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

Associate Award AIDOAA-LA-11-00010
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Technical Progress Report for Year 3
October 1, 2013 to September 30, 2014

Prepared by Eric Crawford, Jennifer Olson, and Ayala Wineman

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

Abbreviations

AFRE	Agricultural, Food, and Resource Economics
CERES	Crop Estimation through Resource and Environment Synthesis
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data[1]
DSSAT	Decision Support System for Agrotechnology Transfer
FEWSNET	Famine Early Warning System Network
GCM	General Circulation Model; Global Climate Model[2]
IAPRI	Indaba Agricultural Policy Research Institute, Zambia
MODIS	Moderate-resolution Imaging Spectroradiometer[3]
NASA POWER	NASA Prediction of Worldwide Energy Resource
UCSB	University of California, Santa Barbara
WISE	World Inventory of Soil Emission Potentials

[1] Produced by researchers at the University of California, Santa Barbara.
[2] A second, more recent, meaning, different from the first (since *general circulation models* are usually a tool for modeling climate), but sometimes used interchangeably (encyclopedia.thefreedictionary.com/Global+Climate+Model)
[3] A payload scientific instrument launched into Earth orbit by NASA in 1999 on board the Terra (EOS AM) Satellite, and in 2002 on board the Aqua (EOS PM) satellite.

Introduction

This project covers a three-year period from October 1, 2011, through September 30, 2014. It was granted a seven-month extension, so the new end date is April 30, 2015. The progress report presented here is for Year 3 (October 1, 2013, through September 30, 2014). 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 Media and Information. 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, respectively, 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 3 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 3 Implementation Plan, and Status Report as of September 30, 2014

Zambia

1. *Research and policy outreach workshops.* A high-level policy/research workshop, proposed earlier by USAID/Zambia, was held on April 10, 2014, at the Chismar Hotel in Lusaka. A large group of guests included the Permanent Secretary of the Ministry of Agriculture, who opened the meeting, representatives of that and other Ministries, researchers from the University of Zambia, international donor agencies and embassy representatives including from USAID, Norway, Japan and the U.K., Zambian NGOs and others. It was organized by the Indaba Agricultural Policy Research Institute (IAPRI). We were asked to do short presentations focused on our main research results and implications for Zambian policy and programs related to climate change and agriculture. Olson, Crawford and Wineman made presentations, followed by other researchers.

After this high-level workshop, USAID/Zambia suggested that IAPRI host a second climate change/agriculture workshop to report and discuss our results for researchers, key staff of the Ministry of Agriculture and USAID, and others. This was held on August 19, 2014 at IAPRI. Olson and Crawford presented their results in more detail than during the April workshop, and a good discussion followed.

2. *Rainfall data analysis:* Two activities were planned to be undertaken:
    a. Analysis of high-resolution precipitation data from FEWSNET/UCSB, called CHIRPS. During FY 2014, the MSU team continued to work with the UCSB team to validate pre-release versions of this dataset for East Africa and Zambia against observed meteorological station data. The CHIRPS daily dataset continued to have major issues, including over-estimating the frequency of rainfall, and serious under- and over-estimates of rainfall in different locations. The UCSB team released a revised version (CHIRPS v1.8) to some members of the general public in April 2014. Unfortunately, UCSB realized in October 2014 that v1.8 had errors in East Africa, especially in northern Tanzania. Nevertheless, we have been attempting to prepare the dataset for analysis at the point and, in ArcGIS, spatial levels. (The CHIRPS dataset is very large—over 180 gigabytes for the daily precipitation dataset at 1 km resolution for Africa.) This has involved writing computer programs and communicating regularly with UCSB and others. As of September 30, 2014, we were just at the point of testing the programs, and extracting the data for analysis.

3. *Development and use of climate-crop models*
    a. The MSU team completed the calibration of the DSSAT crop model for groundnuts, and ran the model under various climate conditions (current and four future scenarios) to examine the projected impact of climate change on groundnut yields. Groundnuts are not as sensitive as maize to expected climate changes, or to the nitrogen deficiencies in Zambian soils.
    b. Maize yield simulations were carried out under different climates and management practices for Zambia, and those results were mapped. Two sets of rainfall data were used for this purpose:
        i. Daily rainfall data from 10 meteorological stations was used to run the crop model for the stations nearest to our three study sites to obtain simulated yield under different management conditions for every year (from 1980 to 2012) for two maize cultivars. The results were presented at the workshops. They illustrated the impact of precipitation variability, including dry spells in the growing season and heavy rainfall events, on maize yields.
        ii. We had planned to run the crop model using the FEWSNET/UCSB (CHIRPS) daily rainfall data. However, the dataset was ready later than we had expected (see 2.a above). This activity was therefore postponed until FY 2015.
    c. Simulations of the impact of projected future climate change on yields were conducted using downscaled GCM climate data for all of Zambia. In FY 2014, 20 simulations were completed for two maize cultivars. (In FY 2015, simulations of the impact of future climate change on groundnut yields were completed.

4. *Refinement of statistical crop yield functions.* Further improvements were made in the statistical crop yield functions, especially related to crop yield response to temperature changes, and evaluation of impacts of temperature variables. A report on this work was drafted (Output 15 from Year 2; see Wineman and Mulenga, 2014).

5. *Refinement of household models*
   Refinements made during FY 2014 include the following. This work is described in Wineman and Crawford, 2014a, and in Wineman, 2014b and 2014c.
   a. Improvement in calibration method to ensure accuracy in representing both current farming patterns and feasible/plausible responses to climate-induced changes in crop yield.
   b. Assessment of alternative model solution methods within Excel.
   c. Improvement of household risk analysis under various climate change scenarios. This task is linked to improvement of the crop yield functions, particularly for cassava.
   d. A more complete gender analysis of our predicted climate-induced changes in cropping choices.
   e. Incorporation of minimum tillage production activities.

6. *Refinement of linkage between climate, crop, and household models*
   a. Estimated district-level yields for 2050 from the DSSAT model for Northern, Eastern and Southern zones were compared to those resulting from the statistical crop yield models. Estimated from the latter were incorporated into the household models., since they were based on survey data on yields reported by farmers.
   b. A method for incorporating a distribution of 2050 yields into the household models was implemented for all crops, to evaluate vulnerability under adverse conditions.
   c. This work was written up in a technical report of household vulnerability to climate change for the three study sites (Wineman and Crawford, 2014a).

7. *Estimation of larger-scale (e.g., national) yield and production outcomes* (proposed for Year 2)
   a. Inputs for this activity were the already-completed estimates 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.
   b. The weights from the CFS and RALS surveys were used to calculate maize area and total future production at the provincial and national level.
   c. The results of this estimation (listed as Output 16 proposed for Year 2) were reported in Wineman, 2014a.

8. *Feedback workshops to share results of analyses with focus groups.* Originally scheduled for Year 2, these were postponed to Year 3. On August 20-21, 2014, Olson, Crawford and Mulenga, an IAPRI research associate working on the climate change project, went to Chiparamba Block, Chipata District, to provide feedback on the research results, and discuss the findings and implications for adaptation. They met with a group of farmers (8 women and 5 men) who had been visited at the outset of the project, and the block's agricultural

extension agent, David Likukela. Due to limited time available during this trip to Zambia, feedback workshops were not carried out in the northern and southern study sites.

Kenya

1. *Analyses of Kenya historical weather data.* The team obtained daily rainfall data from nine meteorological stations in April 2014. The completeness of the datasets are not very good; missing values ranged from 10% to 40% of the total, averaging about 10%. Because of this, many years were discarded for conducting the trends analysis. The write-up of these results which corresponds to Output 17 from Year 2, will be completed by the end of the project.

2. *Development and use of climate-crop models.* In Year 3, a hybrid cultivar developed for the wetter highland zones (Hybrid 614) was calibrated for CERES Maize/DSSAT and modeled. Yield simulations were conducted for three levels of fertilizer application and five climates (current and four GCM future climates) across East Africa to identify the impact of climate change and variability on yields under different management practices. This analysis, which corresponds to Output 18 from Year 2, will be written up by the end of the project.

   In addition, point-level simulations of the two maize cultivars, Hybrid 614 and the drought-resistant cultivar Katumani Composite, were conducted in two sites in Kenya near our field sites where we have daily data (Eldoret and Katumani). The simulations were run with observed rainfall data, and NASA POWER solar radiation and temperature data. Results have been presented (in FY 2015) as graphs of simulated yield over time under the two cultivars and several fertilizer applications.

3. *Focus group surveys*. In order to gather data on labor inputs to crop production to support the household modeling component of the project, Ecodym staff carried out focus group meetings in each study zone (Katumani/Machakos (Central/East semi-arid small farms), Eldoret/Rift Valley (medium- and large-scale farms), and Embu/Meru (Central high potential small farms). Owing to a miscommunication, Ecodym staff did not—during these field trips—carry out the more general focus group discussions originally planned to elucidate farmers' perceptions of climate change and adaptation measures. These FGDs will be conducted during FY 2015, and results will be reported in what corresponds to Output 19 from Year 2.

4. *Development and use of household models.* The two major activities required to design the farm household models were (a) estimation of input/output coefficients for the principal crop production activities to be incorporated in the models, and (b) estimation of statistical crop yield functions to allow modeling of the impacts of climate change on crop yield. Regarding these two activities:

   a. The long-term panel data collected by the Tegemeo Institute of Agricultural Policy and Development (a unit within Egerton University but based in Nairobi) was analyzed to determine the major production activities in each of the three zones, and to estimate the per-acre levels of material and hired labor inputs. The major element missing from the Tegemeo panel data was information on per-acre family labor.

Other crop budgets were obtained from Tegemeo researchers, but they did not provide better data for the sites and production activities incorporated in the household models. Efforts to gain access to a recent nationwide survey, under the Agricultural Sector Development Support Programme, were unsuccessful as of September 30, 2014.

b. At the outset of the project, it was anticipated that the statistical crop yield functions would be estimated by Tegemeo Institute researchers under an existing project funded by the Rockefeller Foundation. When this work was delayed, MSU project PhD research assistant, Ayala Wineman, analyzed available rainfall and temperature data and estimated the impacts of weather variability on crop yield for the crops covered in the household models.

c. Putting the results of the two activities together, an initial set of agricultural household models was completed and used to obtain preliminary results. These were reported in Wineman and Crawford, 2014b, which corresponds to Output 20 from Year 2. Work to improve the empirical basis for the models continued in FY 2015.

d. It is worth noting that contrary to our expectations at the beginning of the project, the data available to support the household modeling, specifically activities (a) and (b) above, turned out to be better for Zambia than for Kenya. While the panel dataset available in Zambia included fewer waves (3) and a shorter time frame than in Kenya (6), in Zambia we found that we were able to supplement the panel data with ten years of data from the national Crop Forecast Survey, which contained information on yields and labor inputs that were superior to the panel data in Zambia and Kenya.

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

1. Zambia: (a) research and policy workshop conducted in Lusaka in April 2014, and another in Lusaka in August 2014; and (b) a feedback workshop in one of the three study sites, conducted in Chipata District in August 2014 by Crawford, Olson and Mulenga. As noted earlier, time constraints prevented carrying out feedback workshops in the other two sites.
2. Kenya: Due to a US State Department Travel Warning for Kenya, our travel to Kenya to collect additional data needed for the household model and to conduct an outreach seminar was postponed. Ayala Wineman was able to visit Kenya in October 2014 to collect data for the household modeling.
3. The Year 3 project report seminar was held at USAID in Washington, D.C. on November 17, 2014.
4. Our project was included as a "climate snapshot" on the website and in the September 2014 Monthly Newsletter of USAID FTF (http://www.feedthefuture.gov/article/snapshots-advancing-global-food-security-changing-climate).

Proposed Time Table of Trips for FY 2015 (to be confirmed with country partners)

October	Wineman travel to Kenya
November	Crawford and Olson travel to Washington
April	Olson and Crawford to travel to Kenya for outreach seminar
April	Olson, Wineman and Crawford to travel to Washington, D.C. for final Year 4 project seminar.

Works Cited

Wineman, Ayala, and Brian Mulenga. 2014. Sensitivity of field crops to climate shocks in Zambia. Draft. August 18.

Wineman, Ayala, and Eric Crawford. 2014a. Climate change and crop choice in Zambia: A mathematical programming approach. Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2014 AAEA Annual Meeting, Minneapolis, MN, July 27-29.

Wineman, Ayala, and Eric Crawford. 2014b. Climate change and crop choice in Kenya. Draft. September 14.

Wineman, Ayala. 2014a. Maize production in the future. March 31.

Wineman, Ayala. 2014b. Modeling minimum tillage among smallholders in Eastern Zambia. Draft. July 22, 2014.

Wineman, Ayala. 2014c. Climate change and crop choice in Zambia; A mathematical programming approach (with detailed appendix). Draft. March 10.

Other Reports and PowerPoint Presentations Available for FY 2014

Crawford, Eric, and Jennifer Olson. 2014. Report on Trip to Zambia Under the Project "Improved Modeling of Household Food Security Decision Making and Investments Given Climate Change Uncertainty." August 16-24, 2014.

PowerPoint Presentations:

Olson, Jennifer, Eric Crawford, Ayala Wineman, Brian Mulenga, Lydia Chabala, and Elias Kuntashula. 2014. Climate Change Impacts on Agriculture and Household Decisions, and Implications for Adaptation. PowerPoint presentation given at Chrismar Hotel, Lusaka, Zambia, Afternoon April 10, 2014.

Olson, Jennifer, Eric Crawford, Ayala Wineman, Lydia Chabala, and Elias Kuntashula. 2014. Overview and current results of studies by IAPRI, MSU, and UNZA on climate change trends and impacts in Zambia. Presented at IAPRI, Lusaka, Zambia, April 8, 2014.

Olson, Jennifer, Gopal Alagarswamy, Jeff Andresen, and Nathan Moore. 2014. Latest results on Climate Change and Variability Impacts on Crop Productivity in Zambia. Presented at IAPRI, Lusaka, Zambia, August 19, 2014.

Olson, Jennifer, Gopal Alagarswamy, Jeff Andresen, Eric Crawford, Joseph Maitima, Amos Majule, Nathan Moore, William Otim-Nape, and Pius Yanda. 2014. Addressing the

Impact of Climate Change on Agricultural Systems in East Africa. Michigan State University, University of Dar es Salaam, African Innovations Institute, and Ecodym Africa. Presented at the Kenya Agricultural and Livestock Research Organisation, Katumani, Kenya, Dec. 15, 2014.

Wineman, Ayala, Eric Crawford, and Brian Mulenga. 2014. Modeling Climate Change Impacts on Farm Households in Zambia. Presented at Chrismar Hotel, Lusaka, Zambia, Afternoon April 10, 2014.

Wineman, Ayala, Eric Crawford, and Brian Mulenga. 2014. Modeling Climate Change Impacts on Farm Households in Zambia. Presented at IAPRI, Lusaka, Zambia, August 19, 2014.

Attachment A: Program Description[4]

Program Description

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

[4] 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	1,535
2004	5,421	2000	1,512
2008	8,094	2004	1,397
2012	(coming mid-2012)	2007	1,342
		2010	1,309

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.
ZMS	Zambia Meteorological Service
ZARI	The Zambia Agricultural Research Institute, under the Zambian Ministry of Agriculture and Livestock