Implementation Plan for Year 3 (FY 2014)—*Draft December 11, 2013*

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. The implementation plan presented here is for Year 3 (October 1, 2013, through September 30, 2014).

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 Year 3 (FY 2014)

Zambia

1. *Research and policy outreach workshop.* Proposed by USAID/Zambia for February 2014, this workshop would consist of separate sessions during a two-day period, one to convene researchers to share results and discuss ways of strengthening the analysis planned for the remainder of the FY, and a second to convene government, NGO, and donor representatives to review results to date.

2. *Rainfall data analysis:* Two activities will be undertaken:
    a. Analysis of high-resolution spatial data from FEWSNET/UCSB. During FY 2013, the MSU team worked with the UCSB team to validate this dataset for East Africa and Zambia. The latest version of the daily data shows a low correlation with station data and indicates too-frequent rainfall events. What remains for Year 3 is to prepare Output 12—the technical report on the findings of the validation exercise.
    b. Additional daily meteorological station data was recently obtained for several stations. These will be statistically analyzed to identify any changes in seasonality.

3. *Development and use of climate-crop models*
    a. Calibrate the DSSAT model for additional cultivars/crops. The MSU team will complete the calibration of a model for groundnuts, initiated during FY 2013.
    b. Carry out historical maize yield simulations under different climates and management practices for all of Zambia, and map those results. Two sets of rainfall data may be used for this purpose:
        i. Daily rainfall data from 10 meteorological stations—received in October 2013 thanks to assistance from USAID/Zambia/EG—will be used to run crop models for the stations nearest our study sites to obtain simulated yield under different management conditions for every year (1980 to 2012) for two maize cultivars.
        ii. FEWSNET/UCSB (CHIRPS) daily rainfall data, if further modifications to this dataset result in sufficient improvement in the daily data.[1]
    c. Refinement of simulated future yields using downscaled GCM climate data for all of Zambia. Twenty simulations (two maize cultivars, two nitrogen fertilizer levels, and five climate surfaces[2]) were carried out in FY 2013. In FY 2014, simulations of the impact of future climate change on groundnut yields will be completed. Results will be presented in maps and district-level statistics
    d. Output 13 from FY 2013 will be completed: Maps and statistics of simulated maize yield change based on (a) observed daily rainfall data, (b) CHIRPS data (if validation tests are passed), and (c) GCM-based future climate simulation results.

4. *Refinement of statistical crop yield functions.* Further improvements in the statistical crop yield functions, especially related to crop yield response to temperature changes, including re-estimation using the new rainfall data obtained for 10 stations, evaluation of impacts of temperature variables, and completion of report on this work (Output 15 from Year 2).

5. *Refinement of household models*
   Work planned for FY 2013 was completed. Further refinements include:
    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. A sensitivity analysis to account for likely trajectories of technology development (e.g., seed improvements).

[1] Validation tests conducted during FY 2013 showed a low correlation between the CHIRPS daily data and meteorological station data, and also a pattern of too-frequent daily rainfall. It is not known whether further improvements in the CHIRPS data will justify using in as an input for the DSSAT crop models.
[2] Current plus estimates for 2050 from four GCMs.

6. *Refinement of linkage between climate, crop, and household models*
    a. Incorporate estimated district-level yields for 2050 from the DSSAT model for Northern, Eastern and Southern zones.
    b. Implement a method for incorporating a distribution of 2050 yields into the household models, to evaluate vulnerability under adverse conditions.
    c. Produce a technical report of household vulnerability to climate change for the three study sites.

7. *Estimation of larger-scale (e.g., national) yield and production outcomes* (proposed for Year 2)
    a. Inputs for this activity will be 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. 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.
    c. ***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. Household model results could be aggregated at the level of each of the three study sites.
    d. Report results of this estimation (listed as Output 16 proposed for Year 2).

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

<u>Kenya</u>

1. *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.[3]

2. *Development and use of climate-crop models.* In Year 2, the DSSAT model had already been calibrated for a short-duration, drought-resistant maize cultivar. In Year 3, a cultivar developed for the wetter highland zones will also be modeled. Yield simulations will be conducted for three levels of fertilizer application and five climates (current and four GCM future climates) across Kenya, and the impact of climate change on yields under these different management conditions will be analyzed. The analysis will be reported in what corresponds to Output 18 from Year 2. In addition, point-level simulations of maize will be conducted in three sites in Kenya similar to the activity described in activity 3.b.i. using meteorological station data on daily precipitation. Results will be graphs of simulated yield over time under different cultivars and fertilizer applications.

3. *Focus group surveys*. To be carried out by Ecodym in the three study zones: Embu (Central/Mt. Kenya high potential small farms), Katumani/Machakos (Central/East semi-arid

[3] That report was to include results of analysis of the FEWSNET/UCSB CHIRPS data. However, these data have not been analyzed in detail because of problems identified during validation (described above).

small farms), and Eldoret/Rift Valley (medium- and large-scale farms). Focus group interviews in Embu have already been completed. Results will be reported in what corresponds to Output 19 from Year 2.[4]

4. *Development and use of household models.*
    a. Data needed for model preparation or refinement will be collected, including that contained in crop budgets prepared by researchers at the Tegemeo Institute.
    b. Models will be developed by PhD students at MSU, with possible involvement of a Tegemeo researcher or other consultant in Kenya.
    c. The statistical crop yield functions that are expected to be one input to these models are being estimated by Tegemeo Institute researchers Kirimi and Gitau under an existing project funded by the Rockefeller Foundation.[5]
    d. Results will be written up in what corresponds to Output 20 from Year 2.

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

1. Zambia: (a) research and policy workshop tentatively planned for February 2014; and (b) final outreach workshops including visits with focus groups in each study area tentatively planned for July 2014.
2. Kenya: (a) interim project progress workshop tentatively planned for February 2014; and (b) final outreach workshops including visits with focus groups in each study area tentatively planned for July 2014. 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. A Year 3 final project report seminar will be held in Washington, D.C., in September, 2014.

Proposed Time Table of Trips for 2014 (to be confirmed with country partners)

February	Olson and Crawford to travel to Kenya and Zambia
July	Olson and Crawford to travel to Kenya and Zambia.
September	Olson and Crawford to travel to Washington, D.C.

[4] This activity has been delayed in part because Dr. Maitima from Ecodym suffered a serious auto accident which required a several-month period of convalescence.

[5] The involvement of Tegemeo Institute researchers in activities under the associate award continues to be constrained by their existing work plan, including activities under the Rockefeller-funded project.

Attachment A: Program Description[6]

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

[6] 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.