Assessment of Climate Change Impacts on Cocoa Production and Approaches to Adaptation and Mitigation: A Contextual View of Ghana and Costa Rica

Ashley Hutchins, Ana Tamargo, Caroline Bailey, Yeongmi Kim
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List of Acronyms

APPTA	Association of Small Producers of Talamanca
CANACACAO	National Association of Costa Rica of Fine Cacao
CATIE	Tropical Agricultural Research and Higher Education Center
COCOBOD	Ghana Cocoa Board
CRIG	Cocoa Research Institute of Ghana
CSA	Climate-Smart Agriculture
CSSV	cocoa swollen shoot virus
EPA	Environmental Protection Agency
ERP	Emissions Reduction Program
FAO	Food and Agriculture Organization
GAPs	good agricultural practices
ha	hectare
GHG	greenhouse gas
ICCO	International Cocoa Organization
IPCC	Intergovernmental Panel on Climate Change
kg	kilogram
LBC	Licensed Buying Company
NCRC	Nature Conservation Research Centre
NGO	non-governmental organization
PC	Purchasing Clerk
PES	Payment for Environmental Services
REDD	Reduced Emissions from Deforestation and Degradation
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USDA ARS	US Department of Agriculture Agricultural Research Service
WCF	World Cocoa Foundation

I. Project Overview

Climate change has large implications for the future of cocoa production and community livelihoods. Farmers in developing countries already face decreasing productivity rates due to a lack of access to extension services, credit, and quality farm inputs such as seeds and fertilizer. Furthermore, increased temperature and rainfall variability has the potential to exacerbate environmental degradation on cocoa producing areas. Private sector companies, non-governmental organizations (NGOs), and governments are heavily invested in securing cocoa production levels due to the significant risk that climate change places on the business of the cocoa industry and the livelihoods of millions of smallholders that provide the industry with the bulk of the supply.

This final report provides the World Cocoa Foundation (WCF) research on climate change impacts and recommendations for a new organizational climate change strategy aimed at its private sector member organizations. The overall goal of this project is provide a common understanding of climate change impacts on cocoa farming and create recommendations for a unified and coordinated approach by WCF for climate change adaptation and mitigation strategies. This research is supporting the key research question, "How can cocoa sector stakeholders best respond to climate change impacts through mitigation and adaptation strategies?" by answering the following sub-questions:

- What are the climate change phenomena that can affect cocoa in Ghana and Costa Rica now and in the future?
- What are the current social, economic, and environmental impacts to date at the producer level?
- What are the forecasted social, economic, and environmental impacts?
- What are the current knowledge gaps about cocoa production in Ghana and Costa Rica? How will this impact our ability to account for climate change?
- What are the current climate adaptation and mitigation approaches in Ghana and Costa Rica?
- What is the private sector currently doing to address climate change? What is their motivation?
- What are areas for collaboration and existing platforms between the various stakeholders, including WCF?

II. Research Methodology

Design

A qualitative design was used to respond to the research questions outlined above by taking an inductive approach to understanding the process of climate vulnerability in the context of cocoa farmers in Ghana and Costa Rica. Our goal was to understand the phenomena of climate change and how it impacts cocoa production as well as the farmers' perspectives of how they perceive climate change, their level of vulnerability, and how they respond to external shocks. To achieve this, the research team used a triangulation approach for gathering data by using literature, key informants, and semi-structured interviews with cocoa farmers.

Methods

The majority of the research was conducted in Washington, DC, where the team used existing literature to collect data to answer the research questions, which included current and forecasted climate phenomena affecting Ghana and Costa Rica; the social, environmental, and economic impacts; and current mitigation and adaptation approaches. Key informant interviews with academia, the private sector, and NGOs were conducted in Washington, DC and over the phone during this time.

The research team travelled to Ghana and Costa Rica in March 2015 for two weeks to conduct further key informant interviews with local actors within the cocoa and climate change fields. Semi-structured interviews were also conducted with cocoa farmers to assess levels of vulnerability and adaptive capacity

in each local context. Interview protocols were developed prior to field travel, which included a mix of open and close-ended questions aimed at collecting data on individual experiences. The protocols were reviewed by WCF staff prior to use; however, the protocol design was flexible and iterative. The questions were adjusted and the team used probing questions depending on participant responses.

In Ghana, a translator was used in order to conduct interviews in the local language, Twi. In Costa Rica, interviews were conducted mostly in Spanish, translated by one of the team members, while a few were done in English when respondent expressed desire to do so.

Sampling

For key informant interviews, the team selected participants using criterion-based, convenience sampling. The team conducted research on organizations and people involved in climate change, cocoa, and/or agriculture research and/or initiatives which would provide expert insight into climate change impacts on cocoa and climate-smart agriculture. Additionally, during some interviews, participants recommended other organizations. For the farmer interviews, the team also used a criterion-based, convenience sampling method, which included criteria such as age, gender, and farm size. The team interviewed thirteen respondents including four females in Ghana and eight respondents including four females in Costa Rica. Recruitment was coordinated through WCF field staff in Ghana and with an individual consultant who has worked with the Tropical Agricultural Research and Higher Education Center (CATIE, its Spanish acronym) and the Ministry of Agriculture on cocoa projects in Costa Rica.

Limitations

The research team was limited by time in the field and therefore was unable to reach a larger sample size that would have provided more data to help validate our findings. However, trustworthiness of the qualitative data was ensured by conducting key informant interviews with individuals from different fields to cross-check information. In Ghana, most of the respondents were part of one farmer association and language was a barrier since we had to rely on a translator and were not able to ensure that probing questions were not leading.

III. Conceptual Framework

The Food and Agriculture Organization (FAO) defines Climate-Smart Agriculture (CSA) as an integrated approach that addresses food security and climate change by achieving the three following objectives:

1) Sustainably increasing agricultural productivity, to support equitable increases in farm incomes, food security and development;
2) Adapting and building resilience of agricultural and food security systems to climate change at multiple levels; and
3) Reducing greenhouse gas (GHG) emissions from agriculture (including crops, livestock and fisheries) (FAO 2013).

Various organizations have begun to apply this definition to the challenges of climate within the context that many cocoa farmers are facing today and will in the future. However, a unified approach to specifically climate-smart cocoa has yet to be established. Developing a climate-smart approach to agriculture requires a framework to measure vulnerability of the system of study to help focus climate-smart activities to the local reality. The research team used various theories of assessing vulnerability as our conceptual framework for our research design. There are various literatures which point to models that exist for vulnerability frameworks in human-environment systems. The diversity of definitions and frameworks can confuse policy-makers and presents a challenge in measuring vulnerability. However, common language exists to define vulnerability. Using some of these common terms related to vulnerability, we created our own framework, as seen in Figure 1, for assessing the level of farmer vulnerability. Our framework was modeled from Turner et al's 2003 system vulnerability framework

using our findings from Costa Rica and Ghana (Turner et al. 2003). It is also important to note that although various versions of vulnerability frameworks exist in literature today with overlapping contexts, each framework must be adapted to the local context.

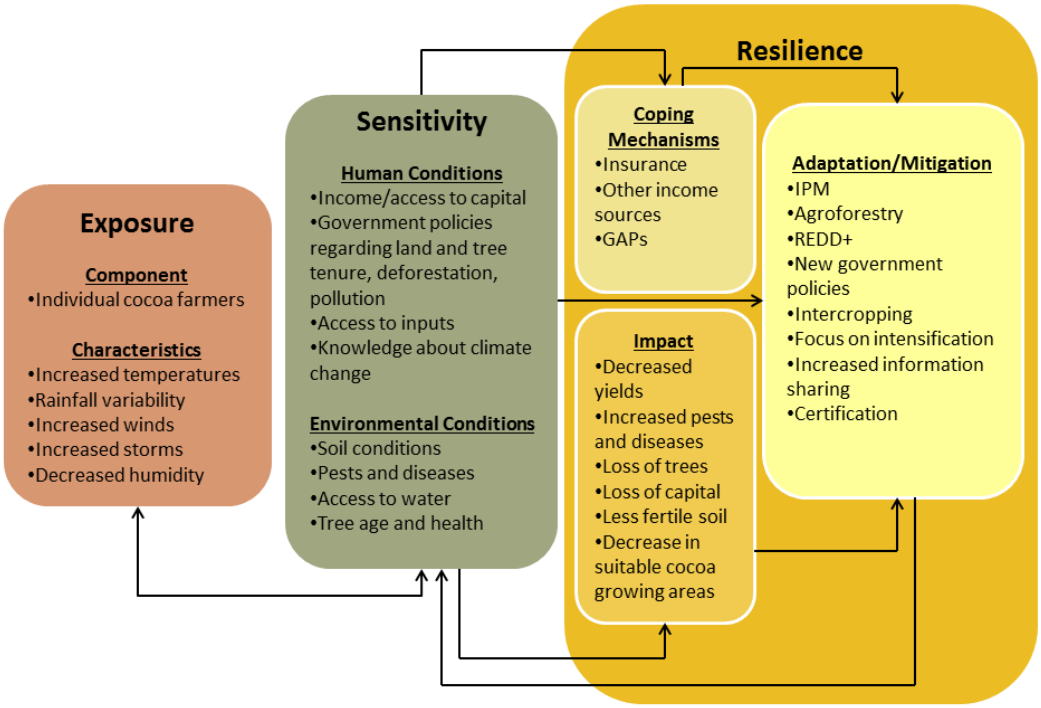

Figure 1. Framework for assessing vulnerability within cocoa sector

IV. Research Findings - Ghana

Background

Approximately 70% of the world's cocoa is grown in West and Central Africa, the vast majority coming from two million small independent family farms each less than two hectares (ha) in size. Ghana was the world's second largest exporter of cocoa reaching a record high of 1,004,000 metric tons in 2010 and 2011. The cocoa industry accounts for approximately 30% of Ghana's total export earnings, making it the second largest source of export earnings and the main export crop. Ghanaian cocoa beans are known for their quality and depth of flavor and are regarded by the International Cocoa Organization (ICCO) as being richer in theobromine and flavonoids than beans from other countries, making them the world's standard against which all cocoa is measured (Ashitey 2012).

The cocoa industry in Ghana is fully controlled by the Government of Ghana, which operates a monopoly over the purchase and export of cocoa beans through the Ghana Cocoa Board (COCOBOD). COCOBOD is tasked with managing the export and internal marketing of cocoa beans, agricultural research, hybridization of seeds, sale of seeds, extension services to farmers, and quality control. The internal purchasing of cocoa beans is done through private sector companies who are registered and licensed with COCOBOD. There were 32 companies listed as Licensed Buying Companies (LBCs) in 2013 (Ashitey 2012). As Krishnakaumar Pillai, General Manager of Biolands from Barry Callebaut reported, the LBCs have Purchasing Clerks (PCs) who buy the cocoa from farmers and then transport it to the district warehouse. Here, the beans are checked for quality and if unsatisfactory beans are discovered, the PC

who bought them from the farmer is responsible for either drying them to meet the standard or, if unsalvageable, pays for them.

All farmers are trained on proper fermentation and drying techniques and all thirteen farmers reported fermenting their cocoa for six to seven days and air-dry the beans on a bamboo mat for approximately a week, turning the cocoa regularly to ensure even drying. These cultural postharvest handling practices are one of the reasons Ghana's cocoa is rated so high in quality. The COCOBOD Deputy Executive Director for Monitoring and Evaluation stated that many other countries use smoke to dry their beans because it speeds up the process; however, it dries the exterior of the bean faster than the interior, which changes the flavor and the fat content. He argued that this was one of the reasons Ghana's cocoa quality is superior to other countries. No cocoa is exported from Ghana which does not meet the government's strict standards.

The Government of Ghana is also heavily invested in pursuing climate change strategies, one of these avenues being through the concept of Reduced Emissions from Deforestation and Degradation (REDD) managed by the Forestry Commission. REDD was introduced as a key factor of the international climate change agenda. REDD+ takes this concept a step further and aims to address a broader set of forest management issues through initiatives sponsored by the United Nations (UN), the World Bank, and others. Ghana recently finished the first phase of REDD+ Readiness by developing a national REDD+ strategy. It received support from the World Bank's Forest Carbon Partnership Facility to implement its REDD+ Readiness Preparation Proposal. Through the "Climate Cocoa Partnership for REDD+ Preparation" project, Olam and Rainforest Alliance, in collaboration with the Forestry Commission, are working to build cocoa producing areas in degraded lands in ecological corridors, helping cocoa trees become more resilient to moisture and temperature changes due to climate change. The project is contributing to Ghana's National REDD+ platform by identifying REDD+ locations and preparing farmers for REDD+ carbon finance options through their increased carbon stocks on their farms (Brasser 2013). The Forestry Commission and COCOBOD have also recently received approval from the World Bank for their Emissions Reduction Program (ERP) proposal, which focuses on the mosaic landscape of protected forests. Several key informants mentioned this new program and were excited about the collaboration between COCOBOD and the Forestry Commission as well as the fact that this will be a payment for results based program.

The Environmental Protection Agency (EPA) of Ghana partnered with the UN Environment Programme and UN Development Programme (UNDP) and received funding from the Danish Ministry of Foreign Affairs to establish the National Climate Change Adaptation Strategy (2010 – 2020). REDD+ initiatives have been highlighted as key aspects of this strategy. President Mahama announced in July 2014 the launch of the National Climate Change Policy which will define a pathway for a green economy by dealing with emerging environmental challenges. Ghana's National Climate Change Policy Framework has three objectives: low carbon growth; effective climate adaptation; and social development. Currently the government is exploring opportunities through partnerships with large companies and small-scale farmers for new revenues from carbon stocks in cocoa producing areas. Lastly, the Government of Ghana has expressed their commitment under the United Nations Framework Convention on Climate Change (UNFCCC).

Climate Change Phenomena

Literature, key informant interviews and farmers all reveal that increasing temperature and rainfall variability are key challenges that cocoa farmers are already experiencing. According to the Intergovernmental Panel on Climate Change's (IPCC) *Fifth Assessment Report*, temperatures in Africa are forecasted to increase at a faster rate than the global average increase in this century. In tropical West Africa, these unprecedented climate changes are projected to occur one to two decades earlier than the rest of the world. By the end of the 21st century, temperatures in West Africa are projected to rise by 3 to

6 degrees Celsius above the late 1900's baseline, according to multiple models (Mcsweeney, New, and Lizcano 2010; Niang et al. 2014).

The UNDP Climate Change Country Profile for Ghana estimates that the country's mean annual temperature will rise by 1 to 3 degrees Celsius by the 2060s and by 1.5 to 5.2 degrees Celsius by the 2090s. Farmers unanimously responded that the weather conditions in Ghana have changed over the last 20 years or however long they had been growing cocoa if it was less than 20 years. All but one farmer indicated that there was too much heat now or it was very hot.

Cocoa producers are located in the southern half of Ghana and have two wet seasons, one from March to July and a shorter one from September to November. According to the UNDP Climate Change Country Profile for Ghana, it is difficult to predict long-term trends for annual rainfall as it is highly variable between years and decades (Mcsweeney, New, and Lizcano 2010). The ranges for forecasted changes in rainfall are quite large. The IPCC's *Fifth Assessment Report* also indicated that most areas of Africa lack sufficient data to draw conclusions on historical precipitation trends over the last century. This report further states that future precipitation projections are less certain than temperature forecasts, as precipitation rates are more spatially and seasonally dependent (Niang et al. 2014).

Peter Läderach et al. noted an IPCC model from 2007 indicated that the average rainfall in the cocoa growing areas of Ghana and Cote d'Ivoire is only expected to decrease by an insignificant amount of 12mm, with the majority of the change taking place after 2030. According to the report Ghana will see an increase in rainfall before experiencing a small drying effect in most of the cocoa growing region (Läderach et al. 2013). Farmers mentioned a reduction in the amount of rainfall in recent years, and when asked about differences between the dry and rainy seasons, two farmers stated that the dry seasons were lasting longer now. There were mixed responses from farmers regarding the quantity of rainfall, but changes in the rainfall patterns was a common theme among farmer responses. Farmers believed the rains were harder to predict and the timing of the rains were changing.

Vulnerability Assessment

Increased temperatures and variable rainfall patterns are also making it difficult to establish new cocoa farms. In the forest and savanna transitional zone of Ghana, climate change is having an impact on soil health and fertility, resulting in increasing savanna horizons (layers) and rapid depletion of forest vegetation. Reduced rainfall and increased temperatures, which lead to prolonged periods of drought, are causing a reduction in soil moisture during the dry seasons and decreased soil fertility. These conditions often lead to cocoa seedling mortality. In other areas and during periods of high rainfall, soil fertility is also negatively impacted by increased leaching of the soils and the lack of farmers applying fertilizer to replace nutrients. This is exacerbated in areas where farmers grow cocoa without shade (Anim-Kwapong and Frimpong 2010).

Farmers interviewed in Ghana all believed that these weather changes were negatively affecting their cocoa production. Eight farmers indicated weather led to decreased yields of cocoa. When asked about challenges they face regarding cocoa, eight out of thirteen farmers indicated the unpredictability of rains and weather were affecting some aspect of their cocoa growing. Three farmers cited plants dying because of the unpredictability of rains. One of these three farmers claimed 70-80% of his 2,000 seedlings died because of the weather. Another farmer indicated that it was hard to know when to spray for pests and diseases because she did not know when the rains were coming. In previous decades, according to both the farmers and some key informants, the rains were very regular and alerted the farmers as to when to begin planting.

In an interview with the Cocoa Research Institute of Ghana (CRIG) Executive Director, Dr. G. J. Naim-Kwapong noted that cocoa is very sensitive to climate conditions and that changes in temperature can

affect the soils, as well as the trees. According to Oyekale, prolonged dry seasons result in cocoa seed mortality, whereas short dry seasons result in decreased pod filling, which affect the size of the beans. Increased rains and prolonged wet seasons slow the drying and processing of cocoa, which reduces the value of the bean and increases the cost of processing both financially and the time required (Oyekale, Bolaji, and Olowa 2009).

A lack of fresh water availability also leads to the increased presence of stagnant water, which has led to increased growth of pathogens and presence of diseases (Gyampoh, Idinoba, and Amisah 2008). Climate change is altering the stages of rates of development of cocoa pests and pathogens and modifying cocoa's resistance to such threats (Oyekale, Bolaji, and Olowa 2009). Dr. Naim-Kwapong noted that there are many pests and diseases that can affect cocoa, which is something that all of the farmers are actively attempting to combat. Eleven farmers mentioned spraying as a part of their daily pre-harvest routine and seven mentioned inspecting their farms for pests and diseases. Climate changes, including decreases in humidity and changes in rainfall have the potential to increase the incidences of pests and diseases as well as altering the types of pests and diseases that find the Ghanaian cocoa farm as a favorable environment.

The main disease that is affecting Ghanaian cocoa farmers is the cocoa swollen shoot virus (CSSV), however the farmers did not volunteer the names of diseases that were affecting them and instead referred to diseases generally. However, the farmers seemed to know more about the pests that were affecting them, possibly because they attributed most of their unsellable cocoa to pests. The most common pest mentioned by farmers was the capsid, followed by the shield stink bug which is likely a reference to the cocoa shield bug. Capsids are sucking insects which feed on cocoa making it difficult to establish. Over 13% of climatic factor failures result in capsid infestations (Oyekale, Bolaji, and Olowa 2009). The cocoa shield bug causes premature ripening by feeding on the cocoa pod and can be found on the upper portions of the tree (Dormon, van Huis, and Leeuwis 2007).

Ten out of thirteen farmers indicated that they are currently constrained by a lack of capital, which can prevent them from expanding their cocoa farms and getting access to the appropriate pesticides, fertilizers, seedlings, etc. It also prevents them from incorporating adaptation techniques such as drip irrigation, which can help address rainfall shortage issues, but is very costly. The current lack of capital will only become more problematic for farmers if yields continue to decrease, but might help prevent additional deforestation to make new lands for cocoa farms. The Ghanaian government has recognized that increased cocoa yields needs to come from intensification of yields on current cocoa lands, not expansion of cocoa farms. However, this does not appear to have yet trickled down to the farmers, who want to increase yields by expanding their cocoa farms. No farmers specifically mentioned intensification on their existing plots. It seemed that farmers believed they were growing as much cocoa as possible on their existing land.

In an effort to increase yields, COCOBOD is currently growing 50 million cocoa seedlings for three years to provide to cocoa farmers and is providing free fertilizer. However, it is unclear which farmers or cocoa growing regions are receiving these seedlings and the survivability rates of these seedlings are also unknown. Five farmers mentioned that it was difficult to get access to chemicals, i.e. fertilizers and pesticides, seedlings, and machinery, even though the COCOBOD program has already been running for a year. The lack of capital will likely worsen the lack of access to inputs, particularly if the COCOBOD program ceases.

The vulnerability of cocoa farmers can be determined by looking at their exposure to the changes of weather, the sensitivities of the farmers to these weather conditions due to their local conditions, and their adaptive capacity. Cocoa farmers in Ghana writ large are also relatively sensitive to these climate changes, particularly as the vast majority are smallholder farmers. Losses of trees or pods may be felt more acutely by farmers that have smaller farms. Further, there are other institutional constraints in

Ghana, such as a lack of tree tenure procedures, which cocoa farmers might not even be aware of. All the farmers believed they owned their cocoa trees. However, key informant interviews with COCOBOD, Nature Conservation Research Centre (NCRC), and the Forestry Commission revealed a lack of policies that ensure cocoa farmers can claim ownership of their trees. Furthermore, timber trees that are located on cocoa farmers' lands may be cut down by someone who has no regards for the farmers and can cause damage to the cocoa farms. While none of the farmers we spoke to mentioned this as an issue personally affecting them, it was brought up by the government and NGOs as an issue facing farmers and might be a bigger issue in other cocoa growing regions.

The fixed cocoa prices in Ghana help reduce farmers' sensitivities to market price fluctuations. On the other hand, farmers are also unable to garner higher prices or additional benefits through competing buyers in Ghana. This prevents them from possibly bargaining for additional inputs or trainings from different LBCs. While most of the farmers we spoke to were a part of an association which had an agreement with an LBC, the ones that were not sold their cocoa to whoever was around. Prior to joining the association, cocoa farmers appeared to sell to whoever was around when their cocoa was ready to sell. There did not appear to be an eagerness to gain any additional benefits from choosing one LBC over another.

In the Ashanti Region, three types of land arrangements were noted by the farmers that were interviewed. First, there is outright ownership of the land. Second, there is partial ownership where after a number of years the farmer will own a portion of the land that he or she is currently farming. In the interim, he or she works the land and pays the landowner with a portion of the profits or crops. Sometimes a cash payment is made in front of the village elders to ensure that their ownership claims will be honored when the pre-determined time comes. The third arrangement is land rental, where the farmer is allowed to use someone else's land in return for a portion of the profits or crops. These land tenure arrangements may make farmers more sensitive to climate change impacts. For all three arrangements, the farmers are incurring risk if there are decreased yields. However, farmers that rent their land may have less say in how the land is used. For example, one farmer who rented a portion of his land mentioned an issue with the current landowner wanting to grow more food crops instead of cocoa. Although the farmer claimed to own his trees, it did not appear as if he could do anything to prevent the landowner from decreasing the amount of land dedicated to cocoa.

Exposure to the climatic conditions is relatively constant among the cocoa farmers in the Ashanti region, but the sensitivity of farmers that are not part of the association appears to be higher. Although our team was only able to interview two farmers in Suponso that were not part of the association, there was a marked difference in the amounts of cocoa lost from pests and diseases between those that were and were not part of the association. The two farmers in Suponso were unable to sell over 2 kilograms (kg) per 100 cocoa pods, whereas the majority of the farmers who were a part of the association lost less than 2 kg. There was only one farmer in the association that lost 2 or more kgs, and the majority lost less than 1.5kg.

Additionally, even though farmers who were not a part of the association had been through training on pruning, spacing of trees, and spraying, they wished that there were more trainings available. One farmer also noted that the training occurred a long time ago and wished that he could be retrained. In contrast, farmers who were part of the association cited a larger variety of training that they had received. Also, when these farmers were asked about what they wished to receive more training on, the responses were related to more innovative techniques, such as irrigation, hybridization and nutrition.

Amongst the thirteen farmers interviewed, perceptions of the causes of climate change and what could be done to change it were varied. However, based on their answers, there seems to be a connection between their perceptions and whether or not they are adopting adaptation and mitigation strategies. Seven farmers mentioned deforestation as a piece of the causes of climate change, two farmers mentioned bush burning,

and two farmers mentioned pollution from chemicals and factories. Of these, all seven answered that something can be done to mitigate the effects. Six mentioned reforestation or preserving the current forests. Two mentioned the need for government policies to curb pollution and one of them also mentioned the need for tighter regulations to prevent deforestation. One of the farmers mentioned that he's not into science so he didn't know the cause of what could be done, but this implies that he realizes science plays a role. Seven out of these eight farmers had changed their cocoa farming practices in some way as a result of the climatic changes.

Five farmers did not know any causes of climate change or believed that it was the work of God; of these five, four reported that they had not changed their cocoa farming practices to adapt to or mitigate the changes in the climate. All five stated that there is nothing that can be done to mitigate or reverse climate change in any way, and it is only up to God. Ghana's EPA Deputy Director, Emmanuel Osae-Quansah stated that they are trying to teach farmers about the science behind climate change because cocoa cultivation is driving deforestation. Mr. Kwakye of the Forestry Commission also argued that cocoa is a major contributor to forest reduction, but it is only one of many. None of the interviewed farmers cited cocoa as part of the problem.

Adaptation and Mitigation Approaches in Ghana

Farm Rehabilitation

Both Dr. Anim-Kwapong of CRIG and Peter Okyere Boateng of COCOBOD Deputy Executive Director of Monitoring and Evaluation mentioned that they are looking into grafting as a solution to rehabilitating some of Ghana's very old farms faster both in maturing and production. They have selected a few farms in various regions to run pilots. However, they were both quick to add a word of caution; grafting is dangerous because many cocoa farms in Ghana are affected by CSSV which affects every part of the tree. Accidental introduction of infected material into a healthy farm has the potential to destroy the entire farm. At a minimum the surrounding eight to ten trees should be cut down. Solidaridad mentioned grafting as a path for increased productivity and argued that the government should not be so hindered by the possibility of spreading CSSV.

Agroforestry

Agroforestry is one of the most common adaptation and mitigation strategies promoted and mentioned as being implemented by farmers. Shade trees can reduce the amount of pesticides needed, which increases soil health, and can create extra income from the selling of the timber. However, 20 years ago full sun cultivation was promoted and the majority of shade trees were cut down. Agroforestry is still in the initial stages of reintroduction in Ghana. A majority of farmer respondents mentioned incorporating shade trees of some type on their cocoa farm as a response to the changes in climate. Eight farmers mentioned intercropping plantains with cocoa, which can serve as shade for younger cocoa plants. This is supported by the literature according to Vaast and Somarriba, farmers in West Africa have interest in planting more types of trees in their farms to sustain cocoa, diversify revenues, and improve their adaptation capacity (Vaast and Somarriba 2014).

Many NGOs, private sector companies, and government agencies are promoting agroforestry. COCOBOD's Peter Boateng stated that they have trained their farmers in the benefits of permanent shade trees; however, they caution farmers on too much shade, because this can cause an increase in pest and disease infestation. COCOBOD is currently growing shade trees. Dr. Anim-Kwapong noted that CRIG is promoting proper shade cover to minimize evapotranspiration from trees and soil and slow down the tree metabolism which will increase the tree's production longevity. He also mentioned that agroforestry is good for the environment in general because it increases Ghana's carbon stock. According to Dr. Anim-Kwapong, cocoa trees need 70% shade and permanent shade trees should be planted a year in advance of cocoa trees if starting a new farm. Agro Eco's West Africa Regional Manager, Willem-Albert Toose, argued that 18 shade trees per hectare should be planted, but farmers may need to plant quadruple that

number to have any impact. Agro Eco is also conducting research to understand how to get more farmers to plant shade trees.

Good Agricultural Practices (GAPs)

One of the important cocoa GAPs is shade management, through pruning and spacing, to manage the shade canopy. Twelve out of thirteen farmers mentioned pruning as a common pre-harvest activity and four of them mentioned that the training they received on pruning was one of the most valuable trainings they had participated in. However, a few of the farmers when asked about their challenges on the cocoa farm mentioned pruning. They explained that they were doing the pruning the way they had been taught, but the canopy still seemed too crowded. In our conversations with various key informants, it became clear that farmers may be pruning, but they are reluctant to cut as much as they should, which causes overcrowding.

Soil management is another important GAP due to the increased temperatures, increased storms, and overall decrease in amounts of rainfall which affect the soil's nutrients and the amount of moisture the soil can retain. There are various CSA techniques which contribute to soil management including mulching, organic and inorganic inputs, intercropping, and irrigation. Dr. Anim-Kwapong was the only key informant to mention mulching. He stated that CRIG was demonstrating to farmers and farmers were using coffee husks to mulch. We observed the practice being implemented on one of the demonstration farms at the CRIG headquarters. However, none of the thirteen farmers interviewed mentioned mulching as either a daily practice on their farm or an adaptive practice they had begun due to the effects of climate change. When visiting the farmers, we did observe one cocoa farm where the fallen cocoa leaves had been left to cover the farm, but it was unclear whether it was intentional for keeping the moisture in the soil, or if it was just a result of cultural or organizational practices.

While all farmers were growing additional cash and food crops, eight farmers said they were intercropping specifically on their cocoa farms with various plants including plantain, cassava, tomatoes, peppers, maize, etc. Mr. Pillai stated that Barry Callebaut promotes intercropping in Cote d'Ivoire and hopes to promote it in Ghana in the near future.

Dr. Anim-Kwapong noted that CRIG is promoting barrier cropping as a way to control the spread of CSSV. CSSV is transmitted by the mealy bug, which is very slow moving and only has 48 hours to infect a new plant after biting an infected tree. By planting trees around the barrier of their cocoa farms, farmers can slow the bug and make it less likely that it will be infectious by the time it reaches the healthy farm.

Diversification of Income Sources

None of the farmers interviewed were solely relying on cocoa for income. All farmers were growing food crops and some were growing additional cash crops. A majority of farmers reported selling 90% of their food and cash crops, but some sold as little as 10-15%. The most prominent cash crops reported were palm, plantain, cassava, and peppers. Despite growing many other crops, all thirteen farmers ranked cocoa as their number one crop today versus only four farmers reporting it as their number one crop 20 years ago or however long ago they started growing cocoa. This seemed to be the result of an increased focus on cocoa, which led to increased yields and was achieved by expanding existing cocoa farms or buying new land.

Certification is another way that farmers can increase their income through the payment of premiums. Mr. Toose from Agro Eco noted that certification is a great tool for getting farmers training, but the premiums are negligible and a majority of the premiums go to the farmer groups which certify the farmers. However, he argued, certification does allow farmers to get things they would otherwise pay for, such as inputs. Solidaridad is a large proponent of certification for increasing productivity and sustaining the environment. Yields at the farm level under Solidaridad's certification programs have increased by 40%

and there is now a platform to reach farmers with other services including financial services, etc. Mr. McCormick from Hershey mentioned that they are conducting a program to promote certification in Ghana and they have a company-wide goal of sourcing 100% certified cocoa by 2020. Charles Tellier, Coordinator for Sustainable Sourcing for Touton firmly stated that for the private sector, "certification is too expensive."

Seven farmers claimed to have other sources of income beyond growing crops, both on and off-farm. Five had off-farm income including owning small shops, serving as PCs for the LBCs, selling prepared foods, and running a microfinance institution. Three farmers raise and sell livestock and one of these farmers also managed a fish pond. CRIG is also researching other ways to use cocoa byproducts so farmers can make and sell these items for additional income. Some of the pilot projects include alcohol, jams and marmalades, soaps, and creams. CRIG is currently training some farmers groups in these techniques.

V. Research Findings – Costa Rica

Background

Costa Rica is considered one of the smallest producers and exporters of cocoa in the world. Cocoa farming began 3,000 years ago in Mesoamerica, eventually leading to Costa Rica be the third largest exporter in the world in 1922. However, due mainly to moniliasis (*Moniliophthora roreri*), which caused many farmers to abandon their cocoa farms in 1973, the level of production in the country has reduced dramatically. Moniliasis, more commonly known as frosty pod, destroyed 80% of Costa Rica's crop forcing many smallholder farmers to abandon their farms or change crops. Before the onset of the fungus, there were 10,000 ha of cocoa planted in Costa Rica. Today, there are only 4,500 ha of cocoa plantations. Compared to 500 kg/ha/year of cocoa by larger producing countries, Costa Rica now produces an average of 200 kg/ha/year.

Much of the cocoa is produced in smallholder farms ranging from two to five ha with integrated agroforestry levels of very high shade, and canopy and crop diversity, most of them are found in the north in the region of Upala and in the southern Caribbean coast in the region of Talamanca. Many of these farmers who have continued cocoa production even after the onset of moniliasis are from remote indigenous communities, such as BriBri and Maleku, since cocoa is culturally significant and embedded in their identify and history. One farmer interviewed in Upala mentioned that only a few farmers who were willing to put in a lot more effort to deal with moniliasis continued to grow cocoa. At least two larger, more developed cocoa plantations located in the Guacimo and San Carlos cantons of Upala exist in Costa Rica, which were visited during the field interviews. They were 120ha and 100ha, respectively.

Although low in yields, Costa Rica has recently become well-known for their high-quality cocoa in the international market. Costa Rica is the only country in Central America and only one of nine in the world that exports 100% fine flavored cocoa, according to the ICCO. All farmers interviewed in Costa Rica care much about the quality of their cocoa. While most farmers ferment and dry seeds before selling, they were careful about the timing and the length of fermenting and drying that keep the maximum quality of their cocoa. Farmers ferment seeds for 4-6 days and dry those for 15-20 days. Eduardo Sommariba at CATIE emphasized the importance for the Costa Rican cocoa sector to target the niche market of high quality cocoa. Due to high cost of labor in Costa Rica, its cocoa sector cannot be competitive in the international market in terms of quantity.

At the national policy level, Costa Rica is widely known for its efforts in conserving biodiversity and driving commitments for national climate change goals. After undergoing massive deforestation due to expanding agricultural frontier, the government placed more than 26%of its land under protection. Regarding GHG emissions, Costa Rica has been receiving funding from the Global Environmental Facility to develop the National Meteorological Institute for a national inventory of GHG emission by

sources. Two national communications have been sent to the UNFCCC laying out its commitments to responding to climate change impacts. Vulnerability studies have been carried out with the support of The Netherlands. Costa Rica has also recently developed its National Strategy for Climate Change (ENCC) to lay out six main pillars of action: mitigation (with the aim to become carbon neutral by 2021), vulnerability and adaptation, precise metric system, development of national capacity and technology transfer, education and public awareness and financing (UNDP 2012). More recently, the Action Plan for Climate Change and Agro-environmental Management (2011 – 2014) was developed as a strategy to respond to climate change threats to the agricultural industry. Elements include risk management, adaptation, mitigation, knowledge management, capacity building, and sustainable production. Efforts have also been made to coordinate among environmental and agricultural organizations, such as with the Innovation and Agricultural Technology Transfer Institute, which promotes CSA practices in coordination with FUNDECOOPERACION, the Central American Indigenous and Peasant Coordinator of Communal Agroforestry, and the National Biodiversity Institute.

Government and financial institutions have developed climate-smart agriculture technology and practices, but have mainly focused on achieving productivity and mitigation. Overall in the agricultural sector, these include requirements for compliance with environmental legislation, opportunities to receive Payment for Environmental Services (PES) and other economic incentives to meet mitigation requirements for export product certification. The PES system, especially for carbon capture, is a national scheme run by the Ministry of Environment and Energy.

Climate Change Phenomena

Studies have shown that Costa Rica is experiencing increases in temperature and rainfall variability, which was also evident from interviews with farmers. The World Bank reports that the country's mean annual temperature has risen 0.2-0.3 degrees Celsius per decade since 1960 (The World Bank Group 2011). This has resulted in an increase in the number of warm days and nights and a decrease in cold days and nights. Since the 1960s, the number of warm days has increased 2.5% per decade and the number of warm nights increased 1.7% per decade. In the same timeframe, the number of cold days decreased 2.4% per decade and cold nights decreased 2.2% per decade (The World Bank Group, 2011). Projections for 2050 indicate an increase of 1-2 degrees Celsius and 2080 projections forecast 2-4 degrees higher, particularly from May to June. Also, temperature changes are believed to be more significant in higher elevation areas than in the lowlands (The World Bank Group 2011).

All respondents felt that climate has changed in dramatic ways, both with an increase of intense rainfall and higher temperatures. In specific, all respondents mentioned longer, drier summers (i.e., dry season), as well as longer winters (i.e., rainy season). Changes in precipitation and temperature have also caused changes in land characteristics, which could signal another factor in land suitability for cocoa. One respondent in the Upala region recounted that, "*This area was a wild valley before my grandfather planted cocoa here. It became a drier area after growing cocoa. Before, we had to take a boat to come here."*

Although respondents reported an average temperature increase, as summers are hotter and winters are drier, they also reported an increase in rainfall variability and weather unpredictability. One respondent in the Talamanca region said, "*There used to be a dry season and rainy season, but now it's mixed. It can be very hot during the morning and rain a lot in the afternoon*". In addition, respondents perceived that the previous year, the rainy season was more intense. It should be noted that there is an importance in acknowledging the micro-climates throughout districts across Costa Rica.

Vulnerability Assessment

Cocoa farmers are highly dependent on the health of the environment for their livelihoods. Farmers reported that their trees were drying up due to increases in temperature and periods with a lack of rainfall;

this affected especially their younger trees causing an increase in tree mortality. Farmers in both the Northern and Caribbean regions noted the increased temperature causing decreased yields. A farmer in San Carlos noted that cocoa trees need enough water, especially when they are younger and not close to any shade trees, since it is easy for water in the trees to evaporate. A farmer in Guatuso also reported that trees have dried up due to the heat. Shifting of summer and winter seasons has also affected farmer decisions on fertilizer application. "*Now, it's hard to decide when to put fertilizer. We used to use fertilizers in the summer, but we don't know when it is summer now",* said one farmer in Guacimo.

An increase in rainfall intensity affects the blooming of flowers causing decreased tree pod productivity. One respondent in the Northern Upala region reported that, "*Flower doesn't bloom when the winter is long. I don't have the capacity to deal with it. When it rains too much in the winter, it can also affect the grafted varieties"*. This farm had various clones from CATIE that increase yield, but still reported that rain affected the delicate flowers. Flooding was also reported by one respondent in the Caribbean region. Unpredictable rain has also caused challenges in planning when to harvest and fertilize due to changes in harvest peak seasons. As noted by one respondent, "*High peak season has also changed. It was from September to October in the past, but now it's April because we have too much rain."* Challenges in farm management due to rainfall also affected other crops that farmers depend on for household nutrition. For instance, one respondent in Upala mentioned how many farmers produce beans, but due to rainfall during our field research visit which was during the dry season, they are unable to harvest. Another farmer in Talamanca said they gave up growing beans since they could not tell when it would rain. Severe storms were reported by one respondent in the Central region of Guacimo, who noted that storms caused shade trees to fall down on the cocoa trees, destroying them. Climate changes also affected the quality of cocoa seeds sold to the market. One farmer said that during extensive humid or rainy periods, the seeds become whiter when drying.

Apart from the increase in heat and rainfall intensity, moniliasis is another of the biggest challenges reported by farmers. Two respondents noted that there used to be an abundance of cocoa, but until 20 years ago, moniliasis incidence has spiked. The fungus affects the cocoa pod but not the tree itself. One farmer in Guacimo reported that 25-30% of their harvest is lost due to fungus. Climate change poses significant risk on increases in moniliasis as literature shows correlation between precipitation and germination of the diseases fungal spores – which is the only method for infecting other trees (Bucker Moraes et al. 2012). In Costa Rica, peaks in diseased fruits occurred at 5-6 months after peak flowering, which coincides with precipitation periods (Bucker Moraes et al. 2012). This link in precipitation and moniliasis incidence does not seem to be realized by the farmers. Black pod, caused by the fungus *Phytophthora spp*, was mentioned only during one interview as another challenge to cocoa production. Witches' Broom (*Moniliophthora perniciosa*), the third disease affecting Latin American cocoa, was not mentioned during any of the farmer interviews.

The degree of farmer sensitivity to these climatic external shocks varies by composition of farm and the demographics of the farmer and community. This includes the quality of cocoa variety, knowledge and application of good management practices, amount of yield they are able to sell, diversification of their income sources with other cash, food crops, and off-farm employment, and support from financial institutions. For instance, the smallest cocoa farms visited during the field research were two and three ha, and both noted climate change is affecting their farming due to temperature and precipitation intensity and unpredictability. This has caused one to stop cultivating beans and has affected both their decisions on when to harvest and fertilize. However, the level of sensitivity differs even between these two smallholders. One farmer has off-farm employment through construction work and as the President of Association of Small Producers of Talamanca (APPTA), which provides income during periods of low cocoa yield. The other farmer has a lower level of record-keeping as she was unable to say how many kgs were sold from her farm, and does not have a stable source of income other than selling cocoa. When looking at yield and income, the second farmer has a higher level of sensitivity to climate change.

However, both farmers are part of farmer associations which have led them to acquire training on good management practices and cocoa processing, resulting in higher adaptive capacity.

All respondents interviewed were aware of climate change and expressed the important link between environmental conservation to help curb climate change. When asked what they think should be done to mitigate climate change, most respondents mentioned the need to plant more trees and increase people's awareness of climate change. Majority of respondents said there is a need to increase knowledge through awareness campaigns to prevent further environmental destruction, especially as some noted, deforestation is still happening. One farmer also expressed the injustice regarding rich countries doing most of the environmental destruction, while poorer countries are feeling the impact.

Adaptation and Mitigation Approaches in Costa Rica

Farm Rehabilitation Using Grafting and Hybrid Varieties

Farm rehabilitation by grafting original trees with superior hybrid varieties has been the most common strategy to increase productivity and sustainability of cocoa trees in Costa Rica over the last 10-20 years. Farmers adopted hybrid varieties to rehabilitate their cocoa farms that are devastated by moniliasis during 1970's and 1980's. Many farmers in Costa Rica had their own nursery to graft hybrid cocoa varieties with their original cocoa trees. CATIE, which has one of the two principal germplasm collections in the world, has already developed new high-yield, quality cocoa varieties that are resistant to frosty pod rot through their germplasm collection, which are already being distributed in Central America and Mexico (CATIE 2014). Some farmers received CATIE-recommended clones directly from CATIE and others selected best trees on their own farm and used those for grafting.

Grafted cocoa trees start producing cocoa pods earlier than the trees from seeds. They start producing as early as two years of age, which is two years earlier than normal trees from seeds. Grafted trees also produce more and/or better pods because grafted clones are usually selected for their higher production, higher level of disease resistance, and/or higher quality. Also, grafted trees are smaller because they do not produce chupons, which makes pruning, harvesting, and pest and diseases management much easier (Somarriba et al, 2011). Data collected from farmer interviews confirm these benefits of grafted cocoa trees. Most farmers that the team interviewed introduced grafting mainly to recover from the damage of moniliasis and also to harvest more pods more easily. Farmers explained that the trees of traditional varieties are taller, dangerous to harvest, difficult to manage, and produce less, whereas those trees that are grafted using selected hybrid varieties produce more, are easier to manage, and are more resilient to moniliasis and climate change. One farmer in Upala said, *"Each grafted tree produces 150 pods a year, and Criollo produces 100."*

Despite significant improvement in tolerance to diseases, there are no recommendations for hybrid cocoa varieties that are high-yielding, tolerant to diseases, better flavored, and more resilient to direct climate impacts such as drought and flood at the same time. Eileen Herrera at the US Department of Agriculture Agricultural Research Service (USDA ARS) pointed out that the idea of cocoa breeding is still underdeveloped within scientific research compared to other trees. She also warned about the potential spread of viruses with germplasm moved from one region to another.

Agroforestry

Agroforestry is considered as an important climate change adaptation and mitigation strategy in Costa Rica. Cocoa has traditionally been cultivated in agroforestry systems and most farmers were continuing agroforestry despite its lower short-term productivity compared to full-sun mono-cropping because they were growing other crops, fruits and timber trees on their cocoa farms. According to Jenny Ordonez at the International Centre for Research in Agroforestry, one of the reasons farmers keep doing agroforestry in Costa Rica is for the timber trees which can be used in the households. Unlike coffee cultivation in Costa Rica which has mostly turned from shade farming to full-sun cultivation, cocoa cultivation continued

using shade farming. The types of shade trees used were plantains, coconut trees, timber, tuber, guava, moringa, lucayna, which provide for both additional sources of income and household nutrition.

Different types of agroforestry were observed in different farms according to the different microclimate of the geographical location and sizes of the farms. Larger plantations were closer to the full-sun intensive farm type because they intend to mainly grow cocoa trees, whereas smaller farms were more integrated, with cocoa trees growing with other fruit trees and natural timber trees. Some small farms were forest farms or rustic farms on mountainous areas, and other small farms had other cash crops or fruit trees in between cocoa trees.

GAPs-Shade Management

Shade management including pruning of cocoa trees, spacing, and planting or removing shade trees to adjust the level of cocoa trees' exposure to the sun and the air was perceived by farmers in Costa Rica as one of the most important management techniques in cocoa production to increase productivity, disease tolerance, and quality of cocoa trees. Shade protects younger trees from strong heat, winds, and intensive rain. Shade also protects the soil and retains moisture, although too much humidity makes trees more susceptible to diseases. As increased climate variability makes balancing exposure to the sun and the air more difficult, appropriate and timely shade management becomes more essential to protect cocoa trees from drying out or being more susceptible to diseases.

All farms were pruning mostly every week to keep stable amounts of sun and air that could reach the pods and the soil. Even though pruning requires intensive labor, farmers understood the advantages of pruning and were willing to prune as much as they needed to. However, different levels of shade management were required depending on the farm type and changing climate. A farmer in the Southern Caribbean Coast who had a more integrated rustic farm with cocoa trees dispersed between other fruit trees and timber trees said, *"I try to maintain shade to reduce the amount of heat reaching cocoa trees. Shade also protects cocoa trees from strong rain and protects the soil."* Another farmer from the large plantation explained that they need to do more pruning to keep the balance of moisture when humidity is high.

Spacing between cocoa trees when planting also affects the level of shade on the farm. If trees are planted intensively, there is more shade, and if trees are more dispersed, there is less shade. Larger farms adopted more intensive spacing than smaller farms. Smaller farms spaced trees 3 or 4 meters apart, which creates enough space to plant shade trees and other crops. Spacing also prevents trees from competing for space.

GAPs-Soil Management

Keeping sufficient nutrients and the appropriate level of moisture in the soil was one of the priorities of farmers. Due to increased rainfall variability, farmers need to adapt to droughts or floods and the corresponding loss of nutrients in the soil. Mulching with cocoa leaves after pruning is a form of soil management and prevents weeds from growing, while providing nutrients and retaining moisture. Almost all interviewed farmers were practicing organic farming and used compost made from cocoa pods as organic fertilizer. One farmer in Talamanca said, *"I've been doing only organic farming, because it keeps nutrition for the soil."* One large plantation was also using coffee waste as an organic fertilizer. Farmers were adopting organic farming both because they were getting better price for the organic label and they could not afford chemical fertilizers or pesticides. Additionally, farmers perceived that organic farming contributes to biodiversity conservation.

There are some criticisms about current organic farming that is practiced without providing sufficient inputs. The president of the National Association of Costa Rica of Fine Cacao (CANACACAO) stated that organic farming is not a good way of soil management because it does not provide sufficient nutrition to the soil, pointing out that poor farmers do not have other choices besides organic farming. One of the farmers noted that those who use chemical fertilizers earn more money, which supports this criticism.

However, using inorganic fertilizer does not improve the soil's physical properties such as structure and porosity, soil microbial activity, and organic matter content which are critical to maintaining soil fertility and nutrient cycling (Vaast and Somarriba 2014). Lawton Lanier Nalley at the University of Arkansas, in the interview, pointed out that shade farming for cocoa had worked well for 100 years, but the introduction of new inorganic fertilizers made cocoa farming require sunlight since those fertilizers do not work without enough sunlight.

Water management is a relatively new strategy that is closely related to soil management. One large plantation in Guacimo wanted to improve the drainage system to deal with too much rain at once, and another new large plantation in San Carlos was using irrigation to deal with drought. This irrigation system was first introduced to cocoa farms in Costa Rica as a new method for soil management, providing dissolved chemical fertilizers in the water to the soil. Even though the farm administrator said it has been successful so far, it is too early to conclude if this is a promising strategy for climate change adaptation in Costa Rica because it has only been in use for a year and it could also be solely appropriate for the specific microclimate environment in that specific region.

Diversification of Income Sources

Smallholder farmers have diversified income sources to supplement their cocoa revenue during low production seasons and also for the years of overall bad production due to unfavorable weather. Farmers had both on-farm income sources and off-farm income sources. On-farm income came from growing other cash crops such as plantain, corn, coconut, yucca, and papaya. Some farmers were also selling the plants of hybrid cocoa varieties that they grafted in their own nurseries to other farmers. One increasing source of on-farm income was chocolate tourism. One Maleku indigenous farmer in Guatuso said, *"We get community income through tourism. We receive 25 dollars per person for tour. We sell artisan products and that's our main source of income."* Another farmer in Upala said that she sells her cocoa to three tourism companies and one local collector. She explained that more and more students who are interested in cocoa because of chocolate tourism visit her farm.

Some farmers were also processing their cocoa beans in various ways before they sell them to the middlemen or to the market, earning higher profits than if they sold raw seeds or dried beans. One farmer in Upala said, "*I toast cocoa beans in oven or fire to increase value. I also didn't know that I could increase the value of my crop that much just by toasting. I learned this from training, and I teach this to other households."* She was also making her own artisan chocolate and selling it to tourists and schools. One farmer in Limon was producing various products from his cocoa, including cocoa butter, canned nuts, nutrition supplements, and drinks. He emphasized the importance of farmers adding value to their cocoa before they sell, saying *"My father used to earn 2.2 dollars for one kg of cocoa seeds that he produced, but I earn 50 dollars from one kg of cocoa seeds... By just putting a nice sticker on your package, it adds value to the product."*

Some farmers had income from off-farm employment. One farmer in Talamanca was hired by APPTA as a president, and was also working as a broker for construction workers. Another farmer in Talamanca was doing some temporary work during low production seasons. She said, *"I sometimes cook for school. It's not easy to find temporary work, but I have to find some work every time I need extra income."* One farmer in Upala said her husband works at an electricity company in the city.

VI. Comparison of Ghana and Costa Rica Findings

A chart summarizing the differences and overlapping findings from both countries is provided below:

Ghana	Common Findings	Costa Rica
Perceptions of climate change		
• Most perceive climate change as human induced and should be mitigated • Some do not have knowledge of climate change or need for mitigation	• Negative impacts on cocoa • Rainfall unpredictability • Increased heat • Increased winds and storms	• All perceive climate change as human induced due to environmental destruction • Rainfall intensity • Longer summers • Less distinction between seasons
Levels of Sensitivity		
• Lack of tree tenure procedures • CSSV, capsid, cocoa shield bug • Lack of pesticides, fertilizers, seedlings, drip irrigation	• Climate exacerbating rate of pests and diseases • Lack of capital to purchase inputs • Some reports of reduced pod yield • Weather unpredictability leading to uncertainty about timing of farm practices • Declining water sources	• Moniliasis • No access to or income for organic fertilizers
Contributing factors to current adaptive capacity		
• No unique characteristics	• Shade management • Intercropping • Soil cover • Income diversification • Access to training on GAPs	• Using hybrid varieties for increased yields and disease resistance • Grafting techniques • Higher prices for organic cocoa • Shade and integrated farms • Irrigation

VII. Recommendations for Climate-Smart Cocoa Strategy

Based on the triangulated findings from all three key sources of information, the research team came up with ten recommendations to assist WCF in creating a new strategy to assist farmers and the cocoa sector writ large to mitigate and adapt to the impacts of climate change. Due to space constraints, seven recommendations are presented below. These recommendations, however, are not all encompassing and should be taken as a foundation which can be built on and modified depending on the particular context.

1. Promote grafting

Grafting can be promoted as a critical climate change adaptation strategy for cocoa farmers both in Ghana and Costa Rica with different approaches for each country based on the stage of its development and application. While grafting is widely practiced at the farm level by the farmers in Costa Rica, it is only being experimented at some government selected farms in Ghana.

Even though grafting is not being practiced at the farm level in Ghana, it is a potential future strategy for rehabilitating old cocoa farms. Introduction of grafting for farm rehabilitation can significantly increase farm productivity. Increased productivity will strengthen farmers overall capacity to deal with climate change impacts by allowing them, first, to sustain cocoa production, second, to invest in other inputs or adoption of other strategies. Cocoa farmers in Costa Rica understand the advantages of grafting well particularly because they had observed that the grafted trees start producing pods earlier and produce more pods. Despite a high level of understanding, not all farmers know how to graft and some farms do

not have their own nurseries for grafting and growing grafted plants. Therefore, scaling up farmer trainings on grafting skills, supporting farmers to establish nurseries on their farms, and distributing grafted plants at a lower cost to more farmers are more relevant strategies in Costa Rica. One farmer interviewed in Costa Rica mentioned that grafting was the most useful skill that she had learned from training, and another farmer said that training about grafting helped a lot even though she had been doing it before the training.

2. Develop climate resilient hybrid varieties

Developing climate resilient hybrid varieties, such as drought tolerant varieties, can be a critical solution to decreasing cocoa production. Despite different levels of expected short term impacts of drier climate in Ghana and Costa Rica, farmers in both countries mentioned drier climate and heat as critical challenges for cocoa production. One key informant at CATIE mentioned that a drier climate might be better for cocoa production in Costa Rica, which has a much higher average rainfall than Ghana. On the other hand, suitable areas for cocoa farming in Ghana were projected to decrease largely due to drier climate. Even if some cocoa farms in Costa Rica can benefit from overall drier climate, stronger heat during the dry season or increased rainfall variability throughout the year may still affect cocoa farming in the country. Therefore, genetic improvements for tolerance to extreme climate such as drought, heat, or flooding can be critical for both countries in the long term.

Even though CATIE has developed many clonal varieties that are more tolerant to diseases which are already growing in Costa Rica and other countries in the region, varieties that are more resilient to climate impacts such as drought, heat and flood have not yet been developed. CATIE's research on genetic improvement of cocoa is more focused on tolerance to diseases that pose immediate threats to cocoa farmers in the region. However, one recent research project conducted in Ghana examined the drought tolerance of different cocoa varieties and attempted to identify specific clones that are more tolerant to drought (Ofori-Boateng and Baba 2011). Further research on the productivity, disease tolerance, and quality of these drought tolerant clones is needed.

3. Train farmers on identification of pests and diseases and treatments

Training farmers in identifying different types of pests and diseases, and corresponding treatment techniques or integrated pest management will be useful to prevent cocoa losses due to pests and diseases. As climate change may create more favorable environments for pests and diseases, cocoa farms are becoming more sensitive due to increased incidences of pests and diseases. While no farmers interviewed in either country made a connection between climate change and the increased number of pests and diseases, one farmer interviewed in Costa Rica said that there are new pests and diseases, requiring them to spend more time and efforts in dealing with those. In Ghana, farmers indicated that majority of unsellable cocoa pods were due to pests, and in Costa Rica, one farmer said that they have 25-30% loss due to fungus.

Simply being able to identify specific disease affected pods can help farmers properly treat their trees, reducing the chance of further losses. One large plantation in Costa Rica trained farm workers on how to identify pests, black pod, and moniliasis, so that workers can properly decide how to handle the affected pods when they found those. Another farmer in Costa Rica explained that she can still use the beans from the black pods to make chocolates, but she cannot use the beans from moniliasis affected pods at all. Due to training, farmers in Costa Rica can differentiate moniliasis affected pods from other pest-affected pods, and can remove those as early as possible to prevent the other pods or trees from being affected. In Ghana, farmers noted inspecting for pests and diseases was a common activity. Eileen Herrera from USDA ARS pointed out that CSSV is spreading without being controlled. Training farmers in methods to identify CSSV affected trees can help limit the spread of the disease and reduce the number of trees that will need to be cut down.

4. **Increase use of locally adapted agroforestry**

Agroforestry is a promising strategy both for climate change adaptation and mitigation andit is currently embraced and promoted by environmentalists and also by many stakeholders in the cocoa sector, including farmers in both countries. Cocoa production in Ghana is moving away from full-sun cultivation and is beginning to plant shade trees and intercrop desirable shade trees, some of which can be used for timber or additional cash crop production, such as plantains and palm. Various types of agroforestry are observed in different regions of Costa Rica.

Since existing farm types, geographical environment, and local climate patterns vary between different locations of cocoa farms in Costa Rica, it is impossible to promote single type of agroforestry to all cocoa farms in the country. For example, planting more productive shade trees can be promoted in rustic farms to increase productivity and diversify income sources. Planting specialist shade that grows very fast can be also promoted as short term adaptation strategy to increasing climate variability such as extreme heat during dry seasons or more intensive rainfall during rainy seasons.

5. **Raise farmer awareness about climate change drivers and provide additional training on adaptation and mitigation strategies**

As shown in the Ghana research, it is important that cocoa farmers have an understanding of climate change and its drivers in order for them to comprehend how to mitigate the overall phenomena and adapt to the effects accordingly. The farmers who admitted to not knowing the causes of the climate change phenomena or who felt it was up to God were the farmers that were not practicing any adaptation or mitigation techniques. Costa Rica may serve as a good example of the level of knowledge cocoa farmers should possess to accurately mitigate and adapt to climate change. In general, farmers need to have access to training and resources where they can get answers to questions. Both farmers in Costa Rica and Ghana expressed a desire for more training opportunities, including refresher courses on trainings that were provided several years ago. They also illustrated situations where they had questions and were either not sure who to ask or the answer they received was inadequate.

Once farmers are aware of the driving forces behind climate change and what can be done to both combat and react to the effects, more training needs to be provided on specific techniques. Training in specific climate change adaptation and mitigation techniques as well as basic GAPs are necessary for farmers to be successful. Agroforestry is one of the main adaptation and mitigation strategies used in the cocoa sector and there are a lot of details that need to be managed in order for it to be successful. Farmers need to understand what types of trees should be planted to provide optimal shade while not acting as a breeding ground for pests and diseases. Farmers should also understand the number of shade trees necessary for their farms and how to manage the shade canopy through pruning for optimal productivity. Training farmers in pruning also requires them to be bought in to the idea that it is acceptable to cut a fair amount off of their cocoa trees. Many farmers are reluctant to do this, particularly if they see a pod growing on a branch, which causes there to be too much shade on the farm.

6. **Coordination of Projects and Research**

Cocoa companies, national governments and NGOs are all working towards increasing farmer resiliency and sustainability, but many of these efforts are being executed independently and without coordination between them. Cocoa manufacturers are understandably focused on the particular farmers that are selling to them, rather than looking at the cocoa sector writ large. There appears to be a lack of coordination between these stakeholders to prevent redundancies in research and activities at the international level, as well as within a country. A streamlined process to share research and information could prevent resources from being spent researching similar topics and instead allow them to be rededicated to other areas.

COCOBOD in is in the initial stages of trying to coordinate all cocoa projects within Ghana and created a project coordination unit through which it hopes to prevent an over concentration of projects and funding

in some areas and gaps in others. COCOBOD believes that all projects in Ghana should be coordinated through this unit, but it is unclear how many organizations have registered their projects with this unit. One challenge in Ghana is that while COCOBOD views itself as the main body through which all cocoa projects, including those that deal with climate change, the Ministry Environment believes that all projects that involve climate change should be coordinated through them. Further, it does not appear that there is a strong collaborative relationship between these two government bodies based on our interviews with the Director of Environment and the EPA.

Among the private sector stakeholders, there seems to be a concern that sharing information on sources of cocoa will provide competitors with an additional advantage. However, Rebecca Asare of NCRC and Yaw Kwakye of the Forestry Commission voiced similar opinions that that companies do not seem to realize that working together to map out farmer productivity and other data in different regions can be done without the trade off of giving away business intellectual property. There needs to be an understanding that sharing this type of information will benefit all stakeholders in the long run. The private sector has a large role to play, but the different companies need to work amongst themselves, as well as the rest of the stakeholders to preserve the cocoa sector.

One recommendation mentioned by from Eileen Herrara from USDA ARS to assist in coordinating research efforts is to create a web-based forum where researchers and large companies can post their publications and research. This will allow others to see what research has already been conducted and also provide a forum for discussion. In conducting our literature review, our team noticed that the data on cocoa and climate change was derived from a variety of sources and it would be helpful for many stakeholders to have access to a central repository, vice having to use time and effort to locate or duplicate research that has already been conducted. Furthermore, this database could provide a forum for sharing lessons learned from prior projects and hopefully increase dialogue for increased coordination.

7. Support information-sharing to reduce risks for unpredictable weather from meteorological stations to farmer cooperatives/communities

Farmers should be equipped with daily updated weather information so they can make important decisions, such as when to plant, so their seedlings are not lost and their crop is not ruined. Many farmers complained of not knowing when to plant due to the change in timing of the rains. If this information could be provided to farmers from meteorological stations either through farmer cooperatives, local communities, or via farmers' mobile phones, this would drastically increase their ability to adapt their farming practices in a changing climate. This type of information would also be useful in the area of extreme weather events so farmers and their families could respond appropriately in the right amount of time. This type of information could increase a farmer's overall resiliency in the face of climate change.

There are several case studies of NGOs implementing participatory action methodologies for designing climate smart approaches. For example, the Participatory Scenario Planning mechanism implemented by CARE provides a space for collective sharing and interpretation of climate forecasts. It brings together meteorologists, community members, local governments, and local NGOS to share relevant knowledge from both the local and scientific perspectives. This initiative helps increase local adaptive capacity by allowing community members to consider their climatic probabilities and assess their hazards, risks and opportunities (Ambani and Percy 2014).

VIII. Capstone Personal Experiences

Ana: I gained a wide range of invaluable experience through the Capstone practicum, including specific critical skills such as communication with various public and private sector stakeholders, client management, teamwork, and developing qualitative data collections tools. I also learned how to think creatively during challenging situations, which is important for a development professional. For instance, planning the logistics for field work was difficult at times, but led my team and me to develop new contingency plans with local partners in the field and strengthened our cross-cultural communications. I was also able to build on thematic expertise in the fields of natural resource management and poverty alleviation not just through extensive research but through dialogue with people in-country, giving me a first-hand perspective of the local realities and complexities within the cocoa value chain.

Ashley: Looking back on the Capstone experience, I realize what a unique opportunity it was to gain actual field experience while working for an actual client. It was an amazing learning experience and I learned how to do some of the preliminary work, such as constructing a Terms of Reference and creating deliverables. Since I am in the process of switching careers from a non-development related sector, Capstone was an awesome opportunity to gain hands-on experience and helped reaffirm my decision to pursue a new career. Moreover, I was able to apply lessons learned in the classroom to the project and since all the team members had slightly different concentrations, each person brought something unique to the group. However, the most rewarding part was being able to talk directly to farmers and to listen to their perspectives and it was astonishing to see how eager they were to share their experiences with us.

Caroline: In my everyday job I hire consultants to do research assignments; so I know what it's like to be an NGO spending precious resources on what you hope is a useful, quality product and the struggle of wanting a self-sufficient consultant, but realizing the less time you devote to the consultant's understanding, the less pleased you will be with the deliverable. Capstone gave me the chance to experience this transaction from the other side, which has changed my view and the way I handle the process. I learned being on the outside of an organization and trying to produce the product they want, but also be realistic about the constraints is a delicate balancing act. This experience reinforced how important communication is from both sides; each side should ask the questions necessary and be clear about expectations and limitations in order for the final product to be comprehensive and achievable. The other valuable takeaway for me was the ability to delve deeper into a sector of development that I am interested in. Understanding how climate change impacts smallholder farmers as well as the intricacies of the cocoa value chain are assets I will take with me as I pursue my development career focused on supporting youth to thrive as the solution to our world's food security challenges.

Yeongmi: Conducting a Capstone project was the most valuable experience during my two years of study. The Capstone project provided an opportunity to practice various knowledge and skills that I learned from other courses. Working as a team, with an actual client organization, on a specific research topic made the project practical, tangible, and professional. Conducting interviews with farmers and learning from them on the farms during the field research reminded me of my earlier encounters with local people in India and the Philippines almost 15 years ago. Back then, I thought I could and should do something useful to help them and that I knew better than they did. Now I know how much I can learn from local people when I am ready to learn and respect the local context. The most important thing I realized was that I really like this type of field work.

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