Case Study

Analysis of the Adoption of CSA Practices for Cocoa Farmers in Lampung Province, Sumatra

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Global Alliance for Climate Smart Agriculture
Rome, 2019

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Keywords: *Climate-Smart Agriculture, Cocoa Farming, Multivariate Probit Model, Ex-Ante Cost-Benefit Analysis, Ethnography*

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Executive Summary
Many cocoa farmers in Lampung Province are increasingly facing losses in cocoa yields. Loses are attributed to increased variability in rainfall and rampant growth of pest and disease; farmers also attribute the loss to rising temperatures, but there have not been quantitative results found for this claim. Climate-smart agriculture (CSA) implementation is considered a viable solution to address the problems that local farmers are facing. The CSA practices analyzed in this paper included (1) regular pruning, (2) use of organic fertilizers, (3) field sanitation, and (4) side-grafting. This case study explores characteristics of farmers who adopt the climate-smart cocoa practices, the potential personal benefits to farmers of adopting these practices and seeks to understand why the adoption of climate-smart practices has been low for cocoa farmers in the region. The multivariate probit regression modeled in the paper found that adoption of CSA practices was positively correlated with receiving training, increased education, and available livestock, being male, and observing climate impacts. CSA adoption was negatively correlated with having higher numbers of cash crops and experiencing cocoa crop damage due to weather events. The regression analysis also showed that CSA practices were all positively correlated with each other thus could be potentially complementary practices. An ex-ante cost-benefit analysis (CBA) found high net present values of incremental net benefits when adopting CSA practices. However, the large costs of investment yielded negative net benefits for the first few years following adoption implementation. Based on focus group discussions and interviews conducted in July 2017, an ethnographic interpretation of the region sought to determine why adoption of CSA practices was low, even with the high personal benefits of CSA adoption found in the cost-benefit analysis. This analysis found that barriers to adoption included lack of agriculture equipment, price constraints, borrowing constraints, and incomplete knowledge of adopting the practices. The combination of these constraints made adoption of CSA practices riskier than what was displayed in the CBA results. This case study suggests that financial assistance programs should be targeted towards farmer groups to limit these constraints. In addition, training of cocoa farmers on CSA practices should be more ongoing and technical, especially for women in the region, to decrease the risks of failure to their adoption.

Farmer on her cocoa plot: Lampung, Indonesia
(Photo by Madelline Romero—CIAT)

1. Introduction

This case study is based on an honors thesis for Cornell University, completed in May 2018, in partnership with the International Center for Tropical Agriculture (CIAT) as part of their project with Mondelez International. The research study utilized a mixed-methods approach that paired economic modeling, cost-benefit analyses, and an ethnographic study, supported by interviews and focus group discussions. It utilized a combination of household survey results, cost-benefit analysis survey outcomes, and fieldwork observations, to better understand the adoption of Climate-Smart Agriculture (CSA) practices by cocoa farmers in Lampung Province and the benefits reaped by farmers through the project.

The 2013 FAO Sourcebook defines CSA as "agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes GHGs (mitigation) where possible, and enhances achievement of national food security and development goals." *Sustainable production* is qualified by meeting the present and future needs of a cropping system, while also incorporating or not detracting from profitability, environmental health, and social equity. *Adaptation* refers to practices that decrease exposure of farmers to short-term impacts while increasing resilience towards long-term climate impacts, and *mitigation* is the practice of either reducing or removing GHG and human pollution of an agriculture practice.[1] The widespread adoption of CSA practices would provide both beneficial ecologic and economic functions in the regions of implementation.[2]

More specifically, this case study seeks to contrast the constraints and benefits of adopting CSA practices for the cocoa farmers in the region. It seeks to understand the determinants of farmers who have adopted CSA practices, asking specifically what the private financial benefits are of adopting such practices, and ultimately why adoption has been so low even after fieldwork proving CSA benefits.

1.1 Background on Climate Change and Cocoa Farming in Indonesia

Indonesia is the third largest cocoa producer in the world behind Cote d'Ivoire and Ghana and produces roughly 375,000 metric tons of dry cocoa beans annually.[3] Cocoa production is highly enticing for Indonesian farmers due to the fact that it can be produced without intensive management- though at poor yield levels, on small plots of land, and in isolated regions. Further, climate conditions on many of the Indonesian islands, including consistent rainfall and tropical temperatures, are ideal for optimal cocoa growth.[4] Ninety percent of all cocoa production in Indonesia comes from family-run smallholder farms, no larger than 5 hectares, taking place on 1.5 million hectares of land total. These smallholder cocoa plots are the primary source of income for almost 1.5 million citizens in Indonesia.[5] Although there has been a consistent growth in cocoa acreage in Indonesia across the last few decades, overall production in the country has dropped significantly.[6] This recent yield decrease- due to rainfall change, rising temperatures, and cocoa disease- reportedly experienced by eighty percent of all small-scale farmers, has led to roughly 300 million USD in annual losses.[7] The drop in cocoa production has been largely attributed to low farm maintenance and investment, as well as pests, (especially the cocoa pod borer) and fungal disease ravaging the region. These factors have decreased crop yields dramatically despite increases in land used for cocoa cultivation. [8] Coupled with the influx of pest and disease, cocoa yields have been negatively impacted by increasing climate variability.

Unpredictable fluctuations in rainfall and humidity, in fact, facilitate the spread of the cocoa pod borers and fungal diseases.[10] To couple with yield losses, farmers have shifted to monoculture plots to further increase sunlight exposure for their cocoa crops in hopes of preventing fungal growth and pod borer disease. However, removal of shade trees can lead to increases in erosion and acidity levels in soil, in addition to making cocoa plots more vulnerable to adverse climate effects.[11]

1.2 Lampung Province Cocoa Issues and Climate-Smart Solutions

The decreases in cocoa yield and rises in pest and disease have led to an increase in ecologically detrimental farming practices specific to Lampung. In the region, 291,000 hectares had been deforested from 1990 to 2016.[12] The vast levels of deforestation among large, carbon-uptake forests, including Lampung, have left Indonesia as the third largest emitter of greenhouse gases (GHG), behind only the United States and China.[13] Further, current cocoa plots in the province now require higher levels of insecticide and inorganic fertilizers to be used as measures to prevent further yield loss.[14] These unsustainable practices are making cocoa farmers in the region more vulnerable to climate change, while further amplifying anthropogenic impacts that are contributing to the rise in global temperature.

Climate-smart agriculture (CSA) is considered as a viable option to address the current problem of climate change impacts that result in cocoa yield losses, as argued in this case study. There are four major CSA practices relevant to cocoa production in Lampung: (1) regular pruning of cocoa leaves and branches, (2) the use of organic fertilizer, (3) field sanitation, (4) and the side-grafting of improved cocoa varieties; each of which will be briefly elaborated in Table 1.

Table 1: Climate-Smart Agriculture Practices for Cocoa in Lampung

1. Regular Pruning	• Removal of diseased and non-productive leaves and branches[8] • Adaptive as detritus can be used to retain water and prevent nutrient runoff • Mitigation measure as it reduces need to remove shade trees[11]
2. Organic Fertilizing	• Application of decomposed organic materials and reduction of inorganic fertilizer • Adaptive as it increases water permeability during floods and retains water during dry spells • Mitigation because it reduces CO_2 emissions and increase soil-organic matter[17]
3. Field Sanitation	• Regular weeding and digging of holes for debris to increase water absorption • Adaptive as it reduces focal humidity and decreases nutrient runoff • Mitigation as it increases soil-organic matter and reduces need for insecticide[8]
4. Side-grafting	• Grafting disease-resistant cocoa hybrids to base of existing cocoa trees • Adaptive as grafted trees are more climate resilient[18] • Mitigation measure due to it being a less wasteful practice[8]

1.3 Background on Fieldwork and Methods

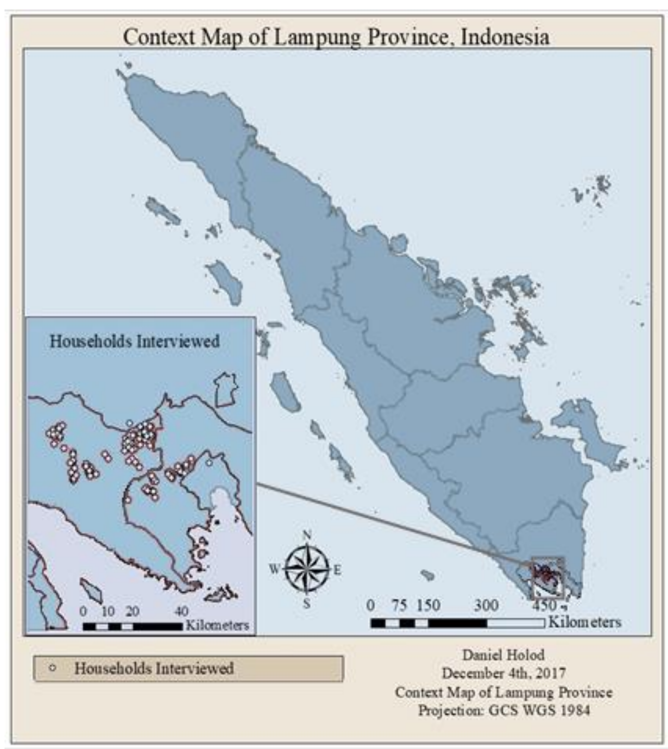
The research for this study was performed during the summer of 2017 with CIAT through their regional headquarters in Hanoi, Vietnam. CIAT is a non-profit organization focused on research for sustainable agriculture in developing countries. In 2017, the organization partnered with

Mondelez, a multinational food production company, to conduct research on cocoa production among their Indonesian farmers. CIAT was tasked with researching the opportunities of cocoa farmers to scale up CSA practices among cocoa farmers, in effect reducing GHG emissions and improving adaptation by preventing deforestation and forest degradation.

The region of focus for the project was Lampung Province, located in southern Sumatra, where cocoa production is highly prevalent. There, Mondelez purchases cocoa indirectly from 20,000 farmers after several levels of aggregation. In Lampung, CIAT looked at three districts in particular: Pringsewu, Pesawaran, and Tanggamus. To better understand the current cocoa situation, CIAT began by conducting household surveys of the cocoa farmers in May of 2017. The survey focused on socio-demographic information, cocoa production, climate impacts, and knowledge of adoption and constraints of CSA farming practices. There were 75 farmers selected from each district, with the resulting and cleaned dataset having 190 households.

Cost-benefit analysis (CBA) interviews were conducted in the region in mid-July of 2017. The CBA interpreted the ex-ante net benefits of adopting packages of the CSA practices previously discussed: pruning, organic fertilizing, field sanitation, and side-grafting of hybrid cocoa crops. Farmers were placed into different packages based on the number of CSA practices they had adopted. Fifteen farmers from the household survey were separated by their adoption of these practices and randomly selected for interviews. Of the fifteen, two farmers were selected for each CSA package, and five farmers who had not adopted any CSA practices were interviewed to interpret the incremental benefits of CSA adoption. The interviews sought to find the input costs of adapting CSA and other cocoa farming practices, and also determined the change in yield amounts of the cocoa plot. Four extension officers, who conduct training on climate-smart cocoa farming in Lampung, were interviewed to validate the numbers found and for expert opinions on yield changes.

Map 1: Households in Case Study



Six focus group discussions (FGD) were conducted in the three regions while the CBA interviews were taking place. Focus groups were separated by gender with roughly ten participants in each discussion group. The FGDs were split into three activities and structured to complement the household survey and cost-benefit analysis. The first activity sought to look at farmers' perceptions of climate change impacts, and the problems they faced in addressing these impacts. The second activity focused on how these problems could best be addressed, and through which organizations these solutions could be made possible. Lastly, the third activity focused on ranking qualities of the CSA packages, based on the cost-benefit analysis, and their preferences of adoption in a context with fewer credit and equipment constraints.

This project took three approaches to best understand the current predicament of CSA adoption for the cocoa farmers in Lampung Province, including through an econometric model, cost-benefit analysis, and ethnography. The objective of utilizing this holistic approach was to paint a clear picture of why CSA adoption has been so low in the region and what could be done to increase CSA adoption. The results of this analysis posit a better understanding of what impacts the adoption of CSA and signal recommendations for more efficient policy and funding initiatives to address the decreased yields and the rise in unsustainable practices of cocoa farming in Indonesia.

The results from the fieldwork conducted in Lampung in May and July of 2017 through CIAT were used for the analyses in this study. More specifically, the regression completed in this study uses the household surveys conducted in May. The CBA interviews were used to create an ex-ante cost-benefit analysis of the adoption of CSA practices for current cocoa farmers. The ethnographic analysis interprets the results of the FGDs and CBA interviews to better understand why CSA were limited in Lampung Provence.

Farmers in Focus Group Discussion: Pringsewu, Indonesia
(Photo by Madelline Romero—CIAT)

2. The Determinants of Adopting CSA Practices through Economic Modeling

Farmers base their adoption of agriculture technologies on a variety of determinants. This chapter reviews the previously described CSA practices and analyzes their adoption by cocoa farmers in Lampung Province. The use of a multivariate regression allows for a better understanding of how characteristics relate, while also considering the association between the various CSA practices, and the influence each practice has with each other.[19]

2.1 Economic Model and Methods

This multivariate probit model analyzes the determinants of farmers who adopt individual CSA practices.[20] As farmers are introduced to certain CSA technologies, they face the option of adopting any combination of these practices. If the utility of adopting a certain CSA package is greater than the utility of practicing with no or other CSA practices, a farmer will adopt the set of practices. Although utility cannot be modeled, a probit regression can be used to see whether or not certain socio-economic or other variables may impact the adoption of each latent CSA variable.[21] If an independent variable was positive for this probit regression, it means that an increase in that variable is correlated with an increased level of adopting the CSA variable being analyzed.[22]

There are also potential relationships between the adoption of the different practices themselves.[20,21] A univariate probit regression of the dependent variable Y on the independent variables X_i ignores any correlation between adopting multiple CSA practices. Ignoring these correlations generates a potential bias and provides inconsistent estimates of generated correlation. Multivariate regressions allow for the covariance among dependent variables, here CSA practices, for all probit equations. The correlations found between the dependent variables can represent a complementary or substitutive relationship of dependent variables, meaning farmers may intentionally choose to use or not use certain farming practices together. However, the correlations between the CSA practices may also be due to other observable or unobservable household-specific factors. Unobservable factors may include cultural differences, risk aversion, how farmers internally value each practice, and farmer preference.[22]

A multinomial choice model, which analyzes every combination of the CSA practices that were adopted, was considered for this study. However, the multitude of options in addition to the 14 independent variables in the model would have been difficult to analyze given the smaller size of the dataset (190 observations). In addition, the multinomial model hinders the opportunity to parse out the determinants of each CSA practice.[23] Further, there is significant literature modeling individual decision making for new farming technologies through the multivariate probit procedure.[19,24,25,26,27]

The dependent variables used for the multivariate probit regression represents whether or not a CSA practice was adopted, with 1 meaning adopted, and 0 meaning not adopted. The dependent CSA variables are regular pruning (*P*), organic fertilizing (*O*), field sanitation (*F*), and side-grafting (*Sg*). In the household survey, farmers were asked whether or not they had adopted these practices. Farmers were also asked if they had planted shade trees (trees that are spread throughout the cocoa plot which break the cocoa canopy) in their cocoa plot as a CSA practice. However, this practice was left out of this case study as the self-reported data on shade trees were unreliable. Many farmers had shade trees on their cocoa plots even though they had listed they had not adopted the practice of planting shade trees. Further, a carbon study conducted by CIAT found that farmers did not have the same number of shade trees that they put down on the household survey.[28] The information gap found in the household survey may have impacted correlations with the regression. This discrepancy may have been due to farmers planting the shade trees over 20 years ago, before they were taught about CSA practices- as found from the interviews from the cost-benefit analysis.

The independent variables in this study were chosen based on the results of previous work done with regards the adoption determinants of farming technologies, and on observations from the interviews and focus group discussions with local cocoa farmers, held in July of 2017 in Lampung, shown in Table 2. Table 3 in the Appendix shows the summary statistics of the variables. The equation modeling the adoption of each CSA practice for the regression is

$$Y_{CSA(P,O,F,Sg)} = ß_1 T + ß_2 a + ß_3 K + ß_4 L + ß_5 I + ß_6 E + ß_7 A + ß_8 S + ß_{9-10} d + ß_{11} H + ß_{12-13} C + ß_{14} D + c + \mathcal{E}.$$

Table 2: Description of Determinants

Variable	Name	Description
T	Training	Whether or not farmers received training for CSA, cocoa practices.
a	Agriculture Investment	Whether or not farmers would plan on immediately investing in agricultural inputs if given an increase in income.[29]
K	Number of Cash Crops	The number of cash crops besides cocoa that farmers own and sell on their total farm acreage. This may signal increases in income or constraints in labor.[20,23]
L	Number of Livestock	The number of livestock that farmers own. Rises in livestock may signal income diversification and climate resilience.[30]
I	Household (HH) Income	Annual income in 10,000 Indonesian rupiahs. Credit constraints are shown to be barriers to the adoption of CSA practices.[18,28]
E	Education of HH Head*	The number of years of education the head of the household has received.[25,30]
A	Age of HH Head*	The age of the head of the household. Age has shown to be both a positive and negative determinant for adopting CSA practices.[30,31]
S	Sex of HH Head*	This variable indicates the sex of the household head. There is varying literature on being male or female impacting adoption.[31]
d	Districts in Lampung	This variable represents districts Pringsewu and Pesawaran. The topography of Lampung Province varies widely (Shown in Map 2 of the Appendix), and these variations, as well as access to primary roads, may impact the level of CSA adoption for the farmers.[26]
H	Number of HH Members	An increase in household members signals the opportunity for additional unpaid labor, a primary constraint for CSA adoption.[21]
C	Climate Observations	These variables denote if farmers have observed significant rainfall and increased temperature. These two trends are predicted to rise in the region as climate change continues.[32] These two impacts are strongly linked with decreases in cocoa crop production.[8]
D	Cocoa Damage	Signals if farmers have received more than 60% damage on their cocoa crops from climate change impacts.[25]

**It is important to note that household heads do not necessarily make the decisions about cocoa practices. Thirty-four of the household's heads had the other partner either make or help make decisions about the cash crop; however, the dominant trend was for household heads to make the decisions.*

Although a multinomial choice model was not conducted for this project, it is important to know how farmers packaged CSA practices together. Table 4 shows the packaging that the farmers chose with respect to pruning, organic fertilizer, field sanitation, and side-grafting. Shade tree planting, as discussed above, was not included with the other CSA practices. Pruning and fertilizer were the most commonly used practices together with 33 farmers adopting both. Only seven of the 190 households had adopted all four of the practices together. Seventy-one of the 190 households did not adopt any of the four CSA practices that were analyzed.

Table 4: Packages of Practices

Practices	Households	Percent
Only Pruning	31	16
Only Organic Fertilizer	1	1
Pruning and Fertilizer	33	17
Pruning and Field Sanitation	10	5
Pruning and Side-grafting	7	4
Pruning, Organic Fertilizer, Field Sanitation	9	5
Pruning, Organic Fertilizer, Side-grafting	21	11
All 4 Practices	7	4
No CSA Adoption	71	37
Total	**190**	**100**

2.2 Results of Multivariate Model

Significant Results

The multivariate probit results, displayed in Table 5, show the direction and statistical significance of independent variables' impact on the adoption of CSA practices. Receiving *training* for CSA practices was significantly and positively correlated with adopting pruning, organic fertilizing, and side-grafting. An increase in the *number of crops* the farmers had on their whole farm was negatively associated with adopting regular pruning, organic fertilizer, and field sanitation. A higher number of *livestock* in a household was associated positively with adopting pruning and organic fertilizing. An increase in *education* for a household head was positively correlated with adopting regular pruning and organic fertilizing. An increase in *age* was associated with a rise in adopting organic fertilizer. Being a *male* household head was correlated with adopting regular pruning and side-grafting and was also positively correlated with the other variables. An observation of *increased temperatures* was positively associated with adopting field sanitation. Observing *too much rain* was positively correlated with adopting organic fertilizer, and the other four practices were also positively correlated. observing *cocoa damage* from climate change impacts was negatively associated with adopting pruning, and negatively associated with adopting side-grafting. Lastly, there was no statistically significant correlation with choosing *agricultural investment*, rises in *income*, *district* of household, and increases in the *number of family members*.

Table 5: Results of Multivariate Probit of Determinants of CSA Practice Adoption

Independent Variables	Pruning	Organic Fertilizer	Field Sanitation	Side-grafting
Training	+**	+***	+	+*
Agriculture Investment	+	+	+	+
Crop Numbers	-***	-***	-**	-
# of Livestock	+**	+***	-	-
Income (10,000 IDR)	0	0	0	0

Education HH	+*	+*	-	+
Age of HH	-	+*	0	0
Male HH	+**	-	+	+**
Tanggamus	+	-	-	+
Pringsewu	-	-	-	+
# Family Members	-	+	+	-
Increased Temp	+	+	+**	-
Too Much Rain	+	+*	+	+
Cocoa Damage	-*	-	-	-**
Constant	-	-**	-**	-

+: positive correlation, -: negative correlation, 0: no correlation
Statistical Significance: *** p<0.01, ** p<0.05, * p<0.1
Number of Observations=190
(HH=Household Head)

Analysis of Results

The positive correlation of training could be explained due to increases of the knowledge required to implement the practice and thus leading to an adoption of these new and sustainable agricultural practices.[23] Training sessions were held by organizations focused on cocoa sustainability teachings and were primarily run through Olam in Lampung. The positive correlation for agricultural investments may show that farmers who adopt CSA practices are more willing to invest in agricultural inputs.[26,30] The lack of statistical significance in the other practices shows parallel results to the analysis of Sheahan et al.'s work noting the lack of agricultural input investment for sustainable farming in developing countries.

The negative correlation associated with an increase in crops in a farmer's total acreage may be due to the farmers being constrained by the amount of labor required for adopting CSA practices. Although studies cite the benefits of increasing the number of crops to decrease vulnerability to climate change,[28] additional crops on the farm may decrease the internal value the farmers' place in their cocoa. It is important to note that the negative correlation is referring to the total crops managed on a farm, not those that are being intercropped within the cocoa plots.

The positive association of CSA adoption attributed to livestock ownership may signal livestock being a saving mechanism for farmers and indicating higher wealth of the farmers, in addition to providing a potential increase in access for organic fertilizer materials from the animals' waste.[8,33]

Education's positive correlation with CSA adoption is similar to that of Saroar's study (2016), which found that education was associated with adopting CSA. This correlation could be associated with higher education leading to a better understanding of CSA practices and thus allowing a better implementation of practices.[30] Increase in age being associated with CSA adoption run similar to the results from the literature review and may be attributed to increased social capital when trying to adopt new agricultural practices.[25,29] Men being associated with adopting pruning and side-grafting may be explained by the observations by Barrett and Marenya on farmer determinants, which outlined that men tend to adopt more sustainable practices because of better access to capital and information, and the resulting focus group discussions validated this reasoning.

The results regarding weather observations positive association with CSA adoption coincide with the various other multivariate analyses on adopting sustainable agriculture.[24,26] The weather observations by farmers of increased temperatures and too much rain are important variables to note, as the IPCC predicts these two weather trends to ramp up as climate change trends continue to occur.[13] Lastly, the negative correlation with cocoa damage and CSA adoption could signal that decreases in yields may limit the adoption opportunities for CSA practices, due to investment in their cocoa plots being deemed as too risky.[34]

There was no statistically significant relation to the district of households and the adoption of CSA practices. These results ran different from the results found in the focus group discussion. In Lampung Province, there are two major mountains, Mount Ratai, located near Pesawaran, and Mount Tanggamus, in Tanggamus.[3] This change in elevation led to varying levels of climate and soil conditions in Lampung. Tanggamus farmers claimed to specifically face a large shortage of water compared to farmers in Pesawaran and Pringsewu. These observances found in the focus groups however did not lead to any significant results from the multivariate model.

Income having no significance is alerting, as relevant research on constraints farmers face in Indonesia consistently includes credit.[13] One possible reason for this lack of correlation is that if nearly all farmers are fiscally constrained, increases in income would go towards other investments prior to going towards cocoa investment. The lack of significant correlation associated with the number of family members could be due to a household not using family labor, as most of the households in the region had their youth in other jobs or at school.[3] In addition, if further labor was needed, farmers tended to hire daily laborers at the rate 60,000 IDR per day. This may mean that access to additional labor was not found in their household, but through the market (labor rate taken from cost-benefit analysis survey, discussed in next section).

Correlation between CSA Practices

The multivariate probit regression found that there was strong correlation among the adoption of all of the CSA practices. This signifies that running a multivariate probit model was the right thing to do versus a univariate model, as the error terms were specifically correlated with each other. Table 6 in the Appendix shows the correlations between the CSA variables. The positive correlation between the agricultural practices may signify that farmers adopt practices as packages to receive complementary benefits from the packages.[24] It is important to note that the correlation between practices may also be due to unobservable factors among farmers such as indigenous knowledge.[27] Shade trees were included in this correlation analysis to further interpret the decision to leave out shade tree adoption for this study.

Harvested Cocoa Pods: Pesawaran, Indonesia (Photo by Madelline Romero—CIAT)

The results show that there was no correlation between shade tree adoption and the other CSA practices, further validifying this study leaving out shade trees from the analysis.

3. A Cost-Benefit Analysis of a Cocoa Farmer Deciding Which CSA Practices to Adopt

This section focuses on an ex-ante cost-benefit analysis of adopting various packages of CSA practices for cocoa farmers currently not adopting CSA. The cost-benefit model is cited as one of the opportunities for economists to understand the adoption of CSA practices. The model is a multi-criteria decision analysis tool that can be used to compare the interactions of various adoption packages.[35] The cost-benefit analysis can show the fiscal situation farmers face when deciding whether or not to adopt CSA practices. These results, in conjunction to the determinants of CSA adoption found within the multivariate analysis, allows for a better understanding of the current status of cocoa farmers in Lampung Province.

3.1 CBA Methods and Variables Generated

A cost-benefit analysis (CBA) looks at the benefits of adopting certain actions of a determined time period, discounted to the present value. The basis of this analysis is an ex-ante CBA of a cocoa farm in which a farmer owns a functioning one-hectare cocoa plot. Ex-ante analyses are conducted before practices are implemented and observe the potential gains and losses of adopting practices. This specific model allows for analyses to be drawn in comparison to farmers not adopting CSA practices, termed here, business as usual (BAU) farming.[35]

This study uses CIAT's cost-benefit template and is publicly available at cbatool.ciat.cgiar.org. CIAT's cost-benefit model specifically looks at the incremental net benefits of adopting CSA practices versus a BAU farmer. The primary component of this analysis is the net present value (NPV) of these incremental benefits. The NPV is found by taking the difference of income when adopting a CSA practice versus BAU farming. These differences in income are summed up and then discounted to the present value. A high discount rate represents an individual who does not value future benefits very much compared to present benefits. It is inferred from the CIAT model that if the NPV of a practice is positive, the practice should be adopted.[36]

In addition to generating the net present value, this study analyzes the internal rate of return (IRR). The IRR represents the discount rate needed to bring the NPV of adopting a CSA practice equal to zero. If the IRR of the cost-benefit analysis is higher, that means it is less risky for a farmer to adopt the practice, as with a high IRR, it would take a farmer discounting the future heavily in order to get the NPV of the entire stream of incremental benefits to equal zero. Finding the IRR is beneficial as it does not require assumptions made to approximate how an individual discounts the future.[36] The equations and descriptions of variables for the NPV and IRR are shown in the Appendix in Table 6. Lastly, this study also analyzes the payback period for adopting CSA practices. The payback period is how long it would take for farmers to break even on their investment in a new agricultural package. This is a beneficial variable to consider, as the benefits of a project may be very high but may be discouraging to farmers due to high costs of initial investment and lengthy of the payback period.

The data for this CBA was conducted during the fieldwork by CIAT in Lampung in mid-July 2017. In this study, farmers were separated into six packages based on their CSA practices. Following this separation, farmers were randomly selected based on their package for CBA interviews. Three farmers using each package were interviewed, as well as five farmers who had not adopted any CSA practice, the latter to be considered as BAU. In addition, four extension officers who helped train farmers on adopting CSA cocoa practices were also interviewed to reassess the results that were generated from the farmer interviews and gain insight on the yield benefits of each package. Thus, this cost-benefit analysis was constructed using a formal survey, expert recommendation, and literature review. The BAU package included random pruning as part of the package. Pruning was partly incorporated with the BAU package, as farmers who did not adopt full levels of regular and formation pruning still practiced a smaller level of pruning within their cocoa plots.

All four of the CSA packages assume the planting of additional cocoa trees. The business as usual plot had 397 cocoa trees per hectare, while the optimal number of cocoa trees per hectare was 1,100 cocoa trees. Improved varieties were included in the planting for the packages that adopted side-grafting. The cocoa trees used were Sulawesi 1 and 2, which have higher yields than the BAU cocoa variety, lokal, and are more resistant to pest and diseases.[8] The net benefits from adopting shade trees net benefits were not analyzed for this cost-benefit analysis.

This CBA looks at the situation of a cocoa farmer on one hectare practicing BAU farming while considering the option of adopting various CSA packages. Thus, the yield change begins in the third year of analysis due to changes in farm management from the CSA practices.[37] Cocoa trees reach their maximum yield production ten years after the planting of the crop; thus, ten years was chosen as the year of maximum yield response from the CSA packages.[38] The maximum yields were due to the usage of side-grafting and planting of more cocoa trees. The input and labor costs of the CBA are shown in Table 7 in the Appendix.

The discount rate for this CBA was set at 10%, using the discount rate commonly incorporated by the World Bank for agricultural products.[39] Also, the interest rate for loans was in the region was 12%, and discount rates for agricultural investments tend to be lower than local market interest rates.[40] The exchange rate and price of yield was taken from the International Cocoa Organization in January of 2018. The financial period analyzed is 25 years as that is the projected efficient life cycle of cocoa trees.[41] Table 8 in the Appendix shows general data used in the CBA.

3.2 Results from the CBA and Interpretation of Risk

Table 9 shows the practices in each CBA package, and Table 10 depicts the changes in productivity for each package of practices, the net present value of the entire stream of incremental net benefits for the individual farmer, the internal rate of return and the payback period for each package. Each of the CSA packages resulted in increased yields, a positive NPV, and an internal rate of return larger than twenty percent.

Table 9: Packages of CSA Practices

Package 1 (All four practices)	Regular pruning, Organic fertilizer, Field sanitation, Side-grafting of improved variety
Package 2	Regular pruning, Organic fertilizer, Side-grafting of improved variety
Package 3	Regular pruning, Organic fertilizer, Field sanitation
Package 4	Regular pruning, Organic fertilizer
Package 5	Regular pruning, Field sanitation
Business as Usual	Random/regular pruning

Table 10: NPV and IRR of Packages

Benefits	Units	BAU	Pack 1	Pack 2	Pack 3	Pack 4	Pack 5
Yield of Cocoa Crop	Kg/Ha	364.7	2,000	1,500	750	550	725
Net Present Value	USD	0	13,932	9,843	1,426	1,201	1,151
IRR	Percent	0	46	43	22	29	21
Payback Period	Years	0	6	6	9	8	9

Production increase from the CSA packages varied from a 75 percent to 600 percent increase compared to the business as usual plot. Package 1, incorporating all of the CSA practices, had the highest productivity at 2000 kg of cocoa produced yearly per hectare. Package 4, which did not incorporate the practices of field sanitation and side-grafting, had the smallest increase in cocoa production at 550 kg per hectare, compared to BAU production of 375 kg per hectare.

The net present value of the incremental benefits of adopting the CSA packages were all positive, though it is important to remember this analysis is ex-ante and the benefits are strictly hypothetical. Assuming the designated yield increased to 2,000 kilograms per hectare, Package 1 had the largest potential NPV of a 13,932 USD increase from a business as usual farmer who used unsustainable cocoa practices. Package 5 had the lowest potential NPV at 1,151 USD, assuming the yield increase and discount rate to be true. The largest decrease in the NPV of adopting the CSA packages occurred between Package 2 and Package 3. The difference between the two packages was the adoption of side-grafting and planting of improved cocoa varieties. Side-grafting and improved variety planting had very low labor and input costs and very strong yield returns. These results are reflective of Obiri *et al.*'s (2007) research, which assessed the benefits of transitioning to an improved variety of cocoa crops in Ghana. Failing to adopt side-grafting and limited farmer knowledge of the access to improved varieties of side-graft scions is discussed in Section 4.

The internal rate of return (IRR) for all of the CSA packages was greater than twenty percent (twice as much as the discount rate, ten percent). A higher IRR shows that it is more likely that a practice is "less risky" to adopt, as the private benefits of adoption are high even if future benefits are discounted heavily. The IRR of Package 1 and 2 were the highest at 46 and 43 percent respectively. The relative closeness in the IRR of the two packages, though having a fairly spread NPV (around 4,000 USD difference), was due to the high labor costs incurred from field sanitation labor from the operation period (years 3 to 25). Similarly, Package 4 had a higher IRR than Package 3 and Package 5, even though the yields for the other two packages were higher. This was again due to the high labor costs of field sanitation. Thus, as Package 3 and Package 5 had the lowest IRR, these two packages are predicted to be the riskiest packages to adopt. It is inferred then that it is the least risky to adopt packages that incorporate the most amount of CSA practices, Packages 1 and 2.[36] With respect to risk, this CBA does not incorporate probability of failure for CSA adoption and assumes that practices are implemented correctly. However, the interviews conducted during the fieldwork found that many farmers had reported the adoption of CSA practices yet lacked the knowledge and training to implement them properly. Thus, it is likely that there are uncertainties within the levels of annual yield returns, and this may lead to risk-averse cocoa farmers limiting their adoption of CSA practices.[34] The uncertainty of CSA success and its implications are discussed in the next section.

The payback period- time required to pay back the investments of adopting the CSA packages-ranged from six to nine years. Similar to the higher NPV and IRR generated, Package 1 and 2 had the shortest payback period (six years), and they were the same due to the labor costs required for adopting field sanitation. The payback period was also less for Package 4 compared to Packages 3 and 5 because of the higher labor costs of field sanitation.

Table 11: Incremental Net Benefits of CSA Package Adoption-Not Discounted (USD)

Year	*Package 1*	*Package 2*	*Package 3*	*Package 4*	*Package 5*
1	$-582	$-513	$257	$325	$223
5	$479	$352	$-237	$-159	$-216
10	$3,001	$2,124	$484	$338	$393
15	$3,063	$2,185	$545	$399	$454
20	$3,118	$2,241	$601	$455	$510
25	$3,168	$2,291	$651	$505	$560

In analyzing the costs and benefits of adopting CSA practices, it is important to look at the incremental net benefits faced each year by individual farmers, as these net benefits will be immediately encountered by the farmer at each given year. Only looking at the NPV and IRR of a cost-benefit analysis ignores the immediate issues of transitioning to CSA. Table 11 displays the incremental net benefits of each practice while not being discounted. The investment costs of Package 1 and 2 are extremely high for the first three years following CSA adoption, due to the implementation of new and disease-resistant cocoa crops. The investment costs for Packages 3 through 5 were low as the only cost for implementing new cocoa crops were the labor costs. However, these packages also yielded negative returns through years two through six. These negative net benefits in the beginning years outline the significant capital investment required for cocoa farmers in Lampung Province. Based on the household survey results, the average income generated from one hectare of a cocoa plot per year is around 300 USD. This means that the capital required for investment is more than the annual income from the same cocoa plot, and farmers may be fiscally constrained to adopt these packages even with the high net present value of the incremental net benefits.

The cost-benefit analysis showed significant private benefits for a farmer with BAU practices and considering adopting a variety CSA practices. These benefits can be interpreted with the determinants of adopting the CSA practices, found in Section 2, for analyzing policy or funding programs to increase CSA adoption in the region. Without an analysis of fiscal constraints, it appears that it is optimal for a farmer to transition to high levels of CSA practices due to the yield increases and high net present value of the incremental net benefits. However, there is significant start-up capital associated required to package CSA practices on top of labor costs and equipment needs.

This CBA may be used to better understand the private benefits of adopting CSA practices assuming that the practices were adopted correctly, and the necessary equipment was available at competitive market rates. However, the CBA's input costs for materials required for the CSA practices did not include transportation costs, nor did it incorporate lack of access to materials. The following section highlights significant constraints that were limiting the adoption of CSA practices among cocoa farmers in Lampung.

4. Ethnographic Analysis of the Constraints Cocoa Farmers Face

The third component of the research project was an ethnographic analysis of how cocoa farmers viewed the adoption of CSA practices, as it interprets the responses of farmers in the focus group discussions and cost-benefit analysis surveys. This analysis was conducted in order to ensure accurate farmers' perspectives, through stories that ultimately highlight niche characteristics of particular districts in question. Thus, in addition to humanizing the farmers with whom research was conducted, this section provides basis for programs that address the unique, localized conditions of the districts. The cost-benefit analysis proved that there are potentially extensive private returns for adopting CSA practices, yet CSA adoption for cocoa farming remains low in Lampung. Although the initial negative net benefits from the cost-benefit analysis may insight reasoning for the lack of adoption, this section hopes to further probe into the paradox of the lack of CSA adoption in the region.

4.1 Focus Group Methods

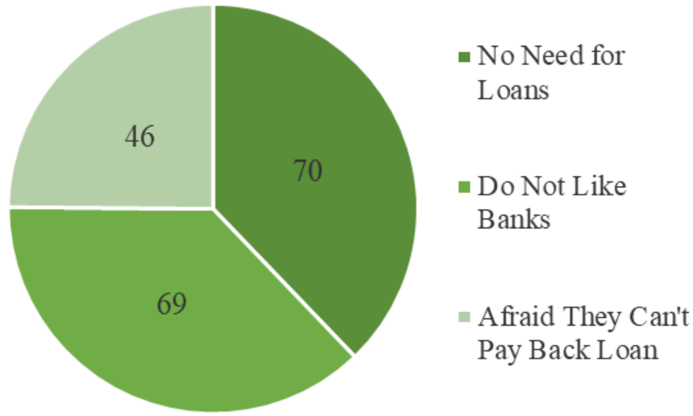
Focus groups were conducted in July 2017 across the three districts in question and in the form of design charrettes. This format allowed for a deeper understanding of particular characteristics and benefits of various farming practices among cocoa farmers.[42] As gender was a variable used in the multivariate regression, the focus groups were separated by gender to consider the different levels of CSA uptake between men and women; resultantly there were three groups of women and three groups of men, and thus six total focus groups. The participants in these discussions were cocoa farmers, who had been gathered by extension officers employed by agri-business Olam and in collaboration with CIAT. These farmers were not necessarily part of the household survey, though all were working in tandem with the Cocoa Life project through Mondelez. The activities for the focus group discussions were constructed through CIAT and conducted by PhD students at the University of Lampung, through a script of the activities and instruction by CIAT researchers. The focus groups were conducted in Bahasa Indonesian, and there was a translator provided for CIAT employees to interject with questions and as it transpired during the activities. Table 12 shows the basic demographics of the participants.

Table 12: Participants in Focus Groups

District	Male FGD	Age Range	Female FGD	Age Range
Pringsewu	8 participants	32-52 years old	11 participants	42-55 years old
Pesawaran	8 participants	34-68 years old	8 participants	36-51 years old
Tanggamus	11 participants	19-79 years old	8 participants	30-62 years old

Three activities were created for the focus groups to try to understand how and why cocoa farmers are and are not adopting CSA practices. The first activity was created to revalidate the findings from the household survey's questions regarding impacts from climate change, and the barriers to adopting appropriate climate-smart practices (regular pruning, organic fertilizing, field sanitation, and side grafting). A further objective of the activities was also to better understand the opinions and behaviors of the local farmers while facing adoption of these CSA solutions, in accordance to their gender and district. The second activity focused on assessing potential solutions to the barriers faced by farmers in adopting CSA practices. Specifically, it probed at the impact of improving credit access and resources for the CSA practice. This activity was motivated by the lack of farmers taking out loans, information generated from the household survey and shown in Figure 1, as only 54 of the 190 households had taken out a loan for cocoa investment. In addition to addressing the lack of credit usage found in the household survey, solutions taken from the second activity hoped to go in tandem with the multivariate model results of training being associated with adoption of the CSA practices. The third activity looked at how farmers in each region packaged the CSA practices and their understanding of how they viewed the significance of combining certain practices. The analyses of these results, through the lens of ethnographic interpretation allows the results of the project to become more personal, putting a face and name to the problems that these farmers face; and also allows for a more localized and specific approach for understanding the constraints that might be limiting the adoption of CSA practices.

Figure 1: Why Farmers Do Not Seek Loans (in number of farmers)



4.2 Key Themes Identified during FGDs and CBA Surveys

The stories of farmers captured during the summer fieldwork provide glimpses into the mechanisms driving the choices of cocoa farmers and identify key themes for the constraints farmers face when adopting CSA practices. While the previous section proved the fiscal benefits of adopting CSA practices, this section elaborates on the less qualitative analysis of CSA adoption. These more intimate accounts allow us to see how the farmers perceive climate change, constraints, and proposed solutions to their problems, highlighting things that may not have been made obvious in previous modeling. Their unique narratives highlight the distinct regional impacts and economic constraints that farmers face when adopting climate-smart practices, as well as personalized recommendations from the farmers to address their constraints.[43] These recounts assume a more personal narrative, to humanize the research subjects and authentically relay the experience of this fieldwork.

Pringsewu District

Climate Impacts and Awareness of CSA Practices:

The first focus group discussions (FGD) were held in Pringsewu. Based on the first activity, the problem tree analysis, the biggest climate impact noted by the farmers was *too much intense rainfall*, followed by *prolonged hot weather*. These climate conditions led to rises in rotten cocoa fruit and higher levels of pest and disease.[6] Farmers in the FGD were well versed in CSA practices and their intricacies. These farmers recognized the potential increase in crop and household welfare through adopting practices but were inhibited by constraints to adoption.

Women's Focus Group: Pringsewu, Indonesia (Photo by Madelline Romero—CIAT)

Challenges of CSA Adoption and Possible Solutions:

Farmers in Pringsewu thought that they could best address the rising climate issues by hiring additional labor, at 60,000 IDR per day (about 4 USD). The additional labor could help in the pruning of cocoa trees more often, which they viewed as the solution to deal with pest and disease. Labor was a significant issue for cocoa farmers, as many in Pringsewu had other cash crops throughout their farms besides cocoa. Further, women were limited in their adoption of regular pruning because of the intensive labor required, and not all of the farmers could afford more efficient cropping tools to reduce the time spent for pruning. Insufficient time was also voiced as a concern, revalidating the results in the probit model, which showed a negative association to adopting CSA with owning other crop fields.

Farmers applied insecticide to decrease the level of pests, but claimed it was not effective as the intense rainfall repeatedly washed away the spray. In addition, farmers struggled with pesticide application because they could not reach the tops of the trees—showing the lack of formation pruning that occurred in the region. The farmers thought the increase in pests was also due to farmers in neighboring plots, who did not adopt sustainable practices, perpetuated the increase in pests. Opposite to the problem of intense rainfall, high temperatures in the dry season led to decreased water availability for the spreading of insecticide and pesticide.

Farmers also struggled to adopt organic fertilizer and suggested inorganic fertilizer practices due to the lack of available products. Many of the participants stated a lack of raw materials or decomposition catalyzers to create compost, only having the husks and leaves of their cocoa plants to use. Many believed the best way to access subsidized fertilizer was through Olam or their local government. In addition, farmers though Olam could help by increasing the supply of compostable materials in the region or facilitate the training of more farmers on how to produce large levels of organic fertilizer themselves.

Both male and female farmers believed an increase in credit could address the lack of proper tools and labor for the adoption of regular pruning and implementation of field sanitation. Men placed significant emphasis on the level of trust required to obtain a loan and thought loans could best come from a bank or through an established local farmer group. Contrastingly, women voiced having little faith in farming groups and Olam for funding, preferring to obtain loans from banks with regimented loan structures that they understood. Many women claimed that the funds they received from the groups and Olam were insignificant and skewed towards the male farmers. Household survey data reflected similar results to those voiced by male farmers, with only 54 of the 190 farmers receiving credit, and most of the funding occurring at a familial or friend level, rather than through Olam or an established bank. A recommendation can thus be made for financing this region, either through a micro-bank or established farmer groups since high levels of trust are paramount for loans to take place. Programs should also be observant of potential gender bias while establishing their funding structure.

Although farmers recognized that side-grafting improved cocoa varieties was a significant way to increase cocoa yields, women were not able to apply the practice due to significant lack in training for this demographic. Men on the other hand, for the most part, had benefited from training and could thus implement the practice. The absence of training for the women points to a possible explanation for the positive correlation between adopting side-grafting and being male, found in the multivariate probit analysis.

As we concluded our cost-benefit interviews, one of the men, Pak N, introduced himself as having been part of the Pringsewu FGD earlier in our studies (Pak and Ibu are formal ways to address male and female adults in Indonesia, respectively. For privacy purposes, farmers' names were not included in the research). Pak N expressed his enthusiasm for knowing how to side-graft, taking out the packaging to explain how he had recently started the practice. He exuded immense pride in showing off the skill, which he had learned through an Olam training session. The fervor in Pak N's descriptions highlights the demand for knowing how to adopt these practices and the empowerment such skills can bring. A recommendation can thus be made for greater levels of training among farmers, women included, as a means of ensuring practice adoption and personal empowerment.

Pesawaran District

Climate Impacts and Awareness of CSA Practices:

The second round of focus group discussions were held in Pesawaran at the base of Mount Ratai. Here, like in Pringsewu, the major climate impacts voiced by farmers were higher temperatures and increased intensity and duration of rainfall. However, the farmers in Pesawarn did not have to worry about low water levels during the dry season, as they were located at the bottom of a mountain and reaped the benefits of mountain runoff and shade. In addition, farmers in Pesawaran had smaller cocoa plots compared to other districts and claimed that labor was not a primary constraint in adopting climate-smart practices. The farmers in Pesawaran were aware of climate change impacts and the climate-smart farming solutions in existence to these problems. Also, like Pringsewu, farmers in Pesawaran, though aware of the potential benefits to their crops, did not adopt CSA practices due to various constraints.

Challenges of CSA Adoption and Possible Solutions:

Among farmers on lower land acreage in the focus group discussions (FGD), lacking adoption was reflective of the infeasibility of investment towards cocoa practices, made further improbable due to constant variability in crop value and yield. Farmers who did not adopt organic fertilizer nonetheless recognized the benefits of this practice yet claimed that they did not have easy access to purchasing compost and could not purchase the materials needed to facilitate decomposition of their organic waste. This lack of adoption indicated a potential information gap or cost constraint regarding accessing the organic fertilizer.[44] Prior to the focus group discussion, CIAT interviewed Pesawaran farmer Pak E for the cost-benefit analysis of his adoption of CSA practices, wanting to gain insight into his adoption of creating organic fertilizer. Pak E was well versed in the production of organic fertilizer, and even purchased additional manure from neighboring farmers with livestock to create more. He then sold his excess fertilizer to neighboring farmers and claimed there was a huge demand for his product. During his interview, Pak E expressed immense excitement for the expansion of his micro-business, again affirming the empowerment reaped by farmers who thoroughly understand CSA practices and their adoption, which transcends mere fiscal stability.[45] There was a significant disconnect between farmers in the focus group, who sited lack of access as a primary issue and Pak E's creation of his organic fertilizer.

This highlights a potential information gap between the farmers in the community and a lack of accessible transportation, as they could likely have been purchasing Pak E's fertilizer. Farmers in the FGD claimed that the nearest source of organic fertilizer materials was thirty minutes away. Coupled with the high costs of transportation and materials needed to make fertilizer at home, many of the female farmers voiced not knowing how to make organic fertilizer in the first place, this even after being trained by Olam. The farmers believe a potential solution to the knowledge gap for women could be additional or more structured training from the agri-business. Women suggested that three rounds of training focused on the creation of organic fertilizer would be sufficient.

Participants in both FGDs also stated that struggles of adopting CSA practices were due to a lack of capital. Farmers could not purchase efficient tools for pruning and field sanitation because of a limited source of income. They thought that these fiscal constraints could be addressed through farmer groups. This focus on community-based loans could be explained by the household survey, where 57 percent of farmers sought their loans from established farming groups, families, or neighbors. Farmers in Pesawaran preferred not to borrow through an established bank because they feared that they would not be able to pay back their loan, even if the interest rate for the loan was lower than the market rate. Like the farmers in Pringsewu, cocoa farmers in the Pesawaran FGD suggested borrowing from their friends or local collective savings where they expected lower interest rates. Farmers in this district, like in Pringsewu, also had other crops to deal with such as rice and seasonal vegetables and were thereby also fiscally limited in addressing their cocoa crop. The FGD members in Pringsewu brought up the potential dilemma of farmer groups, as they tended to have little money to lend out. This is where a company like Olam or Mondelez could step in to help finance these local organizations. The fear of paying back loans is contradictory to the high benefits of CSA adoption conducted in the CBA. As discussed above with side-grafting, this fear may stem from potential failures of CSA adoption and may discourage risk-averse farmers from choosing riskier types of investment.[46]

Farmer on his cocoa plot
(Photo by Madelline Romero— CIAT)

One of the men interviewed during the CBA in Pesawaran was Pak R, a cocoa farmer known locally as one of the best adopters of CSA cocoa practices in the region. Pak R was interviewed for the adoption of Package 1, as he had adopted all of the packages, and resultantly had some of the highest cocoa yields in the district. Pak R was so well known in fact, that he had been interviewed by two international researchers the day before. Pak R beamed with pride as he went into detail sharing specific details of how he had adopted all of the CSA practices. He led the CIAT researchers into his crop fields, where he showed his well-maintained plots, the healthily growing side-grafted trees, and his hybrid crops, all the while describing the benefits reaped in yield increases by these practices. Pak R however appeared to be an exception to the rule, as other farmers in both Pesawaran and

Pringsewu struggled even after Olam training with the implementation of practices, such as side grafting.

Farmers in the focus group discussions recognized and appreciated the benefits of side-grafting resulting in yield-increasing and pest-resistant trees, and many had tried to implement this practice. The branches used for side-grafting often failed however, and those who had tried side-grafting were frustrated with their lack of success in adopting the practice. The farmers believed that their failure stemmed from the lack of materials. They stated a lack of healthy, hybrid scions, like Sulawesi 1 and 2, available for them to purchase.

This failure to adopt side-grafting for the farmer indicates why farmers do not adopt practices, even when the CBA found that private returns on investment of CSA practices are extremely high. The uncertainty of CSA success faced by the farmers who failed to adopt side-grafting, coupled with the lag-time of return on investment suggests that risk-averse farmers may be less willing to adopt practices.[34,47] The high levels of expected net benefits may lack significance if farmers are consistently seeing their CSA practices, like side-grafting, fail. In addition, the varying prices of cocoa may further cloud the benefits of investing in cocoa technology, as the benefits are then furtherly uncertain.[48] The farmers asked for the subsidization and transport branches for side-grafting. Such adjustments could significantly limit the cost of this CSA practice adoption. Farmers also hoped for assistance in providing access to organic fertilizer and the materials needed for facilitation of decomposition of their compost plots.

According to Troung et al. (2017), the spread of sustainable farming practices should involve peer learning, whereby local farmers already versed in the practices help their neighboring farmers adopt the same practices. In addition, farmers yet unfamiliar, should observe the practices used by successful farmers, acknowledging that they can alter these somewhat on their own land. In contrast to such collaboration, farmers in both Pesawaran and Pringsewu were negatively being affected by the lack of adoption among their neighbors, bringing down overall welfare of cocoa crops in the districts.

It was in probing discussion on the subject that obvious resentment was brought up by some of the farmers in the Pesawaran FGD, who complained that their highly-trained and successful neighbors did not want to share their practices, especially in the case of side-grafting. There was a clear tension between, Pak T- a man who remained fairly quiet during the discussion and the owner of the building the FGD was being housed in- and the other farmers in the FGD. This tension mounted when the department Head of Agriculture for the district, who had been sitting in to observe the discussion, spoke up. He thought that farmers were failing to side-graft correctly because they did not recognize the need to put more fertilizer near the side-grafted trees. He scolded the farmers, saying that they should learn from successful farmers like Pak T, or ask for help from the department to teach them. The tensions raised in this FGD on side-grafting highlighted again the existence of an information gap between successful farmers like Pak R and Pak T, that must be addressed if high levels of uptake for the more technical practices, such as side-grafting, are to be adopted. This, in turn, could encourage the more risk-averse farmers or those worried about paying back investment to recognize the private benefits that were found in the CBA.

Tanggamus District

Climate Impacts and Awareness of CSA Practices:

Tanggamus, the westernmost region in Lampung Province, was the site of the last of the FGD. Tanggamus is a region that is acclaimed for its better soil quality compared to Pringsewu and Pesawaran due to its proximity near the base of Mount Tanggamus. It is also the most isolated of the three districts, with the closest major city being Bandar Lampung, located to the east past Pringsewu and Pesawaran. Farmers noted that prolonged heat and lack of rain had most negatively affected their cocoa crop, and that the more intense rain from the wet season was the second biggest climate issue they had noticed.

The farmers in Tanggamus, both men and women, were well versed in the benefits of CSA adoption, as with Pringsewu and Pesawaran. They thought that focusing on proper pruning and organic fertilizer would lead to reductions in pest and disease. Farmers believed field sanitation would help improve their soil quality and that efficient side-grafting would lead to higher cocoa yields.

Challenges of CSA Adoption and Possible Solutions:

Yet again like the two other districts, even with these acknowledged benefits, farmers still struggled to adopt these practices. Farmers struggled to adopt field sanitation and regular pruning because they lacked the necessary tools. Among coordinated groups of about 25 farmers, groups shared roughly three tools for each CSA practice. Time management and cooperation thus were imperative in the adoption process for farmers in the region; especially in the event of field sanitation, a labor-intensive practice, and during which farmers listed time as a large obstacle.

A further constraint faced by farmers in Tanggamus stemmed from their isolated location. The Tanggamus households are situated in the western region of Lampung Province, furthest away of the three districts from Bandar Lampung. Many of the farmers in Tanggamus were housed more than five kilometers from a major road in the region, and most roads were cobblestone and pothole-filled, slowing travel down immensely. This isolation led to high levels of transportation cost constraints. Further, this lack of access was also a primary constraint for the adoption of organic fertilizer. Most of the farmers who did not adopt organic fertilizing were encumbered by proximity, too far from organic fertilizer distributors. Many were left to struggle in attempts to make their own fertilizers with limited resources required to expedite decomposition. Cocoa farmers also competed with rice farmers in the region also for access to

Cobblestone Road: Tanggamus, Indonesia
(Photo by Daniel Holod—Cornell University)

the materials required for organic fertilizer. As a result, many farmers applied manure directly to their cocoa plots.

Side-grafting of certified varieties was claimed to be difficult to adopt for the farmers again because of the remoteness of Tanggamus district. Farmers believed that the practice was the most expensive to adopt because of the lack of trees or tools in the region. Similar to Pesawaran, the risk of failure combined with the price constraints may explain why farmers did not adopt CSA practices even with the high potential benefits generated from the CBA. The farmers in Tanggamus had varying success rates of implementing side-grafted trees and did not think that it was worth experimenting with because of the time required. The nearest place to buy the hybrid cocoa scions from a professional nursery was in Pringsewu, which was typically a half-day trip just to purchase the branches, partly due to traveling on roads like pictured on the previous page. In addition, lack of smooth roads slowed the process of fieldwork, reflecting the intersection of sustainable infrastructure in the districts in question.

Farmers in the Tanggamus FGD believed that investing in farming groups would be a good way to ease the constraints collectively faced in adopting the CSA practices. Presently, farmer groups lacked sufficient capital and equipment to properly support high levels of CSA adoption in this district. A recommendation can thus be made to empower Tanggamus farmer groups with increased capital, as well as the facilitating their opportunities to purchase better types of inorganic fertilizer and materials to make organic fertilizer themselves.

Farmers in Tanggamus thought they could solve their labor constraints in adopting field sanitation by hiring additional labor, financed through a side-business. Here many women in the FGD thought that they could generate additional income by selling snacks like fried banana chips and cookies. One of the participants of the FGD, Pak S, had also been interviewed for the cost-benefit analysis. He and his wife, Ibu P, offered banana chips and other snacks upon entry into their house. Ibu P had successfully started selling these banana chips from the banana trees (“pisang” in Indonesian) also located on their land, to help fund their cocoa practices. Ibu P’s microbusiness epitomizes the work of many women to further support the cocoa farming of their family and offers an example of opportunities that generate additional income to fund labor costs associated with CSA practice implementation.

Pak Son Cocoa Plot: Tanggamus, Indonesia Daniel Holod—Cornell University)

Farmers believed Olam could to be a possible source of additional training and supplying of the materials they needed to adopt CSA practices. In this FGD, women expressed having limited knowledge on adopting the correct levels of pruning, organic fertilizer, and side-grafting, as they had received fewer levels of training than their male counterparts. They collectively thought that if Olam came and specifically trained women, then this demographic of cocoa farmers would be able to more readily adopt the correct practices. In addition to increases in training, farmers would have a better opportunity to adopt side-grafting if Olam focused its efforts on increasing the number of scions of hybrid cocoa trees in Tanggamus. At present, farmers struggled to implement side-grafting because they had little margin of error due to the lack of materials, and also risked large amounts of financial loss if the project failed. Farmers in the FGD thought that receiving ten branches every week for side-grafting would be sufficient for them to implement the practice throughout their cocoa plots. Again, improving access to materials and decreasing price constraints may reduce the risk of adoption of CSA practices for the farmers, and allow them to recognize the perceived private benefits that were generated from the CBA.[46]

4.3 The Role of Religion for Farmers in Lampung Province

On the evening of the focus group in Tanggamus, the call to prayer rang out through the night. Approaching soon after from the Mosque was Pak W, the oldest cocoa farmer who had attended the FGD that day. Pak W, as it turned out, was the Imam for the local Mosque, in addition to his career as a cocoa farmer. Pak W's story of balancing his farming with his religious devoutness and dedication, highlights the focus of religion in Lampung Province, complicating and humanizing the farmers with whom this research was conducted.

Among farmers and government officials, the question was not "Are you religious?" but rather, "What religion are you?" It is imperative to acknowledge the effects of religious devoutness witnessed in our fieldwork, as it impacted the timing and orchestration of our FGD and CBA, as 189 of the 190 farmers practiced the Islam faith. Occasionally, CBA interviews had to be paused for prayer, and in Pringsewu there was an hour-long intermission during the FGD during which the men had to go to the local mosque to pray.

These moments all highlight the role of religion in the lives of these farmers, and to the necessity of balance between their cocoa farming and practice of Islam. The focus and necessity of religious practice outlines how time is valued by the farmers who were interviewed in this study. If a certain practice, such as field sanitation for instance, required an additional three hours of time on the cocoa plot, adoption of this practice would be unlikely for farmers like Pak W who had to consider their religious commitments as well. Religion in regions such as those in question here, must thus be assumed as a variable of impact itself; training programs and research projects must be sensitive to its impacts.

Completion of FGD: Lampung, Indonesia
(Photo by Madelline Romero—CIAT)

5. Implications of Ethnography and Risk Based on Econometric and CBA Results

The multivariate probit model in Section 2 analyzed the determinants of those who had adopted CSA practices. The results showed that farmers receiving extension training on CSA practices were correlated ostensibly with the adoption of CSA practices. In addition, the adoption of CSA practices was positively correlated with increased education, available livestock, if the head of the household was a man, observing climate impacts, while negatively correlated with higher levels of cash crop and receiving cocoa damage. These results provided tremendous insight into the farmers who were most likely to adopt CSA practices and those not. In further pursuing the reasoning behind the private benefits of adopting CSA practices, this study looks to the inferences made by running the cost-benefit analysis. This showed that there were potentially significant fiscal benefits in adopting more CSA practices, with the ex-ante net present value of adopting CSA packages being positive. This is important to note, as increases in income are related to increasing household utility.[20] Yet, farmers in the region still struggled to adopt these CSA practices. The results from this section displayed that farmers were limited in their adoption of CSA practices, at times due to unforeseen reasons. Training by Olam was said to not be widespread enough, especially among farming women. Many of the farmers in all three regions of analysis faced a lack of equipment required for adoption. Cost constraints, which may have been due at times to transportation limitations, was for instance incorporated into the CBA. The knowledge gaps and cost constraints potentially explain why adoption of CSA practices was so low even with the private benefits they may hold.

There were also constraints found in the focus group discussions that prevented the uptake of CSA practices. Pringsewu, like in Pesawaran and Tanggamus, lacked access to subsidized inorganic fertilizer. Pringsewu farmers thought that Olam could help with the transportation of more efficient fertilizer to the region. Further, the farmers in this district lacked the necessary materials to stimulate decomposition of their own organic compost. Farmers in the district also lacked efficient levels of formation pruning due to the absence of equipment. They believed that increased access to credit could also help ease their borrowing constraints, but the farmers emphasized that they must trust the banks.[47] Women in the FGDs had a lack of trust for both established banks and Olam, as sources of capital. Pesawaran farmers were also constrained by the lack of materials needed to adopt side-grafting and organic fertilizer use. Resources for fertilizers were limited due to competition from other agricultural produced by themselves and other local farmers. The farmers in the region thought that access to necessary farming equipment could be increased through funding towards their farmer groups. Such structural support would allow farmers to pool their resources and invest together in the higher capital investments required for CSA adoption. Tanggamus was the most isolated district in the study. Its location at the foot of Mount Tanggamus resulted in higher soil quality but farmers in the focus groups claimed it had more intense levels of drought. This led in contrast to Pesawaran, where farmers believed they had good access to water. Here again, the lack of equipment available for the farmers constrained their ability most immediately to adopt CSA practices. The farmers tended to share three sets of pruning and field sanitation tools in their groups of about 25 farmers. In addition, women received less training than their male counterparts, leading to an information gap in CSA adoption. The high levels of farmers practicing Islam faith should also be considered with how they budgeted their time and resources.

Farmers from all three districts said they did not adopt CSA practices, due to fears regarding initial costs of investment, signaling a potential cost constraint. This result is a significant issue due to high potential net benefits generated from the cost-benefit analysis and places the adoption of CSA into a paradox. The worry of investing in CSA practices seems to stem from three risk-of-adoption issues: the volatile prices of cocoa, the time lag in the return on investment, and the possibility of CSA implementation failure.[34] Prices vary widely for farmers selling their cocoa crop.[6] This variation makes it hard for farmers to gauge what their long-term benefits of adopting CSA practices for cocoa.[46] With a chosen price, the CBA showed that it would take six years, at the very least, to generate positive income from CSA investments, and initial startup costs are extremely high. Thus, investments in these practices need to be rooted in the confidence that the practices will succeed and that higher levels of income will be generated. However, as was reflected in the focus group discussions, many farmers failed in the long-term implementation of CSA practices, especially the more technical ones like side-grafting.

The combination of these three issues make the benefits of adopting CSA practices appear much more ambiguous and riskier than what is displayed in the CBA results. When CSA benefits are viewed as an uncertain return, it makes sense that risk-averse cocoa farmers may not adopt the CSA practices.[48] This interpretation is further verified by the multivariate result of large cocoa crop damage being negatively associated with adopting CSA practices. The increase in cocoa damage signals to farmers that CSA adoption may pose a high-risk investment. With this dilemma parsed out, it is beneficial to understand how the high benefits of CSA adoption generated from the CBA can be recognized. Farmers noted that the failure to adopt was raised due to the lack of equipment necessary for adoption, thus decreasing the cost of acquisition of the equipment, such as side-grafting scions, can lower risk of adoption. Further, failed adoption stems from a lack of farmers implementing the full extent of actions required for each CSA practice. This situation enforces the suggestion that more technical and regimented training programs should be given to the farmers. Although volatile cocoa prices cannot be addressed with the results from this study, though alleviating price constraints and implementing technical training may reduce the risk of adopting CSA practices, and allow farmers to pursue the high private benefits found in the CBA by investing and packaging CSA practices together.

6. Challenges and Limitations of the Study

This study faced roadblocks through its fieldwork and completion of the econometric modeling. Due to these limitations, no causal claims can be inferred from the study, and the scale is limited to Lampung Province; however, there are significant opportunities to scale up or deepen the research completed in this project.

Farmer and his crop: Lampung, Indonesia
(Photo by Madelline Romero—CIAT)

6.1 Limitations

The multivariate probit analysis had a variety of issues throughout the project. While conducting the CBA interviews, it was noted that some of the farmers who had said they were adopting CSA practices had not been fully adopting the practices. The variables of CSA adoption were based on whether or not the farmers believed they had adopted the practices, not if they had actually fully implemented the practice. Further, analysis of household heads may have negated the potential of decision-making capabilities of other members of the household. In addition, no causal claims could be made from the analysis of the multivariate model, and marginal effects of the determinant were not generated. Although the correlations may be indicative of farmers in Lampung, the sample size provided was less than one percent of cocoa farmers in the region. The possibility of reverse causality was a concern for the variables of income and long-term investment. For example, CSA practices adoption may raise income levels, and this could impact income and how farmers would budget their investments if given an increase in income. Income showed to have no level of affecting adoption in the model, so the issue of reverse causality for the income variable was lessened in this study.

An ex-ante CBA innately has a degree of uncertainty because the model is constructed prior to the CSA practices being used. There was no analysis of the risk of CSA practices and their cocoa crop failing, a very important component of how a farmer views the costs and benefits of adopting CSA practices. Price volatility of the cocoa market makes the returns and potential private net-present benefits of cocoa investments more ambiguous. Risk and ambiguous returns have been shown to limit CSA adoption.[48] In addition, the CBA is run from a specific point in time, with a particular prediction of certain levels of yield fluctuation and at a certain price of the crop.[34] The price for cocoa yields varies throughout the year, and the results can change on what price is chosen for the analysis.[5] A single point in time also ignored the potential for climate shock or other factors that could change the yield level or the valuation of future incremental net benefits. Further, the NPV results hinge on determining the discount rate for the model. However, it is hard to gather how a farmer may discount the future.[36] In addition, labor costs were calculated based on the going rate in Lampung Province for hiring a laborer to work for a day. Farmers may value their labor time more than what was generated and may complete the implementation of practices at different speeds than what was assumed by the CBA. The input costs for materials required for CBA adoption did not include transportation costs, nor did it incorporate lack of access to materials. The cost-benefit analysis inputs and results were based on farmer recollection and approximation. Some of the farmers had to think back over ten years to remember about the input and labor costs required for implementing their cocoa practices. Cocoa harvesting, though primarily through two main harvesting seasons, occurs throughout the year. It was thus difficult for the farmer who had not logged their yield levels to recall the amount of cocoa yield they had each year.

This project only looked at the private benefits of adopting CSA practices- yield increases and adaptability to climate change. CSA practices also incorporate mitigation measures and may also decrease pest and disease spread throughout the region. Correct implementation of CSA practices leads to mitigation of CO_2 and reduction of pollutants in the region, thus incorporating positive social returns. This means that positive externalities exist in the adoption of CSA practices. As these external benefits were not discussed, nor mentioned in the FGDs, it may signal that there is an inherent undervaluing of CSA adoption.

The ethnographic analysis of the region was based strictly on the perceptions found through the fieldwork through the lens of data that was collected from the household survey. The farmers for the focus group discussions were chosen through Olam, based on a message sent out to the farmers to see who was interested. Thus, the participants were not randomly selected and may not have been representative of the entire community of cocoa farmers in the province. There were also communication errors during the focus group discussions and CBA interviews, as the researchers were not fluent in Bahasa Indonesian and the translators were not able to say everything that was happening.

6.2 Opportunities to Scale-up Research

For a stronger econometric analysis, an intertemporal survey regarding levels of training, with an addition of control groups, could perhaps lead to a more causal determination of the impact that training has for cocoa farmers in the region. Any survey that is conducted for this focus should incorporate more in-field assessments of adoption, compared to the household dataset used here, to better determine whether or not farmers had adopted the CSA practices. Further, the small sample size that was provided by Olam highlights that further assessment must be done incorporating farmers who are not part of agronomic or community programs. Additional CBA modeling could incorporate varying levels of yield increases and prices of cocoa to have a more holistic understanding of the private net-benefits of adopting CSA practices. To analyze the public implications of scaling up CSA practices among cocoa farmers, external benefits could be analyzed with a more robust CBA. The growth and valuation of social benefits of CSA adoption could be analyzed if the spread of CSA practices was modeled in the CIAT CBA tool and a fiscal value was placed on the social benefits generated per hectare of CSA adoption. This model would allow policymakers to better grasp the total social value of scaling up the adoption of CSA practices. To have a more robust ethnographic analysis, it may be beneficial for people better trained in economic-based anthropology to spend time analyzing the community through more focus group discussions or one-on-one interviews with the farmers.

Based on the work conducted by CIAT, there is forthcoming analyses based on more rigorous adoption results obtained through field assessment. This research should help reduce the measurement error related to whether or not farmers believed they had adopted the practices.

Farmer checking on his crop: Madelline Romero—CIAT)

7. Main Recommendations

This aim of this research project was to help understand the determinants of Lampung Province farmers' adoption of CSA practices, determine their personal financial benefits of adopting these practices, and ultimately discover why the adoption has been so low even after fieldwork proving the CSA benefits. It is important to understand the lack of adoption of sustainable farming practices and ways to increase take-up, as yield efficiency of the cocoa crop in Lampung Province have been decreasing in recent years.[3] Predicted trends in the region point to rises in increased intensity of rain and higher overall temperatures due to anthropogenic climate change.[13] These two climate impacts are already being attributed to the rise of pest and disease for cocoa crops in Indonesia, which have further been significantly decreasing cocoa yields[6]. Without a change in behaviors, farmers may continue to implement unsustainable agricultural practices. Unsustainable agricultural practices have contributed to Indonesia contributing the third largest CO_2 emissions in the world, due to their high levels of deforestation.[14]

Training

Based on the results gathered from the multivariate and ethnographic analysis, Olam should continue with extension training. More specifically, it may be beneficial to have segmented trainings based on farmers' capacity to adopt. Many farmers were aware of the benefits of CSA adoption; the training now needs to be geared to making sure the farmers know how to fully implement the practices. Clustering farmers on their current capacity to adopt may allow for more technical sessions by farmers who already know the types of CSA adoption.[49] There should be a focus on more ongoing sessions that are concentrated on the technical aspects of CSA adoption, especially with attention on training female cocoa farmers. Based on the focus groups and household surveys, there was a lack of training for female household heads. According to further research conducted by CIAT, women contributed to significant components of cocoa production and sale even if they were not listed as the heads of households.[50]

Inputs

Based on the focus group discussions, there should be an increased flow of materials required for the adoption of the CSA practices. Such inputs include improved-variety seedlings and scions for side grafting, materials to help with creating organic fertilizer, access to higher quality inorganic fertilizer, and more efficient pruning and harvesting tools. Increased access to inputs could help increase CSA adoption and help combat the rising levels of pest and disease.[8,10] These inputs could be increased into the communities with the help of supply chain actors such as Olam, as well as with the government at the district and provincial level. Already, Cocoa Life, with support from Olam, has been improving access to improved cocoa varieties through a professional nursery in Tanggamus.

Graduation Financing and Impact Bonds

In order to limit the cost and borrowing constraints, the regional government, local NGOs, and private programs should look into investing in increasing the fiscal capacity of local farmers. There was a perceived lack of trust for formal banks in the region, however there was also issues regarding women's trust towards local funding found in the focus groups. One solution to the funding gap is a step-wise 'graduation' plan that guides farmers to free up capital in incremental investments. Already the Cocoa Sustainability Partnership is addressing ways to target this graduation funding scheme.[51] The long-term economic and environmental benefits raise the potential opportunity for the rising market of social and environmental impact bonds, investments that generate both fiscal and environmental returns, especially with the high potential rises in profits that were generated in the CBA.[52]

Enabling Policy Environment

There are opportunities for NGOs and the local government to support the implementation of CSA projects, by considering the results in this paper. There was a recent workshop in Sulawesi that addressed the decreasing soil degradation, and the goal was to figure out how to implement better soil management at the local farmer level.[53] Coupled with this, SCPP, the largest private-public organization for the cocoa sector which various large international distribution firms are members, has been looking at scaling the implementation of CSA practices in Indonesia.[54] They plan to address the implementations via better farmer organization, market access, certifications, financing proper practices, and gender sensitivity, all components that were discussed in this study. Another organization to consider is the Indonesian Coffee and Cocoa Research Institute (ICCRI), who is the primary cocoa institute in Indonesia for planting materials and agronomic consulting.[55] The Cocoa Sustainability Partnership is also on forefront of policy recommendations for cocoa, through their private-public forums.[56] These current policy programs for cocoa adoption should note the varying distinctions among islands, even within the province of each island as they continue to scale-up their programs up.

Conclusions

The goal of this study was to better understand the characteristics of cocoa farmers who have been adopting CSA practices, the personal benefits of adopting the CSA practices, and how farmers in Lampung Province are reacting to the rises in pest and disease brought about by climate change. The solution to the decreasing yields may lie in the scaling of the adoption of climate-smart agriculture, which can increase cocoa yields while making farmers more resistant to climate-change impacts. The CBA in this study found that there are significant private benefits of CSA adoption; however, farmers are currently not adopting CSA practices due to perceived risk, high costs of investments, and a lack of inputs, proper training, and credit. The lessons learned from this research, while conducted in Lampung Province, could be applicable to other cocoa-growing countries, and the research methods could be replicated.

8. Acknowledgements

This case study was based on an undergraduate honors thesis by the first author, Daniel Holod, while at Cornell University.

The following organizations and funding are acknowledged for their support in the publication of this paper.

Reviewers
Dr. Allison Chatrchyan
Dr. Nicholas Sanders
Tiffany Talsma
Dr. Federica Matteoli

Funding
The Southeast Asian Program through the Einaudi Center, Cornell University
The Arts and Sciences Student Assembly Grant, Cornell University
Engaged Cornell Grant, Cornell University
Einhorn International Discovery Grant, Cornell University
The International Center for Tropical Agriculture

Organizations
Cornell University-Cornell University is a member of GACSA and tries to share information to scale up the global adoption of Climate-Smart Agriculture.[57]

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). This work was implemented as part of CCAFS, which is carried out with support from CGIAR Fund Donors and through bilateral funding agreements.[58]

International Organization for Tropical Agriculture (CIAT)-CIAT is a member of GACSA and is a research and development organization dedicated to development agriculture in tropical regions. CIAT leads the CGIAR Research Program on Climate Change and Food Security to generate evidence and support adoption of climate-smart agricultural policies, practices, and services that alleviate poverty, increase gender equity, and support sustainable landscapes.[59]

The Global Alliance of Climate Smart Agriculture (GACSA)-GACSA is a “voluntary and action-oriented multi-stakeholder platform on climate-smart agriculture”. The organizations goal is to “improve food security, nutrition, and resilience in the face of climate change.”[60]

9. Appendix

Table 3: Summary Statistics
Dependent Variables

CSA Practices	***Not Adopted***	***Adopted***	***Percent Adopted***
Regular Pruning	72	118	62.11%
Organic Fertilizer	119	71	37.37%
Field Sanitation	164	26	13.68%
Side-grafting	155	35	18.42%
Total	648	302	31.79%

Independent Variable Summary Statistics (Italicized are used in model)

	Mean	***Std.***	***Min***	***Max***
Age of Household Head (Years)	48.53	11.45	23	86
Years of Education of HH	8.93	3.49	0	16
Number of Household Members	3.95	1.19	1	8
Total Income (10,000 IDR)	396	457	10	2,660
Cocoa Income (10,000 IDR)	99	123	3.9	1,080
Total Land Area (Ha)	1.39	1.18	0.1	8
Total Cocoa Crop Area (Ha)	0.84	0.74	0.05	5
Farming Trainings Attended	1.09	0.73	0	3
Number of Crops	3.85	1.82	1	12
Number of Livestock	1.08	0.86	0	4
Number of Intercropped Trees	122.51	231.53	0	2,000

Additional Independent Variables (in Number of Households)

Lampung Districts	*Pringsewu*	*Pesawaran*	*Tanggamus*
	61	68	61
Observed Climate Impact	*Low Crop Damage*	*High Crop Damage*	
	128	62	
Sex of Household Head	*Female*	*Male*	
	65	125	
If Given Increased Income	*No Ag Investment*	*Ag Investment*	
	69	121	
Increased Temperature	*Not Observed*	*Observed*	
	139	51	
Too Much Rain	*Not Observed*	*Observed*	
	40	150	

Table 4 displays the summary statistics used for Section 2, the multivariate probit model. Additional variables that were included show the total and cocoa land area of households, as well as the cocoa income of farmers and the number of intercropped trees cocoa farmers own.

Table 5: Results of Multivariate Probit of Determinants of CSA Practice Adoption

	Pruning	Organic Fertilizer	Field Sanitation	Side-grafting
Training	0.629**	0.844***	0.430	0.572*
	0.291	*0.315*	*0.429*	*0.355*
Agriculture Investment	0.135	0.203	0.138	0.044
	0.246	*0.243*	*0.291*	*0.277*
Crop Numbers	-0.329***	-0.265***	-0.201**	-0.127
	0.070	*0.070*	*0.098*	*0.081*
# of Livestock	0.401**	0.418***	-0.029	-0.035
	0.144	*0.136*	*0.170*	*0.152*
Income (10,000 IDR)	0.000	0.000	0.000	0.000
	0.000	*0.000*	*0.000*	*0.000*
Education HH	0.063*	0.071*	-0.008	0.024
	0.038	*0.035*	*0.042*	*0.037*
Age of HH	-0.006	0.465*	-0.004	0.003
	0.011	*0.227*	*0.013*	*0.011*
Male HH	0.526**	-0.006	0.436	0.524**
	0.238	*0.011*	*0.305*	*0.266*
Tanggamus	0.289	-0.013	-0.009	-0.236
	0.278	*0.253*	*0.314*	*0.279*
Pringsewu	-0.160	-0.049	-0.011	0.052
	0.290	*0.285*	*0.349*	*0.309*
# Family Members	-0.015	0.050	0.142	-0.028
	0.094	*0.093*	*0.122*	*0.105*
Increased Temp	0.282	0.042	0.698**	-0.204
	0.268	*0.242*	*0.278*	*0.274*
Too Much Rain	0.391	0.498*	0.630	0.052
	0.290	*0.278*	*0.446*	*0.295*
Cocoa Damage	-0.487*	-0.404	0.020	-0.590**
	0.267	*0.255*	*0.293*	*0.302*
Constant	-0.229	-1.823**	-2.173**	-1.391
	0.908	*0.851*	*1.065*	*0.954*

Wald chi2(70) = 112.27, Prob>chi2 = 0.001
Standard errors below coefficients
*** p<0.01, ** p<0.05, * p<0.1
Number of Observations=190
(HH=Household Head)

Table 5 shows the multivariate probit results of the model run in Section 2. The magnitude of each variable should not be taken into too much consideration as the margins for the multivariate probit model were not taken.

Table 6: Correlation of Residuals of CSA Practices-Rho Correlation

CSA practices	**Coefficient**	**SD**	**Z**
Pruning and Fertilizing	0.703***	0.087	8.11
Pruning and Shade Trees	0.224*	0.124	1.80
Pruning and Field Sanitation	0.474***	0.140	3.40
Pruning and Side-grafting	0.552***	0.117	4.70
Organic Fertilizing and Shade Trees	0.174	0.132	1.32
Organic Fertilizing and Field Sanitation	0.308**	0.136	2.27
Organic Fertilizing and Side-grafting	0.743***	0.088	8.47
Shade Trees and Field Sanitation	0.213	0.177	1.20
Shade Trees and Side-grafting	0.233	0.171	1.36
Field Sanitation and Side-Grafting	0.204	0.151	1.36

*** p<0.01, ** p<0.05, * p<0.1
chi2(10) = 90.0114 Prob > chi2 = 0.0000

Table 4 shows the correlation of error terms between all of the CSA practices. The high correlation among many of the variables shows that there is either positive benefits for adopting certain practices together or correlation due to some other unobservable variable. Having a high chi2 shows that running a multivariate regression is the correct method, as all of the practices regressed together show strong correlation among error terms, thus a univariate model would

Map 2: Elevation Change in Lampung Province (Darker Shades are Higher Elevation)

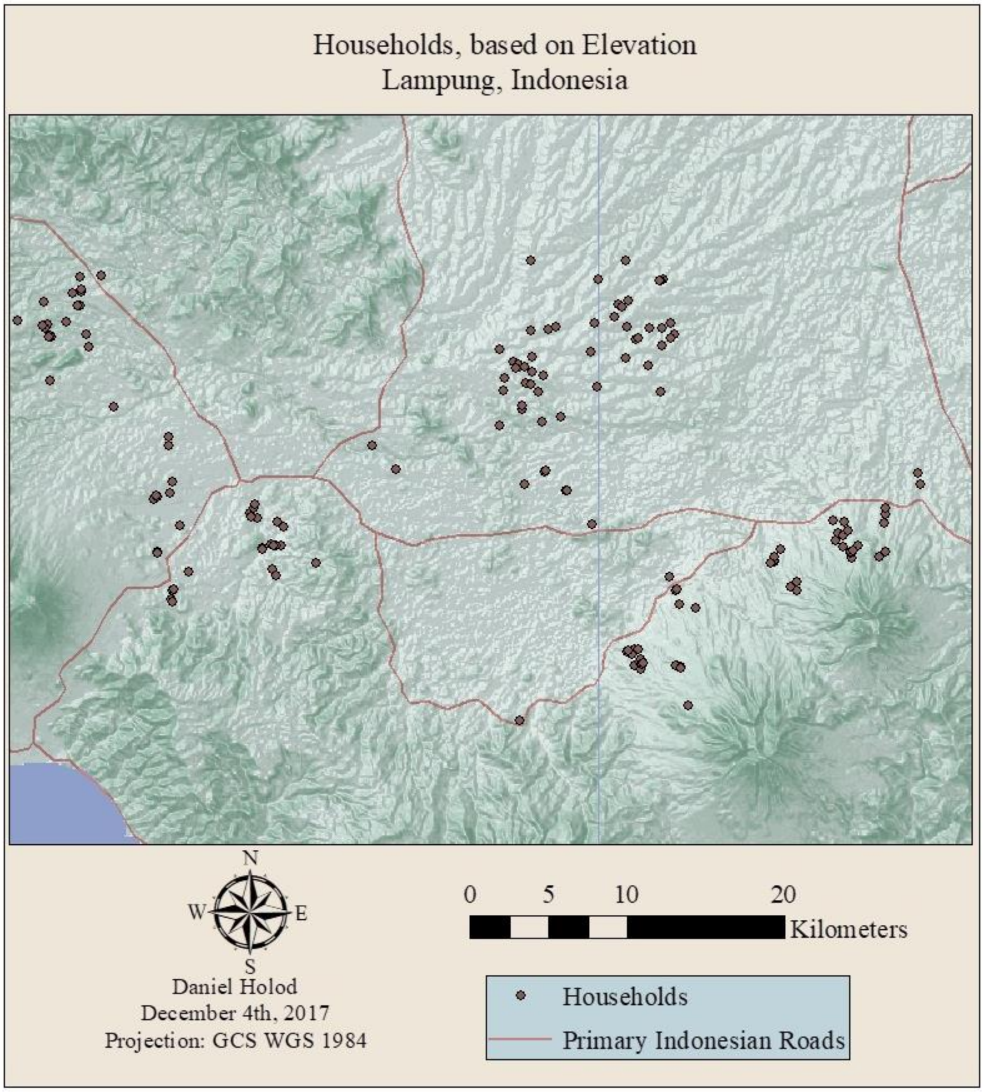


Table 7: Input and Labor Costs of CBA Packages per Hectare

Implementation of CSA Practices-Year 1								(IDR)
Inputs	**Units**	**BAU**	**Pack 1**	**Pack 2**	**Pack 3**	**Pack 4**	**Pack 5**	**Cost/Unit**
Lokal variety	seedlings	0	0	0	703	703	703	0
NPK	kg	225	28	28	28	28	225	2,600
Urea	kg	100	50	50	50	50	100	2,413
KCL	kg	0	46	46	46	46	0	5,833
Raw manure	kg	800	0	0	0		800	226
Pesticide	lt	23	2.8	2.8	2.8	2.8	2.8	168,257
Herbicide	lt	0	1	0	1	0	1	61,550
Making compost	ha	0	1	1	1	1	0	250,000
Improved variety	seedlings	0	703	703	0	0	0	10,000
Bindings (Side-grafting)	IDR/branch	0	397	397	0	0	0	526
Improved Seedlings (Side-grafting)	seedlings	0	397	397	0	0	0	10,000

Planting Equipment	set	1	1	1	1	1	1	131,983
Labor	**Units**	**BAU**	**Pack 1**	**Pack 2**	**Pack 3**	**Pack 4**	**Pack 5**	**Cost/ Day**
Applying fertilizer	man-day	13	9	9	9	9	13	60,000
Spraying pesticide	man-day	38	14	14	14	14	14	60,000
Formation pruning	man-day	0	11	11	11	11	11	60,000
Manual weedings	man-day	0	3	0	3	0	3	60,000
Making hole for field sanitation	man-day	0	10	0	10	0	10	60,000
Making compost	man-day	0	2	2	2	2	0	60,000
Labor for Side-grafting	man-day	0	2	2	0	0	0	60,000
Labor for Additional Planting	man-day	0	10	10	10	10	10	60,000
Maintenance Costs-Years 2-25								
Inputs	**Units**	**BAU**	**Pack 1**	**Pack 2**	**Pack 3**	**Pack 4**	**Pack 5**	**Cost/Unit**
Herbicide	lt	0	1	0	1	0	1	61,550
Making compost	ha	0	1	1	1	1	0	250,000
NPK	kg	225	536.5	536.5	536.5	536.5	225	2,600
Urea	kg	100	244.2	244.2	244.2	244.2	100	2,413
KCL	kg	133	188.7	188.7	188.7	188.7	133	5,833
Mutiara	kg	67	0	0	0	0	67	10,350
Raw manure	kg	367.5	0	0	0	0	367.5	226
Pesticide	lt	4.9	14.8	14.8	14.8	14.8	14.8	168,257
Labor	**Units**	**BAU**	**Pack 1**	**Pack 2**	**Pack 3**	**Pack 4**	**Pack 5**	**Cost/ Day**
Manual weedings	man-day	0	3	0	3	0	3	60,000
Making compost	man-day	0	2	2	2	2	0	60,000
Applying fertilizer	man-day	13	10	10	10	10	13	60,000
Spraying pesticide	man-day	46	46	46	46	46	46	60,000
Regular pruning	man-day	31	33	33	33	33	33	60,000
Intensive weedings (field sanitation)	man-day	0	0	0	0	0	0	60,000
Operational Costs-Years 3-25 (due to harvest of additional trees on existing cocoa plot)								
	Units	**BAU**	**Pack 1**	**Pack 2**	**Pack 3**	**Pack 4**	**Pack 5**	**Cost/ Day**
Spraying pesticide	man-day	0	43	43	43	43	43	60,000
Regular weedings (field sanitation)	man-day	0	34	0	34	0	34	60,000

Table 8: Cost Benefit Analysis General Information Appendix, delete this table.

General Variables	**Discount Rate**	**Exchange Rate**	**Financial Periods**	**Price/Kg**
	10%	13,514 IDR/USD	25 Years	28,400 (IDR)
Yield Change	**Change Begins**	**Response Max**	**Rate of BAU Yield Decrease**	
	3rd Year	10th Year	2 Percent	

Table 7 and 8 display the input costs and general information used for the CBA. These variables were run through CIAT's CBA tool.

Table 12: Incremental Net Benefits of CSA Package Adoption-Not Discounted (USD)

Year	*Package 1*	*Package 2*	*Package 3*	*Package 4*	*Package 5*
1	-582	-513	257	325	223
2	-205	-183	-201	-183	-135
3	-532	-359	-528	-359	-462
4	-27	-3	-382	-259	-339
5	479	352	-237	-159	-216
6	984	707	-93	-59	-94
7	1,489	1,061	52	41	28
8	1,993	1,416	196	140	150
9	2,497	1,770	340	239	272
10	3,001	2,124	484	338	393
11	3,014	2,137	497	350	405
12	3,027	2,149	509	363	418
13	3,039	2,161	522	375	430
14	3,051	2,174	534	387	442
15	3,063	2,185	545	399	454
16	3,074	2,197	557	411	466
17	3,086	2,208	568	422	477
18	3,097	2,219	579	433	488
19	3,108	2,230	590	444	499
20	3,118	2,241	601	455	510
21	3,129	2,251	611	465	520
22	3,139	2,261	622	475	530
23	3,149	2,272	632	485	540
24	3,159	2,281	641	495	550
25	3,168	2,291	651	505	560

Table 12 shows the net benefits of each year for the CBA discussed in Section 3. The table shows that though net benefits are positive, initial net costs are significant for CSA practices.

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