Assessing the Potential of Climate-Smart Cocoa Insurance: A Pathway to Increase Yields and Reduce Farmers' Risks from Climate-Change in Ghana

Justin D. McKinley,

Rebecca A. Asare

& L. Lanier Nalley

Report to the Climate-Smart Cocoa Working Group

Acknowledgements

The authors would like to extend their deepest gratitude to the World Cocoa Foundation for providing data from the Cocoa Livelihoods Program as well as assisting in this study. In addition, the authors would like to thank the contributing partners to the Cocoa Livelihoods Program: Bill & Melinda Gates Foundation, The Hershey Company, Mars Incorporated, Mondelez International, ADM Cocoa, Barry Callebaut, Blommer Chocolate Company, Cargill, Armajaro Trading Ltd., Ecom Agrocacao, Guittard Chocolate Company, Meiji, Noble Resources, Olam International Ltd., Petra Foods Ltd., See’s Candies, Inc., Starbucks Coffee Company, Transmar Commodity Group Ltd., The German Ministry for Economic Cooperation and Development (BMZ), and the Sustainable Trade Initiative (IDH). The Authors would also like to thank Dr. Bruce Dixon and Dr. Jennie Popp from the University of Arkansas Department of Agricultural Economics and Agribusiness for their invaluable contributions throughout this project. Finally, the authors are grateful to the Nature Conservation Research Centre and Forest Trends for enabling this work in Ghana, members of the Climate-Smart Cocoa Working Group who provided input and feedback on the work, and to DFID for supporting Ghana’s Climate-Smart Cocoa initiative.

Contents

Executive Summary

- In 2011, public and private sector entities in the Ghanaian cocoa industry began working together to assess the socio-economic and ecological sustainability of the sector, to identify major threats to cocoa production in Ghana, and to envision a future "desired state" and critical path to achieving this desired state. As a result of this process, there is now widespread consensus that Ghana should adopt a climate-smart cocoa (CSC) approach, and significant steps have been made towards the implementation of this vision, including the submission (and acceptance) of Ghana's "Emission Reductions Program for the Cocoa Forest Mosaic Landscape" to the Carbon Fund of the Forest Carbon Partnership Facility (FCPF) of the World Bank.
- Crop yield insurance was identified by the CSC Working Group as a key element of the CSC approach because of the role it could play in mitigating farmers' risk and reducing forest degradation and deforestation. The idea being that producers could potentially receive crop insurance as a benefit for adopting CSC practices and adhering to climate-smart principles. As such, crop insurance becomes an important element of the entire CSC package, inclusive of trainings and access to credit for on-farm inputs because it reduces the economic risk that farmers would otherwise bear if their yields decline due to changes in rainfall, despite the adoption of CSC practices.
- Crop insurance is limited in Ghana, and there is a paucity of work exploring the potential of crop insurance for cocoa production in Ghana. Two analyses emphasized yield insurance for protection against pests and disease, rather than weather events such as drought. However, because CSC producers will undergo training on best management practices for pest mitigation and disease outbreaks, insurance against these events is not

as necessary and could be counterproductive as it could increase moral hazard and adverse selection.

- Weather Index Insurance (WII) is likely to be the most suitable type of insurance for cocoa production in Ghana due to the reduced transaction costs, as there is no need to make on-farm visits to verify indemnities, and due to the mitigation of adverse selection and risk of moral hazard. Furthermore, cocoa yield is dependent upon weather conditions. The model constructed for this study found precipitation to be a highly significant factor in yield outcomes for cocoa farmers. However, data limitations in the form of location specific weather, present the biggest challenge to developing a WII product for cocoa in Ghana.
- Data for this study came from two separate sources. The first, which provided on-farm yield data and farm characteristics, was provided by the World Cocoa Foundation's (WCF) Cocoa Livelihoods Program (CLP). The data covered 1,200 households in 109 villages, 19 districts, and five regions throughout Ghana. Data was collected over four different survey periods from February 2011 to August 2012. In addition, daily precipitation data was obtained from aWhere Incorporated's[1] online platform. These precipitation data are geo-referenced to match with the individual households from the WCF dataset, with a resolution of five arc minutes ($\approx 9\text{km}^2$). The resulting accumulation is a unique dataset with a large sample size, accurate and precise precipitation data, and a large spatial distribution.
- Data were used for two separate analyses. Firstly, an OLS regression model was constructed to estimate yield by location. Results of this regression model were then used

[1] Accessible online at: http://www.awhere.com/

in a simulation model. Simulations were then run for two separate groups of cocoa producers: (1) those that followed CSC practices and (2) those who did not follow CSC practices. By simulating the data, average yields as well as yield variations were estimated.

- The first finding from this study is the importance of precipitation during the pod maturation period.
- The second finding of importance is that the cocoa producers who followed CSC practices had statistically significant higher yields than those who did not. On average, across all 19 districts, CSC producers' yields were 67.24 kg ha^{-1} higher than non-CSC producers, with the largest observed average yield difference coming from Juaboso at 77.31 kg ha^{-1}.
- The third notable finding was that producers who followed CSC practices were estimated to have less risk than producers who did not follow CSC practices. Risk was defined in two ways. Firstly as the percentage chance of receiving a payment from the insurer. The results of the analysis show that there were fewer indemnity payments (i.e. less yield risk) for CSC than non-CSC producers in each district surveyed in study. The reduction in risk can likely be attributed to the higher average yields for producers who follow CSC practices with only slightly higher yield distributions. The second measurement of risk was the comparison of the Relative Standard Deviation (RSD), in which lower percentages equate to lower yield risk. The measurement for RSD is a ratio between the standard deviation (distribution) and the average of a group of values. Results of RSD also showed less risk for CSC producers. The difference in RSD between the CSC and

non-CSC producers ranged from four percent in Bosome Freho to ten percent in Juaboso with an average difference of seven percent.

- The authors conclude by citing the need for more data to estimate more robust effects of the feasibility of CSC production and cocoa crop insurance. They recommend that the government and private sector make data available and develop data management as a top priority. Cocoa Research Institute of Ghana (CRIG) is cited as an institution that could compile and host such a platform. They also call on insurance providers to weigh in on the discussion, and recommend that a pilot is initiated to test cocoa insurance in a defined landscape.

I Introduction to Climate-Smart Cocoa and Insurance

Climate-smart cocoa (CSC) in Ghana is an idea that extends from climate-smart agriculture (CSA). The FAO (2013) defined climate-smart agriculture as, *"agriculture that sustainably increases productivity, resilience (adaptation), reduces/removes greenhouse gases (mitigation), and enhances achievement of national food security and development goals."* The growing interest in and value that is commonly attributed to CSA is its ability to offer both economic and environmental benefits to producers, combined in a manner to achieve yield gains, as well as stability in food production and prices. In Ghana, stakeholders' interest in adopting a CSA approach for the cocoa sector and production system led to the establishment of the Climate-Smart Cocoa Working Group in 2011. The CSC Working Group was initiated by Forest Trends and the Nature Conservation Research Centre (NCRC), in partnership with over seventeen national and international entities, including the private sector (cocoa buying companies, insurance companies, and banks), government institutions, and civil society and research organizations,. The working group was established with a goal to better understand the main threats to the sustainability of Ghana's cocoa sector, and to define strategies to reduce the illegal entry of cocoa farms into forest reserves (Asare, 2014). Over the following year, the Working Group assessed the sector's "Business As Usual", including issues of sustainability, threats to future cocoa production, and the challenge of deforestation and forest degradation attributed to cocoa farm expansion. The initial output of the CSC working group was a report entitled, "The Case and Pathway toward a Climate-Smart Cocoa Future for Ghana" (NCRC, 2012).

The report concluded that cocoa production in Ghana was on an unsustainable pathway for three primary reasons: (1) predicted changes in temperature and rainfall patterns due to climate change threatened the productive capacity of cocoa trees, (2) the cocoa sector's primary emphasis on intensification without thought to how production increases could promote further expansion and deforestation (and ultimately undermine the condition of the forests which provided critical ecosystem services to the cocoa production landscape), and (3) a total lack of landscape-level land use planning (NCRC, 2012). The report recommended that stakeholders across the sector realign their focus in order to improve cocoa producers' livelihoods by increasing cocoa yields and access to mitigation and adaptation benefits. However, it stressed that this should happen in concert with efforts to reduce the greenhouse gas emissions resulting from cocoa farm expansion into forests, as well as the conversion of other lands with high to medium carbon stocks, and increases in carbon stocks in low-shade cocoa production systems. It also underlined, the importance of landscape-level land-use planning at the community level in order to achieve these aims, and the need to promote biodiversity and ecological resilience within cocoa-farming landscapes (NCRC, 2012).

The CSC Working Group identified key gaps that needed to be addressed or improved for CSC to reach the “desired future state”:

- **Increasing yields** — The need to define and describe climate-smart cocoa best practices, including a focus on extension, inputs, and appropriate soils that will lead to substantial yield increases and increased income for farmers.
- **De-risking cocoa farming**—The need to develop climate yield insurance product and expand access to credit facilities so as to reduce farmers risks from climate change.
- **Landscape planning**—The need to harness a process or mechanism to implement community level landscape planning to curb expansion into forest reserves, target the most appropriate cocoa soils, retire over-age high biomass cocoa farms, and grow forest and trees in the landscape.
- **Data management & MRV**—The need to identify or construct a platform and system to manage and link data at multiple scales related to climate-smart cocoa so that mitigation impacts can be measured and monitored over time.

The first element, increasing yields, is already practiced and available in Ghana through various programs such as those offered by the Cocoa Abrabopa Association and the World Cocoa Foundation’s Cocoa Livelihood Project (Asare, 2014; WCF, 2014). These projects increase yields through access to extension services (training) and access to credit to purchase agricultural inputs. The important difference between these projects and CSC is that the other projects and initiatives focus exclusively on raising yields and incomes, without addressing the ensuing deforestation and forest degradation that typically results from farmers investing their increased income into new cocoa plantings (Asare, 2014). Increasing producers’ yields and incomes is a crucial element of CSC, but so too is mitigating forest degradation and deforestation through landscape scale planning and monitoring, in addition to other measures.

Crop insurance was identified as a vital element to the CSC approach because of the role it could play in not only mitigating farmers’ risk, but also reducing forest degradation and deforestation. The idea being that producers could potentially receive crop insurance as a benefit for adopting CSC practices and adhering to climate-smart principles. As such, the insurance becomes an important element of the entire package because it reduces the economic risk that farmers would otherwise bear if their yields decline due to changes in rainfall, despite adoption of CSC practices. The CSC practices would include recommended management practices, including shade management, and would give producers access to trainings and credit so that they could properly apply agrochemical inputs (inorganic fertilizer, pesticides, fungicide. In addition to adopting these practices, CSC producers would need to refrain from expanding into undisturbed forests or other areas designated during a localized land use planning processes, and when this scheme is applied across a landscape, sizable reductions in deforestation could be realized through proper land use planning. The final element of a CSC approach is to properly measure the livelihood and landscape-level impact through cocoa data management and forest monitoring. In fact, accurate monitoring of the landscape using an MRV system could enable CSC producers to access carbon (REDD+) or emission reductions (ER-Program) payments[2]. This revenue could then be used to at least partially subsidize a crop insurance program for eligible CSC producers.

To date, there has been very little research on crop insurance for cocoa. What research does exist has largely been focused on insuring producers against volatilities in global cocoa prices rather than on-farm yield guarantees. Some plausible reasons for on-farm yield insurance to be largely uninvestigated are that the costs of on-farm assessment for some forms of yield insurance are prohibitively high, especially for low- and middle-income countries and reliable and accurate on-farm data is relatively scarce for production and farm characteristics for cocoa in

[2] For more information see:
FCPF. (2014) *Emission Reductions Program Idea Note (ER-PIN).* Accra
And UN-REDD. (2011). *The UN-REDD Program Strategy*. Geneva

Ghana. However, two recent studies on yield insurance for cocoa have been commissioned in Ghana. Both reports, one from Price Waterhouse Cooper (PWC) (2014) and one from Charles Stutley (2010) emphasized yield insurance for protection against pests and disease rather than weather events such as drought. However, because CSC producers will undergo training on best management practices for pest and disease outbreaks, insurance against these threats is not necessary and could be counterproductive. The incidence of pests and disease on CSC producers' farms should decrease through proper training but providing insurance for pest and disease could actually increase the amount of losses related to these types of threats as a result of moral hazard[3]. For crop insurance to be viable for CSC producers, the type of policy used needs to be compatible with the program.

[3] Moral Hazard occurs when there is no incentive to guard against losses. In this example, there is a potential for producers to not treat pest and disease outbreaks on their farms because they will receive compensation for any losses associated with reduced yields from the outbreak.

II Review of Agricultural Insurance Products and Alignment with Ghana and Climate-Smart Cocoa

Crop insurance is an instrument to mitigate risk in agricultural production. There are two main types of crop insurance: crop yield insurance and crop revenue insurance (Barnett & Coble, 1999). For crop yield insurance, *indemnities* (money paid from the insurer to the insured in the event of a loss) are paid to producers when on-farm crop yields fall below the level of insured yield that is based upon actual production history (APH) (historical observed on-farm yields) of the producer (USDA, 2011). Crop revenue provides revenue protection by guaranteeing commodity prices (Barnett & Coble, 1999; USDA, 2011). For crop yield insurance there are two popular policy types: Multiple-Peril Crop Insurance (MPCI) and Weather-based Index Insurance. Historically, MPCI is the most common type of insurance policy.

2.1 Multiple-Peril Crop Insurance

This insurance type provides coverage against a variety of natural perils such as hail, drought, flooding, or fire damage (Barnett & Coble, 1999). Policy holders pay for each peril that they want to be covered against. MPCI products guarantee a level of expected yield in the event of a loss, typically insured yields are in the range of 50 to 70 percent of actual production history (APH) (Roberts, 2005). MPCI is well-suited for perils in which the amount of crop loss is difficult to measure (Roberts, 2005). In cocoa, an example of this could be losses due to black pod fungus, *Phytophthora megakarya*. Because the severity of a black pod infection is unknown, the insurer does not know immediately if the disease is affecting one tree or the entire farm. MPCI is also well-suited for perils that have an impact over multiple time periods (Roberts, 2005). In cocoa, an example of this could be the Cocoa Swollen Shoot Virus (CSSV) which requires that trees be cut down and therefor indemnities would need to be paid not just for losses in the initial year, but also for the cost of replacing the tree as well as the following years before the replacement tree is once more productive. To verify these indemnities, an insurance adjuster must physically visit farms in order to confirm the losses. On-farm visits from the insurer make MPCI expensive to operate, especially for smallholder agriculture in low-income countries (IFAD, 2011). Furthermore, transaction costs associated with on-farm visits are higher when there are more small farms and the farms exist in a region with poor infrastructure such as roads. Much of the expense of a MPCI program comes from high transaction costs. MPCI programs are also expensive to operate because there are additional claims that are made because of moral hazard and adverse selection[4]. Most MPCI programs operate at a loss and are dependent upon government subsidy (Roberts, 2005; Stutley, 2010).

2.2 Weather-Based Index Insurance

WII avoids the high transaction costs associated with indemnity-based systems such as MPCI (Linnerooth-Bayer, Mechler, & Hochrainer-Stigler, 2011). In an index-based insurance program such as WII, a proxy variable for a region is used rather than evaluating losses at an individual level (Stutley, 2010). Specifically to crop insurance, a weather variable such as precipitation is used (IFAD, 2011; Roberts, 2005; Stutley, 2010). WII reduces transaction costs because on-farm assessments are not needed (Stutley, 2010). Costs are also reduced in WII because the challenges of adverse selection and moral hazard (IFAD, 2011) are eliminated because indemnities are only paid when the proxy variable – such as rainfall – falls below a trigger point (Roberts, 2005). A disadvantage of WII is that it can only cover a small (typically one to two) number of perils, potentially not satisfying the risk-management needs of the insured

[4] Adverse selection occurs when the insured has hidden risks that the insurer is unaware of. In this example, producers may have black pod fungus present on the farm but have not disclosed this information to the insurer.

(IFAD, 2011). In addition, WII is still a relatively new product and requires further technical capacity development and expertise in agro-meteorology (IFAD, 2011).

2.3 Crop Insurance in Ghana

Crop insurance is very limited in Ghana. In December of 2009, a project entitled Innovative Insurance Products for the Adaptation to Climate Change (IIPACC) was initiated with funding from the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (Stutley, 2010). This project was implemented by the National Insurance Commission of Ghana (NIC) and Gesellschaft für Internationale Zusammenarbeit (GIZ) (Stutley, 2010). The stated objective of IIPACC is, *"to support the development of a sustainable agricultural insurance system and to introduce innovative and demand-oriented crop insurance products to protect against financial risks caused by extreme weather events and other forms of climate change"* (Gille, 2013). The establishment of the Ghana Agricultural Insurance Programme (GAIP) was made possible through funding from IIPACC. GAIP's first insurance product became available in 2011 and was a WII that covered over 3,000 smallholder maize farmers from three different regions in northern Ghana (GAIP, 2013). By 2012, coverage had been expanded to cover maize, soya, and sorghum in seven regions (Gille, 2013). Since GAIP discussions began in December of 2009, the program has had success in creating dialogue between the private and public sectors, developing available insurance products, creating regulations, and creating public awareness of the program (Gille, 2013). Unfortunately, GAIP has struggled to create low-cost insurance distribution channels, provide affordable premiums for adequate risk coverage, or actively engage the government of Ghana (Gille, 2013). The government views crop insurance primarily as a commercial initiative rather than a public initiative, even though crop insurance should be viewed as a way to manage agricultural and climate risk for Ghanaian producers. Currently, there is no crop insurance available for cocoa in Ghana.

2.4 Crop Insurance for Cocoa

Cocoa presents some unique challenges for developing and implementing an insurance product. The largest obstacle is that reliable data for cocoa is largely unavailable. In Ghana, agricultural statistics are managed by the Ghana statistics, research, and information department (SRID). However, SRID has not maintained any time-series production and yield databases for plantation tree crops, including cocoa (Stutley, 2010). Furthermore, the Ghana Cocoa Board and its affiliate, Cocoa Research Institute of Ghana (CRIG), are responsible for nearly all aspects of research and development for the cocoa sector. However, collecting and maintaining reliable yield data has not been a priority for these organizations. To date, the Cocoa Board does not have accurate data on the total number of cocoa producers in Ghana or the total area under cocoa production, much less individual producer yield data (*personal communication Mr. E.T. Quartey, Director of Research, Monitoring and Evaluation, Cocobod*). Accurate data is a fundamental need for proper risk assessment.

Another challenge facing cocoa crop insurance is the production life-cycle of perennial crops. Vilsack (2009) describes this production cycle in four stages: (1) establishment: zero yield, (2) development: exponential yield growth, (3) maintenance: relatively constant yields, and (4) decline: reduction in yields. This presents a challenge for crop insurance because the amount of cocoa harvested depends on the age of the tree. Furthermore, in the natural lifecycle of the tree high yielding years tend to be followed by lower yielding years. This makes it nearly impossible to accurately predict yield without knowledge or at least having an estimate of the age of the cocoa tree.

A final challenge in writing WII policies for cocoa is establishing the “trigger points” at which indemnities are paid. Specifically, cocoa production requires a “goldilocks zone” or a specific range that is not too much and not too little. This is true for both precipitation and temperature. Cocoa prefers precipitation between 1,500 mm and 2,000 mm per annum (ICCO, 2013). Annual precipitation below 1,250 mm is unfavorable because high tropical temperatures cause higher evaporation from the tree than precipitation received (Wood & Lass, 1985). Additionally, annual precipitation that exceeds 2,500 mm increases the prevalence of fungal diseases such as black pod and witches’ broom (Wood & Lass, 1985). Cocoa also requires minimum temperatures between 18^{o} – 21^{o} Celsius and maximum temperatures of between 30^{o} – 32^{o} Celsius (ICCO, 2013).

When considering the challenges facing cocoa crop insurance, particularly in the framework of CSC, WII appears to be the most suitable. The suitability is a result primarily of reduced costs as compared to MPCI. The cost savings are a result of reduced transaction costs because insurance adjusters are not required to make any on-farm visits to verify indemnities, thus there is neither adverse selection nor moral hazard. The absence of moral hazard in WII policies is also important because it could reduce the effectiveness of the training programs. For example, a producer who has been trained on CSC may have an outbreak of the black pod fungus (*Phytophthora megakarya*). Because of the producer’s participation in CSC they have the knowledge to manage the disease and the access (financial and physical) to fungicide to treat the disease. However, if black pod were covered by insurance, the producer would not have any reason to spend the time (applying fungicide) or the money (purchasing fungicide) to prevent the disease from spreading and thus reducing on-farm production. Rather, the producer could choose to do nothing and receive payment for lost cocoa yields at the end of the harvest period. WII insurance prevents this scenario from happening by only paying an indemnity in the event of poor weather. WII appears to be the most feasible insurance option for CSC cocoa because the reduced transaction costs would make the program more affordable to operate, WII cover regions rather than individuals which makes it more compatible for landscape planning associated with CSC, elimination of moral hazard increases the effectiveness of training programs, and WII provides coverage for CSC producers against climate variability[5].

[5] This recommendation is based on the conclusion that weather defines most of the production risk, as other risks like disease outbreaks would be abated through proper training and access to agronomic inputs. However, if weather proves not to be the main driver of risk in the future, then a weather index insurance program could have some major flaws.

III Assessment of Insurance Feasibility

3.1 Description of Data

Data for this study came from two separate sources. The first, which provided on-farm yield data and farm characteristics, was provided by the World Cocoa Foundation's Cocoa Livelihoods Program. The data covered 1,200 households in 109 villages, 19 districts, and five regions in Ghana. Data was collected over four different survey periods from February 2011 to August 2012. In addition, precipitation data was accessed from aWhere Incorporated's[6] online platform. These precipitation data are geo-referenced to match with the individual households from the WCF dataset, with a resolution of five arc minutes (about $9km^2$). The final result is a unique dataset with a large sample size, accurate and precise precipitation data, and a large spatial distribution.

3.2 Methods

Data were used for two separate analyses. Firstly, an OLS regression model was constructed to estimate yield. Yield estimates by location in the regression model were then used in a simulation model. Simulations were then run for two separate groups of cocoa producers: (1) those who followed CSC practices and (2) those who did not use CSC practices. The definition of CSC practices was specifically drawn from work by the Climate-Smart Cocoa Working Group (Asare 2014), and constituted those farmers who have undergone input-use training, used inorganic fertilizer, and practiced shade management (Appendix 1). Farmers who had not received input-use training, did not practice shade management, but did use inorganic fertilizer were categorized as not practicing CSC. By simulating the data, average yields as well as yield distribution were observed.

[6] Accessible at: http://www.awhere.com/

3.3 Results

There were three primary findings from this study of particular interest. Firstly, the importance of precipitation during the pod maturation period was identified. The pod maturation period for the main cocoa harvest occurs approximately from June through October. This study assumed the period to be from June 1 until October 31, a total duration of 153 days. Precipitation was found to be statistically significant during this period but at a diminishing rate. Meaning, the first millimeter of precipitation received on the farm is more important for cocoa yields than the 100^{th} millimeter of precipitation. For example, in this study the district with the lowest average daily precipitation was Birim South (2.29 mm day^{-1}) and the district with the highest daily precipitation was BIA (3.72 mm day^{-1}). If Birim South, the district with the lowest average precipitation, were to receive an additional one centimeter (10mm) of precipitation for the entire season, cocoa producers there would receive an additional 10.32 kg ha^{-1} of cocoa. If BIA, the district with the highest average precipitation, were to receive an additional one centimeter (10mm) of precipitation for the entire season, cocoa producers there would only receive an additional 6.4 kg ha^{-1} of cocoa. As precipitation increases the benefit of each additional unit decreases. Literature suggests that too much precipitation will ultimately decrease yields. However, this was not observed in this study, likely because yield observations were limited to just two main growing seasons.

The second finding of importance was that the cocoa producers who followed CSC practices had higher yields on average than those who did not. The third notable finding was that producers who followed CSC practices appeared to have less relative risk than producers who did not follow CSC practices. Risk was measured using the percent chance of receiving a payment from the insurer (table 2) and the relative standard deviation (table 3).

Results shown in table 1 show the average simulated yields for CSC and non-CSC producers. On average, across all 19 districts, CSC producers' yields were 67.24 kg ha^{-1} larger than non-CSC producers, an average gain of 23.79 percent. The largest average yield difference was observed in Juaboso at 77.31 kg ha^{-1}, a yield gain of 24.72 percent. The increased yields come with only slightly higher risks in absolute terms, measured by standard deviation. On average, CSC producers had a slightly wider distribution of yield. The standard deviation observed for CSC producers was 16.76 kg ha^{-1} higher than non-CSC producers. However, this is a relatively small amount and comparing the standard deviation of two groups with different means is not a fair comparison. Rather, this study compared variation in yield (risk) by measuring the percent chance of receiving a payment from the insurer (table 2) and the relative standard deviation (table 3).

Table 1 Simulated yield (kg ha^{-1}) comparison between CSC and non-CSC showing standard deviation in parenthesis

District	Non-CSC	CSC	Average Yield Difference
Adansi South	275.17	341.84	66.67
	(167.99)	(189.53)	
Ahafo Ano South	286.29	356.31	70.02
	(171.49)	(187.85)	
Akyemansa	248.97	310.78	61.81
	(162.03)	(185.13)	
Aowin Suaman	310.07	384.97	74.09
	(178.09)	(197.49)	
Assin North	271.17	335.37	64.2
	(171.46)	(188.78)	
Asunafo North	313.12	389.65	76.53
	(182.43)	(193.78)	
Asunafo South	296.07	371.52	75.45
	(174.44)	(192.17)	
Asutifi	297.51	366.88	69.37
	(171.69)	(186.45)	
Atwima Nwabiagya	271.57	323.83	52.26
	(188.90)	(207.85)	
Bia	310.81	385.85	75.04
	(182.63)	(191.37)	
Bibiani Awiaso Bekwia	298.40	367.08	68.68
	(177.14)	(187.49)	
Birim North	243.16	304.59	61.43
	(165.90)	(181.79)	
Birim South	227.40	282.70	55.3
	(158.25)	(179.03)	
Bosome Freho	239.31	292.64	53.33
	(154.84)	(177.95)	
Juaboso	312.74	390.05	77.31
	(184.22)	(192.51)	
Sefwi Akontombra	303.05	373.66	70.61
	(183.05)	(196.59)	
Sefwi Wiawso	300.57	369.47	68.90
	(177.75)	(196.41)	
Upper Denkyira West	267.42	333.95	66.53
	(167.43)	(188.23)	
Wassa Amenfi West	298.01	367.25	69.24
	(176.14)	(193.89)	

Note: All yield differences are significant at the one-percent level across rows

The probabilities of a producer receiving a payment (due to a loss) from the insurance company (indemnity) are presented in table 2 for the 50 and 70 percent coverage levels for each of the 19 districts surveyed. The probability of receiving an indemnity payment can be shown as:

$$\%\ chance\ indemity = \frac{observation\ below\ trigger\ yield}{all\ observations}$$

The trigger yield is the yield amount at which a producer will receive an indemnity payment from the insurance company due to a loss (USDA, 2011). In this study, the trigger yields were the simulated average yields (table 1) multiplied by the level of coverage that the producer wants for their farm. This study shows results for the catastrophic coverage of 50% (indicating a greater than 50% loss) as well as 70% (indicating a 30% or greater loss) coverage. This means that if a producer yields 400 kg ha^{-1} and has a coverage level of 50%, the producer would be guaranteed a yield of 200 kg ha^{-1}. Any time a producer would have a yield of less than 200 kg ha^{-1}, the insurance company would make a payment to the producer to compensate them for their loss. This study uses the percentage of times that the insurer makes a payment to a producer as a measurement of risk. Table 2 shows that there were fewer indemnity payments (i.e. less yield risk) for CSC than non-CSC producers in every district surveyed in this study. The reduction in risk can likely be attributed to the higher average yields for producer who follow CSC practices with only slightly higher yield distribution. By using percent chance of indemnity as a measurement, yield variance (i.e. risk) is normalized, making an adjustment for the differences in average yields between the two groups.

Table 2 Percent chance of indemnity payment at the district level

	50 Percent		70 Percent	
	Non-CSC	CSC	Non-CSC	CSC
Adansi South	23.6%	21.0%	35.3%	32.9%
Ahafo Ano South	23.0%	18.9%	35.8%	30.8%
Akyemansa	25.3%	23.3%	37.1%	34.8%
Aowin Suaman	21.7%	18.5%	34.1%	29.4%
Asin North	25.0%	21.8%	37.7%	32.5%
Asunafo North	22.2%	17.0%	34.9%	28.6%
Asunafo South	23.5%	17.7%	34.4%	29.7%
Asutifi	20.3%	17.4%	34.0%	29.9%
Atwima Nwabiagya	28.5%	25.1%	40.0%	37.3%
Bia	22.9%	18.0%	34.1%	28.6%
Bibiani Awiaso Bekwia	22.4%	17.9%	35.3%	31.1%
Birim North	25.9%	23.5%	37.0%	35.2%
Birim South	28.8%	24.9%	39.6%	36.9%
Bosome Freho	24.5%	23.4%	37.7%	36.4%
Juaboso	22.9%	15.9%	34.2%	29.1%
Sefwi Akontombra	22.9%	19.6%	35.6%	30.5%
Sefwi Wiawso	22.2%	19.0%	35.5%	30.1%
Upper Denkyira West	24.2%	20.8%	37.1%	33.4%
Wassa Amenfi West	21.7%	20.4%	35.5%	29.9%

Another way to perform a normalized comparison for CSC and non-CSC producers is to look at the coefficient of variance. Because the mean yields of the two groups – CSC and non-CSC – were not equal, the regression error term must be normalized to have a fair comparison of risk. This normalization was accomplished with the coefficient of variation expressed as:

$$CV_\lambda = {}^{\sigma_\lambda}/_{\mu_\lambda}$$

In this equation, the coefficient of variation, (CV_λ) is equal to the ratio of the standard deviation (σ_λ) – yield per hectare – to the mean (μ_λ) – yield per hectare – for the λ^{th} location. More simply, the coefficient of variation is the average yield divided by a measurement of the spread of possible yields. Relative standard deviation (RSD) is the absolute value of the coefficient of variation multiplied by 100 to be expressed as a percentage. Lower percentages equate to lower yield risk. Results for RSD for all 19 districts surveyed are shown in table 3. In every district, producers who followed CSC practices had lower RSD (less risk) than producers who did not follow CSC practices. The difference between the CSC and non-CSC producers ranged from four percent in Bosome Freho to ten percent in Juaboso with an average difference of seven percent. The results of RSD indicate that CSC practices reduce risk in cocoa production in the observed locations. The primary reason for the observed decrease in normalized yield risk is the higher yields obtained by following CSC practices.

Table 3 Relative standard deviation for CSC and non-CSC

	Non-CSC	CSC
Adansi South	61%	55%
Ahafo Ano South	60%	53%
Akyemansa	65%	60%
Aowin Suaman	57%	51%
Asin North	63%	56%
Asunafo North	58%	50%
Asunafo South	59%	52%
Asutifi	58%	51%
Atwima Nwabiagya	70%	64%
Bia	59%	50%
Bibiani Awiaso Bekwia	59%	51%
Birim North	68%	60%
Birim South	70%	63%
Bosome Freho	65%	61%
Juaboso	59%	49%
Sefwi Akontombra	60%	53%
Sefwi Wiawso	59%	53%
Upper Denkyira West	63%	56%
Wassa Amenfi West	59%	53%

IV Conclusions and Recommendations

This study set out to assess the feasibility of crop insurance as part of a CSC landscape initiative in Ghana. In asking whether crop insurance has a role to play in Ghana's cocoa sector, the conclusion appears to be—yes. The results of this study are encouraging for the promotion of CSC. Insurance can help to reduce farmers' risk of yield losses attributed to reductions in rainfall or changes in precipitation patterns. Given that the United Nations Framework Convention on Climate Change (UNFCCC) has clearly indicated that Africa is likely to experiences increases in temperature and reductions in precipitation in the coming decades, this is a serious and real risk for cocoa farmers (UNFCCC, 2007).

The assessment also draws attention to the potential to use insurance as part of a benefits or incentive package for farmers who participate in a landscape-level cocoa program focused on reducing deforestation and degradation and achieving substantial yield increases. The risk for any such program is that while farmers may opt to participate and do everything "right" (adoption of recommended practices, use of inputs, and compliance with locally accepted landscape principles), they may not achieve substantial yield improvements (and associated increase in income) in bad rainfall years, and as a result decide to drop out of the program and abandon the over-arching effort. Crop insurance could provide a buffer to farmers whose harvests decline due to climatic events or changes.

In terms of feasibility, this study argues that WII presents the best match to Ghana's cocoa sector and the goals of CSC. This study also lends considerable weight to the argument that CSC—in and of itself—is viable. Producers who followed CSC practices had higher average yields and lower risk than producers who did not follow CSC practices. Producers engaged in

CSC farming would be more attractive to an insurer given the lower risk of an indemnity payment. Further, there is a distinct possibility to subsidize some of the costs of insurance (e.g. premium) out of emission reductions (ER) revenue.

Despite these encouraging results, more work and information is needed, including a financial analysis that assesses the financial feasibility for farmers and for insurers, in the context of ER revenue and in its absence. Further, the greatest limitation of this work and to developing an insurance product in Ghana is data. Much of the yield variation found in the yield simulations was a result of the deficiencies in the model. Namely, large amounts of variation in the simulated yields were a result of variation in the error term of the regression model used to simulate yields. This large error term was the result of data limitations. Although the data for this study were extensive, it could be more comprehensive. For example, much of the data in this study only derived from yes or no answers, questions about fertilizer use, pesticide use, fungicide use, training, and shade management. Ideally, application amounts as well as time of application for agrochemical use would be preferred. Also, rather than shade management being a yes-no answer, it would have been preferred to have canopy cover measured as a percentage. Another problem with the data was that some variables that are important in estimating cocoa yields were not asked on the surveys. The most important of these missing questions was the age of the cocoa trees on the farm. Because the production cycle of cocoa is characterized by increases in yields up to a certain age, followed by decreases in yield, it is very important to know the age of the trees and the farm's point in the production cycle.

While the results are promising, more research is required prior to large scale implementation of crop insurance for producers who follow CSC practices. The model used for cocoa yield estimations should be strengthened by obtaining more data, including data that was not present in the survey which informed this study. Future studies should be focused in areas with forest reserves that present suitable landscapes for the application of the ER Program.

Specifically, the authors recommend the following next steps:

- The government and private sector cocoa companies (including license buying companies (LBCs)) will need to agree to make multiple years of farm-level data (demographic, agronomic, economic, yield), and national and sub-national production data available, where it exists, and to work towards generating data where there are gaps.
- National and international insurance companies need to begin to weigh in on the discussion in a serious manner.
- An increased focus on data management is needed. This could be compiled and/or hosted by Cocoa Research Institute of Ghana (CRIG).
- CSC insurance should be piloted with groupings of producers in a defined landscape. Only once crop insurance has been tested on a small scale should it be considered for large-scale application.

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V Appendix

Appendix 1 Shade Clarification: Personal Correspondence with Edwin Afari, WCF

Shade management depends on the age of cocoa trees. For productive trees we are looking at the number of mature forest trees with height above 12m and dbh of >30cm that provide adequate canopy cover for cocoa trees. And for young cocoa trees we are looking at using plantain/banana and other crops to provide shade cover.

1. Number of trees per ha matters – Shade tree count (12-16 per ha)
2. Species of Trees
3. Pruning of trees
4. Amount of Shade cover
5. Canopy Cover
6. Placement of trees
7. Removal if there [is] excess shade. Cutting and ringing