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Adidome Farm Institute

Feasibility Study for Irrigation Facility

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Executive summary

Agriculture is the most important economic sector in Ghana, with smallholder farms dominating the sector and accounting for the majority of the total economic output.

Ghana is faced with the challenge of developing efficient regional water management strategies to ensure a more sustainable income for farmers. Vegetable production is low during the dry season, which is about three months due to water shortages and cyclic droughts.

The Adidome Farm Institute, a government run institute for third-year students is exploring irrigation systems for the expansion of agricultural crops. The expansion fields could serve as demonstration plots. Traditionally, farmers use watering cans or hoses & sprinkler systems to water their crops. The Farm is one of three institutes in Ghana which train young adult smallholder farmers in the latest improved farming techniques.

This Feasibility Study discusses three alternatives for irrigation schemes using different water sources for irrigation: 1.) a pumping system with water sourced from the Volta River and piped a 4km distance; 2.) tubewell development utilizing groundwater as the major source for irrigation, and 3.) an integrated water management plan that relies primarily on existing rainwater as the source.

The alternative selection is ultimately not the report writer's decision. Each alternative scenario has pro's and con's. Alternative 3 is the writer's preferred scheme but is one which requires more tasks, commitment and dedication. It is essentially a comprehensive water management plan to efficiently capture, store and distribute water resulting in a sustainable cost-effective farm practice.

The Farm receives much rainfall water - at no cost. Alternative 3 presents a plan which could be implemented to: 1.) capture and store rainfall; 2.) use discharged outfall water from the adjacent Water Treatment Plant, and 3.) pump pond water - to irrigate potentially new agricultural fields which would serve as demonstration plots.

The Scope of Work included a soil analysis. The current crop selection of "heirloom plants" are appropriate for The Farms' soils. Soil Testing proved the addition of nitrogen to the main vegetable garden has been beneficial, encouraging the practice of using animal manure on the Farm's other eleven garden plots.

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Introduction, Background and Purpose

The Scope of Work for this feasibility study indicated the final report will help the Adidome Farm Institute, henceforth referred to as The Farm to "obtain funds and support to purchase, operate, and maintain an irrigation system. Concurrently, preform a soil analysis which may supply information to improve agricultural practices".

The feasibility study would be remiss if it did not embrace the entire site, and the resources of the region and focused myopically on solely a potential plot area (now mostly grassland) to be transformed into crop demonstration plot (s), the size, scope and irrigation requirements of which are largely theoretical.

The Farm is one of three public vocational agricultural institutes under Human Resources Development & Management, Directorate of the Ministry of Food & Agriculture in Ghana. It is located about 300 km from Accra, and lies in the Central Tongu District within the Volta Region. The Farms' mission is to train practicing and prospective farmers on relevant knowledge in the agricultural sector. Currently there are 140 strong students (106 male and 34 female) with an average age of 20. The four academic area of study are; animal production, crop production, farm mechanization and related studies.

An irrigation system is being explored for several reasons, chief of which is to have the capacity to provide crops water year-round. The Farm has been dependent on erratic rainfall patterns, presumably getting more so with global climate change, resulting in flood and drought risk which inhibit crop growth/food security, lessen one's income potential and at The Farm impede academic teaching.

This feasibility study, like all such reports asks many "what is and what if" questions.

> What is the current situation; how much water is utilized, what is the crop yield per acre.
>
> What type of irrigation system will best improve The Farm; cost-to-benefit analysis, pros and cons, and other indigenous factors .
>
> What are the constraints, expectations, and improvements from several alternative irrigation systems.

Feasibility Study Methodology

This feasibility study was conducted by one qualified ACDI/VOCA volunteer in a short time period in two steps: 1) literature reviews from GIDA, IWMI, IFRIP, WB, FOA, MOFA-DAES, U of F, UNDEP, USAID and other sources; and 2) site visits and interviews with local chief, farmers, NGOs, Farm Staff & Students.

Description of Site Area

The Farm initially opened its doors in 1964 with land totaling 33.66 hectares (83.04 acres). Recently, Community Water & Sanitation Agency (CWSA) constructed a Water Treatment Plant (WTP) north of and adjacent to the Farm's buildings. Although this decreases the site by approximately 8,000 square meters the major benefit is The Farm has free use of the WTP overflow water. A large three-story government building for Central Tongu District Assembly of Adidome also seems to be on the original Farm site, bringing the total available land down to approximately 73 acres.

The ecological habitat has been classified as Tropical Savannah Grassland and most of the farm is not under cultivation. Approximately 50 acres (Google Earth does not supply zoomed in view) could be cleared, tilled and planted if water were an available resource. However, the clearing would have to be balanced with Farm livestock grazing needs.

Soil

According to the Volta River Authority, the Adidome Farm region is Tropical Savannah Grassland. Annual rainfall is about 770mm, keeping the soil wet or moist during the rainy season and hard during the dry season. Soil is a clay/loam mixture, dark colored, with smooth texture. The nutrient status is generally good even though there may be low levels of nitrogen. Most local farmers use organic manure as a fertilizer supplement.

Table 1. Soil Test Results Nov. 5, 2014 Mosser Lee Soil Test Kit

Analysts: Abraham Bolombo, Henry Adzaho and Instructor Moses Narteh

No.	Site	pH	Nitrogen (N)	Phosphorus (P)	Potassium (K)
1	Phase 1	7.0	Medium	High	High
2	Phase 1	5.5	Low	Medium	High
3	Phase 2	7.0	Low	Medium	High
4	Phase 2	6.0	Low	Medium	High

5	Phase 3	6.0	Low	Low	High
6	Phase 3	7.0	Low	Medium	High
7	Phase 3	6.5	Low	Low	High
8	Phase 3	6.5	Low	Low	High
9	Garden E	7.5	Medium	Medium	High
10	Garden E	7.0	Medium	Low	High
		6.6 AVG.	**70% Low 30% Med**	**4% Low 40% Med 1% High**	**100% High**

Ten soil tests were performed, seven samples of which were pulled from fields which are potentially new recipients of water from a future irrigation scheme. Collectively, the soils were a bit acidic at 6.5 (7 is neutral) as opposed to alkaline. Typically The Farm soils are low in Nitrogen, an exception is the Garden which has been the recipient of manure fertilizer. Nitrogen does not stay in the soil long, so a 70 percent low range is not surprising, especially after a rainy week. Phosphorous stimulates primary root growth and it also supports many basic functions in plants including strengthening cell walls, water regulation, and flowering.

Potassium is not tied up in organic forms in the plant. Therefore, it is easily leached from plant residue with moisture. Consequently, the timing and quantity of precipitation relative to harvest and sampling can affect the Potassium levels measured by a soil test.

Commercial fertilizers contain N, P and K but are costly and generally not used in small holder farms in Ghana.

These tests were a snippet in time, for accurate portrayals of the soil nutrients, including macro-nutrients, testing should be done often and analyzed well.

Climate

The daily average temperature at the farm site (near Accra) is 24 to 28 degrees C . A research review reports the average rainfall 770 mm or 7. 8 inches. There are two rainy seasons, April, May, June, July and September, October, November.

Traditionally, the peak rainy month is June. Late November- early March (approx. 13 weeks) the harmattan winds tend to blow in from the Sahara desert, bringing dryness and dust to the entire region. Source: www.weather-and-climate.com

Table 2. Garden Area & Crop

Garden	Size – square feet	Crop November 2014
A	6,144	Gboma (African Spinach)
B-1	17,920	Cassava
B-2	5,520	Maize
C-1	7,616	Cow Pea, Millet
C-2	9,792	Cassava
D	17,024	Cassava
E	26,880	Assorted Vegetables
F -1	65,472	Pawpaw
F -2	62,720	Watermelon
G	76,160	Vegetables
H	16,128	Vegetables
I	15,808	Pineapple
12	**327,184 sq.' TOTAL**	**or 7.5 acres**

The current garden scheme of 12 small gardens scattered mainly in-between the buildings total an area of 327,184 sq. ft. (7.5 acres). The vegetable gardens (A, E, G, H, I) collectively total 125,312 sq. ft. (2.8 acres).

Only the Vegetable Gardens are typically watered, and this is on an as-needed basis . Watering is done by The Farm students, with use of a yellow ¾" hose. Water comes from the tanks, which is treated water.

The cost of water at The Farm was $368.00 USD or GH₵ 1,124.20 for the month of October. The usage was 702 Liters (185 gallons).

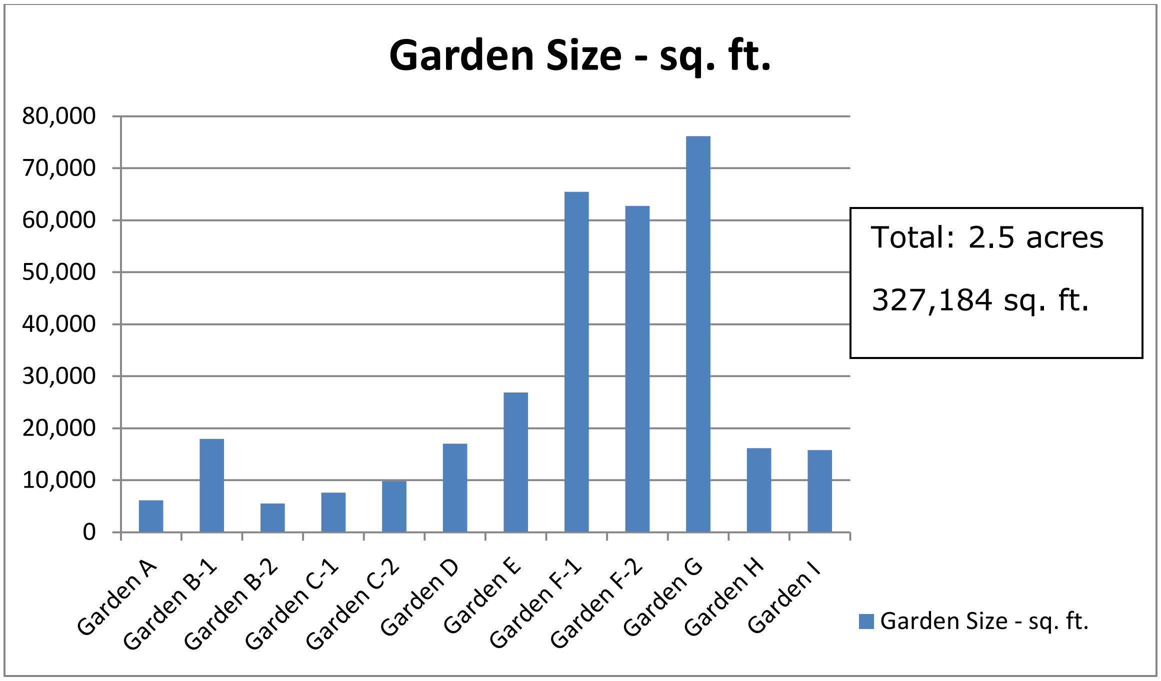

Chart 1. Garden Sizes In Relative Square Feet

Water Source Choices

Water source choices for irrigation are; rainwater, surface water or ground water.

The largest area of surface water is the impounded Volta River, with the big Akosombo hydroelectric dam upstream. The Farm Institute is located many miles downstream from the Dams' reservoir, and the river itself is 4 km (2.5 miles) away and quite robust. The Volta River is the water source for Community Water and Sanitation Agency utility and supplies the region with most of its water needs.

Groundwater in the Farm region seems to be a perched water table, and said to be saline at even a shallow (≤ 1.5 m) depth.

Rainwater is free and plentiful but seasonal, and should be captured and stored for use in the drier months: usually December, January and February.

Water sources could likely come from a combination of sources to adequately supply the Farm's needs during extended dry periods.

Traditional and Emerging Irrigation Choices

The selection elements for every irrigation system(s) are; type of crop and desired water schedule; size, shape, location and terrain of the field; energy availability, reliability and cost; initial equipment investment cost; source of water and cost, and; labor requirements.

Further, the regional irrigation systems in Ghana may be sub- classified into two types: traditional and emerging.

Traditional systems have been initiated and developed by the government and/or select NGOs. They tend to be costly and conventional. Because the topography of large agricultural areas are rather flat, a seminal component are irrigation systems which rely exclusively on pumping. Pumps in this traditional category need costly petroleum based fuels. The maintenance of the pumps and pipes is continuous, and arguably the region lacks the capacity for easy mechanization repair.

Emerging systems are non-conventional: such as utilizing unusual materials and/or power supplied by the sun, wind, or animals to serve as energy for pumping. Solar power appears to be the energy of choice in this region. Emerging systems are as varied as the entrepreneurial spirit. They are relatively small-scale with more affordable and perhaps simplistic pumping, maintenance, energy requirements and distribution components. Published literature about these systems is relatively scare. It is nice to think there is an alignment of the emerging technologies with the strengthening export market for horticulture and agriculture.

The Central Pivot

The central or center pivot is a widely used irrigation system and the named in the Scope of Work for this Feasibility Study. The center pivot is a self-propelled system that rotates around a central pivot point. The drive mechanism for this system may be water pressure, hydraulic oil or electric motors. The time required for a rotation depends on the system size, pump or well capacity and the amount of water to be applied at each application.

Since center pivots cover a circular area, they are best adapted to fields that are round or square. Because the majority of fields at Adidome Farm are neither, some part of the field may remain unirrigated. On some irregular-shaped fields, farmers could install part circle systems to cover the maximum amount of area. These systems generally cost more on a per-acre basis since they are not capable of completing a full circle. Hence, center pivots have end guns that are large sprinklers located at the outer end of the system. These can be turned on and off as the system moves around the field; they allow the system to water an additional 100 to 150 feet in corners and other irregular parts of the field.

Further decisions for a Central Pivot system are the selection of sprinkler options; low, medium and high pressure systems, and choice of the traveling gun system such as a cable-tow or hose-pull.

Solid Set

In lieu of the Central Pivot System, a Solid Set irrigation system, consisting of portable above-ground aluminum pipes with sprinklers spaced at intervals along the pipe. Permanent solid set systems consist of buried pipes (usually PVC plastic) with evenly-spaced sprinklers mounted on risers. These systems are typically used on small acreages and/or crops that have a high cash value such as sod. Permanent set systems are also frequently used as under-tree sprinkler systems on pecans and as overhead systems for frost/freeze protection on apples, peaches, blueberries and strawberries.

That said, the small size of the desired Demonstration Plots at the Farm and location in Ghana, do not merit the scrutiny of a complex Central Pivot System nor the permanent Solid Set.

Micro-Irrigation

Therefore, Micro-Irrigation Systems such as drip irrigation, industrial strength garden hoses, tanks on vehicle and garden sprinklers are more appropriate.

Commonly used in the field are 300 gallon tanks for watering hard to reach places. The vehicle for pulling a cart with the water tank could be a small all terrain vehicle or ATV or a compact tractor with a relatively narrow track width and ability to easily traverse a rocky pathway.

Current Water Storage & source Scheme

This feasibility study begs the questions: How much water do they have, how much is needed and where will it go? The amount and location are listed below: note all polytanks store treated water purchased from the local utility.

Table 3. Polytanks - Size & Volume

Polytank – gallons	**Number**	**Volume**
500	10	5,000 gallons
400	2	800 gallons
300	5	1,500 gallons
60	3	180 gallons
40	1	40 gallons
	21	**7,520 gallons or 28,466 liters TOTAL**

Table 4. Concrete Storage - Size & Volume

Concrete Tanks	**Number**	**Volume**
5m x 4.4m x 1.96m (L x W x H) = 43.12 m^3	Six (6)	258.72 m^3
		258,720 Liters 57,493 gallons Total

One of these tanks stores a uncalculated mixture or treated and rainwater.

Table 5. Underground Tank – Size & Volume

Underground Tank	**Number**	**Volume**
4.24m x 3.39m x 1.81m (L x W x H)	One (1)	30.16 m^3
		30,160 Liters or 6,702 gallons TOTAL

Table 6. Summary – Water Storage Tanks

Water Storage Tanks	**Volume**
Polytanks	7,520 gallons

Concrete Tanks	57,493 gallons
Underground Tank	6,702 gallons
	71,715 gallons TOTAL

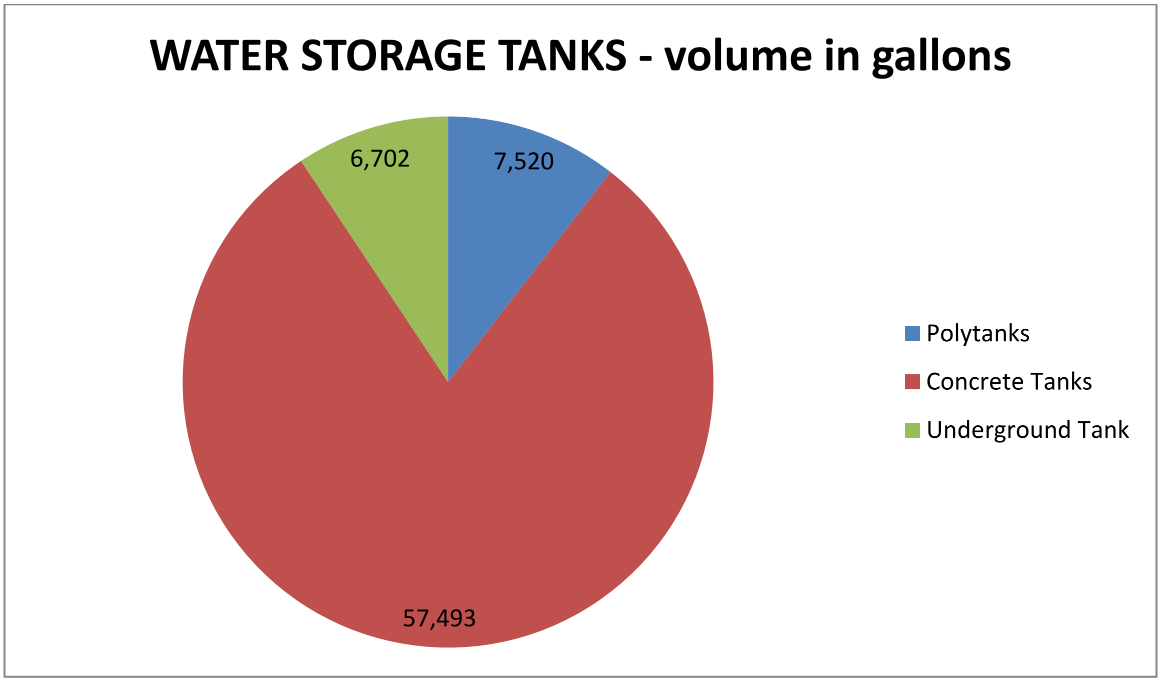

Chart 2. Water Storage Tanks - relative volume

How much of this water is used for irrigation and how much for domestic use? This needs to be determined in the foreseeable future.

Overflow pool

A shallow, ground -level concrete structure, looking very much like a swimming pool is a new addition to the Farm. It serves to store overflow treated water from the adjacent Water Treatment Plant (WTP). The WTP Manager has guaranteed a minimum weekly flow of 280 m^3 or 2,494 sq.′ , holding 73,968 gallons. This results in covering 7.5 acres of gardens with .36 inches of water a week. A pumping or syphoning method is needed to move the water out of the pool and onto nearby gardens or into a tank for transport to further away gardens.

Reservoir Pond

The required ideal size of an irrigation pond is based on the number of acres to be irrigated. A general rule is 1 acre-foot of water storage for each acre of land to be irrigated. A 10-acre pond with an average depth of 10 feet would be needed to irrigate 100 acres. This rule assumes no recharge to the pond from ground water or underground springs . Because the water in the pond is exclusively gravity fed run off from the surrounding fields, the stewards must be aware of the likelihood to dry out the pond completely during the height of the dry season.

Rainwater and overflow water from the WTP flow downhill to a pond serving as a reservoir. The pond is semi-contained on one side by a earthen berm, with a height of 1.5 to three feet. The berm is constantly trampled by "community cattle" which are strays, or are in a small herd driven by locals. Community herds of goats and sheep also visit the pond, but are not destructive to the berm. The pond is measured (Nov. 2014) at 233 meters in perimeter and three (3) feet deep resulting in storage of potential irrigation water of 3,960 m^3 or 87,986 gallons. The pond is adjacent to the east-west paved road that goes to the Sogakope settlement. The rough earthen berm suffers from leaks, and a solid replacement containment wall of approximately 240 feet would be desirable. Gated fencing around the pond, to control vagrant livestock from polluting the water and trampling the wall is also desirable.

The available water for domestic and irrigation purposes from the tanks (71,715 gallons) and the reservoir pond (87,986 gallons) is a total of 159,701 gallons.

Table 7. Total Water Supply _ gallons

Stored in tanks (from Utility)	71,715 gallons
Overflow Pool	73,968 gallons
Reservoir/Pond	87, 996 gallons
	233, 679 Total

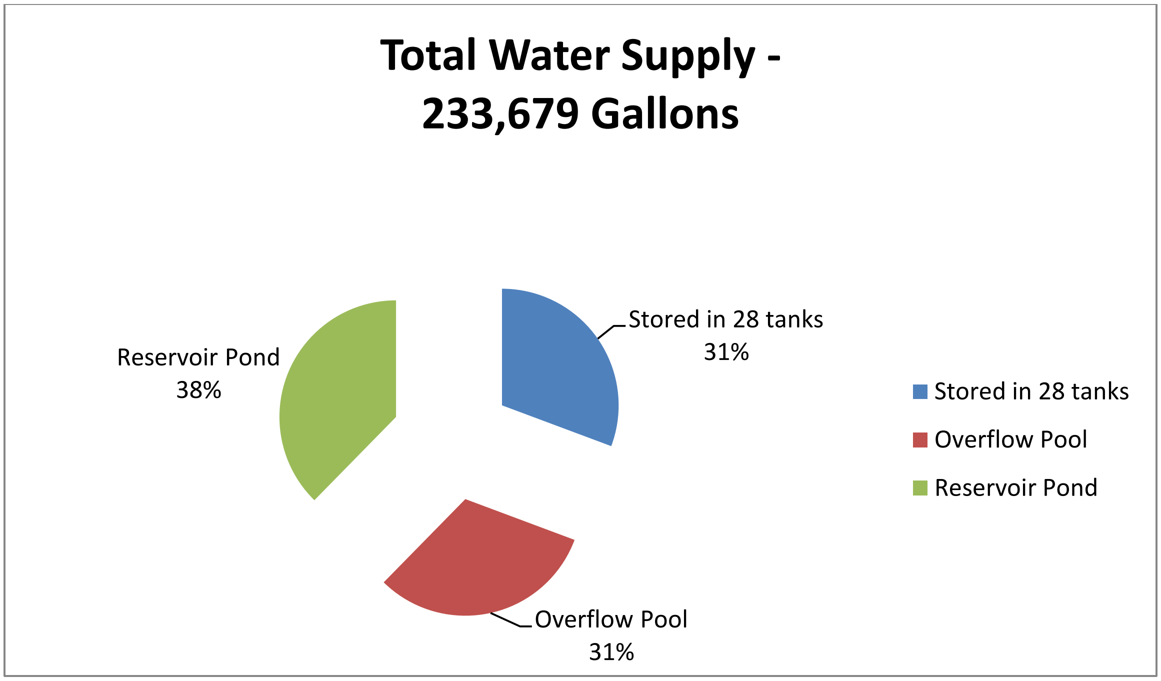

Chart 3. Total Water Supply - gallons

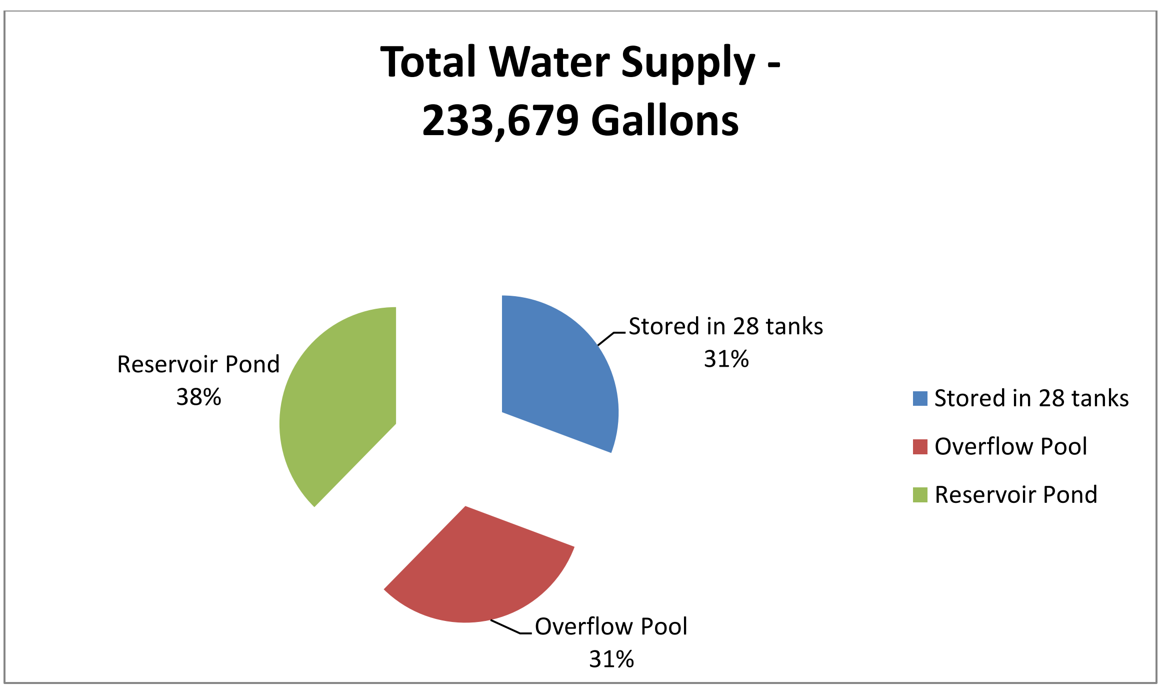
Total Water Supply -
233,679 Gallons
Stored in 28 tanks
31%
Reservoir Pond
38%
Overflow Pool
31%
Stored in 28 tanks
Overflow Pool
Reservoir Pond

Chart 3. Total Water Supply - gallons

Alternatives

This Feasibility Study discusses three alternatives for water supply in detail, but it is out side the scope-of-work to be construed as a engineering design or a capacity building document.

All approaches rely on drip irrigation sometimes called trickle irrigation which works by applying water slowly, directly to the soil drop by drop. The high efficiency of drip irrigation results from two primary factors. The first is that the water soaks into the soil before it can evaporate or run off. The second is that the water is only applied where it is needed, (at the plant's roots) rather than unnecessary waste. Estimates range from 40 to 80 percent water savings with drip irrigation systems, mainly by reducing evaporation rates.

Alt. 1 Traditional Irrigation Scheme

Ghana's experience with public irrigation systems have been the pumped systems, and have proven to be largely unsuccessful. Strong arguments have been made for the country to encourage private sector investment here rather than continuing to sink public funds in poorly operated and maintained public irrigation schemes.

Fixed start-up and annual operating costs for a 2-inch diameter drip-irrigation system for ten acres are itemized in the table below for a ball park figure, as local data was not forthcoming. Source: University of Florida, IFAS Extension, HS 1144 "Drip Irrigation Systems for Small Conventional Vegetable Farms and Organic Vegetable Farms" est. 2007.

Table 8. Estimated installation Costs 10 acres

Drip Irrigation System Components	Unit Cost	Quantity	Total USD $
Mazzel injector	150	1	150
Dosatron injector	2100	1	2100
Pressure gauge	15	5	60
Water meter	412	1	412
Water meter fittings	11	2	22
Water filter	87	1	87
Backflow prevention	405	1	405
Ball valve	12	4	48

Main line	.51/ft	660 ft	337
PVC fittings	3.2	10	32
Solenoids valve	31	10	310
Irrigation controller	250	2	500
Pressure regulators	32	10	320
Total fixed cost USD			**$2,683**

Table 9. Estimated Annual costs

Irrigation water sub main line	69	1200 ft.	250
Drip Tape	105	10 roll	1050
Poly-to-drip tape Connectors	50	3 bags of 100	150
Tape-to-tape connectors	50	2 bags of 100	100
Flush Caps	75	3 bags of 100	225
Replacement filters (screen only)	15	1	15
Total Annual Costs			**$1,790**

Notes: This 10-acre field is divided into 10 irrigation zones; each zone measures 330 x 130 sq. ft.; shape of zones and type of crop will affect the number of rows, and thereby the number of connectors needed; Annual costs should also include pumping station maintenance, and gas/oil for pumping station. Prices will vary depending on supplier.

Alt 2. Tubewell Development

In the Volta Basin, annual groundwater extraction through boreholes, hand dug wells, and piped systems has steadily increased, as of 2011 approximately 44 % of the population had improved access, for small farms and domestic use.

Groundwater usage will necessitate hiring a firm to test, drill and equip for tubewell installation and year-round use. One well hole might not produce enough. Water quality must be periodically tested. High salinity readings have reportedly been an issue in the dry season due to a perched water table. The survey and installation costs would be approximately GH₵ 3,323.00.

The positive elements of Alt. 2 tubewell development are, 1) the close proximity on the Farm site, so gardens adjacent to the well head can be easily tended; 2) the water would be free; 3) the maintenance of a tubewell pump is relatively simple as compared with long distance pumping and piping from the River which is 4km away; and, 4) the technology is successfully workable and has been in existence for many years.

Alt. 3. Existing on-site water

This alternative is an emerging alternative to pumping. It relies on maximizing water storage by capturing more rainwater and minimizing water losses. Student community by-in, good record keeping, and periodic analysis is essential in the long-term implementation of this plan.

Rainwater harvesting from roof runoff could be employed which could use up to 20 storage tanks for 20 buildings, resulting in thousands of more gallons to be used for irrigation purposes.

Water from the Reservoir Pond could be utilized by an installation of a pump or pumps to move the water uphill to designated areas. The Farm is currently exploring this portable solar powered pumps as an option.

Water from the Overflow Pool is a source of water ideal for crops as it has already been filtered and is free. Like the reservoir pond water, it too needs to be pumped to the desired location. The Pool is centrally located to the twelve gardens and on flatter topography than the hillside leading down to the pond, which is the potential site for the Demonstration Plots.

Water from the groundwater has real potential and needs to be explored with testing from a good local vendor for subsequent installation of tubewell irrigation wells.

Sufficient data does not yet exist to determine the water yields per crop at the Adidome Farm Institute. A long-range goal of agricultural expansion needs to be initiated by the systemic gathering of vital statistics on the water, soil, soil amendments and crops vigor.

The twelve farm gardens are of varied sizes, shapes and constituents. Most receive no additional water, as the plants are “heirloom plants” which have adapted to their particular location over many generations. The vegetable gardens are the exception to not being watered, likely because they have salable value in the twice weekly marketplace.

Alternative Discussion and Conclusion

Each alternative was briefly discussed from a pro's and con's perspective. The Farm, in conjunction with donor partners will decide which direction is best to proceed with in carrying out the long-term goal of agricultural expansion.

The table below summarizes some of the elements brought out in this report.

Table 10. Alternative Matrix

	Alt 1	Alt 2	Alt 3
Anticipated start up cost	**High**	**Medium**	**Low**
Implementation challenges	**High**	**Low**	**Medium**
Maintenance Challenges	**Medium**	**Low**	**High**
Agricultural expansion	**High**	**Potentially**	**Low**

Sufficient water supply is adequate for the gardens in existence. Better use of the water supply however can be implemented. Capturing and using roof runoff rainwater and the overflow pool water instead of costly utility supplied water would be more efficient both economically and environmentally.

To alter some of the grassland/pastureland to agricultural crop use land will require additional waters from untapped sources. Groundwater extraction testing should be explored beginning with tests from a reliable vendor. Political discussions about tapping into the existing pipeline from the River with the Community Water and Sanitation, thereby eliminating a redundant 4km transport pipe should be broached as well.

There are many agencies in Ghana that could/should spearhead this inquiry, including the International Food Policy Research Institute - Ghana Strategy Support Program; International Water Management Institute – West Africa Service Center; and the Ghana Irrigation Development Authority – Planning, Budgeting, Monitoring and Evaluation.

Donors and non-government organizations which may be interested teaming with this inquiry include the ; World Bank, United Nations Food and Agriculture

Organization, the World Food Programme, Netherlands Development Organization, GIZ, US Agency for International Development.

What next ?

The request for the feasibility study was made with the aim that the report would be used to source for funding for an irrigation facility. The Agricultural Technical and Vocational Training project (ATVET) which is being funded by GIZ was adopted by the African Union (AU) summit in 2011 to return agricultural training to the center of development efforts of the continent. A solid demonstration plot would be useful to achieve the ATVET goals.

Another source of funding the institute is the Skills Development Fund (SDF), which is an initiative of the Government of Ghana in partnership with the World Bank and DANIDA. SDF is managed by a Project Support Unit of the Council for Technical and Vocational Education and Training.

Table 11. Anticipated donor cost information for useful items in three cost categories; small, medium and large.

SMALL	MEDIUM	LARGE
Soil Moisture-Sensing probes	Liner for Pond	Partial Retaining Wall for Pond
Water Test Kits	Drip Irrigation Hoses	All Terrain Vehicle
Soil Test Kits	Industrial Strength Garden Hoses & Couplings	Trailer and tank for ATV
Water Flow & Rate Gages for Pumps	Fencing for the Pond	Central Irrigation system pump for river and distribution piping:Alt 1.
Reference books	Solar pumps	IT updates
Screen Nets for Overflow Pool e.g. swimming pool skimmers	Tanks or containments for roof water runoff storage	

SELECTED REFERENCES

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National Irrigation Policy - Ministry of Food & Agriculture
mofa.gov.gh/.../Ghana-Irrigation-Development

Other:

Volta Region, Town & Country Planning Department, (est. 1994) "Site Plan for Farm Institute Adidome", Large Blueprint

For consideration:

www.khanacademy.org a free website that "teaches everything"

www.smilinggardener.com a free video/text website for improving gardening

www.water.org works with collecting data and measuring movement

www.edis.ifas.ufl.edu numerous online publications by professional experts.