Implementation Plan for Year 4 (FY 2015)—*Draft September 10, 2014*

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

Introduction

This project covers a three-year period from October 1, 2011, through September 30, 2014. It was granted a seven-month no-cost extension through April 2015. The implementation plan presented here is for this extension in Year 4 (October 1, 2014, through April 30, 2015).

Purpose of Award

The complete Program Description for this award is contained in Attachment A. Briefly, the purpose of the activities supported under this Award is to link the multiple-year household survey datasets 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.

Work Plan for Seven Months in Year 4 (FY 2015)

Zambia

1. *Rainfall data analysis*
   Analysis of high-resolution spatial data from FEWSNET/UCSB known as CHIRPS. During FY 2013 and FY 2014, the MSU team worked with the UCSB team to validate this dataset for East Africa and Zambia and found many problems of systematic bias. UCSB continued to work on the dataset, and released version 1.8 in mid-2014. The MSU team will examine this latest version by statistically comparing it to Zambia observed meteorological station precipitation data.

2. *Development and use of climate-crop models*
   Carry out historical maize yield simulations under different management practices for Zambia. In FY 2104, this was done using observed precipitation data (meteorological station data). If the results of the CHIRPS dataset analysis from (1) above is promising, we will conduct maize simulations using the CHIRPS dataset as well.

3. *Refinement of statistical crop yield functions.*
   The estimation of statistical crop yield functions is complete and has been used as the basis for the agricultural household model analysis. A technical report on this work will be submitted in the first quarter of calendar 2015. In order to perfect the crop yield functions for broader circulation and possible publication, we would like to address a few technical issues, and will do so if the necessary expertise can be mobilized in the time remaining.

4. *Refinement of household models*
   Work planned for FY 2014 was completed except for a sensitivity analysis to account for likely trajectories of technology development (e.g., seed improvements). It is difficult to choose among the large number of possible improvements. Illustrative analysis for Eastern Province will be carried out to determine the percentage improvement in maize yields that would be necessary in order to offset anticipated impacts of climate change by 2050.

Kenya

1. *Complete the analyses of Kenya historical weather data.* The analysis will focus on recently obtained daily rainfall data from several meteorological stations including the Katumani research station. The analysis will be reported in what corresponds to Output 17 from Year 2.

2. *Development and use of climate-crop models.* In Year 3, a maize cultivar developed for the wetter highland zones was modeled spatially for Kenya, to add to the short-duration drought-resistant maize cultivar that we had previously modeled. In Year 4, additional point-level simulations of both short and long-duration maize cultivars (already done for Katumani and Eldoret) will be conducted for Meru/Embu and other sites using meteorological station data on daily precipitation. Results will be graphs of simulated yield over time under different cultivars and fertilizer applications.

3. *Development and use of household models.*
   a. The statistical crop yield functions that were expected to be estimated by Tegemeo Institute researchers have not been forthcoming. Instead they will be estimated by MSU graduate research assistant Ayala Wineman.
   b. Data short-comings affecting completion of the linear programming models of agricultural households in the three sites will be addressed. This includes specification of per-hectare yields and labor requirements for the crop production activities, and representation of the multiple-year input requirements and outputs associated with key tree crops such as coffee and bananas. Further trips to Kenya, and additional work by in-country consultants, will be carried out in order to mobilize additional data and information to address these issues.
   c. Results of the crop yield and agricultural household model analysis will be written up in what corresponds to Output 20 from Year 2, to be submitted in April 2015.

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

1. Zambia: (a) outreach presentation tentatively scheduled for March 2015.
2. Kenya: (a) Final project workshop in Nairobi tentatively planned for January 2015; and (b) final feedback workshops in each study area tentatively planned for January and February 2015. Final Nairobi workshops will involve the Tegemeo Institute of Agricultural Policy and Development, and 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).
3. Washington, D.C.: (a) Year 3 progress report seminar tentatively scheduled for November 2014 and end-of-project progress report seminar tentatively scheduled for April 2015.

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

November 2014	Olson, Crawford, and Wineman to travel to Washington, D.C.
January 2015	Olson and Crawford to travel to Kenya; possible travel by Wineman to Kenya from Tanzania
March 2015	Olson and Crawford to travel to Kenya and Zambia.
April 2015	Olson, Crawford, and Wineman to travel to Washington, D.C.

Attachment A: Program Description[1]

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

[1] 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	8,839 (new panel) a/	2007	1,266
		2010	1,850

a/ Information updated, December 2013.

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 datasets 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 georeferenced. 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.