USE OF GROUNDWATER IN TREE CROP IRRIGATION

A CASE OF COCOA IN GHANA
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## ACRONYMS

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<tr>
<td>CHED</td>
<td>Cocoa Health and Extension Division</td>
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<tr>
<td>CMC</td>
<td>Cocoa Marketing Company</td>
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<td>COCOBOD</td>
<td>The Ghana Cocoa Board</td>
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<td>CRIG</td>
<td>Cocoa Research Institute</td>
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<td>CSSVD</td>
<td>Cocoa Swollen Shoot Virus Disease</td>
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<td>FEATS</td>
<td>Farmers Economic Advancement Through Seedlings</td>
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<td>GAC</td>
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<td>GDP</td>
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<td>Ghanaian New Cedi</td>
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<td>High Performance Tree Seedlings</td>
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<td>Ministry of Food and Agriculture</td>
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<td>Memorandum of Understanding</td>
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<td>PERD</td>
<td>Planting for Export and Rural Development</td>
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<td>Quality Control Company</td>
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<td>SME</td>
<td>Small and Medium Enterprise</td>
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<td>SPD</td>
<td>Seed Production Division</td>
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ABOUT THE FEATS LEARNING SERIES

The Farmers’ Economic Advancement Through Seedlings (FEATS) Learning Series is carrying on the Mennonite Economic Development Associates (MEDA) tradition of sharing lessons learned during project implementation. This new series covers MEDA’s learnings in the tree crop industry in Ghana during a seven-year period (2015 - 2022). Topics include:

1. Building Sustainable Small-scale Cashew Nurseries: Key Results and Lessons from the FEATS Project
2. Establishing the Model for SME Operations: Designing the Benchmarks for Growth
3. Scaling Up Farmers’ Capacity Building: The Use of Technology on the FEATS project
4. Use of Groundwater in Tree Crop Irrigation: A Case of Cocoa in Ghana
5. Building the Capacity of Women Entrepreneurs: The FEATS Women-led SME Story
6. Gender Messaging through Talking Books: The FEATS Project
7. Supporting Women Farmers’ Access to Finance: The FEATS Project

ACKNOWLEDGEMENTS

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Special thanks to the Government of Canada, which provided funding for the FEATS project.

Thanks also to all FEATS partners – both private and public sector partners – and MEDA’s generous private supporters.
EXECUTIVE SUMMARY

Despite the immense contribution of cocoa production to Ghana’s economy, it is confronted with many challenges. The majority of cocoa farms are low yielding, resulting in low productivity and incomes for the farmers. Major factors identified for the low yields of the crop include old age of trees and devastation caused by the Cocoa Swollen Shoot Virus Disease (CSSVD). According to the Ghana Cocoa Board (COCOBOD), about 40% of cocoa tree stock including over 1.9 million hectares of cocoa plantations in Ghana are overaged (more than 30 years old) or diseased, leading to an increased demand for quality planting materials. Cocoa is sensitive to deficits in soil moisture due to its shallow rooting system and high evapotranspiration through its broad leaves. Implementing irrigation systems is an intervention that can be used to ensure adequate water in the soil for the cocoa plants. Therefore, supplementing the soil moisture deficit through irrigation is expected to stabilize and increase the cocoa yield, especially in the critical seed gardens, the only source of quality cocoa planting material in Ghana. Irrigation is a well-known remedy in such a situation, with the potential to enhance resilience against drought by enabling crop production during periods of erratic rainfall and dry spells.

Consequently, the FEATS project collaborated with the Ghana COCOBOD to install 28.3 hectares of automated drip irrigation facilities at its cocoa seed gardens at Bunso in the Eastern Region and Goaso in the Ahafo Region in July 2020 using water drawn from boreholes. The successful installation of the automated drip irrigation systems using only groundwater was a unique and significant breakthrough and a potential game-changer for the cocoa industry in Ghana. To ensure sustainable operations, FEATS also facilitated the training of COCOBOD staff and field workers in the requisite specialized knowledge and skillsets to operate and maintain the drip irrigation systems at the two stations. Consequently, COCOBOD has been able to double the pollination rate, producing two cycles of cocoa seed pods per year, instead of the usual single cycle of production without irrigation.

Major recommendations/learnings of this paper are the need to procure relevant experts with extensive knowledge of the subject matter to facilitate the efficient establishment of drip irrigation facilities. The successful use of only groundwater to irrigate large cocoa plantations by FEATS and COCOBOD opens the gateway for extensive use of groundwater for irrigation in the cocoa industry, to irrigate not only cocoa seed gardens, but any farm in Ghana. The paper also provides valuable information targeting policy-level decision-makers such as the Ministry of Food and Agriculture (MOFA) to invest and embark on the strategic exploitation of groundwater resources in the agricultural development of the country.
1. ABOUT THE FEATS PROJECT

The FEATS project, was a seven-year (2015-2022) initiative funded by Global Affairs Canada (GAC) that aimed to improve the economic wellbeing of men and women farmers in export-linked tree crops industries of Ghana.

Ghana’s economy and workforce are heavily dependent on agricultural commodity exports, with the tree crops sector being one of the biggest contributors to the country’s gross domestic product (GDP). It is estimated that between 44.1% to 51.5% of Ghana’s labour force is engaged in agriculture, with the sector accounting for 18.2% of GDP in 2020.

Despite the significant contributions of tree crops to the export earnings of Ghana, the tree crop sector is yet to realize its full potential and is hindered by: (i) low participation of women, (ii) low area under cultivation, (iii) inadequate access to quality planting material, (iv) underdeveloped value chains for rubber and cashew, (v) non-existence of shea plantation establishment, and (vi) lower capacity of farmers to understand and effectively use new knowledge to improve their farm operations.

The FEATS project was therefore designed to help address some of the above-named challenges facing tree crop farming to encourage increased productivity and incomes for farmers.
1. Increased Supply of Quality Tree Crop Seedlings

The project worked to improve both the technical and infrastructural capacities of small and medium enterprises (SMEs), mostly women-led, engaged in the business of producing tree crop seedlings to develop a sustainable market for quality seedlings to meet the needs of tree crop farmers across the country.

2. Increased Access to Quality Seedlings by Tree Crop Farmers

Through trainings and innovative incentive programs, the project educated farmers on the benefits of planting quality seedlings and how to profitably grow quality tree crops for enhanced productivity. Through its seedling purchase discount voucher program, the project worked to increase farmers’ adoption and planting of quality seedlings by facilitating their access and ability to purchase the needed quantity of quality seedlings for their farms.
3. Improved Business Environment

The project is strengthening policy/strategy capacities of the Ghana government, its agencies and leading private firms that need to foster commercial markets for High Performance Tree Seedlings (HPTS) and quality seedlings. Over its seven-year mandate, the FEATS project aimed to support 100,000 male and female farmers by working through 25 tree-crop sector farmer and industry associations to plant 21 million tree crop seedlings. Additionally, 35 small enterprises and their employees were supported with technical and innovative matching grant assistance to ensure the production of quality tree crop seedlings to meet farmers’ needs.

2. SITUATIONAL ANALYSIS OF THE COCOA INDUSTRY IN GHANA

2.1 Location and Physical Setting

Bunso and Goaso are in the Eastern Region and Ahafo Region of Ghana respectively. Both towns lie within a wet semi-equatorial climatic zone with two wet seasons of unequal rainfall intensity. Both towns have moist semi-deciduous forest vegetation cover. Bunso experiences relatively high rainfall with annual values ranging between 1,600 and 1,700 mm while Goaso experiences rainfall of 1,300 - 1,400 mm. The soils at Bunso have low porosity while the soil type around Goaso is sandyloam.

2.2 Contribution of Cocoa to Ghana’s Economy

Cocoa is the backbone of Ghana’s economy. It is the third-largest export commodity, contributing about 30% of the country’s total export earnings. Cocoa contributed to 1.8% CAD $537,063 (GHS 4,186 million) of Ghana’s GDP in 2017; 1.6% CAD $557,078 (GHS 4,342 million) in 2018 and 1.4% CAD $566,701 (GHS 4,417 million) in 2019. Cocoa production employs about 800,000 small holder farmers. About 90% of these farmers live in rural areas within Ghana’s forest ecological zone where the cocoa crop thrives. Cocoa is not the only source of livelihood for these rural farmers but also attracts social

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2 Ghana Statistical Service, 2019
3 Ghana Statistical Service, 2020
amenities, such as roads to transport the commodity to exit ports, schools, hospitals, markets, etc., from the government, improving their living standards, and enhancing rural development.

2.3 Ghana Cocoa Board (COCOBOD)

The Ghana Cocoa Board was established by ordinance in 1947. The functions of COCOBOD center on production, research, extension, internal and external marketing, and quality control of cocoa classified into two main sectors: pre-harvest and post-harvest management performed by specialized divisions of the board.

The divisions of COCOBOD include Cocoa Research Institute (CRIG), Seed Production Division (SPD), Cocoa Health and Extension Division (CHED), Quality Control Company (QCC) and Cocoa Marketing Company (CMC). The functions of SPD and CHED are relevant to this Learning Series paper.

**Seed Production Division (SPD):** The objective of the SPD is to multiply and distribute high quality cocoa planting material in efficient and cost-effective ways in adequate quantities to farmers. To ensure the production and delivery of improved cocoa varieties, SPD currently operates 27 cocoa stations spread within cocoa growing regions. To effectively ensure sustainable cocoa production, COCOBOD introduced the distribution of hybrid cocoa seedlings to farmers free of charge. Consequently, COCOBOD has given the SPD the mandate to raise 60 million seedlings for distribution free of charge to farmers. The SPD is the only nationally mandated source for the supply of cocoa planting materials to farmers in Ghana produced through the seed gardens.

**Cocoa Health and Extension Division (CHED):** The Division is responsible for the control of cocoa swollen shoot virus disease, rehabilitation of old and unproductive cocoa farms and extension services. CHED’s activities include sectoring and surveys in cocoa districts, treatment of infected farms, assisting farmers to replant treated farms with disease tolerant and improved hybrid varieties and conduct of periodic re-inspection of treated and replanted farms to prevent the reinfection of treated farms. The division also has oversight and management responsibility for the new cocoa extension system which operates as a public private partnership, providing efficient and cost-effective extension services to cocoa farmers by assisting them to acquire knowledge and skills in good agricultural practices.
2.4 Effect of Climate Change on Cocoa Production

Cocoa has large broad leaves that transpire water quickly under high temperatures. Also, its relatively shallow root system with the majority of fine and coarse roots located in the top 0.4–0.8 meters of the soil make it difficult for deep water extraction. Prolonged inadequate access to water can negatively impact yield, and seasonal variation in cropping patterns is often largely determined by the timing of rainfall and dry periods. This indicates that water for irrigation purposes in cocoa farming is essential to increase pod production. For instance in Ghana, the maintenance of the top 0.30 meters of soil through supplementary irrigation increased pod production by 40% during a severe dry season and reduced the incidence of young fruit (Cherelle) wilt – a fruit-thinning process in cocoa.\(^4\) Soil moisture is very important to cocoa production in Ghana. Rainfall or soil moisture plays a very important role in cocoa production and impacts growth, leaf production, photosynthetic activity, and stomatal behaviour. However, the threat of climate change leading to less, or more erratic rainfall in the tropics, and higher temperatures and drier air, uncertainty in yield forecasting will increase and yields will decrease on average.

There is evidence of a decline in the annual rainfall of the forest ecological zone where cocoa thrives.\(^5\)

With erratic rainfall and high temperatures affecting cocoa production, the over-reliance of the COCOBOD’s cocoa seed gardens on rainfall for pod production is risky and a threat to cocoa production in Ghana. Also, anthropogenic actions such as illegal mining and bad farming practices have contaminated surface water with chemicals, such as mercury and nitrates. This has made surface water unwholesome for irrigational purposes. To intervene, FEATS in partnership with COCOBOD, constructed drip irrigation facilities at Goaso in the Ahafo Region and Bunso in the Eastern Region to irrigate seed gardens to boost pod production for supply to farmers.

The selection of the drip irrigation as a method of supplying water to the root zone of mature and young cocoa trees is not only innovative but important as wholesome underground water was used for irrigational purposes.

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2.5 Irrigation of Cocoa

The availability of water is an essential requirement in cocoa cultivation. Water limitation is one of the major challenges faced in the cocoa growing regions. Long dry spells and erratic rainfall patterns even during the wet season adversely affect cocoa production.

Implementing irrigation systems is an intervention that can be used to ensure adequate water in the soil for the cocoa plants. Therefore, the control of the soil moisture deficit through irrigation is expected to stabilize and increase the yield of cocoa. Irrigation is a well-known remedy in such a situation, with the potential to enhance resilience against drought by enabling crop production during periods of erratic rainfall and dry spells.6

There are two irrigation methods suitable for field cocoa production: Drip and Sprinkler irrigation. Drip irrigation is generally considered the most water-efficient as it distributes water directly to and uniformly within the rooting zone of the crop. It also enables precise control of the amount of water applied, thereby reducing evaporation, and enabling deep percolation. The drip method has also been widely applied to the cultivation of other commercial crops because the volume of soil moistened at a particular water application is controlled. It is therefore recommended in areas where source water is scarce. The FEATS project chose the drip irrigation system for this intervention. The sprinkler irrigation method is similar to natural rainfall. Water is pumped through hoses and then sprayed onto crops with sprinkler systems.

Figure 2: Drip lines delivering irrigation directly to the root zone of the crop
Figure 3: Example of sprinkler irrigation water showing sprinkler head creating the rainfall effect

2.6 Availability and Quality of Water Resources at Bunso and Goaso

Both towns of Bunso and Goaso have large rivers, namely the River Birim and River Goa, respectively. However, due to anthropogenic activities and the high prevalence of illegal mining (galamsey) activities, the quality of the surface water from the two rivers has been compromised. The rivers are polluted, making it unsuitable for irrigating cocoa as this can affect the growth and quality of pods.

This situation required the need to explore groundwater as a sustainable source of water for irrigating cocoa seed gardens at Bunso and Goaso. Groundwater is of relatively high quality and therefore suitable for supply of reliable water crops. The geology of Bunso and Goaso irrigation are composed of Birimian rocks which have undergone fracturing and metamorphism making them marginally favorable locations for groundwater storage as aquifers. In Ghana, groundwater is usually tapped through shallow wells and boreholes. This is highly prevalent in rural areas where access to pipe borne water and quality surface water is usually low. Boreholes tapped from Birimian aquifers have yields ranging between 0.41 and 29.8 m³/h with average yields ranging between 7.4 and 12.7 m³/h.7

Previous drilling activities conducted at Bunso and Goaso seed gardens resulted in the establishment of ten production boreholes, five for each station. The borehole drilling depths at Bunso ranged between 35.0 and 80.0 meters with an average value of 54.4 meters, while Goaso had drilling depths ranging between 48.0 and 95.0 meters with an average value of 66.2 meters.

To ascertain the suitability of the boreholes, they were subjected to constant pumping tests for three hours and for an hour of water recovery regime. At Bunso, constant pumping rates ranged between 21.0 and 71.0 l/min with percentage recovery rates ranging between 34% and 73% of the initial static water levels before pumping test after an hour recovery regime. Similarly, the five boreholes drilled in Goaso, which had depths ranging between 48.0 and 95.0 meters were subjected to three-hour constant pumping tests. The boreholes could only sustain constant rates ranging within 12.0 and 40.0 l/min and could only be recovered within 27% - 53% of the initial static water levels.

Water demand per design of the irrigations systems installed at Bunso and Goaso were each expected to utilize 390.0 m³/day. On the other hand, systems at Goaso were expected to be connected to a water supply source that could be sustained at about 750.0 m³/day. Notwithstanding, the drilling campaign and pumping tests, it was established that for the irrigation systems to be optimally

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Scaling Up Farmers’ Capacity Building

functional, there was a need to drill new high yielding boreholes or improve borehole yields of the existing boreholes to meet a deficit of 207 m³/day (144 l/min) for each of the two sites at Bunso and Goaso at 560 m³/day (389 l/min).

3. FEATS INTERVENTION

3.1 The Need for Irrigation of Seed Gardens

In past years, the SPD has experienced a reduction in seed pod production attributable to poor rainfall distribution during the major rainy season and reduced rainfall during the minor season. The poor rainfall distribution coupled with a severe dry season markedly affect the establishment and subsequent growth of young plants, as well as flowering and fruit set and leads to poor yield of the trees, resulting in the inability of the division to achieve its annual seed production targets. Also, Ghana is experiencing reduced cocoa production from aging cocoa trees and some parts of major production areas are seeing an outbreak of the Cocoa Swollen Shoot Virus Disease (CSSVD).

COCOBOD explains that most cocoa farms are low yielding, resulting in low incomes for farmers. Major factors identified for the low yields include the old age of trees and devastation caused by the CSSVD. According to the CHED, about 40% of the over 1.9 million hectares of cocoa plantations in Ghana have low productivity because the tree stocks are either over aged (more than 30 years old) or infected with CSSVD. COCOBOD has a rehabilitation program to replant 760,000 hectares using high quality cocoa hybrid planting material to improve crop productivity sustainably and increase annual production levels.

Also, COCOBOD remains the only source of hybrid cocoa pods to farmers in Ghana, and the need to stem the declining production from its seed gardens was therefore identified as an important intervention by the FEATS project, since it was only through this strategy that farmers could be guaranteed the right quantity of quality cocoa pods to replace their aging and diseased plants. Through stakeholder engagements, irrigation of the seed gardens was identified as a critical intervention that could be implemented to reverse the declining trend of pod production. As a result, the seed gardens of Bunso and Goaso were identified as the best suited to serve a high number of cocoa farmers in Ghana once they were irrigated.
3.2 Key Activities

The FEATS project and COCOBOD signed a Memorandum of Understanding (MOU) and Scope of Work (SoW) agreements in 2016 and 2018, respectively, to work on establishing irrigation facilities at COCOBOD’s seed gardens at Bunso and Goaso. The agreements defined key activities, and respective roles and responsibilities. The supply and installation contracts for the drip irrigation works were commissioned in January 2019. The installation of the facilities at the two sites were completed and commissioned in mid-2020 and the facilities have been operational since then. Some key processes and activities that were undertaken included:

i. Feasibility studies and conceptual design for the establishment of 50-hectare high quality drip irrigation systems at Bunso and Goaso cocoa seed gardens

ii. The selection of vendors for the supply and installation of 50-hectare drip irrigation facilities at seed gardens at Bunso and Goaso

iii. The provision of water & power for irrigation by COCOBOD

iv. Conduct of fresh hydro geophysical and hydro-geological studies at Bunso and Goaso seed gardens

v. Training of COCOBOD irrigation technicians in operations and maintenance

vi. Commissioning and handing over of the irrigation systems.

3.2.1 Feasibility study, design, and tender documents

Based on visits to the proposed sites at Bunso and Goaso by FEATS, data collection and meetings with stakeholders, an outline for the establishment of the irrigation facilities was determined. The conceptual design recommended groundwater as a source of water for irrigation. The irrigation systems included boreholes, electric pumps mains and lateral pipelines to deliver water to the root zone of the cocoa plant through drip emitters. Recommendations for automating the irrigation system included using a semi or fully automated fertigation system. Another recommendation included a proposal for system management staffing. Based on the outlined design, FEATS developed tender documents for the supply and installation of the semi-automated drip irrigation systems for Bunso and Goaso.
3.2.2 Supply and installation of semi-automated Drip Irrigation Systems at Bunso and Goaso

The tender documents were issued for a vendor to provide a detailed design of the facility, supply the requisite equipment, and install on site in August 2018. The selection process culminated in a contract agreement signed in January 2019 with site works completed by July 2020.

3.2.3 Provision of irrigation water and power

Between November 2018 and February 2019, COCOBOD provided ten boreholes with five at Bunso and five at Goaso and all had submersible pumps installed by April 2019. The installation revealed borehole yields would not be sufficient to irrigate the 30 hectares of irrigable land. This resulted in further work to explore options for providing more water to adequately supply irrigation to all developed irrigable areas. FEATS therefore commissioned fresh hydro-geophysical studies in December 2019 to overcome a water supply gap identified based on independent assessment of yields of the ten COCOBOD boreholes. The construction of pump houses was completed in September 2019 and the power supply including internal wiring of the pump houses were completed in five months.

3.3 Hydro-Geophysical Studies

The methodology of hydro-geophysical studies consisted of a desk study that involved compiling and assessing topographic and geological maps, existing borehole information and reports on previous hydrogeological studies undertaken in the study area to establish the current knowledge about lineament patterns and fractures, the presence of suitable aquifers and their thickness, groundwater quality, the mean aquifer and water table depths, and the expected lithological sequences. A reconnaissance survey was also conducted to locate target areas for geophysical investigations. It was comprised of an assessment of topography, geology, hydrogeology, structural features, water points, and soil surveys to detect sufficiently permeable strata that, because of their relative elevation or depression, geological history, and hydrology, could be water bearing. Furthermore, social, logistical, and accessibility were also considered.
It also included setting out traverse lines in the selected target areas. Hydrogeophysical studies leading to the delineation of zones of high groundwater potential for the drilling of high-yielding boreholes for irrigation purposes at Bunso in the Eastern Region and Goaso in the Ahafo Region of Ghana was carried out. The geophysical studies were conducted using Magnetotelluric geophysical techniques to detect prominent geophysical anomalies as well as an estimation of depth-to-aquifers to inform planning and drilling. Hydrogeophysical properties of existing boreholes were evaluated to serve as decision support data to inform the selection of the most promising and suitable zones for drilling. Results from the study indicated that:

- Groundwater potential was high, therefore high yielding boreholes could be established to meet the water deficit.
- Borehole drilling depths were relatively shallow ranging between 35.0 and 95.0 m.
• Zones of relatively high groundwater potential had successfully been delineated at Bunso and Goaso to guarantee access to a sustainable water supply.

• To guarantee the establishment of sustainable boreholes for the automated irrigation systems, the following recommendations were made:
  • Boreholes drilling depths be within 140.0 - 150.0 m to ensure that all prevailing aquifer zones are optimally harnessed.
  • To prevent silting of boreholes, all boreholes must be fully-lined with unplasticized polyvinyl chloride (uPVC) pipes and well gravel-packed.
  • Boreholes drilled must be well grouted with a mixture of cement and sand to prevent potential infiltration of pollution sources.
  • Borehole yields were expected to be high ranging between 150.0 and 300 l/min [216.0 and 432.0 m³/day].

3.4 Irrigation Water Supply and Demand for Bunso and Goaso Seed Gardens

With respect to water demand as per the design of the irrigation systems installed at Bunso and Goaso, the two sites at Bunso (Area 1 and Area 2) were each expected to utilize 390.0 m³/day. On the other hand, Goaso systems were expected to be connected to a water supply source that could be sustained about 750 m³/day. However, after the drilling campaign and pumping tests, it was established that for the irrigation systems to optimally function, there was an urgent need to drill new high yielding boreholes or improve borehole yields of the existing boreholes to meet the deficit of 207 m³/day (144 l/min) for each of the two sites at Bunso and 560 m³/day (389 l/min).

3.5 Monitoring and Data Collection

FEATS and COCOBOD’s collaboration also included monitoring and collecting relevant qualitative and quantitative data on irrigated seed gardens requirements, and knowledge management. The regular quarterly cocoa pod production figures derived from the irrigated plots was to determine increases in pod production against the baseline figures prior to the commencement of field irrigation activities.
4. RESULTS

4.1 Semi-Automated Drip Irrigation Facilities

The FEATS project eventually completed the installation of three semi-automated drip irrigation systems at Bunso and Goaso cocoa stations in July 2020 with water supplied from boreholes. A total of 28.3 out of the planned 30 hectares was developed. Details of the installations are provided in the table below:

Table 1: Semi-automated drip irrigation systems installed at Bunso and Goaso cocoa stations

<table>
<thead>
<tr>
<th>Description of Item</th>
<th>Bunso Area 1</th>
<th>Bunso Area 2</th>
<th>Goaso</th>
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<tr>
<td>Area Developed</td>
<td>6.2 hectares</td>
<td>8.1 hectares</td>
<td>14.0 hectares</td>
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<tr>
<td>Boreholes (Drilled/Developed/Utilized)</td>
<td>4/2/2</td>
<td>4/4/4</td>
<td>8/8/5</td>
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<td>Reservoirs (Volume/No of 25,000 litre polytanks)</td>
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<td>150 cu.m.3/6 no.</td>
<td>300 cu.m.3/12 no.</td>
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<td>Pump houses (3 no.)</td>
<td>High pressure centrifugal pump, filters, fertigation kit, control panel, valves, borehole timers and water meter</td>
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<td>Pipelines and drippers</td>
<td>63mm-90mm dia. mains, 40mm-63mm dia. submains, 3 mm dia. drip laterals and 4 litres per hr drippers (2 per cocoa tree)</td>
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<tr>
<td>Head Control Units (Double/single)</td>
<td>2 no./1 no.</td>
<td>2 no./2 no.</td>
<td>3 no./2 no.</td>
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<tr>
<td>Number of unit areas</td>
<td>3 no</td>
<td>4 no</td>
<td>8 no</td>
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All three facilities had similar features comprising:

- A water supply system, with boreholes supplying water to reservoirs for irrigation.
Figure 6: Drip Irrigation Pump station showing pipework to fertigation equipment, fertilizer mixing tanks, valves, filters and the control panel

- A drip irrigation system, drawing water from reservoirs to irrigate the root zones of cocoa trees pumped at high pressure from the centrifugal pumps at the pump station through a network of pipelines.

Figure 7: Irrigation Technician maintaining drip lines along cocoa trees

- A fertigation system for applying fertilizer to the root zones of cocoa trees through the same network of pipelines.

4.2 Trained COCOBOD Irrigation Staff

Both office staff and field workers of COCOBOD were equipped with the requisite specialized knowledge and skill set to operate and maintain the automated drip irrigation system established at the two stations. The recruitment of staff and training activities were carried out as an important part of the scope of the implemented work agreement. Through a series of trainings carried out to strengthen staff and worker capacities, 12 field workers, including their supervisors, were recruited and trained to carry out the irrigation activities
at both seed gardens. An irrigation reference manual compiled from the irrigation consultant’s reports and other project documents was developed and provided to COCOBOD staff members. This material serves as a useful reference guide for maintenance and efficient operations of drip irrigation facilities.

4.3 Double Pollination

As a result of the establishment of the drip irrigation systems, COCOBOD’s capacity has been strengthened to implement a double pollination program and increase seed pod production significantly. Double pollination implies there will be two cycles of flower pollination and therefore, two cycles of seed pod production in a year. Previously, only one cycle of flower pollination and production was practiced at the two sites from May to December. But now, there are two seed pod production cycles, with the first cycle of flower pollination starting from April to September, and the second from December to May. This double pollination program, which is being experimented, will enhance tree growth and increase seed pod production significantly.

4.4 Rapid Rehabilitation of Seed Garden at Bunso

Treatment of the CSSVD essentially involved the destruction of all affected trees and replanting the “clean” fields with new, disease-free planting materials. The installation of the irrigation facility to supply water has, however, fast-tracked the rehabilitation and treatment program by saving approximately seven months since water was readily available during the dry season to irrigate the newly planted clones.

4.5 Use of Appropriate Geophysical Techniques

The underlying factor was a better knowledge of the nature/characteristics of the aquifers in the project areas and that aquifers in the Bunso and Goaso areas resulted from secondary porosity developed in rock formations. The secondary porosity meant that boreholes could have a significant yield variation in close proximity to one another. A borehole located in a fractured zone could result in a high yield while one drilled into a competent rock formation would hold very little water.
The technique used generated imagery based on the electro conductivity in the underlying rock formation with specific color codes (in the current instance red colored zones reflected low conductivity and absence of water while blue colored zones of the underlying rock formation reflected high conductivity suggesting the presence of water.

![Figure 8: 2D-Apparent Geo-Electrical Resistivity Pseudo-section at Goaso Area Traverse A](image)

5. LEARNINGS AND RECOMMENDATIONS

5.1 Procurement of Relevant Expertise is Essential for Successful Delivery of Drip Irrigation Facilities

FEATS sourced external expertise at three critical points in the entire process to successfully develop and install the drip irrigation facility. These comprised of:

**Irrigation Agronomist:** The development of the concept by the irrigation agronomist was sufficient to define the broad parameters of the drip irrigation facility to be provided. This formed the basis for the next level of intervention, the design, supply, and installation of the facility.

**Hydrogeologist:** The initial effort at drilling the ten boreholes could not support the entire 28 hectares. High-level technology was used to delineate the location of high yielding boreholes.
Irrigation Equipment Vendor: The decision to select a vendor to design, supply, and install the drip irrigation system allowed high specification equipment and systems to be procured and installed.

The approach allowed FEATS to gain access to expertise outside the project team to develop and install the drip irrigation facility.

5.2 Strategic Exploitation of Groundwater Resource in Ghana

COCOBOD drilled ten boreholes without obtaining the required supply of water to irrigate the 30 planned hectares. The ten boreholes could at most do less than 50% of the planned developed area of 30 hectares. Based on the knowledge that the underlying geology and aquifer types and by employing a particular hydro-geophysical method, FEATS was able to delineate specific points for locating and drilling six relatively higher yielding boreholes.

5.3 First Time Use of Groundwater for Tree Crop Irrigation

The successful installation of the automated drip irrigation of 28.3 hectares of cocoa seed gardens using only ground water was a significant breakthrough, establishing the feasibility to use ground water to irrigate cocoa plantations everywhere in Ghana, creating the foundation for more innovative change to occur within the cocoa industry in Ghana. Before this development, it was only possible to irrigate cocoa plantations in areas within easy reach of adequate surface water sources. The non-availability of surface water resources in the form of perennial rivers and streams would have been sufficient to rule out any consideration for irrigation development. This successful use of only groundwater to irrigate a large cocoa plantation, therefore, opens opportunities for the extensive use of groundwater for irrigation in the cocoa industry, to irrigate not only cocoa seed gardens, but rather any farm in Ghana.
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