Feed the Future Innovation Lab for Small Scale Irrigation

Second Dialogue on Climate Resilience Cocoa:

Co-designing sustainable and inclusive irrigation to leverage the climate-resilience cocoa initiatives

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Introduction

Through the Feed the Future Innovation Laboratory for Small Scale Irrigation (ILSSI), the Small-Scale Irrigation Multi-Stakeholder Dialogue (SSI MSD) was established in 2019 as a unique strategy to bring stakeholders together to encourage collective thinking across sectors and explore new opportunities and solutions to scaling SSI in Ghana. This 8th SSI MSD meeting and the 2nd dialogue focusing on cocoa was jointly organized by the International Water Management Institute (IWMI), the International Institute of Tropical Agriculture (IITA), and the Ghana Cocoa Board (COCOBOD), under the sponsorship of the Feed the Future Innovation Laboratory for Small Scale Irrigation (ILSSI) through Texas A&M University (TAMU). The dialogue provided an interactive learning and collaboration space for key stakeholders and actors in the cocoa industry and related industries to share experiences, insights, and solutions to cocoa irrigation in Ghana. Specifically, it aimed to:

- Identify the effects of climate change on cocoa production and the existing resilience strategies,
- Assess the irrigation potential for cocoa production, and
- Co-identify gaps for designing best-fit irrigation for the different cocoa production systems (Annex 1).

The meeting was held on March 16th, 2023, at Airport View Hotel in Accra, Ghana. A total of eighty-four (84) invitations were sent via email to individuals representing government agencies and departments, development partners and donors, irrigation technology and equipment supply, private sector actors, research institutions and farmer organizations. Actual attendance was forty-nine (49) out of which six (6) joined virtually through Zoom. The highest attendance (Figure 1) was from research organizations (31%), followed by government actors (25%). The third largest attendance was by private sector companies working in the cocoa industry, irrigation technology companies and cocoa farmers making up 12% of the attendance each. This shows a significant improvement in attendance by private sector companies in the cocoa industry compared to the first cocoa dialogue organized in October 2021. Development partners and donors had the least attendance at 8%, highlighting the need to engage more development partners and donors to support cocoa irrigation.

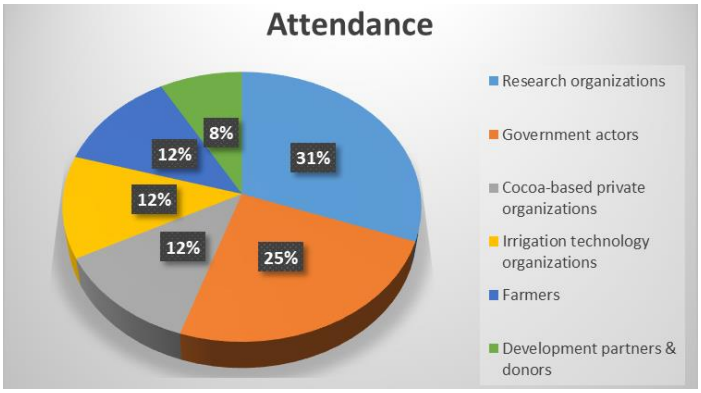


Figure 1: Overview of attendees

The meeting started with a welcome speech from Dr. Olufunke Cofie, Country Representative, IWMI-Ghana. She highlighted some initiatives on irrigation for cocoa both from Ghana COCOBOD and other

stakeholders in the West African sub-region. The challenges experienced in cocoa production call for further stakeholder engagement to attain climate resilience. As research-for-development organizations, IWMI and IITA focus on applied research to solve existing developmental challenges. Climate change has led to changes in rainfall patterns, extreme floods, and droughts, accelerated erosion, poor water quality, outbreak of water-borne diseases and rising sea levels amongst others that pose a risk to agriculture. She stressed the need to transform the water system to prevent destruction in the ecological cycle and food value chains and to find adaptation and mitigation measures from the water perspective. The multistakeholder dialogues, therefore, offer opportunities to discuss current solutions, gaps and to identify scalable solutions for addressing the challenges of farmer-led irrigation. This supports the drive to revive the cocoa sector in Ghana, Cameroun, Nigeria, and Ivory Coast.

Reverend Edwin Asare, Director at Cocoa Health, and Extension Division, COCOBOD stated that irrigation is one of the main functions under the Productivity Enhancement Program (PEP). Recognizing its importance, COCOBOD took a loan of 350 million dollars from the African Development Bank. Of that loan, about 130 million dollars was allocated to irrigation. Long dry spells reduced cocoa yields, from 1,047,000 metric tons in 2020/2021 to 684,000 metric tons in 2021/2022, losing about 35% productivity within just a year. Some parts of the seven cocoa regions have adequate amounts of rainfall, but the transitional areas have severe water challenges. Water harvesting techniques are, therefore, piloted on farms and in the Cocoa Research Institute of Ghana (CRIG). Apart from water scarcity, quality of water is also an issue due to an increase in illegal mining in cocoa growing areas.

The first section of the dialogue focused on the current state of the cocoa sector in Ghana. It started with a presentation by Reverend Edwin Afari, focusing on cocoa production regions. This was followed by a presentation by Leonard Rusinamhodzi, System Agronomist for West Africa from IITA, focusing on cocoa production systems. The final presentation for the first part of the dialogue was by Dr. Komlavi Akpoti of the International Water Management Institute, focusing on water resource availability and suitability in cocoa production areas of Ghana. Cocoa farmers at the dialogue discussed ‘what should be done differently to enable cocoa farmers’ resilience to climate change and socioeconomic impacts’.

The second section focused on cocoa irrigation initiatives and water lifting and application technologies for cocoa. It was started with a presentation by Romain Aka, Research Scientist at Barry Callebaut, sharing cocoa irrigation in Ivory Coast, followed by presentations from Aireli-AG on cocoa irrigation pilots in Ghana; Moses Tampoe, Irrigation Manager of Pumptech on solar-based water-lifting technology for cocoa; and Fares Al-Ayadi, Irrigation Service Manager of Interplast on water application options for cocoa. The final presentation was done by Kekeli Gbodji, IWMI-Ghana on cocoa farmers’ willingness and ability to invest in water lifting technologies.

Key highlights from presentations

Cocoa production systems: challenges and opportunities

There is a high potential for good cocoa yields in Ghana and other countries in West Africa. However, farmers currently produce only a fraction of their potential, an average of 500 kilograms per hectare. The combination of water and nutrients has an impact on cocoa production and yields which is being perpetuated by a vicious cycle. Cocoa farmers get low yields and therefore low incomes. This limits their ability to buy inputs. The low use of inputs in aging cocoa farms results in poor yields, repeating the cycle of low income, low inputs, and lower yields year on year. Figure 2 presents the root causes to the cocoa yield perpetuation.

Despite the yield perpetuation, farmers still produce cocoa for various reasons such as economic benefits, maintaining the inherited cocoa farms even if they are not economical, pride or the prestige that comes from owning a cocoa farm. Cocoa production is however beset with multiple challenges that may be related to management, environmental, economic, or social reasons (Figure 3).

Figure 1: Causes of low cocoa yield in West Africa (Adapted from Wessel & Quist-Wessel, 2015)[1]

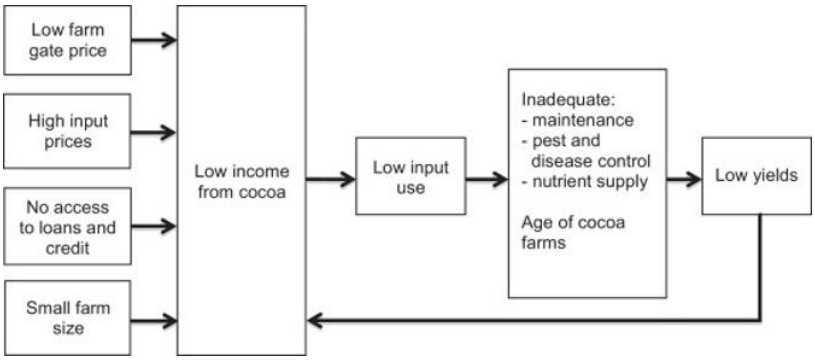
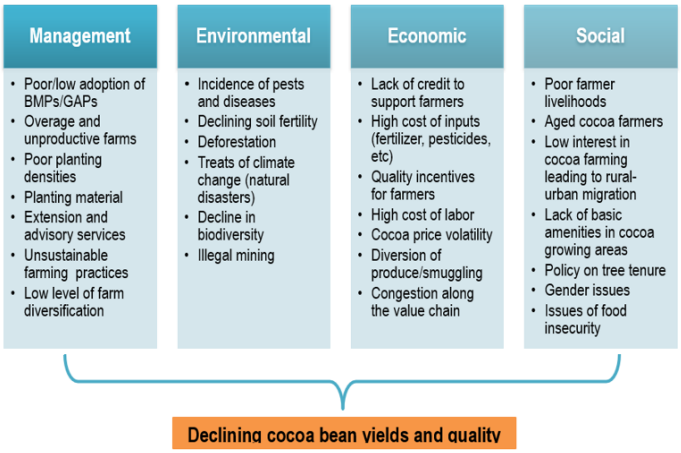


Figure 2: Main challenges of cocoa production[2]



Land tenure is a major challenge in cocoa production. Lack of clarity surrounding land/tree tenure is a major constraint to general farm management practices and cocoa productivity. Land access may be through outright purchase, gift, license, inheritance, lease, or sharecropping. Sharecropping is the most efficient means of accessing land for cocoa cultivation, especially for migrant farmers and the landless poor. It involves two main land tenure systems: *Abusa* and *Abunu*. Under the *Abusa* system, the tenant farmer takes a third of the proceeds from the farm while the landowner takes two-thirds of the proceeds. The Abusa system is usually used when the landowner has already planted cocoa before the tenancy agreement is reached. Under the *Abunu* system, the landlord and tenant share proceeds equally (50:50). The Abunu system is often used when the tenant farmer starts a new cocoa farm on land provided by the landowner, usually on virgin land. The land may be divided physically between the landlord and tenant but does not necessarily confer proprietary rights to the tenant for that portion of land. The tenant usually requires the consent of the owner to replant old trees or to rehabilitate diseased trees.

The current initiatives for cocoa irrigation in Ghana and Ivory Coast

Irrigation is the most important water use sector accounting for about 70% of global freshwater withdrawals and 90% of consumptive water uses. Irrigation is necessary for cocoa due to the erratic rainfall patterns, uneven distribution of rainfall within the year and crop water requirement deficit of about 50%. Crop Water Requirement (CWR) for cocoa varies between 130 mm/month and 235 mm/month. Adopting irrigation for cocoa revegetates disturbed soils in dry areas and during times of below-average rainfall and prevents soil consolidation. Cocoa plants under irrigation face less plant stress as irrigation makes up for the crop water requirement deficit. Farmer productivity increases with

[1] Wessel, M., & Quist-Wessel, P.F. 2015. Cocoa production in West Africa, a review and analysis of recent developments. NJAS: Wageningen Journal of Life Sciences, 74(1), 1-7.

[2] Leonard Rusinamhodzi, 'Cocoa production systems: challenges and opportunities', the 2nd Cocoa Dialogue on 'Co-designing sustainable and inclusive irrigation to leverage the climate-resilience cocoa initiatives', 16th March 2023

irrigation, stabilizing output and yield level. With access to water all year round, farmers can apply granular fertilizer effectively and bring most of the fallow land under cultivation, increasing yields.[3]

Ivory Coast's cocoa production accounts for 40% of global cocoa output. Some 700,000 to one million cocoa farmers produce an average of 1.5 tons of cocoa beans per farm per year. *Barry Callebaut* has operated in Ivory Coast since 1964 employing about 500 people across its three subsidiaries.[4] Since 2012, the company has operated a CHF 1 million (EUR 833,000 / USD 1.05 million) Center of Cocoa Excellence in Ivory Coast. The Center of Cocoa Excellence is situated in Pacobo in the Department of Tiassalé in the south-central cocoa growing area.[5] This includes training facilities for farmers and a 30-hectare "showcase farm" to demonstrate state-of-the-art intercropping techniques and other yield enhancement practices such as grafting to rejuvenate aging cocoa farms and double farm productivity. Barry Callebaut uses the farm to test different approaches for growing cocoa with other crops.

One trial carried out on the farm is the intercropping project since 2017 (Picture 1). Different forms of irrigation are practiced on the 12-hectare cocoa farm which has been divided into four blocks. Water is drawn from an artificial lake created on a half-hectare of the land. Three and a half hectares of the farm are irrigated using drip irrigation powered by an automated solar pump. The pump measures the amount of water sent to the cocoa plants at each point in time. A second block is irrigated using a diesel pump with the capacity to pump 850 litres of water per hour to the cocoa farm. Cocoa trees are watered 6 days a week, receiving about 12-18 litres of water per day. Data is collected on the operations of the pump and the volume of water discharged. A third block of the cocoa farm is irrigated manually using water hoses or watering cans. The parts that are accessible by a tractor are watered using a tank mounted on a tractor and a hose. Parts that are not accessible by a tractor are watered by workers using watering cans.

Picture 1: Irrigation at cocoa intercropping trial in Ivory Coast[1]

Some lessons were learned during this cocoa trial. Water stress is different across various parts of the farm. Irrigation therefore must be done based on the needs of the plants. The drip-irrigated plants did not suffer from water stress. Irrigation helps to improve soil quality in the dry season for cocoa. The blooming of gliricidia flowers in the dry season on the farm attracts pollinating insects such as bees. Finally, shading and leaves from teak trees help to mitigate the effect of water stress on cocoa trees and minimize the growth of weeds. However, where teak trees are planted too close to cocoa trees, there is competition for nutrients.

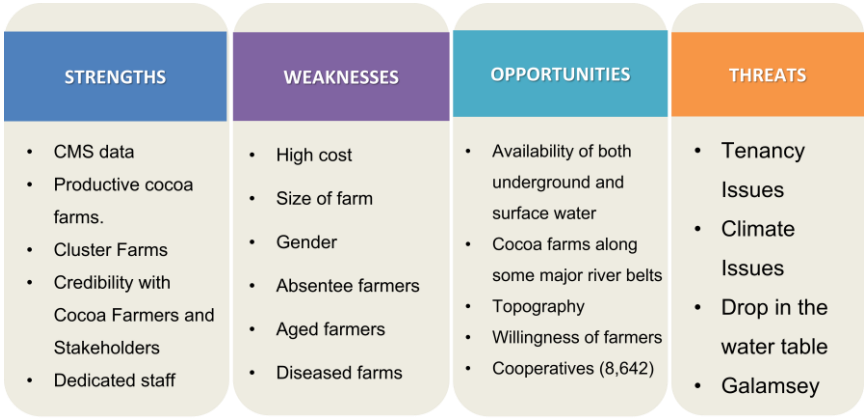
Ghana's cocoa production is challenged by various factors. Cocoa tree productivity is below the international average due to inadequate fertilizer and water application. Cocoa production is strongly affected by the fluctuating rainy season and cocoa trees suffer from soil-borne diseases due to the use of non-adapted irrigation methods. Irrigation is, therefore, necessary to reduce the low and/or inconsistent rain affecting production in terms of quantity and quality and reduce the period needed to obtain commercial production of cocoa trees and extend the production period along the year and increase the productivity per hectare, up to 100%.

COCOBOD has carried out some irrigation pilots covering an area of 244 hectares with the aim to extend the pilots by 4,000 more hectares. Each farmer was supported to irrigate a hectare of cocoa. The extension of the pilots is however on hold due to challenges experienced, mostly by smallholder farmers (Figure 4). The challenges include lack of maintenance regimens by farmers, training for beneficiaries on

[3] Rev. Edwin Afari, 'Cocoa sector in Ghana: a state-of-art: cocoa production regions', the 2nd cocoa dialogue on 'Co-designing sustainable and inclusive irrigation to leverage the climate-resilience cocoa initiatives', 16th March 2023
[4] https://www.barry-callebaut.com/sites/default/files/2019-01/ar07_cabosse_e_final.pdf (April 3, 2023)
[5] https://www.barry-callebaut.com/en/group/media/news-stories/barry-callebaut-breaks-ground-its-first-center-cocoa-excellence-west (April 6, 2023)

irrigation materials, and proper handing over. as well as insufficient power generated by solar panels, inadequate groundwater, and poor ability to store rainwater for future use. Many boreholes dug for the COCOBOD pilots are non-functional due to low water yields.

Figure 4: SWOT analysis for irrigation systems in cocoa farming



Furthermore, most of the smallholder farmers whose farms were used for the pilots are yet to repay COCOBOD for the investment as agreed, despite the improving yields. This indicates that (smallholder) farmers cannot afford irrigation equipment because of their small farms and limited production. Financing mechanisms are key to supporting farmers to acquire irrigation equipment, especially highly effective women farmers. Absentee farmers further hinder the COCOBOD's ability to make quick decisions with farmers as the caretaker farmers require the permission of farm owners to take any decision. Also, the aging cocoa farmers have a lower likelihood of adopting improved technologies including irrigation. The average age of cocoa farmers is 55 years in Ghana. The youth must therefore be encouraged to enter the cocoa industry. Finally, diseases make it impossible to irrigate certain farms. The cocoa swollen shoot disease for instance may require trees to be cut, the farm rehabilitated, and new cocoa trees planted.

COCOBOD has taken some innovative steps toward managing the cocoa sector by implementing a Cocoa Management System (CMS) to map farmers across the cocoa regions. Currently, about 1.239 million farms have been mapped. The current productive cocoa farms are about 980,000 and cover an estimated area of 1.380 million hectares. An estimated number of 762, 000 farmers cultivate these farms with about 274, 000 of them being female. Farmers are mainly smallholders with an average farm size of about 2.4 hectares. CMS implementation will provide relevant information for future interventions.

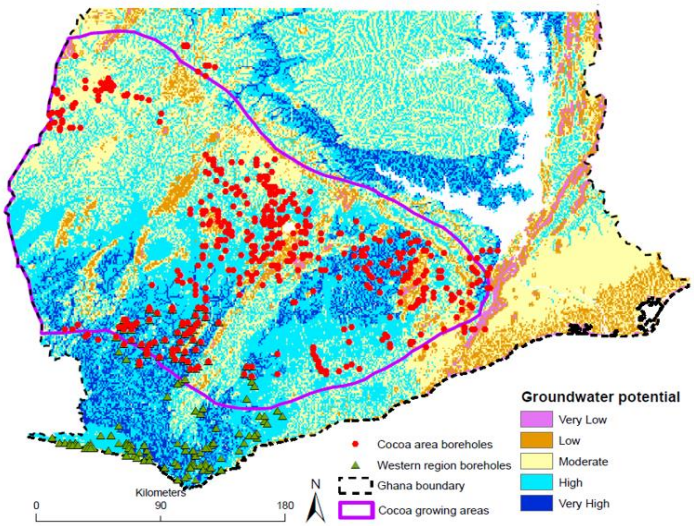
Water resource availability and suitability for cocoa irrigation in Ghana

Annual rainfall change over the last 50 years shows a decreasing trend in the cocoa growing areas. This precipitation affects cocoa yields more than any other climatic variable. Low precipitation leads to scarcity of soil water. High evaporation rate implies more soil water stress and drought. Cocoa-producing regions are increasingly vulnerable to adverse weather conditions as climate change advances. Groundwater and surface water are both available in the cocoa growing areas which cover an average land size of 22,126 km^2. There are about 125 km^2 of surface water resources which may differ depending on seasonality. This includes water bodies and ponds along rivers, small reservoirs, lakes, and lagoons such as Lake Bosomtwe, which has an area of 49 km^2, and the Barekese dam, which supplies water to most of Kumasi.

Cocoa farms are however not uniformly distributed in the landscape. This influences their access to water resources – while some farms have easy access to water, others have limited water resources. The use of surface water for irrigation is a challenge due to heavy pollution from illegal mining (*galamsey*), especially along most of the river networks (Offin, Ankobra, Birim, Anum, and Tano) with downstream pollution affecting both land and water (Picture 2). There is also a high sediment load into the river systems because of illegal mining activities.

A significant portion of the cocoa growing areas (~80%) has moderate to very high groundwater availability potential (Picture 3). There is a high potential for obtaining groundwater in areas modelled as having high or very high potential. However, borehole water yield may not be sufficient throughout the year to support cocoa irrigation due to poor groundwater recharge. Decline in rainfall may induce reduction in groundwater recharge with potential negative impact on irrigation. The effects of climate change on water availability and the incidence of pests and diseases make it necessary for adaptation. Without adaptation, Ghana stands to lose 60% to 100% of its cocoa production in the next 50 years. There is potential to expand the area under irrigation in cocoa production by implementing sustainable cocoa irrigation practices.

Picture 2: Effects of illegal mining activities on water resources[6]



Picture 3: Groundwater potential for cocoa irrigation

Solar-powered irrigation pilot in Ghana

In Ghana, Arieli-AG[7] has installed solar-powered drip irrigation (SPDI) systems for COCOBOD in that water lifting is done with solar technology and water application is by drip (Picture 4). A total of 65 SPDI systems have been installed in Assin Fosu, Nuanua, Kwame Tatra and Ayinasu in the Central Region and Suhum and Asuboi in the Eastern Region. The pilot, which was planned to last for 6 months, has been extended for years as the initial plan and design failed to consider some key factors such as maintenance. The major challenge is that over 50% of the boreholes dug were dry. The pilot drilled about 250 boreholes but only 50 boreholes could be used.

In response to the dry wells, Aireli AG has acquired new water detection technologies. The River G Water Detector works by three exploration systems of groundwater and artesian wells in the ground. It has a 3D imaging system that enables one to see the presence of water in the ground. It also uses a geophysical search system to determine the quantity, depth, type of water and the percentage of its salinity in the ground. Additionally, it has a long-range system to search for water within vast areas to a depth of 1,500 meters underground and up to 3,000 square meters in the front range.

Dosing tanks installed could also not be used due to the lack of soluble fertilizer for the system. The cocoa fertilizer available is granular and not suitable for the dosing tanks installed. The project plan did not consider the type of fertilizer by cocoa farmers in Ghana. Arieli-AG partners with Netafim Ltd to design, manufacture, and supply drip irrigation systems while FOB Engineering Ghana Ltd to install and maintain SPDI systems. ICL Fertilizer manufactures and supplies fertilizer while the Cocoa Cure Center

[6]Komlavi Akpoti, 'Water resource availability and suitability for cocoa irrigation in Ghana', the 2nd Cocoa Dialogue on 'Co-designing sustainable and inclusive irrigation to leverage the climate-resilience cocoa initiatives', March 16, 2023

[7]**Arieli-AG** was established to share expertise and capabilities for solving agricultural challenges especially related to high yields using less resources. The company uses eco-friendly methods to support the production of cocoa, cotton, and coffee. Arieli-AG has its headquarters in Cyprus and its R&D and its research and development arm in Israel but has operations in Ghana, Nigeria, Ivory coast, Benin, and Burkina Faso.

(CCC) in Israel provides best practices methods, agronomical support, and introduction of new technologies in collaboration with the CRIG. The CRIG localizes research, follows COCOBOD protocol of growing and collaborates with the CCC. CRIG is currently working with the CCC to find a vaccine for the cocoa swollen shoot disease.

Picture 1: Cocoa pilot components[8]

The potential to use **solar-powered irrigation pumps** (SPIPs) for water-lifting for cocoa irrigation is high because of the abundance of sunlight, less dusty conditions in cocoa growing areas and less heating of modules thus better performance. Various SPIPs suppliers are active in Ghana's market. For example, Pumptech is a Ghanaian water infrastructure development company founded in 2007, offering complete irrigation solutions made up of Lorentz and Grundfos pumps and accessories (Picture 5). Pumptech offers submersible pumps that can pump water from deeper depths. The company also provides free training for operation and troubleshooting, repairs and maintenance, a two-year warranty against manufacturer's defects and a dedicated technical team. Pumptech plans for new outlets in Takoradi, Kumasi and Sunyani to serve the high potential demands for irrigation in cocoa production regions.

Picture 2: Pumptech pumps and accessories[1]

Drip irrigation has high potential for irrigated cocoa production as it saves water, minimizes the incidence of diseases, and reduces run-off and thus erosion and leaching. Interplast—the biggest pipes manufacturer in West Africa since 1970—offers durable and sustainable irrigation solutions for cocoa (Picture 6). These irrigation solutions may be purchased as a kit or specifically designed to fit a particular farm. Drip lines are suitable for cocoa because they come in different thicknesses, with different flow rates and spacing of emitters. Drip pipes can be designed to fit farms where cocoa trees are unevenly spaced. Interplast also has the financial capacity to supply products for large projects. Distributors work across all regions making access to Interplast products easy. With a dedicated department for irrigation, Interplast offers spare parts, after-sales support, and training for farmers.

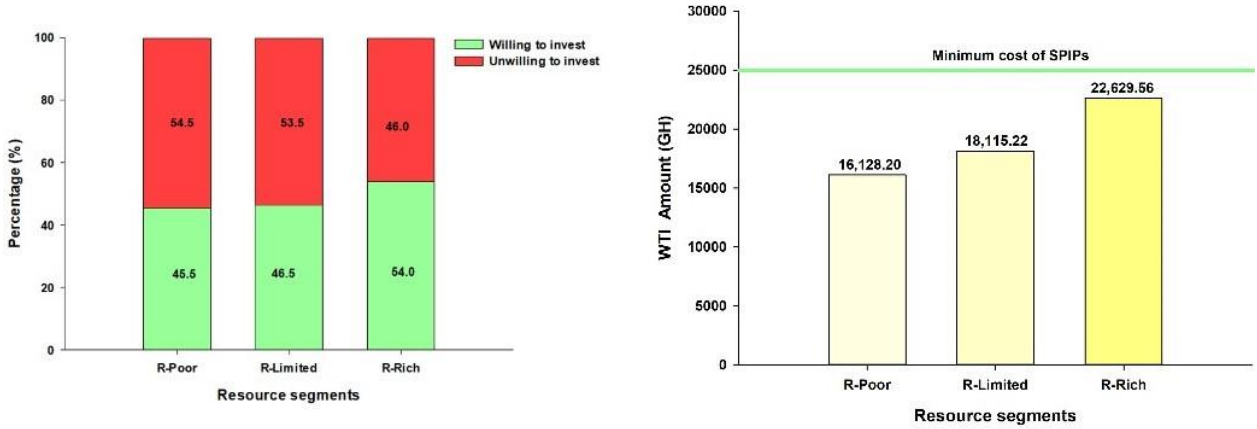
[8] Alex Agyepong, 'Cocoa irrigation pilots in Ghana', the 2nd Cocoa Dialogue on 'Co-designing sustainable and inclusive irrigation to leverage the climate-resilience cocoa initiatives', March 16, 2023

Picture 3: Interplast products and services[9]

Effective demand for solar technologies for cocoa irrigation in Ghana

Solar-based irrigation provides a solution to climate change-related challenges to cocoa production. However, lowering financial barriers and enabling affordability are essential to catalyzing cocoa farmers' investment in solar-based irrigation. It is, therefore, necessary to identify farmers' willingness and ability to invest in SPIPs. The IWMI carried out a study in 2022 in 11 out of the 70 cocoa districts from Western North, Western South, Brong Ahafo, and Ashanti regions. From a survey of 523 households, willingness to invest (WTI) of three cocoa farmer segments was identified (Figure 4).

Figure 3: Willingness to Invest (WTI) in SPIPs by cocoa farmers[10]



Resource-poor farmers have land size between 0.1 to 6 acres while **resource-limited farmers** have land between 6 and 16 acres. Most of the resource-poor and limited segments were not willing to invest in SPIPs. **Resource-rich farmers** have cultivations of over 16 acres. Although most of the resource-rich farmers were willing to invest, the amount they are willing to invest is below the minimum pre-determined market price of SPIPs. An estimated price of 25,000 Ghana Cedis (about 2,119 USD)[11] for a SPIP - water lifting technology only, was used as a benchmark to measure willingness and ability to pay.

Different factors affect farmers' WTI in SPIPs, depending on the resource segment. Resource-poor farmers are mostly influenced by farm size, educational level, and the age of cocoa trees. Farmers with older cocoa trees are less likely to invest in SPIPs. Resource-limited farmers are influenced mainly by access to credit, income levels and access to extension services. Resource-rich farmers' willingness to invest is mostly influenced by income levels, off-farm activities, and educational levels.

The farmer's real ability to invest (ATI) was also investigated by identifying the farmer's income streams and how much of those funds they are willing to commit to purchase water-lifting technologies. Income sources include the cocoa farm, other crops, off-farm income, and livestock. Even among the resource-

[9] Fares Al-Ayadi, 'Interplast irrigation solutions for cocoa trees', the 2nd cocoa dialogue on 'Co-designing sustainable and inclusive irrigation to leverage the climate-resilience cocoa initiatives', March 16, 2023

[10] Kekeli Gbodji, William Quarmine, and Thai Thi Minh, 'Effective demand for solar technologies for cocoa irrigation in Ghana', the 2nd Cocoa Dialogue on 'Co-designing sustainable and inclusive irrigation to leverage the climate-resilience cocoa initiatives', March 16, 2023

[11] Exchange rate of 1USD to 11.80 Ghana Cedis as of May 5, 2023

rich farmers, the majority can only complete payment for SPIPs after five years. Several options must be explored to increase the farmer's ATI. This includes sustaining COCOBOD's Productivity Enhancement programs to reduce aged and diseased cocoa trees through rehabilitation and forestry, pruning, hand pollination and irrigation.

Designing and tailoring suitable business/financing models to different farmer segments are key to customizing the supply of solar-based irrigation. Resource-poor and limited farmers may be supported through capacity building and financial assistance to diversify their income and improve access to microcredit services. Stakeholders such as COCOBOD, research organizations, donors and development partners may also support farmers to increase their income through alternative income-generating activities. These include livestock rearing, mixed cropping and off-farm generating activities such as agro-chemical trading, household items retail, rentals of spraying equipment and provision of transport services such as taxis, '*tro tro'* and *motor king*. Improving access to financial services include supporting the formalization of village savings and loans groups, capacity building, and supporting financial institutions to offer agricultural loans and insurance products. The COCOBOD should also increase irrigation awareness by strengthening extension delivery.

Farmer spotlight

Farmers at the dialogue shared their experiences with cocoa farming in Ghana, focusing mainly on their challenges. **Causal effect between irrigation and low yield** is a major challenge. Low yields are attributed to limited irrigation and agricultural water management. Excess rainfall may also destroy flowers or small cocoa pods while excessive dry spells may reduce cocoa yields. Irrigation is necessary but farmers cannot invest due to the high cost of irrigation equipment, poor access to irrigation spare parts even in major towns such as Kumasi, inferior drip pipes that easily break on their own or through animal bites and destruction of drip lines during weeding and blocked drip lines and lack of district level experts to service irrigation equipment. Others include poor water quality due to illegal mining and poor management of excess water for future use. There is low storage of rainwater for use in the dry season.

Causal effect between low yield and agronomic practices is another major challenge. Poor management of cocoa soils is common as many farmers grow cocoa without applying organic matter to retain soil moisture and increase soil nutrition. This mines the soil nutrients and leads to lower and lower yields year on year. There is also a lack of shade trees to conserve soil moisture in some farms. The influx and the lack of regulation of agro-chemicals on the market lead to the misuse of agro-chemicals. Crops may not receive the right amounts of nutrients they need and may even lead to cocoa trees dying off. Farmers do not have a means of verifying certified agro-chemicals from COCOBOD. Misuse of weedicides in cocoa farms may also kill earthworms and other soil organisms and sometimes, cocoa trees. Currently, there are no severe laws against the destruction of cocoa trees although some trees of economic value like rosewood have laws regulating how and when they may be cut. Finally, cocoa farmers highlighted improper pruning techniques that lead to cocoa trees being wrongly pruned, resulting in low yields.

Aging cocoa farmers pose a threat to the industry. The youth may be attracted to the industry by making the industry youth friendly. Most cocoa growing areas lack modern amenities such as electricity, telephone and internet connectivity which are now part of the lifestyle of the youth. Internet connectivity also allows farmers to obtain weather forecasts to direct their activities such as spraying the farms. Additionally, modern equipment such as motorized slashers may be introduced into the industry to attract the youth. Where such modern equipment has currently been piloted or given out as awards, uptake has been slow due to inadequate training on equipment usage by COCOBOD and extension teams. Modern equipment will save farmers time and appeal to the youth who may not want to spend days or weeks on simple tasks like weeding. Solar panels may also help to provide electricity in cocoa farms and may be used for irrigation purposes as well.

Low prices for cocoa in Ghana compared to Ivory Coast are identified as another challenge. Farmers find it more lucrative to smuggle cocoa to Ivory Coast due to price differences. Farmers receive 800 Ghana Cedis for each bag of cocoa while buyers pay 1,600 Ghana Cedis per bag in Ivory Coast. Farmers may also sell through middlemen at 1,200 Ghana Cedis a bag. Cocoa smuggling is a major challenge for

COCOBOD which is estimated to have cost Ghana about 180 million USD dollars in the 2021/2022 cocoa season. COCOBOD estimates that 75,000 tons of cocoa were lost to smuggling in the 2021/ 2022 cocoa season.[12]

Finally, the **over-reliance on COCOBOD** for investing and commercializing cocoa production lead to low performance of cocoa farms. Many farmers do not operate cocoa farms as a business but over-rely on COCOBOD for pruning, fertilizer provision and other needs. Farmers, therefore, do not invest personally to ensure agronomic practices are carried out at the right time if COCOBOD is unable to meet their demands at that time.

Reflecting on suitable irrigation solutions for cocoa and stakeholder roles

Discussions were done in three groups. The irrigation experts and irrigation technology companies discussed the elements that must be considered when designing the best-fit irrigation systems for cocoa. These include the type of farming system the farmer is practicing such as mixed cropping and the sustainability of the irrigation design as well as the farm size, topography and water source, availability, quality, and quantity. Others are crop water requirements which are dependent on the growth stage of the trees and the soil type, source of energy for water lifting, cost-benefit analysis of investing in irrigation technologies, and ease of use of the technology.

Different stakeholders discussed how they can best support cocoa irrigation. They identified financial institutions and donors as one group of actors. They may offer financial support in the form of low-interest loans and/or grants to increase farmer ability to purchase irrigation equipment. Researchers may conduct studies to show the most cost-effective business models for promoting cocoa irrigation among smallholders (less than two hectares of cultivation), medium-scale (two to five hectares) and large-scale (over five hectares).

COCOBOD can sensitize farmers on the benefits of irrigation, good agricultural practices, and agroforestry. The Licensed Buying Companies (LBCs) and input suppliers may support COCOBOD in implementing the Cocoa Management System. This will help to gather data on the cocoa industry and recoup any irrigation investments made. It will also minimize cocoa smuggling and cocoa theft. Non-Governmental agencies (NGOs) may provide technical backstopping for cocoa irrigation and help to create market linkages. They may also support policy advocacy, monitoring, evaluation, learning and communication. Finally, the Ghana Irrigation Development Authority (GIDA) may support farmers by working with research to find tailor-made cost-effective irrigation systems for cocoa production.

Cocoa farmers reflected on how cocoa farmers' investment in irrigation can be accelerated. Sensitizing farmers on the importance of irrigation can be done by raising awareness on irrigation. This may be carried out by GIDA, COCOBOD, farmer groups and other stakeholders in the cocoa value chain. Secondly, an increase in the price of cocoa will increase incomes of farmers and their ability to invest in irrigation technologies. COCOBOD must take the lead in negotiating fair prices for cocoa purchase in Ghana. Affordable but durable irrigation technologies should be introduced to farmers. Suitable technologies may be bundled with financial services such as subsidies, grants and soft/long-term loans provided by financial institutions, donors or cocoa buying and processing companies locally and globally. Cost-sharing arrangements may be explored among clustered cocoa farmers. This will decrease the cost per farmer to access irrigation technologies. Finally, it is necessary to explore the business model of a lead farmer buying water-lifting technology and selling water to neighboring farms.

Key lessons from the dialogue

As indicated by Reverend Edwin Afari '*the Ghana Cocoa Board is seeking to go beyond the irrigation pilots by collaborating with private and public sector organizations to find affordable and cost-effective solutions for small, medium, and large-scale farmers*. *The way forward for COCOBOD is how to scale irrigation in the seven cocoa regions by offering suitable irrigation bundles, cost-sharing repayment*

[12]Adombila, M. A. (March 23, 2023). $180m of cocoa lost to smuggling. *Daily Graphic*, 35.

strategies using suitable business models that offer profit to private sector participants and tackling the issue of water quality for both surface and groundwater.'

Reflecting on this need, some key lessons were drawn from the dialogue. *First*, policy enforcement is necessary for the sustainability of irrigation in the cocoa industry. Unregulated access and use of groundwater may affect the long-term availability of water for cocoa irrigation. Additionally, poor enforcement of laws against illegal mining is polluting both surface and groundwater resources needed for irrigation. *Second*, working with local solutions offer a better alternative for cocoa irrigation. The Ghana Cocoa Board must focus on local suppliers and products suitable for Ghana's climate instead of importing solutions that may only work for the farmer in the short term. This should be accompanied by stocks of spare parts and technical assistance to support farmers after installation of irrigation equipment. This includes finding irrigation layouts that support traditional weeding techniques or improved techniques for weeding that can combine effectively with drip irrigation.

Third, a multi-stakeholder approach to capacity development is key for improving the capacity of cocoa farmers to afford irrigation technologies. This includes good agricultural practices, business management training and record keeping. This will improve farmer access to formal and informal credit and support from the development and donor community. *Finally*, irrigation cannot work in isolation. A systems approach must be adopted to ensure irrigation will benefit the farmer and improve productivity. Irrigation solutions must therefore consider soil nutrients, declining volumes, and recharge of groundwater, increasing incidence of pests and diseases, social constraints, land tenure systems and other factors that may limit the impact of the irrigation solution.

Annex 1. The meeting agenda

2nd Cocoa dialogue: Co-designing sustainable and inclusive irrigation to leverage the climate-resilience cocoa initiatives

Venue: Airport View Hotel

Time: 8.30 – 16.30 on 16th March 2023

Objectives:

- Identify the effects of climate change on cocoa production and the resilience strategies available.
- Access the irrigation potential for cocoa production
- Co-identify gaps for designing best-fit irrigation for the different cocoa production systems

Time	Activity	Remarks
08.30 – 09.00	Registration	IWMI
09.00 – 09.15	Welcome by IWMI, IITA, COCOBOD	IWMI/ IITA/ COCOBOD
Sharing and learning about the Cocoa sector in Ghana and other countries		
09.15 – 10.15	Cocoa sector in Ghana: a state-of-art - Cocoa production regions - Cocoa production systems (land size, land tenure, management) - Water resource availability and suitability (quantity and quality)	 Rev. Edwin Afari, COCOBOD Leonard Rusinamhodzi, IITA Komlavi Akpoti, IWMI
10.15 – 11.00	Farmer spotlight: What should be done differently to enable cocoa farmers' resilience to climate change and socioeconomic impacts?	All participants (spotlighting cocoa farmers)
11.00 – 11.30	Coffee Break	
11.30 – 12.30	**Cocoa Irrigation initiatives**	
	- Cocoa irrigation in Ivory Coast - Cocoa irrigation pilots - Solar-based water-lifting technology for cocoa - Water application options for cocoa	Romain Aka, Barry Callebaut Alex Agyepong, Aireli Moses Tampoe, Pumptech Fares Al-Ayadi, Interplast
12.30 – 13.45	Lunch break and networking	
13.45 – 14.00	2. Cocoa farmers' willingness and ability to invest in (solar-based) irrigation	Kekeli Gbodji and William Quarmine, IWMI
14.00 – 15.00	Breakout discussion	
	1. What are elements that need to be considered when designing best-fit irrigation systems for cocoa 2. What and how can different stakeholders support irrigation in cocoa? 3. How can cocoa farmers' investment in irrigation be accelerated?	All participants
15.00 – 15.45	Reporting back	All participants
15.45 – 15.50	Reflection: What key messages have come out from today's section?	All participants
15.00 – 16.00	Follow-up and meeting closure	All participants