Improved Modeling of Household Food Security Decision Making and Investments Given Climate Change Uncertainty

Associate Award AIDOAA-LA-11-00010
under Food Security III, CDG-A-00-02-00021-00

Technical Progress Report for Year 2
October 1, 2012 to September 30, 2013

Prepared by Eric Crawford, Jennifer Olson, and Ayala Wineman

March 10, 2014

Project Web site: http://fsg.afre.msu.edu/climate_change/index.htm

Introduction

This project covers a three-year period from October 1, 2011, through September 30, 2014. The progress report presented here is for Year 2 (October 1, 2012, through September 30, 2013). The amount of the award is $698,865. Project Co-Principal Investigators are Eric W. Crawford, Professor, Department of Agricultural, Food, and Resource Economics (AFRE), and Jennifer M. Olson, Associate Professor, Department of Telecommunications, Information Studies, and Media. Other investigators include Jeffrey Andresen and Nathan Moore, Department of Geography, and Gopal Alagarswamy, Center for Global Change and Earth Observations. Other project personnel at MSU include Ayala Wineman, PhD research assistant (AFRE); Aaron Pollyea, Research Technologist (Geography); and Daniel Ddumba, PhD research assistant (Geography). Collaborating researchers in Kenya and Zambia are Joseph Maitima, Director, Ecodym Africa International (Kenya), and Brian Mulenga, Research Fellow, Indaba Agricultural Policy Research Institute (IAPRI, Zambia);

Purpose of Award

The complete Program Description, Year 2 work plan and progress indicators for this award are contained in Attachments A, B and C. Briefly, the purpose of the activities supported under this Award is to link the multiple-year household survey data sets that MSU has been involved in collecting in Kenya and Zambia, and MSU's coupled climate, crop, land use, and water availability models developed for East Africa, in order to improve understanding about how rural households are adapting to climate change (in terms of agricultural production practices and technologies, and perhaps other income-earning strategies), and about the impacts of anticipated future climate scenarios on farm household production, income, and food security. This information will help refine the climate change models and estimates of future household technology adoption and investment decisions, with implications for country program and policy priorities.

Activities and Outputs Proposed in the Year 2 Implementation Plan, and Status Report as of September 30, 2013

Zambia

1. *Rainfall data analysis*
    a. Analysis of monthly rainfall data for stations in the Northern and Southern provinces and preparation of graphs of seasonal and 9-year moving average annual rainfall (already completed).
    b. Analysis of high-resolution data from FEWSNET/UCSB. Status: *The MSU team met the UCSB team in Santa Barbara in April 2013, and has since communicated regularly with them to test the UCSB data sets against observed data for East Africa using various statistical approaches. The version of the monthly data set ready by September 2013 showed a low correlation with station data for several locations, with some locations having underestimated and others overestimated precipitation. The daily precipitation data set indicated too-frequent rainfall events. UCSB is working on revising the data sets. The monthly and daily data sets were not yet ready by the end of FY13. What remains for Year 3 is to continue working with UCSB, and*

to prepare Output 12—the technical report on the findings of the analyses described in 1.a and 1.b above.

2. *Development and use of climate-crop models*
    a. Calibrate the DSSAT model for two new maize varieties in Zambia—medium- and long-duration (already completed)—and if possible for other crops. Status: *The MSU team is working on calibration of a model for groundnuts.*
    b. Run the downscaled GCM data through a weather generator to derive daily data for the crop models (expected April 2013). Status: *Completed.*
    c. Use rainfall data to simulate maize yields for all of Zambia over the period of the historical data. This would be done for the two new maize varieties and for three levels of fertilizer. Status: *Completed.*
    d. Use the FEWSNET/UCSB data set as input for maize yield simulations under different climates and management practices for all of Zambia, and map those results. Status: *Not done since the UCSB daily rainfall data were not sufficiently validated. Recently received daily rainfall data from 10 new meteorological stations was used to run crop model for the stations nearest our study sites to obtain simulated yield under different management conditions for every year (1980 to 2012).*
    e. Conduct simulations of projected future yields using downscaled GCM climate data. Produce maps of projected yield, and expected change in yield from current climate conditions. Status: *Completed. More simulations were carried out than originally planned due to the interesting initial results—a total of 20 simulations (two cultivars and 2 nitrogen fertilizer levels, and 5 climates—to better analyze potential adaptation strategies.*

Output 13: Maps and statistics of simulated maize yield change based on (a) results of the already-completed DSSAT modeling using daily rainfall data (for Chipata and Lusaka stations), (b) the FEWSNET/UCSB data set, and (c) GCM-based future climate simulation results.

Expected by: August 2013. Dependent on availability of the UCSB data set.

Status: *Regarding Output 13, (a) and (c) were completed; (b) was not used for the reasons discussed in 1(b) above.*

3. *Refinement of household model*
    a. Conduct analysis of labor data from recent Crop Forecast Survey data, and compare with results of focus group surveys carried out in November 2012 and February 2013. Use as basis for revising labor coefficients in the household model.
    b. Refine other input coefficients for maize based on the recent Burke et al. study of the cost of maize production, and on analysis of the 2012 RALS data.
    c. Update price coefficients.
    d. Using the 2012 RALS data, and if necessary data from the 2008 household survey, develop 2-3 farm household types for each of the three study zones, reflecting different farm and family sizes and levels of resource endowment. Include coefficients for these household types in the model.
    e. Carry out initial runs of the model in each study zone for each household type.

Output 14: Models for Northern, Eastern, and Southern Provinces with updated labor, input-output, and price coefficients.
Expected by: July 1, 2013.
Status: *Activities 3.a through 3.e were carried out. A draft report was prepared by Ayala Wineman on June 21, 2013, entitled "Climate change and crop choice in Zambia; A math programming approach." The report covered: model construction, climate trends and predictions, crop yield functions, math programming model results for both a baseline scenario and under anticipated climate change. Regarding 3.b, input coefficients were revised for all crops, not just maize, based on the 2004 and 2008 supplemental surveys, as well as 2 years of the CFS and RALS 12. Regarding 3.d, so far only the 2008 supplemental survey has been used for household characterization. Other accomplishments include development of various alternative objective functions representing farmer risk and food security preferences, experimenting with a two-period model for Northern Province to better represent cassava production, and incorporating and labor and maize buy/sell markets into the model.*

4. *Refinement of linkage between climate, crop, and household models*
   a. Incorporate results of the DSSAT model for Northern, Eastern and Southern study regions into the agricultural household model. *(Underlining added here and in 4.b for clarification.)*
   b. Refine the statistical crop yield estimates based on incorporation of UCSB historical rainfall variables, as described above for Year 2 activity 1. Work is also needed to implement the procedures for incorporating the future climate scenarios into the statistical crop yield models, and to validate the models in consultation with MSU and Zambian crop scientists.
   c. Use the UCSB rainfall variables in a revised econometric analysis of the impact of weather variables on household food security.
   d. Compare results of the statistical yield models to the yield data collected in the Crop Forecast Surveys during the 2000 to 2012 period.

Output 15 Report on development of statistical crop yield models and comparison with survey data on yields.
Expected by: July 2013: dependent on availability of the FEWSNET/UCSB data.
Status: *(a) DSSAT model results are ready but have not yet been incorporated into the household models because of the need to do additional simulations and analysis to explain initial apparent inconsistencies between simulated DSSAT yields and yields observed in the national survey data. These inconsistencies were caused by two factors. First, we initially planned to use the simulated yields from DSSAT averaged by agro-ecological zone (AEZ) in the household model. However, significant climatic and soil heterogeneity in the AEZs, led to the AEZs having simulated mean yields that were much different from those reported in the surveys. To address this, a smaller area around the surveyed villages in the three study regions will be used to derive simulated mean yields.*

Second, the initial set of DSSAT simulations incorporated very low nitrogen application levels. Because of the severe limiting effect of low nitrogen on yield in Zambia, yield in the wetter north was not better than in the drier south, contrary to expectations. In much of the south there is sufficient water to permit adequate crop growth and yields. The lower levels of leaching in the south led to simulated yields that were similar to those in the north, which are negatively affected by high rainfall and leaching. Subsequent DSSAT simulations assumed a moderate level of nitrogen applied (split application). The higher rate of applied nitrogen replaces some of the nitrogen leached. Nitrogen is thus not such a limiting factor and yields are much higher, especially in the north where the plants have lots of water.

(b) The validation of the CHIRPS (UCSB) data continued beyond September 30, hence they were not used as outlined. Instead, 4.b was completed using historical meteorological station data, and downscaled GCM projections. Validation of the crop yield models also involved consultation with team climatologists regarding the rainfall variables used, and with econometricians regarding the specification of the model.

(c) Since the UCSB data were not ready, this activity was partially completed with alternative data, i.e., historical dekad (10-day) meteorological station data.

(d) The statistical crop yield models were estimated based on the CFS data, so the comparison outlined in 4.d was not relevant.

5. *Estimation of larger-scale (e.g., national) yield and production outcomes*
    a. Inputs for this activity will be the estimated distribution of future maize yields for all of Zambia based on the GCM and DSSAT model results, and the calculation of changes from current to future yields. Both are described in Year 2 activity b.
    b. The projected future yields will be compared to yields shown in the 2012 CFS and RALS data.
    c. Using the weights from the CFS and RALS surveys to calculate maize area, total future production could be calculated at the provincial and national level.
    d. ***Note*** These calculations will represent a simplification in that the changes in maize production in response to future climate scenarios would not take into account any change in maize variety, production input levels, or area under maize. Analysis using the household model will allow for those changes to be incorporated.

<u>Output 16</u> Report on results of 5.b and 5.c.

<u>Expected by</u>: September 2013.

<u>Status</u>: *DSSAT model results were generated as planned for two maize varieties under two different nitrogen fertilizer levels. However, activities 5.a through 5.c were not carried out because of the additional time required to address issues outlined in the status discussion of 4.a above.*

6. *Feedback workshops to share results of analyses with focus groups.* Originally scheduled for Year 2; postponed to Year 3.

Kenya

1. *Analyses of Kenya historical weather data.* The analysis will be completed using the same statistical approach and spatial time series climate data set (from FEWSNET/UCSB) as that used in Zambia. Contacts will be made to seek daily rainfall data for the Embu and Katumani research stations, which is known to exist, and if possible also for the Kitale research station.

Output 17	Report on results of Kenya activity 1.
Expected by:	September 2013. The daily meteorological station data was recently obtained and the statistical analysis is not completed. The analysis of the spatial rainfall data is dependent on availability of FEWSNET/UCSB data.
Status:	*Daily rainfall for several meteorological stations, including Katumani, was obtained in late FY13. As mentioned above, the UCSB data was not yet ready to analyze during Year 2.*

2. *Development and use of climate-crop models.* DSSAT models have already been calibrated for short- and long-duration maize varieties. In Year 2, yield simulations will be conducted for two levels of fertilizer application in Kenya (already completed).

Output 18	Report on results of Kenya activity 2.
Expected by:	September 2013.
Status:	*The DSSAT model had been calibrated for a drought-resistant maize variety (Katumani composite) earlier. In Year 2, it was also calibrated for a higher-yielding maize hybrid (H614) suitable for sub-humid to humid AEZs. Yield simulations were conducted for three levels of fertilizer application of the Katumani variety, and one fertilizer level for the hybrid. A technical report of the methodology and initial results will be submitted in March 2014.*

3. *Focus group surveys*. To be carried out by Ecodym starting in June for the three study zones, tentatively planned for Embu (Central/Mt. Kenya high potential small farms), Machakos (Central/East semi-arid small farms), and Rift Valley (medium- and large-scale farms).

Output 19	Report on results of focus group surveys.
Expected by:	July 2013.
Status:	*A serious accident suffered by consultant Dr. Joseph Maitima entailed a lengthy recovery, which has delayed the focus group meetings.*

4. *Initial development of household models.*
   a. Discussion is needed with the Tegemeo Institute regarding an appropriate collaborator for this activity. Some development of household models may have occurred under Tegemeo's Rockefeller Foundation-funded project.
   b. Data needed for model preparation or refinement will be collected, including that contained in crop budgets or available by analyzing the most recent national household survey.

Output 20: Write-up of initial prototype household models.
Expected by: September 2013.
Status: *(a) The project team met with Tegemeo Institute staff in July 2013, and were briefed on work being carried out by Tegemeo under its Rockefeller project, including statistical maize yield modeling similar to that undertaken by the MSU team for Zambia. Possible collaboration between our team and the Tegemeo staff was discussed. This analysis by Tegemeo was not completed as of September 30. (b) Efforts made to collect crop budgets and related information during the July 2013 visit, or to identify someone to carry out this work, were not successful. The Tegemeo Director suggested follow-up discussions with other Tegemeo staff involved in past preparation of crop budgets, but MSU team staff were not able to do so prior to September 30.*

Outreach. Outreach on project progress will be carried out in Zambia, in Kenya and in Washington, D.C., as follows:

1. Zambia: During the July trip by Olson and Crawford, an outreach seminar will be held at the Indaba Agricultural Policy Research Institute, hosting representatives of government ministries (e.g., Ministry of Agriculture) and donor agencies (e.g., USAID and SIDA). *Status: This outreach seminar was held on July 17, 2013 hosted by USAID-Zambia, and generated much discussion and interest in results to date, in results anticipated from remaining planned activities, and in activities that might be undertaken after Year 3. (See trip report for details.)*
2. Kenya: During the April/May trip by Olson, briefing sessions will be held at the Tegemeo Institute of Agricultural Policy and Development and with representatives of government agencies (e.g., Ministry of Agriculture and KARI) and donor agencies (e.g., USAID/Kenya, USAID/East Africa, Rockefeller Foundation, and World Agroforestry Centre). *Status: Completed.*
3. A Year 2 progress report seminar will be held in Washington, D.C., in September, 2013. *Status: By mutual consent between MSU and USAID/BFS, this seminar was held on October 28, 2013. The PowerPoint presentation from this seminar is available.*

Proposed Time Table of Trips (to be confirmed with country partners)

April/May Olson to travel to Kenya to work with Ecodym staff to initiate the focus group surveys. *Status: As noted, a serious accident suffered by consultant Dr. Joseph Maitima has delayed the focus group meetings.*

July Olson and Crawford to travel to Kenya and Zambia. *Conducted.*

September Olson and Crawford to travel to Washington, D.C. *Status: travel and briefing implemented on October 27-28.*

Collaboration with related projects

a. Participation by Jenny Olson in: Climate Change Vulnerability Assessments: Recent Approaches and Results March 27 – 28, 2013, Washington, DC. Role: Breakout Group One Facilitator, March 27. *Status: Conducted.*

b. Association of American Geographers, Annual Meeting 2013, Los Angeles. Paper Session (Jennifer M. Olson, Organizer: 3101 Climate change and food security in East and Southern Africa: Current challenges in basic and applied research, Thursday, April 11, 2013. Session was organized with Chris Funk of UC Santa Barbara and his team, and will include 3 presentations by MSU climate change researchers and 2 presentations by the UCSB team and their collaborators from NOAA and NASA.[1]
Status: *Conducted.*

[1] For details, see: http://meridian.aag.org/callforpapers/program/SessionDetail.cfm?SessionID=17544&cal=true

Attachment A: Program Description[2]

<u>Program Description</u>

Introduction

The activities proposed for implementation under this associate award will contribute directly to the goals of the Feed the Future (FTF) initiative. FTF focuses on sustainable reductions in hunger and poverty, with two key objectives: "accelerating inclusive agriculture sector growth and improving nutritional status" (FTF 2010, v). Climate change is recognized as a cross-cutting issue to be considered in designing programs to address FTF goals. The FTF Guide recommends that assessment of climate risk should be incorporated into food security efforts, stating: "Ensuring a sustainable and resilient agricultural development strategy requires countries to understand the potential implications of current and anticipated climate risks and vulnerabilities on the strategic objectives of their food security programs" (FTF 2010, 30-31).

Relatedly, the FTF Global Food Security Research Strategy notes that "advances in modeling of climates, production systems and actual or potential threats (e.g. pathogens, drought) can help guide research investments." (FTF 2011, 38). In addition, Zambia and Kenya include significant areas that fall into two of the Research Strategy's priority production systems, namely maize-based production systems in Southern and Eastern Africa and the East Africa highland system in which maize is also important. Regarding the former system, the Research Strategy notes that "maize is the defining crop for millions of food-insecure smallholders," and that "sustainable intensification equates with improving resilience in the face of frequent drought through improving soil moisture holding capacity and diversification for both fertility and income growth" (FTF 2011, 31)

Background

An increasingly important limiting factor for increased food production in Africa and Asia is climate, particularly low or erratic precipitation. Efforts to increase food production need to consider expected changes in climate as they affect agricultural productivity. These changes will affect high productivity zones, availability and access to food in neighboring deficit zones, as well as regional trade patterns. Efforts to develop agricultural responses resilient to climatic changes are limited by a lack of information on current and future environmental limitations, particularly at the sub-national level, and on their likely impacts on household food security.

Coupled climate, crop, land use and surface water simulation models can allow realistic analyses of the direct and interactive impacts of climate, soils and technological factors on crop production at a small fraction of the staff, financial and time requirements associated with standard field-level research. Nationally representative farm household survey data can provide the basis for modeling household production and income-earning activities in major agroecological zones, and for evaluating the impact of climate and weather factors on household food security outcomes.

Michigan State University has two groups of faculty members and researchers whose work relates to the above topics. First, a group of geographers and agro-climatologists has a regional

[2] As set forth in the technical proposal for the award.

climate-land modeling framework calibrated for East Africa that explores current and future effects of climate and management factors on crop production. Second, the MSU Food Security Group, consisting of nearly 20 faculty members based on campus and in the field, carries out a number of projects related to food security, of which the most significant is the Food Security III Cooperative Agreement. FSG projects in eastern and southern Africa have included support for multiple years of nationally representative farm household surveys, collected by the Central Statistical Office in Zambia and by the Tegemeo Institute and the Central Bureau of statistics in Kenya. These surveys include panels of the same households covering three different years in Zambia (with a fourth panel wave planned in 2012) and five different years in Kenya. Years and sample sizes are shown in Table 1. A map of the survey coverage in Zambia is in Annex F.

Table 1. National Farm Household Panel Surveys in Zambia and Kenya

Zambia		Kenya	
Year	**Sample Size**	**Year**	**Sample Size**
2001	6,922	1997	1,581
2004	5,421	2000	1,422
2008	8,094	2004	1,372
2012	(coming mid-2012)	2007	1,266
		2010	1,850

The East Africa regional modeling framework generates mapped results at the 18 x 18 kilometer scale, and site-level, higher-resolution results at the 6 kilometer scale. Climate data coupled to a process-based crop model can identify the effects of climate, climate variability and management practices such as fertilizer use, crop variety and planting dates on yields of rice, maize and other crops. The climate model coupled to a surface water model can provide information on the impact of climate change on water availability for human consumption, irrigation, or electricity generation. The model results can inform decisions on what crop varieties and management practices would be the most productive under current and projected future climate change. It can also provide information on the impact of climate change and variability on the amount of production available for household food security and trade. This type of modeling analysis can therefore directly support the value chain development objectives addressed by USAID.

In addition to modeling future crop productivity and water availability, analysis of historical data (remote sensing and meteorological station data) can provide information on climate trends from the 1960s to present, and their impact on maize and rice productivity. Critical questions being asked by governments, such as how rainy seasons are changing in length, start date, and reliability, or whether droughts are becoming more frequency and severe, can be examined.

There are several different potential approaches to defining the onset and cessation of the rainy season. For onset there are two potential approaches we are likely to use:

(1) Onset = first four rainfall events of 10 mm or more with no 7-day dry spell between any two such rainfalls. The reverse would be the cessation of the rainy season. Or,

(2) From Liebmann et al. (2007), using a formula for accumulated rainfall: Where the rainy season is the longest period for which anomalous accumulation remains greater than the annual

mean accumulation. This would also define the cessation point. For reliability, each station has data for a reliability function based on rainfall probability as outlined in Tshecko (2004).

The research and the policy-making process is being informed by engagement with rural communities to learn of their strategies for responding to current and expected climate change. Ecodym will be engaging with rural communities in Kenya through focus group discussions. MSU will hire local consultants to conduct focus group discussions in Zambia. Such information can inform the experimental design and the interpretations of modeling results, and results in more realistic and effective adaptation mechanisms.

MSU's Food Security Research Project (FSRP) in Zambia, funded for 2010-2015 by USAID and SIDA, will include nationally representative household data collection and food policy analysis that supports the goals of FTF and the Comprehensive African Agriculture Programme (CAADP). Climate change research by University of Zambia faculty and collaborators will be supported under the FSRP competitive grants program, and will focus on identifying farm household coping and adaptation strategies in response to climate change. The household-level economic modeling proposed for this Award will provide information on the impact of potential FTF project interventions and of climate variability on different household wealth categories, and support economic, nutrition and food security impact analysis of project interventions and climate change.

Purpose of Award

The purpose of the activities supported under this Award is to link the multiple-year household survey data sets available to MSU, and MSU's coupled climate, crop, land use, and water availability models, in order to improve understanding about how rural households are adapting to climate change (in terms of agricultural production practices and technologies, and perhaps other income-earning strategies), and about the impacts of anticipated future climate scenarios on farm household production, income, and food security. This information will help refine the climate change models and estimates of future household technology adoption and investment decisions, with implications for country program and policy priorities.

Proposed Activities

Briefly summarized, the proposed activities are as follows. The work will be carried out in two pilot countries, Zambia and Kenya, with Zambia activities beginning in Year 1 and Kenya activities beginning in Year 2.

1. Historical analysis of rainfall patterns over space and time using weather station data and a new promising Africa-wide data source, African Rainfall Estimation Algorithm (RFE).RFE and the Rainfall Estimation Algorithm refer to the same thing. RFE is the acronym for the operational product (daily precip. estimates across the African continent at 0.1 deg. spatial resolution), which is based on version 2.0 of the algorithm implemented in 2001. Data are currently available back to 2001 but efforts are underway to extend the data series back to 1982. Data are available via ftp at ftp.cpc.ncep.noaa.gov/fews/newalgo_est/ Nick Novella (Nicholas.Novella@noaa.gov) is the primary NOAA contact for this program.
2. Analysis of impact of past climate variability and trend changes on maize yields, using climate-crop models, and on indicators of household well-being such as food security and

income, using the multiple-year household data.As a comprehensive, dynamic crop model, DSSAT simulates crop growth and productivity on a daily or more frequent basis and directly links the effects of water supply on plant growth and development. Maize, for example, is very sensitive to a short dry period during its flowering stage. DSSAT should better reflect the overall impact of precipitation amounts and timing during the growing season than the Water Resource Satisfaction Index (WRSI) model, which is based on the mass water balance approach. Dynamic crop growth during the season is not explicitly accounted for in WRSI.

3. Projection of future climate scenarios and their impacts on maize yield and output. The results of downscaled GCMs and linked crop modeling will be geo-referenced. The output will be in the form of maps and data (e.g., maps of change in temperature, precipitation during growing season, change in maize yields, etc.). The scale of analysis is flexible; we have been using 6 km for the high-resolution, localized analyses.
4. Construction of farm household models, and incorporation into those models of projected future climate change and maize yield scenarios in order to identify impacts on future household production, farm and off-farm incomes, and food security. The result will be a prototype model that would provide household-to national-level information on impacts of recent and future climate change and variability (see Table 2).
5. Use of focus groups to guide the design and interpretation of (1) and (2), and feedback groups to discuss the outcomes of (3) and (4).
6. Outreach to key stakeholders in the pilot countries and in the U.S.

Attachment B: Performance Indicators and Targets, FY 2012 to 2014

Indicator	Target FY 2012	Target FY 2013	Target FY 2014
4.8.2-6 Person hours of training completed in climate change supported by USG assistance	a/		
4.8.2-14 Number of institutions with improved capacity to address climate change issues as a result of USG assistance	3 b/	8 c/	10 d/
4.8.2-26 Number of stakeholders with increased capacity to adapt to the impacts of climate variability and change as a result of USG assistance	4 e/	65 f/	105 g/
4.8.2-27 Number of days of USG funded technical assistance in climate change provided to counterparts or stakeholders	40 h/	36 i/	18 j/
Custom Indicator: Number of climate mitigation and/or adaptation tools, technologies and methodologies developed, tested and/or adopted as a result of USG assistance	3 k/	7 l/	9 m/

a/ No training explicitly included in proposal or budget.

b/ IAPRI (Indaba Agriculture Policy Research Institute, Zambia); UNZA (University of Zambia); GART/ZARI Research Station, Zambia.

c/ (b) plus 3 farmer groups (Zambia) and Ecodym plus Ministry of Agriculture (Kenya)

d/ (c) plus 2 farmer groups (Kenya)

e/ IAPRI (1 researcher); UNZA (3 researchers)

f/ (e) plus 3 farmer groups x 20 participants (Zambia) plus Ecodym (1 researcher)

g/ (f) plus 2 farmer groups x 20 participants (Kenya)

h/ 20 days (Zambia) plus 20 days (Kenya)

i/ 18 days (Zambia) plus 18 days (Kenya)

j/ 6 days (Zambia) plus 12 days (Kenya)

k/ Methods for identifying climate trends; crop model calibrated for Zambia; draft farm household model for Zambia.

l/ (k) plus crop model calibrated for Kenya and draft farm household model (Kenya) plus two adaptation technologies identified for Zambia

m/ (l) plus two adaptation technologies identified for Kenya.

Attachment C: Annotated List of Acronyms

CCSM	The "Community Climate System Model" GCM developed by the National Center for Atmospheric Research in Boulder, Colorado.
CSIRO	A GCM developed by the Commonwealth Scientific and Industrial Research Organization of Australia.
DSSAT	The Decision Support System for Agrotechnology Transfer is a process-based crop model (i.e., models the entire phenology or life-span of the crop) that has inputs such as soil characteristics, radiation, fertilizer inputs, planting date, crop cultivar characteristics and daily temperature and rainfall. It thus facilitates comparing simulated crop yields across different locations, climate, management, and/or cultivar characteristics.
ECHAM	A GCM developed by the Max Planck Institute for Meteorology in Hamburg, Germany.
FSRP	The Food Security Research Project, funded by USAID as an associate award under the Michigan State University Food Security III cooperative agreement.
GART	The Golden Valley Agricultural Research Trust, a public/private organization of the Zambian Ministry of Agriculture and the Zambia Farmers Union. It conducts research and promotes agricultural methods for small scale farmers including conservation farming.
GCM	General Climate Model, or Global Circulation Model (used interchangeably). This is the general term for climate models developed to simulate global atmospheric circulation patterns over space and time including the impact of enhanced GHG.
GHG	Greenhouse gases, including water vapor, carbon dioxide, methane, nitrous oxide and ozone, which absorb and emit radiation in the atmosphere.
HadCM3	A "Hadley Centre Coupled Model," a GCM developed by the UK Meteorology Office in Exeter, UK.
IAPRI	The Indaba Agricultural Policy Research Institute in Zambia (newly established, houses the FSRP).
MSU	Michigan State University
SRES A1B	"Special Report on Emissions Scenarios" (SRES) refers to levels of greenhouse gas emissions that are used in GCM scenarios to make projections of possible future climate change. SRES levels were established by the Intergovernmental Panel for Climate Change (IPCC, the international body preparing consensus scientific reports on climate change). A1B represents a moderately aggressive level of enhanced GHG (some adoption of reduced GHG emissions and eventual slowing of population growth).
UNZA	The University of Zambia.

WISE	A global (including the tropics) database of soil profile information developed by the Consultative Group on International Agricultural Research (CGIAR). The Food and Agriculture Organization (FAO) and the International Soil Reference and Information Centre (ISRIC) have combined WISE with other data to form a spatially explicit soils database.
WorldClim	A spatially explicit global database representing the “average” monthly climate based on modeling several years (1950-2000) of available meteorological station data. In our project, it represents current climate.
ZMD	Zambia Meteorological Department
ZARI	The Zambia Agricultural Research Institute, under the Zambian Ministry of Agriculture and Livestock