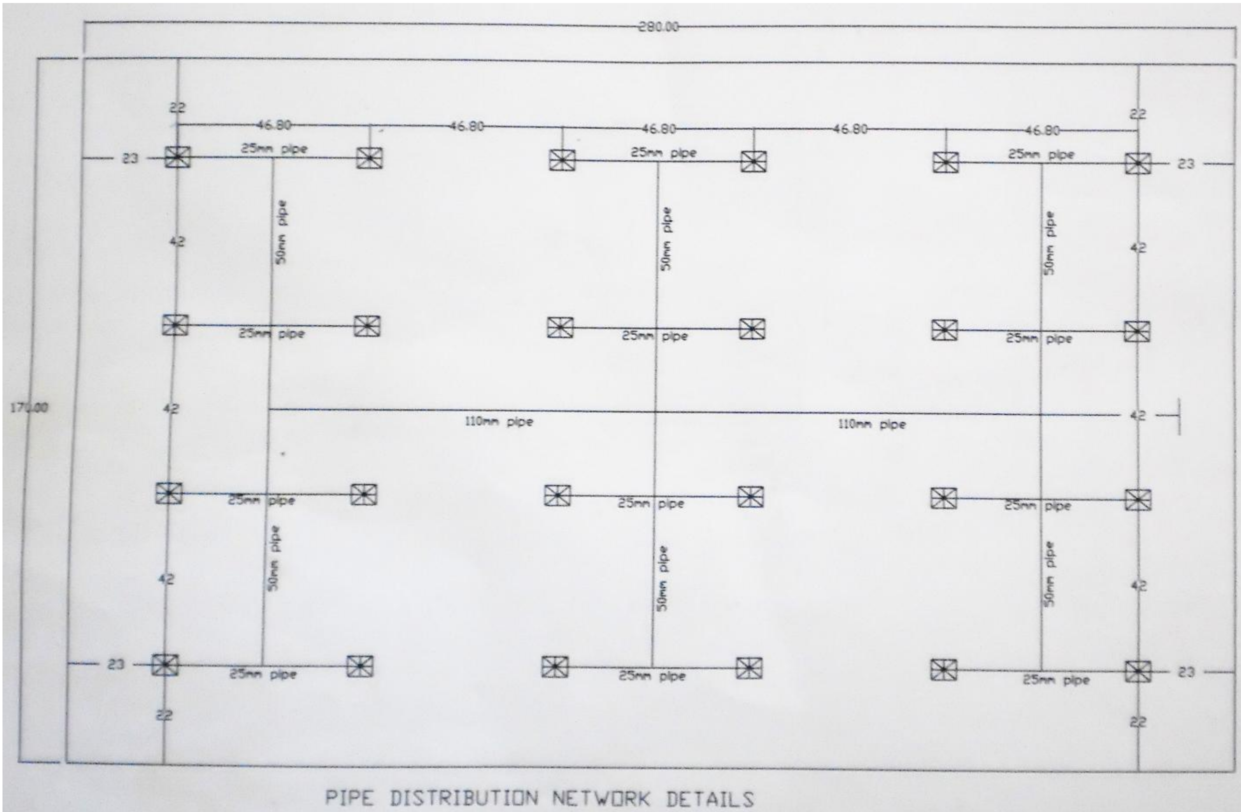


Figure 13 - Pipe Distribution Network

Recommendations:

As this project is near completion and the Ministry of Agriculture is looking into expanding this project to regions other than the West Coast Region, it is imperative that the design be reviewed and improvements be implemented. From our observations, there are a few areas we see potential for adjustments that may result in reducing the cost of the project as well as improving the satisfaction of the beneficiaries.

Implementing a Drip Line System:

An immerging technology in the agriculture world is the drip line system. The system involves running a pipe system just under the surface of the garden. The network of pipes will be connected to a main elevated reservoir and a simple valve will be switched in order to water the gardens. Drip line systems are ideal for situations where rows of crops are planted, which is the case for the existing gardens.

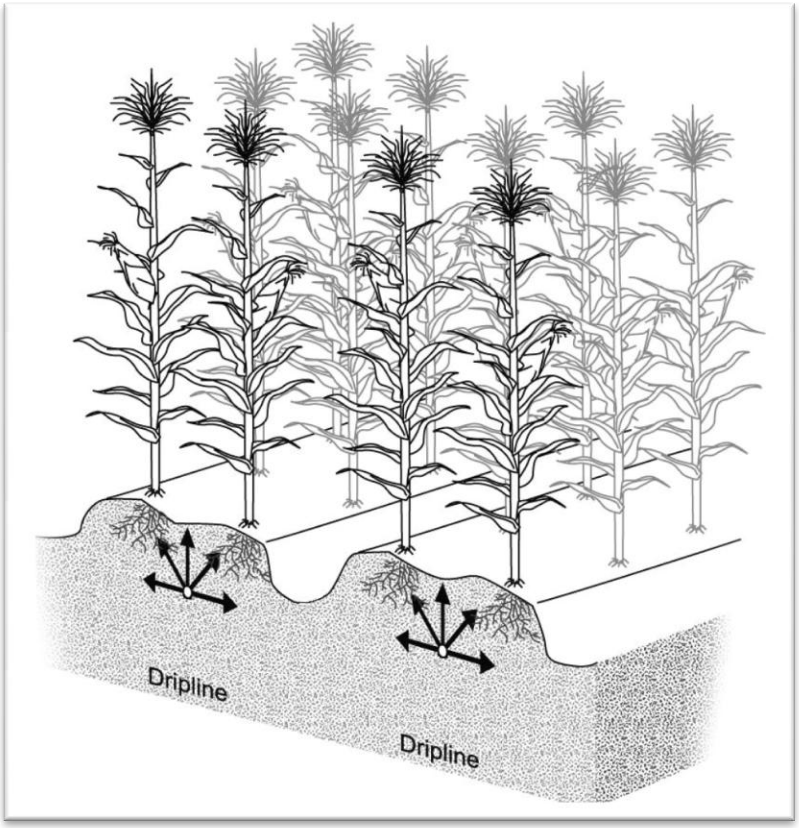


Figure 14 - Drip line Schematic

One of the key benefits to this system is the great decrease in labour for the gardener. With the current reservoir system, the gardener will have to continually walk back and forth to the reservoir in order to water the crops. The drip line system will significantly reduce the amount of work the women will have to do and the amount of time they will be gardening. This additional time could then be used selling the crops at the market and thus, increasing the family income.

Secondly, since the drip line system waters the plant directly, the amount of water lost in transport from reservoir to the crop and in runoff will be greatly reduced. Water is applied under the surface and only the area close to the root of the plant is wetted, unlike surface irrigation whereby water is lost wetting more of the surface profile than necessary (FAO., 2007) . Most drip line systems also have the available feature of releasing fertilizer in the network as well, which would also reduce waste.

As the direct drip line system will only require one central supply reservoir, there will no longer be the need for the 24 ground reservoirs. This will not only greatly reduce the cost of the project, but it will increase the garden area that can be used for crop growth.

Crop Preservation Room:

At this time in the project, only 10 of the 20 village gardens will have a crop preservation room. Without adequate refrigeration most of the crops produced in these gardens will spoil within a few days. Having the cool preservation rooms built at only half of the sites is insufficient. In the future, due to the large yield expected from these sites, it is strongly recommended that each site contain one of these preservation rooms.

Project Logistics

Contractors: GAM-Solar

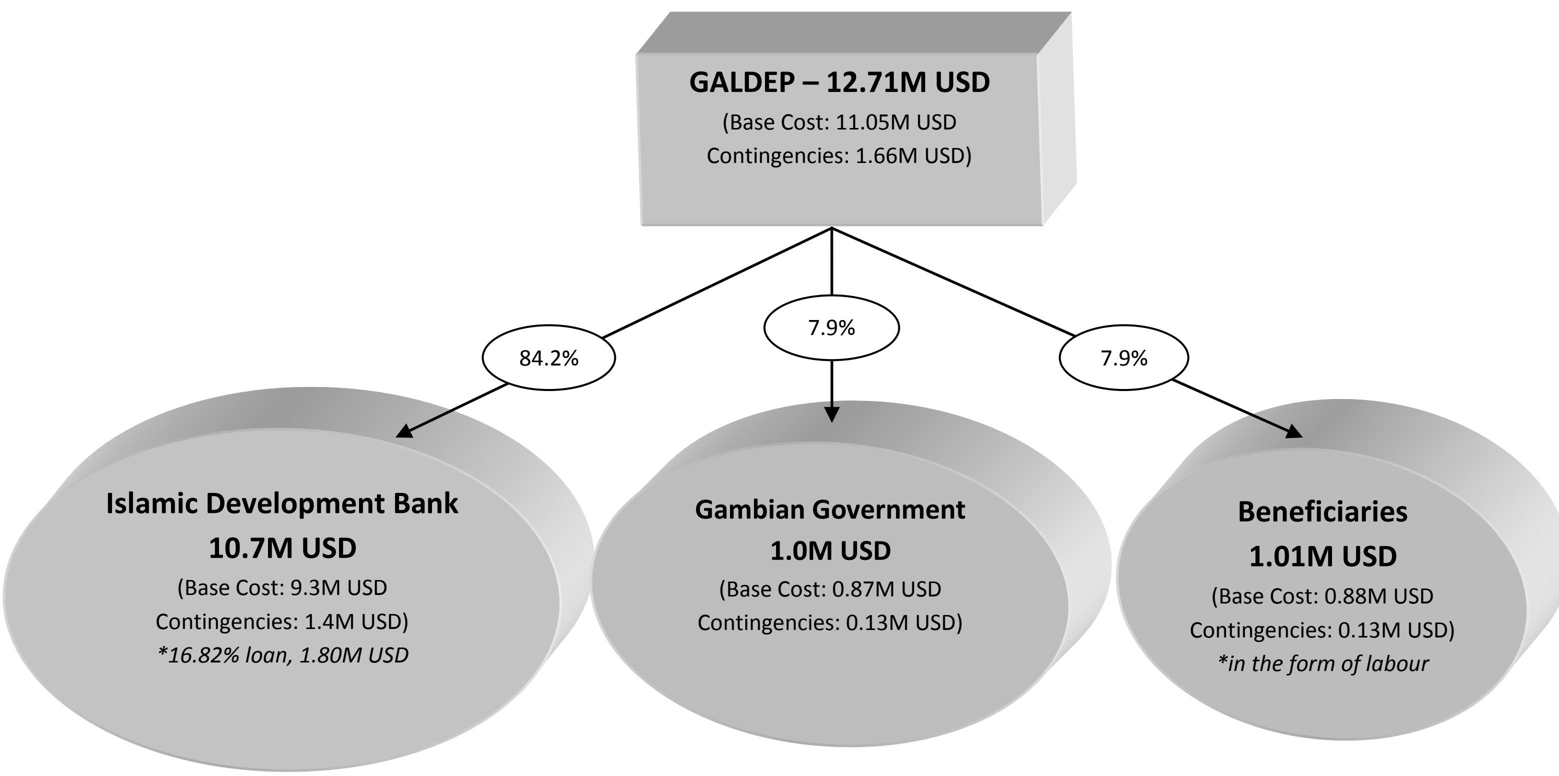
- Responsible for the design and build (subcontracted) of the elevated tank, ground reservoirs, fence enclosure, borehole and pump system.

Consultant: The Gambia Ministry of Agriculture, Soil and Water Management Services

- Responsible for conducting a soil analysis and geological survey of each site.

Funding: IDB, Gambian Government, Beneficiaries

Cost Breakdown:



Conclusion

As the Gambia is still reliant on the import of crops which can be grown in country, it is imperative that they continue their efforts in the agricultural sector. From what the students have observed on their internship, there are many projects currently on the go and planned for the near future that address this issue. With the help of the recommendations made in this report and hopefully the commitment of future UWO interns as well as their Gambian connections, a meaningful turnaround can be made in this area. Many new methods, improvements and adjustments to the existing schemes may hopefully be considered, but only with the devotion of the farmers and villagers will the progress continue.

Overall, the students have learned a great deal from this internship. Although there were setbacks to do with inconsistent work schedules, they were fortunate enough to make use of their time by exploring and understanding a wide variety of the projects going on in the country. They hope that their recommendations will be just as useful as the amount of experience they received while in the Gambia.

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