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Irrigation Development in Ghana:
Past experiences, emerging opportunities, and future directions

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THE GHANA STRATEGY SUPPORT PROGRAM (GSSP)

WORKING PAPERS

ABOUT GSSP

IFPRI's Ghana Strategy Support Program (GSSP) was launched in 2005 to address specific knowledge gaps concerning agricultural and rural development strategy implementation, to improve the data and knowledge base for applied policy analysis, and to strengthen the national capacity for practical applied policy research. The primary objective of the Ghana Strategy Support Program is to build the capabilities of researchers, administrators, policymakers, and members of civil society in Ghana to develop and implement agricultural and rural development strategies. Through collaborative research, communication, and capacity-strengthening activities and with core funding from the U.S. Agency for International Development/Ghana (USAID), GSSP works with its stakeholders to generate information, improve dialogue, and sharpen decisionmaking processes around the formulation and implementation of development strategies.

ABOUT THESE WORKING PAPERS

The Ghana Strategy Support Program (GSSP) Working Papers contain preliminary material and research results from IFPRI and/or its partners in Ghana and have not been peer reviewed. They are circulated in order to stimulate discussion and critical comment. The opinions are those of the authors and do not necessarily reflect those of their home institutions or supporting organizations.

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Acronyms

AgGDP	Agricultural Gross Domestic Product
CRI	Crops Research Institute
CSIR	Council for Scientific and Industrial Research (Ghana)
FABS	Food Agricultural Budgetary Support
FAO	United Nations Food and Agricultural Organization
GDP	Gross Domestic Product
GH¢	The third Ghanaian cedi was adopted July 1, 2007.
GIDA	Ghana Irrigation Development Authority
HP	Horse Power
ICOUR	Irrigation Company of Upper East Region- manages Tono & Vea schemes
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ITFC	International Tamale Fruit Company
IWMI	International Water Management Institute
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt fur Wiederaufbau-German Government-owned development bank
KNUST	Kwame Nkrumah University of Science and Technology
LACOSREP	Land Conservation and Smallholder Rehabilitation Projects (I and II)
MOFA	Ministry of Food and Agriculture
NGOs	Non-Governmental Organizations
NPK	Primary fertilizer nutrients: nitrogen, phosphorus and potassium.
O&M	Operation and Maintenance
PIM	Participatory Irrigation Management
RF percent	Rainfall Percentage
SARI	Savanna Agricultural Research Institute
SRI	Soil Research Institute
UDS	University for Development Studies, Ghana
UWADEP	Upper West Agricultural Development Project
WB	World Bank
WRI	Water Research Institute
WUAs	Water User Associations

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CURRENCY EQUIVALENTS

(Exchange rate effective November 2010)

Currency Unit = Ghanaian Cedi (GH¢)

US$ 1 = 1.44400 GH¢

1. Introduction

Agriculture has a central socioeconomic position in Ghana. This sector accounts for about 65 percent of the work force, about 40 percent of the gross domestic product, and about 40 percent of foreign currencies acquired through exports. Although agriculture is a key part of the country's economy, the structure of the sector is vulnerable because it relies on rainfed agriculture during a roughly six-month rainy season. Droughts and other types of unseasonable weather pose risks for farmers. Under these conditions, irrigation development offers the promise of greater food security and the rural-area development by ensuring yearlong agricultural production.

Despite considerable potential for development and the emphasis placed on irrigation development in many plans, less than two percent of the total cultivatable area in Ghana is irrigated. Moreover, even within this small area, researchers lack a clear understanding of where in Ghana different types of irrigation infrastructure are used and to what effect. Less than a third of the estimated total irrigated land in Ghana lies within 22 well-known public schemes, and not enough is known of the location, development and management of the informal irrigation schemes that account for the remaining two-thirds of total irrigated land. Although donors and policymakers express interest in providing new funds for irrigation development, the lack of reliable data on where irrigation currently exists, trends in its development, and opportunities and constraints within formal and informal schemes undermines consensus about how to build on what already exists in the sector.

Ghana's overall national goal is to attain a middle income status with a per capita income of US$1,000[1] by the year 2015. The agricultural sector must lead in achieving this national goal, as agriculture employs more than 50 percent of the total economically active population (Kundell 2008). Agriculture in Ghana is predominantly practiced on smallholder, family-operated farms, which produce about 80 percent of total agricultural output. About 2.74 million households either operate small farms (most of themless than 2 hectares) or keep livestock (MOFA 2008). Cultivable land is still abundant as only 38.9 percent of total agricultural land area is currently cultivated. Yet productivity of existing farmland is generally low and uncertain, because of prevailing traditional low-input, shifting-cultivation farming systems and dependence on rainfall.

Ghana cannot achieve economic growth and poverty reduction targets without significant improvement in the agricultural sector (Kyei-Baffour and Ofori 2006). Growth in agriculture may be achieved both through extensification (putting more land under cultivation) and intensification (increasing the productivity of existing land). In most cases, irrigation is central to increasing productivity of existing agricultural land.

Ghana is endowed with sufficient water resources for irrigation-based intensification. Estimates of Ghana's irrigation potential are wildly divergent, ranging from 0.36-1.9 million hectares to slightly more than 33,000 ha under irrigated cultivation (FAO 2005; Agodzo and Bobobee 1994). Irrigation development in Ghana has been justified as a way to achieve (1) food security, (2) poverty reduction, and (c) rural employment. This argument is specifically related to the Northern regions, as they are characterized by mono-modal highly variable rainfall distribution.

[1] All dollars are U.S. dollars.

Despite irrigation's considerable potential and the emphasis placed on it in recent plans, the proportion of potential irrigable land actually under irrigation is insignificant. In addition, the performance and productivity of existing irrigation schemes, particularly those that were publicly developed, are generally low (GIDA/JICA 2004).

This study was initiated to develop an understanding of irrigation in the country, including the geographical distribution of various types of irrigation taking place, the nature and economics of crops under irrigated agriculture, the potential for development of various types of irrigation, and the key limitations to such development.

The study was seeking answers to the following pertinent questions:

- Besides the known public schemes, what other types of irrigation systems are there in the country? Where are they developed most and for what purpose are they used?
- What are the opportunities and constraints of the various irrigation typologies?
- How profitable are the irrigated agricultural production systems in Ghana?
- What policy conclusions or recommendations may be made to strengthen the irrigated agricultural sector?

1.1 Methodology

The study was carried out in three steps:

Step 1: Brainstorming, literature reviews and analysis of secondary data. Information on irrigation systems in Ghana was gathered through:

(1) A one-day brainstorming workshop involving professionals from Ghana Irrigation Development Authority (GIDA), University for Development Studies (UDS), International Water Management Institute (IWMI), International Food Policy Research Institute (IFPRI), and Kwame Nkrumah University of Science and Technology (KNUST), conducted December 2008

(2) Collation of information, reports, and data from GIDA, IWMI, and other sources

(3) Review of relevant literature, including a wide range of files, online publications, and published and unpublished reports on relevant works in Ghana

(4) Interviews with key informants

Step 2: Development of typologies of irrigation systems. Based on the insights obtained from Step 1, typologies of irrigation systems in Ghana were developed. This classification of irrigation systems was intended to provide an objective appraisal and comparison of irrigation systems, according to their common physical, management, and social characteristics, to be further refined in the future. The classification criteria included:

(1) Ownership of irrigation infrastructure or equipment, whether by government, community or individuals
(2) Source of water, that is, whether the water source for irrigation is from surface water (i.e., river, lake, run-off from catchment area) or groundwater (i.e., sub-surface/shallow groundwater and deep aquifer)
(3) Initiators or financiers of the irrigation systems (i.e., government, NGOs, community, individuals)
(4) Management and operation (i.e., whether the system is managed/operated by GIDA/Irrigation Company of Upper East Region (ICOUR), jointly by farmers and GIDA/ICOUR, partnership/contractual, private, etc.)
(5) Source of power for abstracting, conveying and distributing water

(6) Type of infrastructure or technology involved
(7) Size or scale

Step 3: Primary data collection through reconnaissance survey, key informants survey, field observations, and interviews with farmers either individually or in groups. A countrywide reconnaissance field survey collected relevant data for further analysis of the identified irrigation system typologies. The ten regions of Ghana were classified into three regional groups:

- Regional group I comprised Volta, Greater Accra, Central and Western Regions;
- Regional group II encompassed Brong Ahafo, Ashanti and Eastern Regions; and
- Regional group III remaining three Northern regions, namely Upper West, Northern and Upper East Regions.

Corresponding to the three regional groups, three multi-institutional and multi-disciplinary teams consisting of research and development professionals (i.e., an agronomist, an irrigation engineer, and an agricultural economist) carried out the survey. Agricultural Extension Agents from relevant Ministry of Food and Agriculture (MOFA) offices assisted them. Key information checklists and semi-structured questionnaires were developed corresponding to each of the proposed irrigation typologies. Using the data, we estimated the area irrigated and the costs of and returns from the cultivation of different crops, and identified constraints on the development of different types of irrigation.

The rest of the report is presented in six sections. The overall extent of irrigation and its management are presented in section two. Ghana's water resources and the effect of variability of rainfall on the country's GDP are discussed in section three. In section four, the typologies of irrigation are presented. Section five focuses on the economics of irrigated agriculture. Finally, section six offers some recommendations.

2. Irrigation in Ghana

At present, productivity of developed farm land in the country is generally low and variable due to reliance on rain, particularly in the drought and flood prone Northern regions. With abundant cultivable land and sufficient water resources, Ghana offers ample scope for growth in agricultural production through irrigation development. Yet, as stated above, very little potential irrigable land is developed. The performance and productivity of existing irrigation schemes, particularly those that were publicly developed, are generally low.

2.1 Irrigation Development

Irrigation is central to the intensification strategy. Records date irrigation's beginnings in the country to about a century ago, but serious irrigation efforts date to the past fifty years. Between its inception in the 1960s and the year 1980, approximately 19,000 ha of irrigated land had been developed. By 2007 the area in irrigation had expanded to 33,800 ha.

Irrigation systems observed in Ghana may be classified into two types: conventional systems, which are mainly initiated and developed by the Ghanaian government or various non-governmental organizations (NGOs), and emerging systems, which are initiated and developed by private entrepreneurs and farmers. Little is officially known about emerging systems, but they are expanding at a rapid rate, mainly fuelled by access to relatively affordable pumping technologies and to export markets for horticultural crops.

Conventional/Public Irrigation. Of the irrigated land, slightly less than 9,000 ha was developed by the Government of Ghana, with the remainder of the land having been developed by the private sector. Government-developed irrigation includes 22 public irrigation districts in the entire country. Most of the development of these public irrigation districts has been conducted with financial and technological support stemming from bilateral cooperation with China, the former Soviet Union, Taiwan, Japan, and the Republic of Korea. Additional support has come from international organizations, including the UN Food and Agriculture Organization (FAO) and the World Bank (WB).

Table 1 illustrates the 22 public irrigation districts managed by GIDA and ICOUR. These public irrigation districts are scattered around Ghana, and cover a total of 8,800 ha. Approximately 11,000 farming families benefit from these districts, with cultivated area per household averaging approximately 0.8 ha. The 22 public irrigation districts are classified into 13 small-scale irrigation districts of 100 ha or fewer (these account for about 60 percent of all the districts), five medium-scale irrigation districts of between 100 and 500 ha, and four large-scale irrigation districts of 500 ha or greater. There are eight districts irrigated by pump, five districts irrigated both by pump and gravity, and nine districts irrigated by gravity (Miyoshi and Nagayo 2006). As Ghana is topographically flat, with little land suitable for gravity-type irrigation development, many irrigation districts are forced to build and maintain costly pumps.

As can be seen in the table, as of June 2003 six of the 22 public irrigation districts had abandoned irrigated agriculture. All of these abandoned districts require pump irrigation although some also use gravity. As a result of this abandonment, only 5,192 ha of the total 8,800 ha were still potentially operational for irrigation. However, as can be seen in Appendix 1, government investments in rehabilitation resulted in four of these irrigated districts have been or are undergoing rehabilitation. As a result more than 7,000 ha are now operational.

Emerging Irrigation Systems— Emerging irrigation systems are eclipsing conventional systems in terms of area irrigated,yield obtained, production levels, and value of production. These systems include tubewell irrigation, small motor-based irrigation, out-grower systems, and others. Surface-water-pumping-based private and communal irrigation systems are widely observed over all of Ghana's ten administrative regions, though they are particularly abundant in the Eastern, Ashanti, Brong-Ahafo, and Volta regions. Sub-surface and groundwater-based irrigation systems are not evenly distributed across the regions but are fast spreading beyond traditional enclaves such as the Volta region's Keta strip. Unlike public irrigation systems, which seem to be primarily designed for rice production, the major crops grown under emerging irrigation systems are horticultural. However, some staple crops such as maize, rice and cassava are cultivated either solely or in association with vegetables.

Table 1: Public Irrigation Districts (as of June 30, 2003)

No.	District	Area of developed land (ha)	Area of irrigated land (ha)	Irrigation type	Target crop	Remarks
1	Ashaiman	155	56	Gravity-type	Rice and vegetables	
2	Dawhenya	200	150	Gravity & pump-type	Rice	
3	Kpong	2,786	616	Gravity-type	Rice and vegetables	
4	Weija	220	0	Pump-type	Vegetables	Abandoned 2003-Rehabilitated
5	Afife	880	880	Gravity-type	Rice	
6	Aveyme	60	0	Gravity & pump-type	Rice	Abandoned 1998-Rehabilitated
7	Kpando Torkor	40	6	Pump-type	Vegetables	
8	Mankessim	17	17	Pump-type	Vegetables	
9	Okyereko	81	42	Gravity & pump-type	Rice	
10	Subinja	60	6	Pump-type	Vegetables	
11	Tanoso	64	15	Pump-type	Vegetables	
12	Sata	34	24	Gravity-type	Vegetables	
13	Akumadan	65	0	Pump-type	Vegetables	Abandoned-Rehabilitated
14	Anum Valley	89	0	Gravity & pump-type	Rice	Abandoned-Rehabililitated

Table 1: Continuation

No.	District	Area of developed land (ha)	Area of irrigated land (ha)	Irrigation type	Target crop	Remarks
15	Amate	101	0	Pump-type	Rice	Irrig Abandoned
16	Dedeso	20	8	Pump-type	Vegetables	
17	Kikam	27	0	Gravity & pump-type	Rice	Irrig Abandoned
18	Bontanga	450	390	Gravity-type	Rice and vegetables	
19	Golinga	40	16	Gravity-type	Rice and vegetables	
20	Libga	16	16	Gravity-type	Rice and	
21	Tono	2,490	2,450	Gravity-type	Rice and vegetables	
22	Vea	850	500	Gravity-type	Rice and vegetables	
	Total	8,745	5,192			

Source: Miyoshi and Nagayo 2006.

Groundwater Irrigation. Agricultural use of groundwater, once mainly in domestic use, is rising due to access to pumping technologies. Groundwater irrigation provides potential employment opportunities, particularly during the long dry season in the Northern Savannah Zones of Ghana. It is also already one of the major livelihood strategies in the coastal zones of Volta region, particularly for those with access to electricity. However, full realization of the economic potential of groundwater faces numerous challenges including absence of explicit policy support, lack of access to affordable drilling technology, and cost of energy for abstracting water. Rice yields and profitability are better under private systems as compared to public systems. Vegetable cultivation is generally profitable under all typologies of irrigation system, except under the communal borehole system, which exhibits negative gross margins.

2.2 Irrigation Potential

Irrigation development in Ghana has followed the global irrigation investment pattern, with a peak in 1970. However, the scale of overall development has remained low. Of the total 6.9 million ha of cultivable area in 2007, there were only 33,800 ha of irrigated land. This represents less than 0.5 percent of the total area. Of the gross estimated 1.9 million ha of potentially irrigable area, less than 2 percent has been developed.

Currently, public irrigation systems play an insignificant role in the overall agricultural economy of Ghana despite substantial efforts to develop the sector since 1950s. The cost of development (and also of rehabilitation) per unit area in use or per unit volume of water supplied is higher than the figures for comparable developing countries (Inocencio et al. 2007). Capacity under-utilization is a major problem in many existing irrigation facilities. The potential areas that can be developed in each of the public irrigation schemes are much higher than the developed or equipped areas. In addition, in any given year, only a fraction of the developed or equipped area is actually cultivated. Rehabilitation of many of the irrigation schemes is long overdue. Unfortunately, the quality of the implemented rehabilitation projects is also questionable, as some schemes still suffer from structural defects despite repeated rehabilitation works.

2.3 Irrigation Management

GIDA is a government organization that comes under the jurisdiction of the Ministry of Food and Agriculture. GIDA is the only public organization linked directly to irrigation development and management. The forerunner of GIDA was the Land Improvement and Preservation Unit, which was established in the early 1950s within the Department of Agriculture to conserve soil in the northern part of Ghana. This Unit was expanded to the Irrigation Development Department within the Ministry of Agriculture in 1965, and then established as GIDA by government decree in 1977. GIDA is in charge of surveying candidate sites for irrigation development, designing and constructing facilities, managing and maintaining irrigation-project districts under further development, and disseminating farming technology among farmers. As detailed in Table 1, GIDA has developed 22 irrigation-project districts of varying sizes covering a total area of 8,800 ha across the country.

Since its establishment, GIDA has developed and managed public irrigation systems utilizing government subsidies, and public funds to cover staff costs. However, as part of the government's policy of structural adjustments, GIDA reduced its staff from roughly 1,500 personnel (in the 1980s) to 739 in 1993, 441 in 1994, and 377 in 1995. By 2004 only 304 employees remained. These included 121 head office staff (including Irrigation Development Center (IDC) staff), 73 staff members at the Regional Offices, and 110 staff members at the Site Offices. As part of structural adjustment, GIDA's budget has also been cut dramatically. As detailed in Table 2, by 2003, personnel expenses accounted for 82 percent of total expenditure. The aggregate of administrative expenses and project expenses is no more than about $120,000. Thus, it is no longer possible for GIDA to manage 22 public irrigation districts sustainably (Miyoshi and Nagayo 2006).

Table 2: Breakdown of GIDA Expenditure in 2003

Account	Expenditure (US$)	
	Government of Ghana	Aid agencies
Personnel expenses	548,183 (82%)	
Administrative expenses	78,045 (12%)	
Service expenses (project expenses)	43,974 (6%)	
Investment (facilities construction)		2,699,093
Total	670,202 (100%)	

Source: Miyoshi and Nagayo 2006

As previously mentioned, GIDA's personnel and budget were substantially reduced as a part of the government's structural adjustments. As a result, early 1990saw fundamental changes to the management framework of public irrigation districts. The previous “government-led management” system had become difficult to maintain, and so “Participatory Irrigation Management (PIM)” was introduced, whereby beneficiary farmers and others could manage the irrigation facilities.

In Ghana, since the introduction of the system of PIM in early 1990, operation and management of irrigation facilities in public irrigation districts has been mostly conducted using funds collected from irrigation service charges paid by beneficiary farmers. Irrigation service charges are determined by factors such as the irrigated land area of each farmer, the irrigation type of the district in question (pump, gravity, et. al.,), and the standard of the facilities. Therefore irrigation service charges per unit area (ha per season) differ by amounts ranging from several ten to several hundred US dollars. For example, in the Dawhenya Irrigation District, the irrigation service charge is $110/ha per year due to extensive pumping, while in the Afife and Ashaiman Irrigation Districts, which are served by gravity, the irrigation service charges are $22/ha per year (Miyoshi and Nagayo 2006).

As mentioned previously, the total developed land area in the public irrigation districts is approximately 8,800 ha, but actual irrigation land areas have been decreasing year after year. As of 2003, the area had decreased to approximately 5,200 ha. This decrease results from such problems as a decline in capacity to convey and distribute water due to aging facilities, abandonment of irrigated agriculture due to the complete collapse of facilities (pumps, etc.), and suspension of irrigated agriculture (due to inability of users to bear the costs of operating pump stations). Recent government investments, including rehabilitation of nine existing irrigation schemes at a total cost of GH¢6.5 million, has brought much of this irrigated area back in production (Kunateh 2010).

2.4 Irrigated Agriculture

Ghana’s irrigated agriculture aims to produce rice and vegetables. With urbanization and the growth of the middle class, the amount of rice consumed is steadily increasing. Along with these structural changes of Ghana’s society, the consumption of rice is growing in comparison with former staple foods such as yams and other tubers, because rice has the advantages of being easy to cook and easy to store. By 2007, more than 8,000 irrigated ha were planted in rice, with yields of around 4.0 t/ha. In the year 2008, the total national consumption of rice was approximately 700,000 tons per year, while in 2010 rice consumption was estimated to exceed 900,000 tons. Local rice production has not been able to keep up with the increasing consumption, so Ghana is reliant on imported rice for more than 70 percent of its domestic consumption.

Ghana’s Ministry of Food and Agriculture has attempted to reduce the amount of imported rice by increasing domestic rice production. This policy, however, is undermined by the declining profitability of rice cultivation. Competition with imported rice, which is less expensive and better, combines with the increasing prices of imported agricultural materials and equipment to reduce farmers’ incentives for cultivating rice. Under these circumstances, farmers’ interests shift to the cultivation of more profitable vegetables (including okra, fresh maize, cabbages, red peppers, tomatoes, and onions).

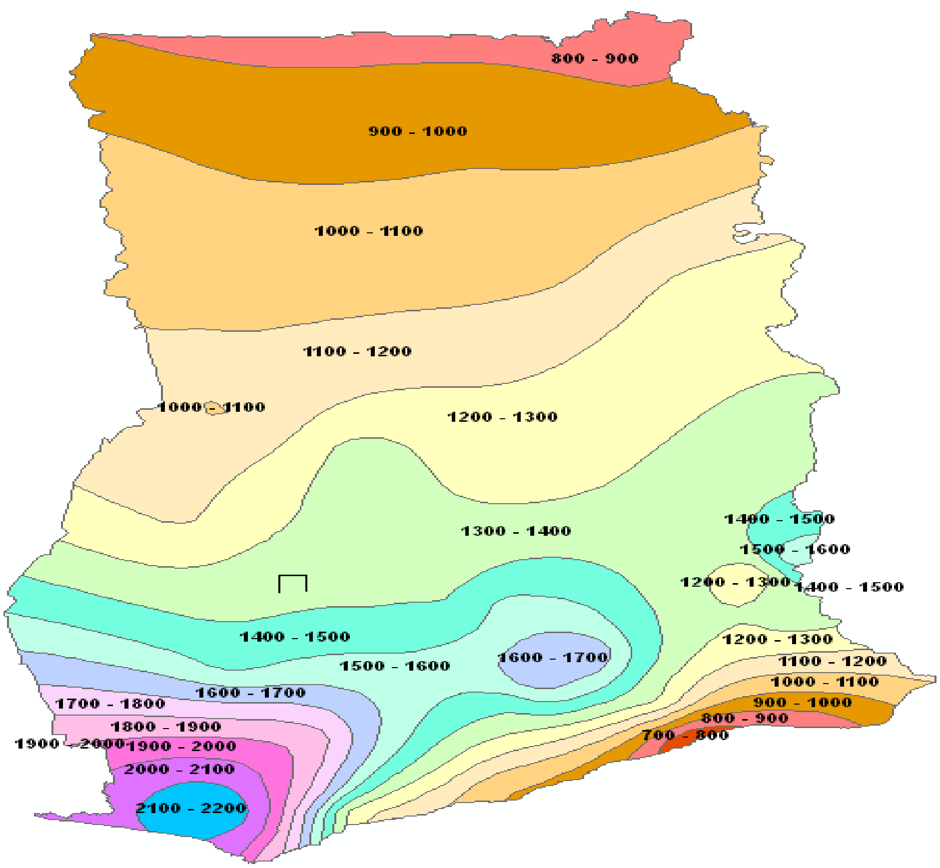
3. Ghana's Water Resources

Total withdrawal as a percentage of total renewable water resources is 1.8 percent. In 2000, about 652 million m^3 were withdrawn for irrigation (about 66.4 percent of total withdrawals), 235 million m^3 for domestic purposes (about 23.9 percent of total withdrawals), and 95 million m^3 for the industry (about 9.7 percent of total withdrawal), giving a total water withdrawal of 982 million m^3 (FAO 2005). Current water use for hydroelectricity generation at the Akosombo Dam, which is not counted as consumptive water use, is 37.843 km^3 per year. Thus only a small proportion of total renewable water resources are withdrawn, with irrigation constituting the highest consumptive use of water in Ghana.

3.1 Precipitation

Ghana receives average annual precipitation of 283.2 billion m^3. The mean annual rainfall is estimated at 1,187mm with mean annual temperatures ranging from 26.1C near the coast to 28.9C in the extreme north (FAO 2005). The distribution within the country is far from uniform, with the southwestern area better watered than southeastern coastal areas and northern regions. As can be seen in Figure 1, rainfall received generally decreases as one moves from south to north. Annual potential evapotranspiration is about 1350mm in the south and 2000mm in the north. The larger part of the northern regions has mono-modal rainfall regimes, characterized by a single rainfall peak. After peaking in August/September and continuing until the rise season is finished, rainfall has a rapid decline to a complete cessation (Friesen 2002).

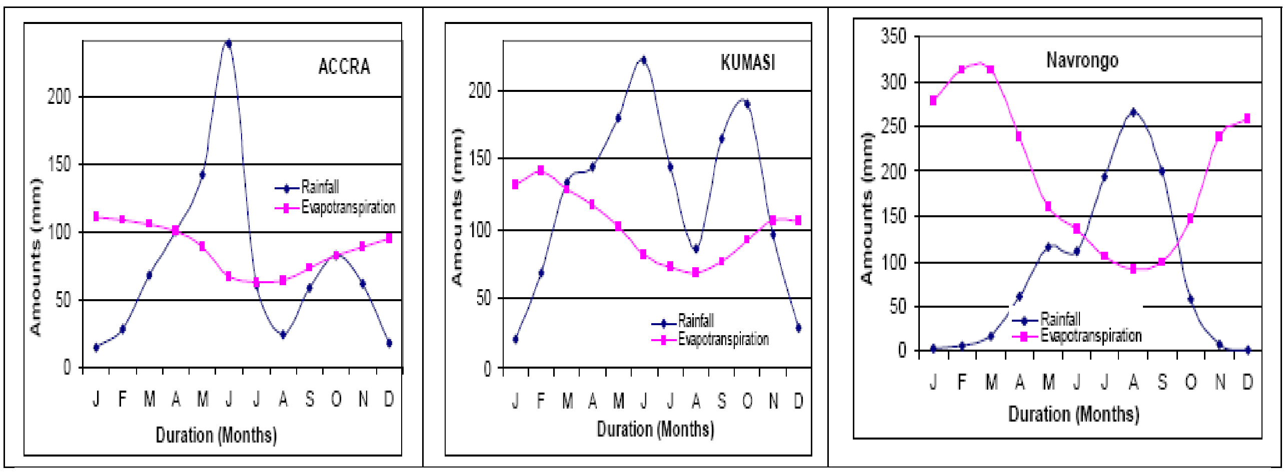
Figure 1: Rainfall Isohyets of Ghana



The southeastern corner of Ghana is characterized by unusually low rainfall rates along the coast. In the southwestern part, there are two rainfall regimes with different intensities. The main rainy season begins in April/May and ends in July, with the maximum rainfall occurring in June when the maritime instability causes a surge of the moist south-westerly air stream resulting in the intensification of the monsoon rain. The minor rainy season occurs between September and November (Kankam-Yeboah et al. 2005).

Although Ghana has an abundance of water from rainfall, this resource is very unevenly distributed both geographically and seasonally (Figure 2). Even in the high rainfall belt in the south and west of the country (typified by the rainfall distribution of Kumasi), water can be scarce in the dry season, which lasts three to five months. In the northern and the southeast regions (typified by rainfall distribution of Navrongo and Accra), annual rainfall is normally less than 1,500 millimeters, and, in some areas, below 500 millimeters, with the dry season spreading over eight to nine continuous months.

Figure 2: Mean Rainfall & Evaporation - Navrongo, Kumasi, and Accra (1961-2004)



Source: Kyei-Baffour and Ofori 2006.

The northern region is characterized by unimodal rainfall of short duration and excessive evapotranspiration allowing only 4 to 5 months of farming and 7 to 8 months of extended dry season. Thus, irrigation is needed there to enable farming during the long dry season. In the wetter middle and southwestern sectors also there is distinct dryness and the minor wet season tends to be short and unreliable. The coastal savannah belt records the smallest amount of rain nationwide. In the middle, southwest, and southeastern sectors of Ghana, the case for irrigation development can be made based on the proximity of these regions to major demand centers and necessary infrastructures. Generally, however, rainfed agriculture may not be able to support the future population of the nation unless coupled with investments in the irrigation sector. Crop yields are consistently greater in irrigated farming than rainfed farming (Swamikannu and Berger 2009).

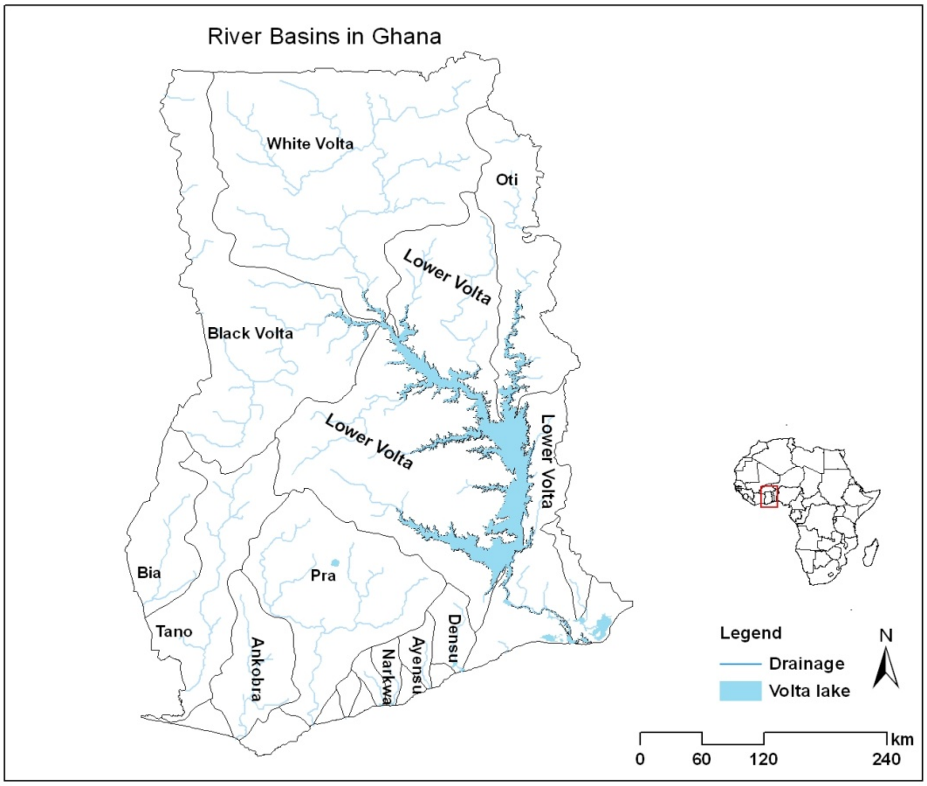
3.2 River Systems

Ghana is drained by three main river systems: the Volta, Southwestern and Coastal River systems (see Figure 3):

- The Volta river system consists of the Oti and Daka Rivers, the White and Black Volta Rivers, and the Pru, Sene and Afram Rivers—the basin covers 70 percent of the country area;

- The southwestern river system comprises the Bia, Tano, Ankobra and Pra Rivers and covers 22 percent of the country area;
- The coastal river system comprises the Ochi-Nakwa, Ochi Amissah, Ayensu, Densu and Tordzie Rivers, covering 8 percent of the country area.

Figure 3: River Basins of Ghana



The mean annual runoff ranges from 51 to 93m^3/s, representing only about 69 percent of rainfall (Kankam-Yeboah et al. 2005). The mean annual runoff from Ghana is 39.4 billion m^3, with the Volta, Southwestern and Coastal systems draining 64.7 percent, 29.2 percent and 6.1 percent, respectively. This amount of runoff is enough to support most domestic and irrigation uses in the country if it is adequately managed. The total actual renewable water resources are 53.2 km^3 per year, 43.1 percent of which originates from outside of Ghana's international borders. About 22.9 km^3 of surface water enter the country annually, of which 8.7 km^3 come from Burkina Faso, 6.2 km^3 from Côte d'Ivoire and 8 km^3 from Togo. The renewable water resource per person is 2,489 m^3 per year. The corresponding value for SSA, Europe, and North America are 6,322.5, 10,655.1, and 19,992.5 m^3 per person per year, respectively. The current total per person per year water withdrawal is about 50m^3. The corresponding value for SSA and North America are 173 and 1,663 m^3 per year, respectively. The total dam capacity of the country is estimated at 148.5 million m^3. Thus, Ghana is endowed with adequate water resources, particularly given the country's current demographic situation.

3.3 Groundwater Resources

In addition to the surface water resources Ghana is also endowed with groundwater resources even though this resource is not well-studied or understood. Reports portray a pessimistic view about yields of aquifers in Ghana. For instance, Kortatsi and Frempong (2005) claimed that apart from the Keta basin, borehole yields hardly exceed $6m^3$/hr. Another report claims that groundwater yield can be as high as $183m^3$/hr in limestone aquifers (Darko 2005). Except for low pH (3.5-6.0), high iron values (1-64 mg l"1) in a few cases and high salinity values (5000-14 584 mg l"1) in some coastal aquifers, groundwater quality is generally considered good for domestic and agricultural purposes. Aquifers underlie almost all areas in the country.Occurrence of groundwater, however, is controlled principally by local geology and other factors, such as topography and climate. In northern Ghana, aquifers have been located at between 10 and 60 meters deep with an average of 27 meters. In southern Ghana, due to thicker soil cover, boreholes are deeper, ranging between 25 and 90 meters deep, with an average of 42 meters (Bannerman 1986). Only about 5 percent of the urban water supply is from groundwater.

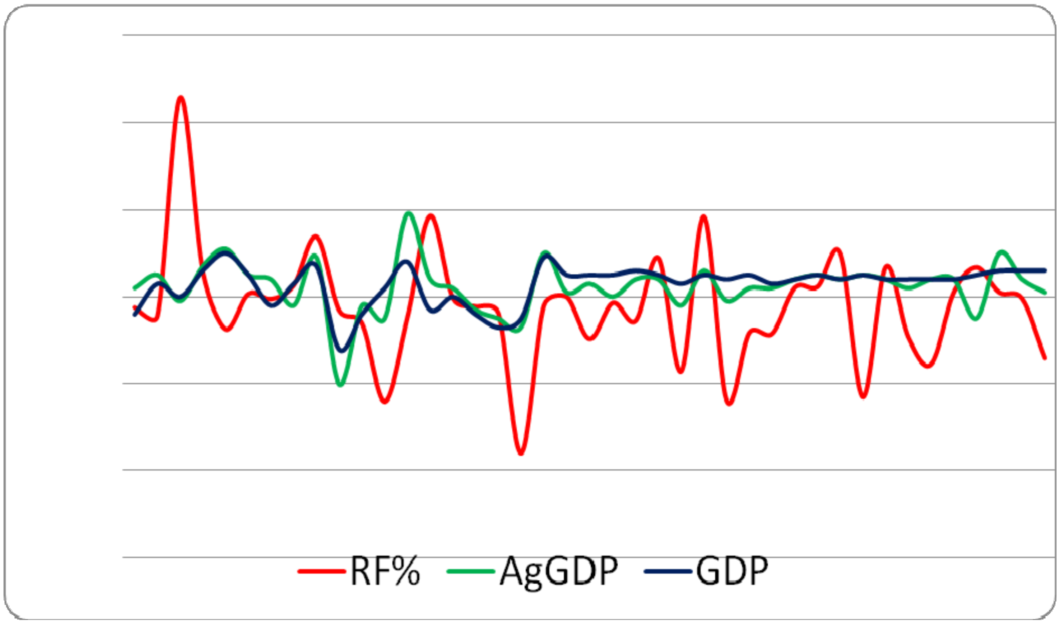
Ghana has more than 56,000 groundwater abstraction systems, comprising boreholes, hand-dug wells and dugouts (Kortatsi 1994). In the Volta basin, annual groundwater production through boreholes, hand dug wells, and piped systems has increased substantially over past decades, reaching an estimated 88 million m^3/year, giving approximately 44 percent of the population improved access to groundwater (Nicola and Van de Giesen 2005). Despite the rapid development, groundwater production is still less than 5 percent of the average annual groundwater recharge in most of the basins, so that the present production should not be expected to have any significant impact on the water balance. Similarly, a study in Nabogo basin (a subcatchment of the White Volta river basin), showed that current well pumping rates yield significantly less water than annual groundwater recharge to the basin (Lutz et al. 2007). Model results for several scenarios, involving increased population, access to potable water for all citizens, and/or decreased rainfall indicate that extraction rates will still be less than groundwater input to the Nabogo basin (Lutz et al. 2007). The assessment of groundwater recharge and development suggests that it would be sustainable from a geo-scientific point of view, at least in the foreseeable future (Nicola and Nick 2005).

3.4 Hydrology and GDP

Ghana often experiences floods and droughts and therefore requires greater water control.. The country faced widespread floods in 1962, 1963, 1996, 2002, and 2007, with droughts in 1977, 1983, and 1992. Flood prediction studies have detected some periodicities in flood occurrence. The periodicity of 5.6 years was found to be highly significant, while 2.7 years was of borderline significance (Oduro-Afriyie and Adukpo 2006).

As expected, the occurrence of floods and droughts affects various economic sectors, particularly agriculture. The effect of rainfall variability on Ghana's agricultural GDP and overall GDP is depicted in figure 4. From the figure it can be observed that prior to 1984/85, Ghana's economic performance was in tune with the level of rainfall received, decreasing sharply during drought (negative rainfall deviation from long-term mean) and increasing sharply during abundant rainfall (positive rainfall deviation from the long-term mean). However, beginning in the mid 1980s, the responsiveness of economic performance to rainfall has substantially diminished.

Figure 4: Rainfall Variability and Ghana's Macro-economic Performance



4. Typologies of Irrigation Systems in Ghana

Ghana's irrigation systems may be classified into four major typologies based on such criteria as ownership/management, source of water, type of infrastructure or technology involved, and source of power for abstracting, conveying, and distributing water. These are:

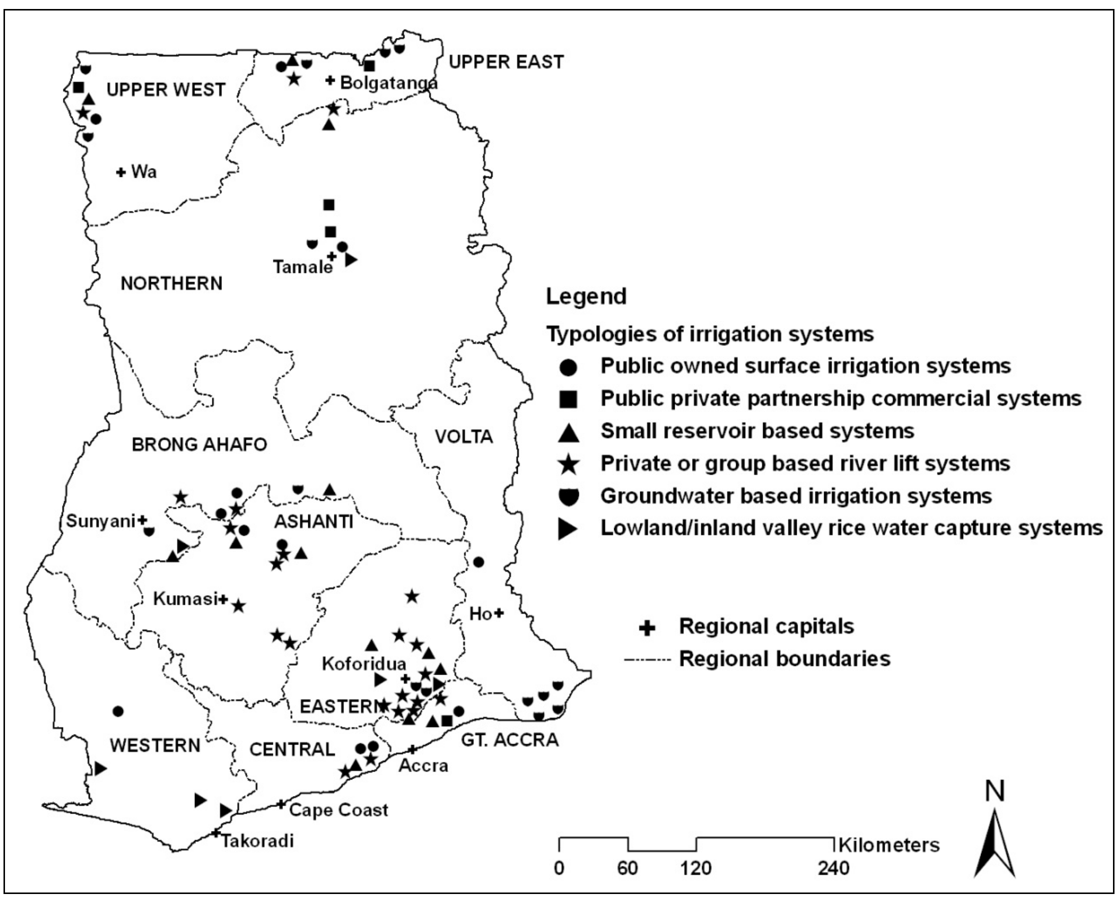
- public systems;
- small reservoirs and dugouts;
- river/lake lift private systems; and
- groundwater systems.

These four typologies can be subdivided:

- Public-owned surface irrigation systems;
  Public-private partnership commercial systems;
- Small reservoir- and dugout- based systems;
- Private- or group-based river-lift systems;
- Groundwater-based irrigation systems; and
- Lowland/inland valley rice water capture systems.

The distribution of these six irrigation systems in the regions of Ghana is depicted in Figure 5.

Figure 5: Distribution of Irrigation System Typologies in the Regions of Ghana



4.1 Public systems

There are 22 existing and many planned or under-construction irrigation schemes in this category. These schemes are operated and maintained by GIDA and ICOUR[2], with beneficiaries paying a fixed irrigation service fee for the the delivery of water[3]. Farmers also play a role in the management of these irrigation schemes. Table 3 divides the schemes into seven sub-types based on the source of surface water, the type of power for abstraction, conveyance and distribution of water, and in-field water application technology. GIDA and ICOUR, who manage these systems, may also provide credit packages to the farmers in the form of machinery hire services and input supply. To see the size, number of households, geographic distribution, crops grown, and status of these systems, see Appendix 1.

Table 3: Twenty-Two Public Irrigation Schemes and their Modes of Irrigation

Mode of irrigation	Name of schemes
Run-off-river diversion and gravity-fed systems	Sata, Annum Valley
River pumping-based and gravity-fed systems	Aveyime, Kikam
Reservoir-based gravity-fed systems	Libga, Afife, Bontanga, Gollinga, Tono, Vea, Ashaiman, Kpong, Okyereko
Reservoir pumping-based gravity-fed systems	Dawhenya
Lake pumping-based sprinkler irrigation systems	Weija, Kpando-Trokor, Amate, Dedeso
River pumping-based sprinkler irrigation systems	Subinja, Tanoso, Akumadan
Reservoir pumping-based sprinkler irrigation systems	Mankessim

Farmers using these schemes number about 10,848. In total these schemes have a potential area of about 14,699 hectares of which only 8,745 (59.5 percent) were developed for irrigated farming (Miyoshi and Nagayo 2006). Due to inadequate and deteriorated facilities at the various schemes, actual land cultivated has been changing from season to season and at times dwindling. Most of the non-functioning or underperforming schemes are pump-based.

Because of limited resources, GIDA has entered into contractual arrangements with private companies at some of the irrigation schemes. The purpose of the partnership is to allow the private companies to use the schemes' excess water and land in exchange for rehabilitating the infrastructure. Systems with partnerships are largely export-oriented. Examples of such arrangements are many. For instance, a private company known as Ghana Flower and Greens has a 25–year formal lease agreement with GIDA at Dawhenya irrigation scheme. The company has developed 30 ha of the potential land of Dawhenya irrigation scheme and draws about or makes use of 8000 m^3/ha per year. However, there is no restriction on volumetric quota of water used. The irrigation water is pumped from Dawhenya dam to the silos and to the green house for distribution. Drip irrigation and micro-sprinklers are used for irrigating the flowers.

Another example is the partnership of International Tamale Fruit Company (ITFC) with GIDA at the Libga irrigation scheme. ITFC offered to reconstruct Libga in order to attain ten years of water use rights from the scheme, while ITFC needs water for its out-growers, as water is scarce in the district. Details of the agreement are not transparent enough, but it was claimed

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[2] ICOUR was established to manage the two larger irrigation schemes of Ghana, namely Tono and Vea, which are situated in the Upper East region. Initially the organization was supported from internally generated sources of income with income generated used for organization and management of the schemes and paying staff salaries. Now staff salaries are covered by government, as are some operation and management costs.

[3] The most common mechanism of levying irrigation service fees is charging per unit of irrigated area, with the units often differentiated by type of crop and season.

that in case of extreme water shortage community usage rights take precedence over the company’s water right. Communities’ chiefs were part of the deal.

4.2 Small reservoirs and dugouts

The main distinguishing attributes of small reservoirs and dugouts are:

- size,
- priority of water use,
- structural details, and
- management system.

Dugouts are usually smaller in surface area, volume of water impounded, and number of beneficiaries. A dugouts is an area scooped to create more depth and to impound more water. Unlike small reservoirs, dugouts have no intake structures, canals, or laterals and are planned primarily for domestic and livestock use, with limited use for irrigation. Dugouts usually serve one to two villages and are constructed in locations where other forms of domestic water supply are non-existent, or where reservoirs cannot be constructed due to topographic unsuitability. Small reservoirs and dugouts are common throughout Ghana’s ten administrative regions. Small reservoirs are created by impounding water behind an embankment whereas dugouts are formed by digging down to remove earth. These reservoirs provide a source of water for livestock watering, domestic use, irrigation, fish production, and a number of other beneficial uses.

Small reservoirs and dugouts are usually initiated and financed by donors and designed or constructed by GIDA or private contractors. Numerous NGOs and donors (e.g., International Fund for Agricultural Development (IFAD), Plan Ghana, Red Cross, and Action Aid) have been involved in promotion of these systems starting as far back as 1970s and 1980s. In the case of dugouts, communities’ contributions to development are substantial; they are constructed mainly by the district assembly. After completion of construction, Water User Associations (WUAs) are established for managing and performing maintenance and operation activities. Sometimes dugouts are created unintentionally by road construction and mining projects. In these cases nearby community members claim collective ownership. The surface area of small reservoirs and dugouts ranges from 3 to 30 hectares and they are used for livestock, irrigation, fishing, and domestic water supply.

Recently, GIDA and MOFA inventoried small reservoirs and dugouts for Ghana’s ten administrative regions. In these regions, as can be seen in Table 4, they identified 786 small reservoirs and 2606 dugouts.

Table 4: Summary of Small Reservoirs and Dugouts in 10 Regions

No.	Region	Number of		Total small dams and dugouts	Cultivated area (ha)
		small dams	Dugouts		
1	Greater Accra	35	218	253	120.0
2	Upper West	84	54	138	712.0
3	Upper East	149	129	278	895.0
4	Eastern	75	115	190	438.0
5	Volta	167	136	303	103.0
6	Central	23	265	288	342.0
7	Ashanti	22	219	241	677.0
8	Western	50	783	833	820.0
9	Brong-Ahafo	50	289	339	1,360.0
10	Northern	131	398	529	649.0
	Total	786	2,606	3,392	6,116.0

Source: GIDA and MOFA 2008.

Total estimated area irrigated by these systems is about 6116 ha, which is comparable to the area irrigated by the 22 public irrigation schemes described in the preceding section. Despite the general perception that the number of small reservoirs and dugouts is greater in the three northern regions of Ghana as compared to the rest of the regions, Table 4 shows that they are distributed evenly around the country.

There are several notable projects engaged in promoting these systems in the three northern regions, including Land Conservation and Smallholder Rehabilitation Projects (LACOSREP I and II) and Upper West Agricultural Development Project (UWADEP). These were operated in the Upper West, Upper East, and Northern regions of Ghana. LACOSREP I, UWADEP, and LACOSREP II planned to put into operation a total of 106 small reservoirs (26 in Upper West, 80 in Upper East) for dry season irrigation, fishing, and livestock bathing, bringing benefits to more than 100,000 households. To date, only 90 small reservoirs had been constructed and put into operation serving about 1,000 ha of irrigated gardens. Of this area only 132 ha (out of the 1000 ha) are newly opened lands while the rest are rehabilitations of existing dams. These projects brought together about 50,000 households into WUAs. These projects' systems use open channel irrigation methods, which waste considerable quantities of water. Irrigation activities are done in the proper command area as well as in the catchment area of the reservoirs (Birner 2008).

Small reservoirs in the country are faced with significant physical, social, and institutional problems. These include: breakage of canals, choking of canals with weeds, construction delaysn, and lack of organizations for managing and sustaining the schemes. For instance, a WUA could be identified for only 31 of the 126 small reservoirs visited in Upper East. For the 31 reservoirs that had a WUA, the participation of farmers in the design, construction and management of the infrastructure is limited (Birner, 2008).

Private reservoirs and dugouts are used mostly for irrigation in the southern parts of the country. In the three northern regions (i.e., Northern, Upper West, and Upper East), small reservoirs are initiated and developed through the assistance of NGOs and Ghanaian government (i.e., district assemblies, MOFA, etc.). In southern and central regions such as Brong Ahafo, Ashanti, Greater Accra, where small-reservoirs/dugouts are extensively found, private individuals can initiate and develop infrastructure. Thus in these areas use of small reservoirs for irrigation is common among large scale plantation farmers. This practice dates back as far as the early 1980s. Private small reservoirs/dugouts are used during both dry and wet seasons. Even though the infrastructure is privately owned, sometimes nearby communities are allowed to use the water for both domestic and irrigation purposes, particularly when there is a scarcity of water. The potential command area of private small-reservoirs and dugouts ranges from 2.8 to 120 ha. The surface area of the private dugouts varies between 0.4 to 2 ha. The construction is done by contractors such as Hydrotech Company Ltd. Unlike communal small-reservoir systems, privately owned systems are almost always associated with other irrigation equipment or accessories such as motorized pumps, galvanized pipes, pipe hose, sprinklers, and drip systems that are used to better manage water.

In Greater Accra, a farmer was growing rice on an area of 20 ha land using water from a small reservoir. To illustrate the situation of a privately owned small-reservoir, details of this farm are summarized in Box 1.

Box 1:A privately owned small reservoir at AFIENYA in Greater Accra
This reservoir is owned by an individual, who inherited it from his parents. Construction of the reservoir was started in 1979 and completed in 1983 with family funds. The initial purpose of the system was for irrigation; however, it is currently used for livestock watering as well as for irrigation. The planned command area was 28 ha, out of which 20 ha are currently in use. The main crop cultivated is rice and labor for farm operations is from three neighbouring communities. The difference between planned command area and area in use is due to lack of funds to develop the whole area. Irrigation water flows by gravity through an intake at the reservoir. One main canal and six laterals serve the fields. Rice fields are all bounded into basins. The dam wall has an elevation of 34m. The maximum surface area of the dam is 10 ha. At maximum storage, the volume of water is about 520,000 m^3. Crops grown are mainly rice, tomato, and pepper. These crops are grown twice in a year, i.e., during the rainy and dry seasons. However, during the 2008 rainy season only rice was grown.

Private small-reservoir/dugout systems are common in the Eastern and Ashanti regions. Many farmers in the Eastern region use dugouts for crop cultivation both in the rainy and dry seasons.

4.3 River/lake lift systems

These systems use manual and/or motorized pumps to access water from a variety of sources, such as rivers, streams, and lakes. They are further differentiated into private smallholder systems, communal smallholder systems, and large-scale or commercial systems.

Private small-holder systems. In this system, individual farmers use small petrol or diesel pumps to pump water from nearby rivers, streams, and lakes to their fields. Petrol engines are the most common type. Most farmers own just one pump, with few owning two. They purchase the pumps from nearby major towns, although some farmers claimed to have purchased the pumps from as far as Nigeria and Samkasi in Togo. Price per unit depends on the model and size of the pump as well as the place of purchase. Pumps obtained from Togo are about half the price of pumps purchased from Ghana. Farmers who do not have their own pumps rent pumps at a fixed per diem cost, ranging from GH¢8.0 to GH¢10.0 in Ashanti, or at a cost of GH¢50.0 per season.

Pumps are not fixed but rather moved from one point to another depending on individual farm location. Pumps are fitted with a number of distribution pipes, with the number depending upon how far the irrigable land is from the abstraction point, but usually not more than 300 m. Pipes are of 10 m length and 0.04 m in diameter and can be moved from one farm to another. Pumps are usually placed close to the source of water, and water is pumped to the field and distributed by the use of pipes, hoses or sprinklers. Pumped water is used for dry-season vegetable growing. In the wet season, usually these irrigable lands flood, so farming cannot be done there.

Communal small-holder systems. This system is similar to the previous one except that in this case farmers own pumps in a group. The system is based on acquisition of small pumps with size ranging from 2.5 to 11.5 HP. Groups are mostly initiated by NGOs and MOFA. In some cases, farmers themselves form a group. Number of members depends upon the number of pumps owned, and the size of suitable land for irrigation. Sources of finance for procuring pumps include market women, Food Agricultural Budgetary Support (FABS), and MOFA. Area irrigated per household is usually less than 0.5 ha. Farmers are usually organized, with well-established leadership and a written constitution. The leadership organizes meetings and manages loans. Demand for membership in such groups is high and membership numbers continually increase. Also, the actual area irrigated increases as new members join the group. Pumps are not fixed but rather moved from one point of the river to another depending on individual farm locations. Pumps are usually operated for a period of 3 months in the dry season.

Farmers use pumps together and farm on communal lands and sometimes on private lands. They may have title to individual lands and farm individually while jointly executing some activities, such as planting and plowing. In contrast, weed control, watering, fertilizer application, and harvesting are done individually. Water distribution in the field is by flooding or through a sprinkler system. Farmers usually take water in a sequential manner and pay dues during the cropping season for operation and management of the pumps. They purchase fuel for irrigating their fields and also pay a maintenance fee. Farmers are scattered and not confined to a particular place. In addition, in the western region, farmers keep moving from one area to another as a strategy to combat nematode infestation.

Commercial or large-scale systems. Pump owners operate larger farms (ranging from 1.2 to 100 ha) using high capacity or multiple small capacity pumps. Notwithstanding the scale, irrigation practices are similar to the other pumping-based irrigation systems. Farmers also use high capacity pumps with permanent pump houses situated along rivers. Large scale commercial farmers adopted pump-based irrigation in the early 1990s, about a decade before smallholders started.

They also may contract with out-growers to augment their crop supply. In Ghana the out-grower systems refer to the situation where a nuclear farmer, usually a large-scale export oriented farmer, enters into contracts with groups of farmers. The nuclear farmer provides services such as input supply, marketing of outputs, delivery of water to the field, and extension advice. The farmers provide land and labor to the production processes.

An example of such system is found in Northern Ghana region. The nuclear company is the ITFC. Outgrowers of ITFC have cultivated grafted mango for export since 2001, under the strict regulations imposed by the company, which are necessary in order to meet EuropGAP certification standards as well as traceability for export to the European Union (EU). Most of the farmers were heads of households with larger tracts of land at their disposal, parts of which they used to try grafted mango production. These lands were formerly used for cultivation of maize, yam, groundnut, and other subsistence crops. Size of grafted mango plots for most farmers was about 0.4 ha, and the area was fenced to protect young plants. ITFC provides farmers with all required inputs for mango production, from seedlings through water supply, fencing, organic manure, polytanks and accessories for irrigation to boron or other micronutrients required for higher yields. They also give technical advice to farmers and a regular extension service. At the end of the production cycle, a market is guaranteed, as ITFC buys the entire mango output and then deducts cost of inputs when remunerating farmers.

4.4 Groundwater irrigation

The construction and use of wells of various sizes (depth and width) for irrigation is very common across the ten Ghana regions wherever shallow groundwater is available. This is especially prevalent in the three northern regions and southeastern coastal strips of Ghana. Many versions of groundwater irrigation systems appear, including shallow well-based irrigation systems and borehole irrigation systems. The shallow well irrigation systems are further differentiated into seasonal and permanent shallow well/tube well systems.

Seasonal shallow wells. These wells are used by farmers in areas with high water tables in low-lying areas, often along river banks, on riverbeds, in swampy areas, or close to poorly functioning formal irrigation schemes. This system is widespread and is used during the dry season for vegetable farming. In the wet season, the river banks often flood, so most shallow wells are silted and areas under cultivation are waterlogged, making the use impossible. In the Upper East region, dry-season shallow well-irrigated areas are used during the wet season for cultivating staple crops such as maize, sorghum, millet, and others. Thus, farmers are required to refill wells at the end of the dry season. Some public irrigation schemes are poorly maintained and their open channel systems function badly, resulting in wastage of water. Farmers dig shallow wells outside the official irrigation command area and downstream the main drainage channel to take advantage of the drainage and “wastewater” lost from the irrigation system.

Shallow wells are unlined and irregularly shaped, but are usually near cylindrical. Depth of seasonal shallow wells ranges from 1 to 5m depending on the level of the water table and the technology used for lifting water. Diameter ranges between 0.7 to 1m but most are 1m in diameter. Simple tools like bars, axes, and hoes are used for digging. A rope is tied to a bucket and the loose soil is collected and pulled out of the well until the water table is reached. Slopes are trimmed to specification when the water table is reached to enable the well to collect enough water.

Permanent shallow well irrigation systems.—These wells are developed closer to the homestead or even in the living compound (as found in the Upper West and Upper East regions), near urban centers (as in Ashanti and Eastern regions), and in fields away from homesteads (as in Keta district in Volta region). Permanent shallow wells can be lined with cement or are unlined. Farmers prefer lined wells, but many do not have the financial means to acquire the requisite materials for lining. Unlined wells are irregularly shaped. Well depth ranges from 1 to 14m depending on the groundwater level. The diameter ranges between 1 to 2m. As with seasonal shallow wells, simple manual tools are used to construct the wells.

The output of these wells is rather low and water is usually lifted manually. Consequently, farmers may have a number of wells to minimize labor required for irrigation. The number of wells per unit area varies widely from region to region. It ranges from as low as 2 wells to about 100 wells per hectare, as observed in Keta strip. Permanent shallow wells are used throughout the year mainly for vegetable farming, domestic use, and livestock watering. Diverse technologies are used for lifting and distributing water from these wells, including rope and bucket, rope pump with bucket, and motorized pumps.

Shallow tube-well irrigation systems. Shallow tube-well irrigation systems are commonly found in the Volta region, specifically in Keta strip. They are individually owned and used for irrigation and domestic purposes. Since they are permanent, they are usually dug on private land.

Communal borehole irrigation systems. These wells were developed in the Upper East, Upper West, and Northern regions in 2000. These were part of the MOFA's Village Infrastructure Project, which is funded by the World Bank (WB) and Kreditanstalt fur Wiederaufbau (KfW). Windmill pumps and 50 m^3 ferrocement water storage facilities were installed at existing borehole sites, with a yield of about 150 l/min. This program promoted use of wind energy, but has never been operationalized in the Upper East and Upper West regions. Its 5m Poldaw wind pump, when operational, can lift water from a depth of about 80m into a storage reservoir. The 50m^3 storage reservoir is 1.83m from the ground. Water from the reservoir is allowed to flow freely by gravity with the help of main outlet valve installed close to the reservoir and a supporting valve or a control valve which is 150m away from the storage reservoir. Falling groundwater levels have been observed in the upper regions where more than 2,000 boreholes have been drilled since the 1970s to provide potable water to rural communities (FAO 2005).

5. Economics of irrigated agriculture

With extremely high investment costs and additional costs for imported inputs and fuel, the economics of irrigation in Ghana are questionable. Even rice, with a very high local demand, is a marginal part of public irrigation schemes due to low yields. In general, vegetables are economically viable in both public and private irrigation schemes, although credit, storage, transport, and marketing are all important factors that determine profitability.

5.1 Investment costs

Data on public irrigation development investment costs are incomplete but are generally considered to be high. Based on a 2006 publication, the average per-hectare cost of development of public irrigation schemes is above $15,000 (Kyei-Baffour and Ofori 2006). Table 5 illustrates the range of investment costs for a limited number of irrigation schemes. Extremely high costs in Tono are somewhat misleading as they include the development of three townships, a club house, a swimming pool, a paved road network, streetlights, and power to the site.

Irrigation schemes such as Ashaiman, Afife, Vea, Aveyima, and Weija cost between $5,000 and $14,000/ha. Of these schemes, with a total developed area of 2,165 ha as of June 2003, only 1,436 ha were actually irrigated. Costs of small (around 100 ha) schemes that use pumps range between $4,000 and $6,500/ha (FAO, 1995). These irrigation development costs are high compared to other countries in Africa. For example, development costs in the White Nile Pump Irrigation scheme in Sudan were $1,000/ha and development costs in the Central Tunisia Irrigation project were $3,400/ha (Inocencio et al. 2007), while in West Bengal, India, development costs for comparable new small irrigation schemes are around $4,000/ha (World Bank private correspondence). Rehabilitation costs in Ghana are also high, ranging from $400 to $5,000/ha. In contrast, rehabilitation costs in Azerbaijan are $900/ha while in Kyrgyzstan they are around $300/ha (World Bank, private correspondence).

Table 5: Irrigation Development Investments Costs for Irrigation Schemes in Ghana

Irrigation Scheme	Region	Potential Area (ha)	Developed Area (ha)	In Use Area (ha)	Investment Costs (US$/ha)
Kpong	Greater Accra	3,028	2,786	1,500	$2,200
Tono	Upper East	3,860	2,490	3,500	$40,000-$50,000
Small Scale Irrigation Proj	9 Regions	2,300	2,300		$13,260
Small Farms Irrigation Proj.	Ashanti, Brong Ahafo, Western and Volta	820	820		$14,512

Source: FAO 2005 and Kunateh 2010.

Reasons for higher irrigation development cost in Ghana include:

- inadequate local expertise in planning and construction of irrigation projects;
- involvement of expensive expatriates at all stages of the project cycle;
- inadequate feasibility studies leading to costly design changes;
- costly involvement in construction of on-farm works;
- delays in imported inputs (due to foreign exchange shortage) during the 1960s-1980s;
- avoidable mechanization of construction rather than labor-intensive techniques;
- use of tied funds often involving additional supervision and administrative costs;
- procurement of non-standard equipment with special operation and service arrangements;
- relative inflexibility in project construction by governments and lending agencies;

- use of foreign firms for construction;
- over-designing due to insufficient knowledge of local conditions; and
- high bids based on perceived risks of operating in Ghana.

The main investment costs of groundwater development for agriculture include (see Table 6):

- drilling cost, which includes both material and human labor cost;
- number of wells to be constructed per unit area;
- pump sets of different types and makes (including electric pumps in the case of Keta);
- accessories such as water hose, PVC pipes, etc.;
- on-farm water distribution technologies such as sprinklers.

See Appendix 2 for details of investment costs of sprinkler irrigation-based tube well irrigation systems.

The number of wells to be constructed per unit of cultivated area depends on the depth and availability of water, the planned size of irrigated area, the type of technology involved in lifting and distributing water, and the seepage rates from the surrounding grounds into the well. Water is collected from the wells using different pumping technologies such as motorized pumps, hand pumps, treadle pumps, and rope and buckets. Motorized pumps are used particularly for wells sunk on the river beds. Field watering is also done manually, mainly using the same buckets, by pouring water on the field crops or using water hoses, pipes, and sprinklers. The cost of digging seasonal wells includes material and labor, and the digging has to be repeated every year. Filling the well at the end of the season takes about 2 days. The major cost component for lined permanent wells is human labor and cement for lining. Costs of groundwater structures required to irrigate a hectare range from GH¢182.8 to GH¢7,035.

Table 6: Estimated Investment Cost of Shallow Groundwater Irrigation Systems

Cost items	Seasonal shallow wells		Permanent shallow ells		
	Riverine	In-field	Un-lined	Lined	Tube-wells
Mean area irrigated in ha	0.2-0.3	0.4-0.8	1.2	0.1-3.0	0.4-5.0
Number of wells per ha	12.5	5-12	75	75-105	2.5
Cost per well (GH¢)	40.8	15.2	555.0	67-638.95	1329.2
Cost per ha (GH¢)	675.5	182.8	2740.7	3,155.3- 7,035.00	3323.0

US$1= GH¢1.4124

The investment cost of smallholder surface water pumping-based irrigation systems is influenced by location, horse power (HP) of the pump, the model/brand of the pump, and the size of the cultivated land. On average, it is GH¢788.5 per hectare, of which the cost of accessories is GH¢383.4. As can be seen in Figures 6 and 7, investment cost per ha increases with HP of the pump and declines with the size of the cultivated area (Figure 6 and 7). Figure 6 shows that the majority of the smallholders own pumps with HP ranging between 2 and 7.

Figure 6: Relationship Between Investment Cost and Horse Power of the Pump

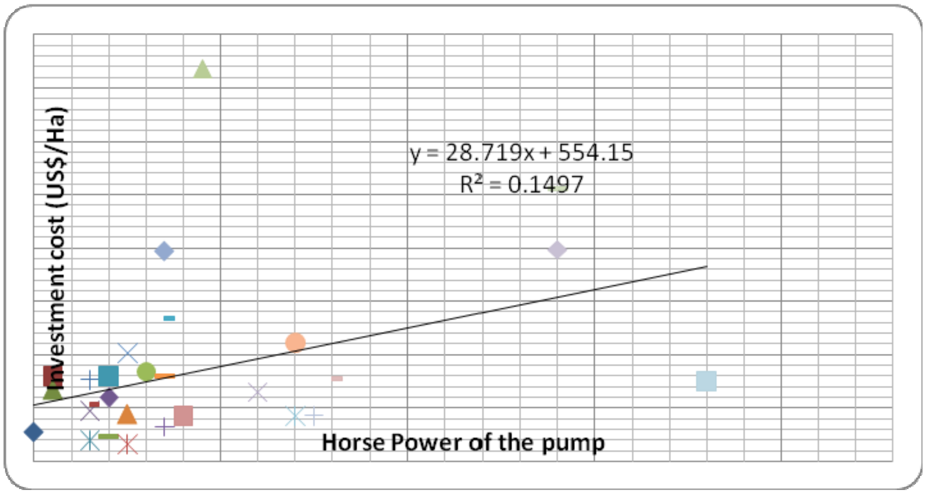
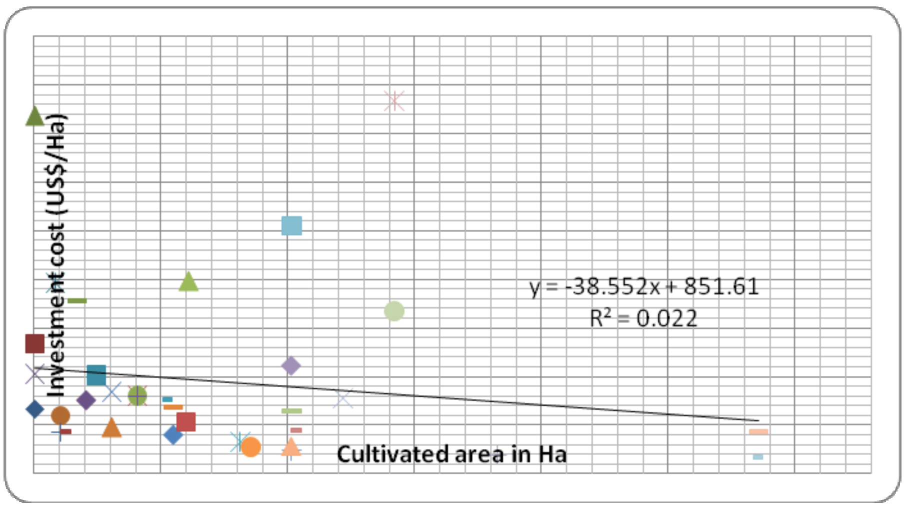


Figure 7: Relationship Between Investment Cost and Cultivated Area



Both figures indicate a weak relationship among investment cost, HP of the pumps, and size of cultivated area. This indicates that additional factors affect investment costs, and also indicates the inefficiencies of pump markets in Ghana.

5.2 Cropping pattern, yield, and profitability

The major crops cultivated under the different irrigation typologies are shown in Table 7. The main cereal crop grown in the public irrigation systems is rice, mainly in the wet season (and to a lesser extent in the dry season). This is usually followed by vegetable crops. In a few schemes, such as Okeyereko and Libga, private companies grow cut-flowers and nurseries for mangoes. A similar cropping pattern is observed in communal small reservoirs. However, privately owned small reservoirs cultivate mainly vegetables and nurseries. River, stream, lake, and groundwater pumping-based irrigation systems mainly produce vegetables and nurseries, and to a limited extent maize, cassava, and rice.

Table 7: Cropping Pattern

Irrigation systems	Cereals	Vegetables	Others
Public systems	Rice	Kenaf, okra, eggplant, tomato, ayoyo, onions, olera, cabbage	Flowers, grafted mangoes, groundnut, forage crops, pineapples
Small reservoirs and dugouts	Rice, maize	Cabbage, pepper, tomatoes, okra, cucumber, watermelon, egg plant	Nurseries (cacao, citrus, palm oil, oranges, mangoes, cashew, teak)
River/lake lift systems	Maize, rice	Pepper, Inions, cabbage, eggplant, lettuce, watermelon, tomato, cabbage, carrot, onion	
Groundwater irrigation	Maize, cassava	Tomato, onion, okra, pepper, kenaf, alefu, ayoyo, cowpea leaves, pumpkin leaves, Local leafy vegetables, cucumber, Garden eggs, cabbage, lettuce, shallot	Beans, citrus seedlings, nurseries for oil palm

During the field studies it was observed that public irrigation systems mainly cultivate rice, while the private and communal irrigation systems grow mainly vegetables.

Yield, variable costs, and gross margins for rice under different irrigation types are presented in Table 8. Mean yield for rice recorded for private smallholders involved in pumping and private small-reservoir or dugout schemes is almost double that observed in public schemes. The inferior yield level observed in public schemes translates into poor profitability, as indicated by gross margin. On public schemes, the difference between net profit and gross margin is not especially significant because depreciation on fixed assets is low because farmers do not own major farm equipment. Most of the materials that constitute fixed cost items are low value and rudimentary technologies such as hoe, sickle, cutlass, tarpaulin, or Knapsack sprayer. Thus, the difference between total and variable cost of production is minimal. Except for farmers that own their own irrigation systems, fixed cost constitutes 2.6-5.6 percent of the total cost of production, depending on the crop and irrigation type.

A host of factors contribute to the performance differences between public and private schemes, chief among them the low use of yield-boosting inputs (e.g. fertilizers and pest control technologies) which can be inferred from the low mean level of variable costs.

Table 8: Estimates of Profitability of Rice Production under Different Systems

No	Irrigation typology	Yield (t/ha)	Gross Margin (GH¢/Ha)	Variable cost (GH¢/Ha)
1	Public System: run-of river diversion + gravity-fed (Annum Valley Irrigation Scheme in Ejisu-Juabeng district, Ashanti)	2.5	-219.0	581
2	Public system: River pumping + gravity-fed (Okyereko Irrigation Scheme in Gomoa East District of the Central Region)	4.0	1623	1344
3	Surface water pumping: private smallholder	5.5	4732	1384
4	Small reservoir/dugout: private commercial	6.3	2370	1346

US$1= GH¢1.4124

There are several factors that influence profitability:

- water control offered by the system, which influences yields;
- costs of irrigation;
- crops grown (which could be a function of access to markets); and
- use of complementary inputs.

Similarly, yield, variable cost, and gross margins for vegetable crops under different irrigation systems are depicted in Table 9. The average vegetable yield recorded ranges between 3.5t/ha for reservoir plus gravity-fed public irrigation systems to 28.6t/ha for lake pumping plus sprinkler-based public irrigation systems. Of course, optimum yield levels vary widely depending upon the type of vegetable grown; therefore, as vegetable crop types vary widely, yields are not comparable from location to location. Net and gross margins are a better indicator of productivity for vegetables. The average yield and gross margins for vegetable crops is marginally better under public irrigation systems as compared to the other irrigation typologies.

Table 9:Yield and Profitability of Vegetable Production by Irrigation Typologies

	Yield (t/ha)	Variable cost (Gh¢/ha)	Gross margin (Gh¢/ha)
Groundwater irrigation			
Communal borehole		701	-298
Permanent shallow well	9.7	1005	2851
Seasonal shallow well	8.0	1042	922
River/lake pumping			
Private smallholder	6.0	1124	2294
Communal smallholders	10.0	1156	2986
Public systems			
Run-off river diversion +gravity-fed	6.3	1038	3521
River pumping +gravity-fed	4.3	996	412
Reservoir +gravity-fed	3.5	538	2386
Lake pumping + sprinkler	28.6	3239	7073
River pumping + sprinkler	9.9	1113	1639
Reservoir pumping + sprinkler	5.4	1612	2040
Small reservoirs/dugouts			
Communal	14.3	1250	2173
Private	4.0	940	1424

US$1= GH¢1.4124

However, these comparisons can be misleading as the yield figure is influenced by the mix of specific crops included in the vegetable category. The yield levels for the specific crops are shown in Table 10.

The major vegetable crops cultivated under public irrigation schemes are okra and garden eggs, while varieties of vegetables are produced in the other irrigation system typologies. Private smallholder pump users tend to grow a wide variety of vegetable crops as compared to communal pump users, and few private smallholder pump users were seen growing rice. Communal smallholder pump users are growing a narrow range of vegetable crops, namely okra, garden eggs, and tomato. This is because the communal pump users are engaged in export business, and therefore, they grow similar crops to enhance the volume of supply for exporters.

Table 10: Yield Levels for Vegetable Crops (t/ha)

	Rice	Carrot	Pepper	Tomato	Garden egg	Okra	Cabbage	Onion	Water-melon	Lettuce	Cucumber
Groundwater irrigation											
Communal borehole											
Permanent shallow well							16.0			1.4	11.6
Seasonal shallow well				6.0	9.5			8.4			
River/lake pumping											
Private smallholder	5.5	3.1	3.9	3.5	9.0	3.8	11.1	7.7			
Communal smallholders				3.4	5.7	10.3			20.7		
Large scale/commercial											
Public systems											
Run-of river diversion +gravity-fed	2.5					6.3					
River pumps +gravity-fed	4.0				2.4	6.2					
Reservoir +gravity-fed				3.5							
Lake pumping + sprinkler						28.6					
River pumping + sprinkler						9.9					
Res. pumping + sprinkler					7.9	3.5	4.7				
Small reservoirs/dugouts											
Communal							14.3				
Private	6.3		1.0	4.2	9.4	1.4					

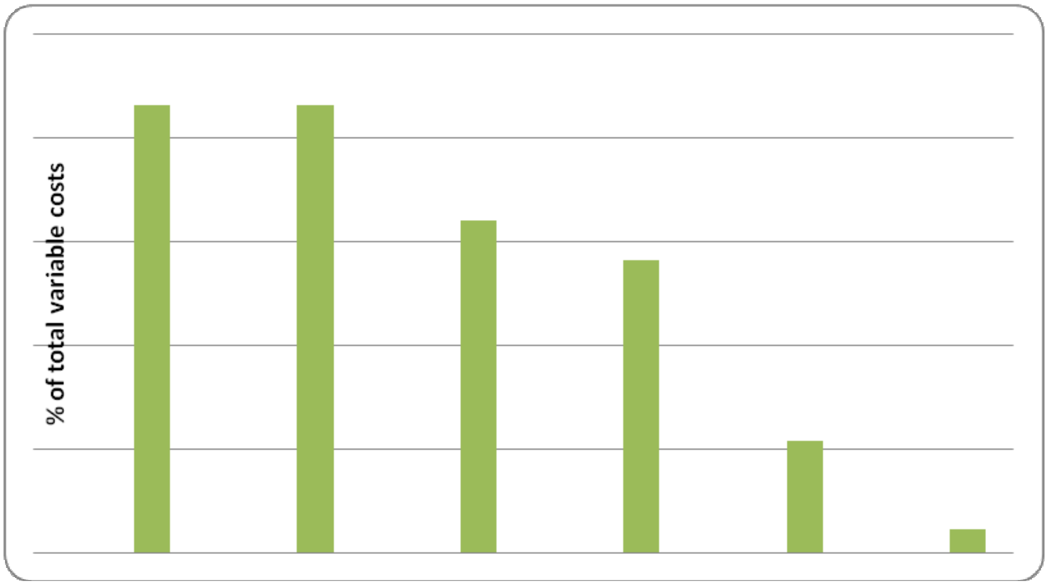
The level of profitability is affected very much by the type of crops cultivated. For instance, a farmer who privately owns a small reservoir used his water to raise nurseries and achieved a gross margin of $40,226.6 per hectare at a variable cost per hectare of merely $5192.6. However, this seems to be an exception. Vegetables are laborious crop to cultivate, but they produce steady income, as they can be harvested many times (up to 10-15) when water supply is regular and market in urban centers is assured. They require a steady water supply, even though they may not consume more quantity of water than rice. The average number of irrigations as reported by farmers is summarized in table 11.

Table 11: Irrigation Frequency by Crops

Crop	No of irrigations
Tomato	1- 7 times a week for 3 months
Pepper	Twice a week for 4.5 months
Onion	Thrice a week for 3 months
Kenaf	1-2 times a day for 3 months
Cowpea leaves	Twice a week for 3 weeks
Okra	Once a day for 4 months
Alefu	Twice a week for 3 months
Rice	Once a week for first 2 months

Land preparation, fuel, fertilizer, planting material/seed, and pesticides/herbicides constitute the bulk of the variable cost of production. The relative significance of variable cost components slightly vary from crop to crop. However, soil fertility management, water management (including fuel for pumps), pest control, harvesting operations, and land preparation constitute the lion's share of the variable costs. For nurseries, planting operation and planting material cover the bulk of the variable costs. Figure 8 details some of the major cost elements for rice production. As can be seen, this figure includes slightly more than 80 percent of the cost elements with the remaining costs including harvest, transport, and marketing. With a private reservoir, water management costs are only around 2 percent of the total production costs.

Figure 8: Cost Elements for a 20 ha Irrigated Rice Farm Using Private Small Reservoir



Labor cost constitutes significant proportion of the cost of production; off-season vegetable crop production is a particularly labor-intensive exercise. Labor constitutes 31 percent to 64.2 percent of the variable cost of production depending on the type of the crop. Even though there is slight variation from region to region, the four major labor demanding operations are harvesting and threshing, water management, weed and pest control, planting, and land preparation. The labor required varies from 113.9 to 212.5 person-days/ha depending on the crop type. Bird-scaring can be a major labor consuming activity for irrigated rice cultivation.

Per ha investment cost for private smallholder irrigation systems is substantially lower than for public systems. Hence, a given sum funds a far greater area and number of farmers if smallholder-based private irrigation is encouraged (Box 2).

Box 2: The breadth of outreach of two irrigation typologies

- Two 3.5 HP pumps, communally owned by 100 farmers irrigates about 20 ha in Ashanti
- Two small reservoirs, Tanga and Weega reservoirs in UE, irrigate 7.65 ha, serving about 314 farmers. This is about 0.024 ha per household!

Reported yield levels are highly variable and in many instances lower than the optimal expected yield levels. All in all, income from dry season irrigation production is considerable despite the usually small area of plots cultivated. Level of income realized by farmers differs despite growing similar crops due to variations in management skills among other possible factors.

6. Constraints to irrigated agricultural development

Most of the constraints observed are common to all forms of irrigation systems. The major constraints can be grouped into six major areas:

- financial and institutional issues;
- access to Inputs and Services;
- output marketing and post harvest handling or value additions;
- technical constraints;
- biophysical constraints;
- labor availability; and
- land availability.

6.1 Financial issues

Financial problems can be viewed at irrigation-scheme level and at farm-household level. At irrigation scheme level, money is required to maintain, operate and/or rehabilitate the infrastructure. Government budgetary allocations are usually inadequate, and the fund generated through irrigation service fee collection is also insufficient. Thus, there is a tendency to rely on donors or NGOs. This situation led to the deterioration of irrigation infrastructure, the breakage of canals, and the leakage of the weir's sluice gate. Moreover, due to insufficient funds, most public irrigation schemes could not fully develop their potential irrigable area.

At the farm-household level, farmers demand financial services to cover their investment needs and working capital requirements. Credit services for developing wells, acquiring water lifting devices, and financing expenses for crop production inputs are limited. If available, the terms of credit are high (about 22 percent). Thus, the cost of capital is generally high, and farmers have limited access to formal financial services, for instance procuring, maintaining, and operating pumps. The formal financial sectors tend to service commercially oriented farmers. Farmers, when approached, complain that banks unduly restrict the amount of money that can be accessed. Even when farmers are allowed credit, they report unnecessary delays in accessing the agreed amount.

In general there is no assistance to farmers to obtain inputs, and they buy these materials on the open market. Even if available, these inputs are acquired at high cost, thus reducing farmers' incentives. Most of the irrigated crops do not qualify for the Ghanaian government's current fertilizer subsidy policy. Even those crops (e.g., rice) that qualify for fertilizer subsidy, are only subsidized during the wet season. Energy for lifting and distributing water is also a problem. The price of petrol, diesel, and electricity tariffs are high. In areas relying on electricity for lifting water, intermittent power supply poses a problem.

6.2 Access to Inputs and Services

For productive and profitable irrigated farming, reliable, available water is necessary but not sufficient. Sustainable irrigated farming requires complementary crop-yield-enhancing inputs in the right quantity, quality, at the right cost and time. These key inputs include seeds, fertilizers, herbicides, insecticides, etc. In Ghana, availability of these inputs, particularly improved seeds and fertilizer, is always an issue.

Certified vegetable seeds are not easily available in Ghana. In cocoa-growing areas, NPK fertilizers are in short supply for dry-season irrigated farming as NPK is not essential in cocoa growing areas. There are few or no dealers in the cocoa growing areas catering to the input needs of irrigated agriculture.

Unavailability of efficient water lifting technologies and affordable well drilling technologies is a constraint to the development of groundwater irrigation. Farmers claim that these technologies are not available in the quantity or (often) quality desired, which also applies to accessories such as sprinklers, pipes, drips, etc. Choice of irrigation equipment adds another factor. At the moment, farmers acquire pumps using common sense rather than knowledge of the technical details of pumps.

The most prevalent land preparation technologies are the hoe and cutlass, suited to slash and burn-based cultivation systems but ill-fitted to irrigated agricultural production systems. Consequently, farmers rely on high-tech land preparation technologies such as tractors and power tillers accessed on hire bases from both private sources and irrigation service providers such as GIDA and ICOUR. Availability of farm machines affects cropping intensity, timeliness, and the size of the area one can cultivate. When these machines are publicly owned (as in the case of GIDA and ICOUR), availability and maintenance pose a problem, as do the presence or absence of maintenance service providers for irrigation equipment.

Farmers require professional advice to find appropriate seed and type and rates of agrochemicals for diverse irrigated crops. Yet extension personnel are not regularly available and extension service in the irrigation sector lacks. Moreover, at present no advice is available to farmers on the amount of water or irrigation schedule they should use for a particular crop. Extension personnel are not conversant with the details of emerging irrigation systems. Even in the public irrigation systems, farmers complain about various agricultural problems related to cultivation of rice. Production of irrigated vegetables is an intensive enterprise in which farmers crop up to four times a year. Their knowledge of cultivation techniques and use of inputs is poor.

6.3 Output marketing, post-harvest handling and value additions

Irrigation farmers in Ghana are market-oriented by virtue of the nature of crops they cultivate and the fact that they consume a smaller share of what is produced. Yet, there are limited marketing channels or market participants. The paucity of alternative marketing channels and market participants allows few buyers (e.g., market women, rice millers) to bid the price down. Crop purchases are also usually on a credit basis at extremely low predetermined prices. Buyers only pay producers after selling the product at much higher prices. In the out-grower schemes, farmers claim that the price of inputs and outputs is determined by the company without consultation. Often, buyers provide input credits to their customers as a way of guaranteeing output supply. The variability and uncertainty of output prices complicate farmers' production decisions.

Most of the outputs are perishable, requiring special storage and transportation facilities. Storage for grains is limited, and storage for perishable vegetables, such as tomato, is rare. Little consideration is given to improved post-harvest handling practices despite the perishable nature of the products. The perishable nature of irrigated crops provides gives leverage to middlemen (and -women), such as export agents, to influence prices.

Inadequacy of storage and processing facilities means that produce has to be sold as soon as it matures. Rice is sold as paddy, to the farmer's disadvantage, due to the difficulties in processing. Poor post-harvest handling of rice (i.e., the use of rudimentary threshing methods) significantly reduces the quality of the resulting local milled rice, which in turn fetches lower prices. Thus, local farmers often cannot compete with cheap and better quality products from aboard, especially in the case of rice.

6.4 Technical constraints

Inadequate planning and faulty design is sometimes the culprit behind the deplorable situation of irrigation equipment and the system. For instance, at the Gung communal borehole irrigation site, which operates by windmill pump, farmers complain that water drawn by the pump is insufficient for their needs during peak production periods. The reason for this difficulty lies not with the water yield of the borehole, but with low wind speed. Better assessment of potential wind speeds during initial project conceptualization could have averted some of these problems. Inadequate facilities and design problems are often major reasons behind inadequate distribution of water from a source to farmers' fields.

The design of most of the irrigation projects is standard, despite variations in topography, soils, crops grown, skills of the users, etc. Some of the design-related problems include over-designing, over-estimation of realizable command area, and faulty layout of canals and laterals. At some schemes, inadequate feasibility studies lead to costly design changes during construction, which leads to cost overruns. In addition, canals are not well-aligned, and water sometimes does not reach farmers' fields when it is needed. At some locations, pump houses are submerged in the lake during certain times of the year.

Irrigation infrastructure, by default or design, is used for multiple purposes, including livestock watering, domestic use, crop production and fishing. However, irrigation infrastructure designs fail to consider the multi-functionalities and the crop–livestock interactions. Unless fields are fenced, livestock often destroy irrigated crops during the dry season, when feed sources are limited. Moreover, livestock pose a significant threat to the stability of irrigation infrastructure such as reservoirs, as the availability of almost year-round lush grass along the banks of the reservoirs attracts crowds of animals from the surrounding communities.

Siltation of reservoirs and canals and extreme flooding events are the major impediments to the sustainability of some irrigation systems. Agricultural practices in the immediate catchment area of reservoirs cause severe siltation problems in many cases. Siltation diminishes the storage capacity of reservoirs and de-silting and rehabilitation can be financially demanding.

Due to deterioration in infrastructure, many public irrigation schemes are relegated to the status of rainfed systems, only allowing one production per year. At many of the public irrigation schemes, the infrastructure has collapsed, resulting in water waste and restricted irrigation schedules. Even rehabilitated schemes suffer from broken-down irrigation infrastructure.

6.5 Biophysical constraints

Dry-season vegetable production is severely constrained by pests and diseases, which cause significant yield loss or force farmers to purchase expensive crop-protecting chemicals. In particular, problems with nematodes impede profitable production of crops. Birds and fowls also destroy crops, as irrigated crops are the main food items available during dry season.

Poor drainage systems affect crop yields. For instance, the Sata irrigation scheme developed technical complications from the start related to the irrigation delivery system, field levelling, and field drainage. Actually, the scheme has no drainage facility. At Tono, floods affect certain parts of the developed command area in the rainy season, therefore further reducing the cultivated area. In the coastal areas, farmers have reported increases in salinity during the dry season.

6.6 Labor availability

In most areas, where irrigation is introduced, particularly in the three Northern regions of Ghana, land-person ratio is high and farmers tend to focus on extensive agriculture. In any normal year, the main rationale of the savanna zone farmers is to put as much land as possible under cultivation and maximize returns to labor. The labor intensive nature of most of the practices also pushes the farmers to rely on expensive labor-saving technologies such as herbicides for weed control. In the northern regions, southward migration of young people significantly affects farm labor availability. Moreover, in the mixed crop-livestock farming of Northern Ghana, the overlapping of agricultural operations, such as the coincidence of peak irrigation season with peak harvesting and threshing operations of rainfed crops, constrains labor.

In situations where water is manually lifted and distributed, irrigated farming becomes labor intensive. Where pumps are not used, farmers complain about the drudgery involved in manually lifting water (using buckets). The high frequency of irrigation in sandy coastal areas, contributes to labor demand. Some crops, such as shallot, involve cumbersome post-harvest processing routines. Thus, the lack of timely availability of casual labor can cause a production bottleneck. Inadequate labor availability and high cost of labor are particularly severe problems in the western and central regions.

6.7 Land Tenure and availability

Land tenure is an issue, particularly in the northern regions, where rice lands are occasionally taken back by the original owners or even appropriated. Land for development of public schemes was acquired by the government, which made only limited compensation to the land owners, and consequently disputes still linger in many areas, despite the fact that the scheme management gave priority in irrigated farm land allocation to the original land owners. There are certain rules that an irrigator has to fulfill in order to continue cultivating in the public schemes and the irrigated land use right is renewed every five years. If these rules are broken, the farmer can be evicted and the land given to another farmer. Land tenure insecurity is also one of many reasons why farmers resort to seasonal rather than permanent shallow wells, despite the inefficient drudgery of digging and refilling wells every season. Many farmers work on plots leased or given to them at little or no cost. Therefore, they do not enjoy the assurance that they will be using the same plot of land next season.

Land availability is also a problem in the intensive groundwater irrigation areas of south-eastern coastal regions of Ghana. In coastal areas, most farms are located in the township, and hence there is little room for area expansion. Farm size in the area is very low, but irrigation has significantly enhanced its carrying capacity. Even in the land-abundant northern regions of Ghana, per capita irrigated land size is limited. Public irrigation systems are designed on egalitarian principles, meaning that irrigation schemes are designed to benefit as many households as possible. This results in lower per capita and per household irrigated area. Hence, farmers cannot make a living from irrigated agriculture, and they consider it a supplement to other, more important livelihood strategies.

7. Conclusions and Recommendations

Ghana's hopes of attaining middle-income status and significantly reduced poverty by 2015 hinge among other things on what the country does in its agricultural sector. Cultivable land is still abundant and the country is endowed with water resources. But the productivity of the so-far-developed farm land is generally low, and farming is dependent on rain-fall, making it prone to droughts and floods, particularly in the northern regions. However, given the current demographic situation, production levels of the major staple food crops in a normal-rainfall year are adequate, although seasonal food insecurity is wide-spread.

Growth in the agricultural economy may be achieved both through extensification, and intensification. Irrigation is central to the intensification strategy. Irrigation potential is huge but untapped. Estimates of Ghana's irrigation potential diverge wildly and serious irrigation development efforts are a recent phenomenon. Yet the desire for food security, poverty reduction, and rural employment in areas characterized by mono-modal and highly variable rainfall distribution (such as the northern and southeastern coastal regions) all make irrigation development a necessary strategy. Despite considerable potential and the emphasis placed on irrigation development, an insignificant proportion of the potential irrigable land is actually developed.

Ghana seems to have comparative advantages, due to the strategic geographic location of the country (i.e., proximity to major demand centers, including European markets, regional markets, and others), with a readily available port, functioning air transport system, and abundance of land and water resources with the potential for accelerated development of irrigated agriculture. The potential comparative advantage is not yet realized. Thus, there is renewed focus on the development of irrigation sector. However, crafting smallholder-friendly irrigation investment plans is a challenge. There is a need to balance irrigation development based on large-scale commercial farming (mainly driven by foreign and local investment) with smallholder-oriented irrigation development focused on rural poverty reduction and food security. Emerging institutional arrangements, such as public– private partnerships, contract farming, and out-grower systems, may help effect this balance.

Management of irrigation systems by GIDA and ICOUR has not proven to be a viable means of ensuring sustainable irrigation in the country. With the reduction in total government budget, GIDA ends up spending almost all of its funds on staff salaries, with little funding provided for irrigation organization and management. In contrast, private irrigation is expanding in the country with the costs borne by the beneficiaries rather than the State. Based on Ghana's unsuccessful experience with public irrigation, there is a strong argument for the country to encourage private sector investment rather than continuing to sink public funds in poorly operated and maintained public irrigation schemes.

The following recommendations are suggested to revitalize Ghana's irrigation sector:

- Improve capacity utilization of existing irrigation systems
- Strengthen irrigation institutions, organizations, and policies
- Give support to emerging individualized and group-based irrigation systems
- Step up capacity building initiatives

7.1 Improve capacity utilization of existing irrigation systems

Give priority to the capacity utilization of the existing irrigation infrastructure before embarking on new developments, and learn from the weakness of the existing systems in planning new ones. Full use each scheme's excess land and water (where applicable) by:

- encouraging private investment through innovative institutional arrangements such as public–private partnerships, out-grower systems, and contract farming;
- encouraging the use of pumps and pipes so that farmers can convey water to scheme areas hitherto unused;
- facilitating conjunctive use of surface and groundwater through further development of wells in existing irrigation schemes;
- modernizating of the systems, as well as rehabilitating them, to enhance the flexibility of water supply and distribution, so that farmers can access water at the time they need and make crop choices according to individual circumstances;
- encouraging change in the existing crop repertoire toward high value remunerative crops; and
- intervening in the current land tenure system by formalizing prevailing land contractual arrangements, so that irrigated farmland may be consolidated and size of irrigated land per household increased to the point of economic viability.

7.2 Strengthen irrigation institutions, organizations, and policies

- Reform those organizations/institutions serving the irrigation sector so as to better care for emerging irrigation systems, and perhaps create a special apex body (or a section within GIDA) with a mandate to serve this sector. This is particularly required for groundwater-based irrigation.
- Develop the irrigation or agricultural water management research capacity of GIDA and encourage collaboration or partnership with existing research institutes of CSIR such as WRI, CRI, SRI, and SARI.
- Encourage the wider adoption of irrigation equipment by providing incentives. Review irrigation equipment import and trade policies, and assess the efficacy of the policies on the price of equipment and the actual adoption and dissemination of the technologies.
- Create quality standards for irrigation equipment so that farmers will have access to genuine equipment, accessories and parts as well as after sales maintenance.
- Strengthen information management system capability GIDA so that it can create, maintain, and disseminate important data, such as estimates of irrigation potential differentiated by regions and source of water; estimates of current irrigated area differentiated by regions, crops, and irrigation typology; and other data important for planning purposes.
- Strengthen project planning, implementation and supervision, particularly giving due attention to the contracting mechanism, which badly needs transparency and accountability.

7.3 Give support to the emerging individualized and group-based irrigation systems

- Prioritize emerging irrigation systems in the country’s irrigation development agenda for better breadth and depth of poverty and food security outreach of water management interventions.
- Encourage the agricultural use of groundwater, where applicable, by creating a database of groundwater quantity and quality differentiated by regions and agro-ecological zones.
- Improve rural energy supply and diversify rural energy sources so that people can tap water from various sources for crop cultivation and other productive uses.

7.4 Step-up capacity building initiatives

Capacity building is required at various levels:

- to improve the disciplinary mix of technical staff of GIDA for better planning and implementation of hydro-agricultural infrastructure;
- to improve the capacity of existing staff through targeted short and long-term training;
- to provide targeted training for private entrepreneurs engaged in the supply chain of agricultural water management equipment/technologies, such as dealers, retailers, and maintenance service providers, and also to farmers; and
- to train farmers regarding the appropriate choice of type and rate of application of pest control chemicals and the safety precautions required in their applications.

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Appendix 1: Salient Features of the 22 Public Irrigation Schemes

Name of scheme	Region	Number of households	Area (ha)			Crops	Status
			Potential	Developed	In use		
Afife	Volta	1024	950	880	880	Rice, Okra	Operational
Aveyime	Volta	83	80	60	0	Rice	Rehabilitation
Anum Valley	Ashanti	115	140	89	76	Rice, Okra, Pepper	Operational
Bontanga	Northern	550	570	450	390	Rice, maize, Pepper, Okra	Operational
Golinga	Northern	80	100	40	40	Rice, maize, Pepper, Okra	Operational
Ashaiman	Greater Accra	120	155	155	70	Rice, maize, Pepper, Okra	Operational
Dawhenya	Greater Accra	235	450	200	0	Rice	Non-operational
Okyereko	Central	131	111	81	42	Rice, Chilies, Okra	Operational
Kikam	Western	22	27	27	0	Rice	Non-operational
Vea	Upper East	2000	1197	850	500	Rice, Tomato, Sorghum	Operational
Amate	Eastern	127	203	101	0	Maize, Pepper	Non-operational
Dedeso	Eastern	69	400	20	0	Tomato, Pepper	Non-operational
Tanoso	Brong Ahafo	211	115	64	60	Okra, Maize, Cowpea	Operational
Sata	Ashanti	52	56	34	24	Okra, Maize, Cowpea	Operational
Mankessim	Central	32	260	17	17	Watermelon, Sweet potato	Operational

Appendix 1: Continuation

Name of scheme	Region	Number of households	Area (ha)			Crops	Status
			Potential	Developed	In use		
Akumadan	Ashanti	97	1000	65	0	Tomatoes, Maize, Cowpea	Rehabilitation
Subinja	Ashanti	32	121	60	30	Eggplant, Pepper, Okra	Operational
Libga	Northern	41	20	16	16	Rice, Maize, Pepper, Okra	Operational
Weija	Greater Accra	171	1500	220	0	Pepper, Tomato, Cabbage	Rehabilitation
Kpong	Greater Accra	2300	3028	2786	1500	Rice, Passion Fruit, banana	Operational
Kpando-Torkor	Volta	106	356	40	40	Okra, Maize	Operational
Tono	Upper East	3250	3860	2490	3500	Rice, Soy bean, Tomato	Operational
Total		10848	14699	8745	7185		

Appendix 2: Cost Details of Typical One Hectare Sprinkler Irrigation Scheme at Keta

Phase	Item No.	Component	Quantity	Unit Cost (GH¢)	Total Cost (GH¢)
Tube Well Development	1.1	6" x 10' PVC Pipe	3	9.00	27.00
	1.2	4" x 20' PVC Pipe	2	8.00	16.00
	1.3	Labor for Tube well	1	50.00	50.00
	subtotal				**93.00**
Pump Installation	2.1	Foot Valve	1	13.00	13.00
	2.2	4"x2" Reducer	1	5.00	5.00
	2.3	Pump Installation	1	25.00	25.00
	2.4	Pump (Pedrollo /Cear) Horse Power	1	450.00	450.00
	subtotal				**493.00**
Pipe Network	3.1	2" x 20' PVC pipe	128	9.00	1152.00
	3.2	1" x 20' PVC	16	6.00	96.00
	3.3	2" T Joint Socket	56	2.50	140.00
	3.4	2" x 1" Reducer	64	1.50	96.00
	3.5	2" L Joint Socket	8	1.50	12.00
	3.6	1" x 25m Water Hose	5	30.00	150.00
	3.7	Sprinkler	24	15.00	360.00
	3.8	Fancet 1"	64	1.50	96.00
	3.9	Valve Socket 1"	64	1.50	96.00
	3.10	Labor	1	150.00	150.00

Appendix 2: Continuation

Phase	Item No.	Component	Quantity	Unit Cost (GH¢)	Total Cost (GH¢)
	subtotal				**2348.00**
Electrical Installation (varies with site)	4.1	Meter House	1	20.00	20.00
	4.2	Meter	1	200	200.00
	4.3	4mm Copper Cable (80m)	2	45	90.00
	4.4	2.5mm Copper Cable (80m)	2	37	74.00
	4.5	Switch	1	5	5.00
	subtotal				**389.00**
	TOTAL				**3323.00**