Feed the Future Innovation Lab for Collaborative Research on Grain Legumes

PROJECT TECHNICAL DESCRIPTION

COVER PAGE

Code and Title of Legume Innovation Lab Project: SO2.1 **SUMMARY PAGE (must print on one page)** Farmer Decision Making Strategies for Improved Soil Fertility Management in Maize-Bean Production Systems
Name, institutional affiliation and contact information of Lead U.S. Principal Investigator and University: Robert E. Mazur - Iowa State University Department of Sociology, 302 East Hall, Iowa State University, Ames, Iowa 50011-1070 Phone: (515) 294-9286, FAX (515) 294-2303, Mobile: (515) 520-0608, mazur@iastate.edu
Name(s) and institutional affiliation of all Host Country (HC) and U.S. Co-PIs: Eric Abbott - Iowa State University (ISU) Andrew Lenssen - Iowa State University (ISU) Ebby Luvaga - Iowa State University (ISU) Russell Yost - University of Hawai'i at Manoa (UHM) Julia Bello-Bravo - University of Illinois at Champaign-Urbana (UICU) Barry R. Pittendrigh - University of Illinois at Champaign-Urbana (UICU) Moses Tenywa - Makerere University (MUK), Uganda Onesimus Semalulu - Soils Fertility & Control Unit, National Agricultural Research Lab (NARL), Uganda Ricardo Maria - Mozambique Agriculture Research Institute (IIAM), Mozambique

Project Period:	**Total Funding for 4.5 year Project**	**Total non-federal cost share commitment by U.S. institution(s)**
04/01/2013 – 09/29/2017	$1,700,000	$137,435

HCs where project activities will be implemented:	**HC institutions to be sub-contracted (abbreviated names):**	**Percent of total project funding budgeted for each HC institution to be subcontracted**
Uganda	Makerere University (MUK)	10.71%
	National Agricultural Research Lab (NARL)	8.90%
Mozambique	Mozambique Agriculture Research Institute (IIAM)	16.48%

Authorized Lead U.S. University Representative:

Name - Andrea Rich
Title - Pre-Award Administrator
Mailing Address - Office of Sponsored Programs Administration, 1138 Pearson Hall
Iowa State University, Ames, IA 50011-2207
Email Address - egrants@iastate.edu
Phone Number - 515-294-5225

Signature: Andrea R **Date:** 7/2/2013

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Name, institutional affiliation and contact information of Lead U.S. Principal Investigator and University:
Robert E. Mazur - Iowa State University
Department of Sociology, 302 East Hall, Iowa State University, Ames, Iowa 50011-1070
Phone: (515) 294-9286, FAX (515) 294-2303, Mobile: (515) 520-0608, rmazur@iastate.edu

Name(s) and institutional affiliation of all Host Country (HC) and U.S. Co-PIs:
Eric Abbott - Iowa State University (ISU)
Andrew Lenssen - Iowa State University (ISU)
Ebby Luvaga - Iowa State University (ISU)
Russell Yost - University of Hawai'i at Manoa (UHM)
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Authorized Lead U.S. University Representative:
Name - Barbara M. Neese
Title - Interim Manager, Pre-Award Services
Mailing Address - Office of Sponsored Programs Administration, 1138 Pearson Hall
Iowa State University, Ames, IA 50011-2207
Email Address - egrants@iastate.edu
Phone Number - 515-294-5225

Signature:_____ **Date:**_____

SUMMARY PAGE (must print on one page)

Code and Title of Legume Innovation Lab Project: ***SO2.1***

Farmer Decision Making Strategies for Improved Soil Fertility Management in Maize-Bean Production Systems

Name and Institutional Affiliation of the U.S. Lead Principal Investigator:

Robert E. Mazur - Iowa State University

Abstract:

Poor and declining soil fertility is the primary constraint to common bean productivity among smallholder farmers in Africa, affecting cropping systems, food security, nutrition, incomes, and livelihoods. Adoption of improved crop management practices, particularly regarding soil fertility, has been modest. Our *central premise* is that addressing soil-related constraints requires understanding farmers' current practices and enhancing their capabilities in diagnosing and finding solutions to yield constraints.

To contribute to widespread and sustainable improvements in bean productivity and soil fertility, our research objectives are to: (1) characterize smallholder farmers' agricultural motivations, current knowledge and practices, problem diagnoses, and livelihood and risk management strategies; (2) develop and refine models about their decision making; (3) develop and validate appropriate diagnostic and decision support aids; and (4) develop and assess the effectiveness of innovative approaches for dissemination of information and decision support aids, training, and follow-up technical support.

Working with smallholder farmers in rainfed maize-bean cropping systems in Masaka district in Uganda and Gurué district in Mozambique, at 1000-1200m altitude with annual rainfall 1000-1500mm, *our approach and methods* involve: (1) participatory rural appraisal and baseline surveys for activity planning, taking into account critical social, economic and cultural factors that impact decision making and adoption of new strategies and technologies, and for monitoring changes over time; (2) farmer innovator and scientific analyses of soil-related constraints; (3) participatory on-farm studies using identified possible solutions; (4) participatory, gender equitable development and validation of diagnostic and decision support aids; and (5) development and pilot-testing of innovative socio-technical approaches for communication, dissemination, and scaling up.

Summary Checklist ***(select as many as appropriate)***

	Project involves the use of proprietary transgenes or the generation of genetically modified organisms (GMOs)
✓	Project involves human subjects and requires approval
	Project involves animal use and requires approval
	Project involves the use of agricultural pesticides and requires a Pesticide Evaluation and Safe Use Action Plan
✓	Project involves M.S. or Ph.D. degree training of HC personnel at a U.S. university (How many?) ___3___

A. Technical Approach

1. Problem Statement and Justification

Smallholder farmers in Africa - women and men - manage complex multifunctional maize-bean cropping systems in diverse landscapes and agroecosystems, but continue to register low yields (far below genetic potential), and experience pervasive poverty and food insecurity (Athanase et al. 2013; Yamano & Kijima 2010). Typically yields from 200 to 500 kg ha^{-1} are significantly less than the 2000 kg ha^{-1} often obtained in researcher-managed studies (Woldemariam et al. 2012; Anon. 2013). Common beans serve multiple important roles in their cropping systems, food security, nutrition, incomes, and livelihood resilience.

Low productivity of beans in maize-bean systems is due to many factors, including low soil fertility (Nekesa et al. 1999), excess water during plant growth (Athanase et al. 2013), limited availability of improved seed varieties, insects (Ogenga-Latigo et al. 1993; Ampofo and Massomo 1998), and diseases (Opio et al. 1993), and undeveloped value chains (Tomo et al. 2013). Grain legume research programs continue to identify and develop improved technologies and management practices that can sustain the agricultural resource base and substantially increase yields (TAC 2001). Increasingly variable precipitation patterns - combined with decreasing soil quality - has resulted in low and stable or decreasing crop yields (Anon. 2013). Indeed, poor and declining soil fertility is considered by far the primary constraint to common bean productivity, responsible for 30% of the widely acknowledged 'yield gap' (Folmer et al. 1998; Kapkiyai et al. 1998)

Degradation of soil quality (physical and chemical) and inherent problems of weathered soils (nutrient deficiencies, low pH, toxicities) (Folmer et al. 1998; Khomo et al. 2011; Kumwenda et al. 1996) limit grain legume productivity across the tropics on smallholder resource-poor farms (Laker 2005). Unlike improved varieties, adoption of improved crop management practices, particularly those addressing soil fertility, has been modest for beans. Smallholder farmers in Africa, particularly women, face significant constraints to increase yields, because they:

- have limited knowledge of how to diagnose problems that limit productivity
- lack a clear understanding of interrelationships among technologies and management practices important for enhancing farm system productivity, stability, and resilience
- lack full understanding of the economics of farming as a business, what is required for benefits of investments in new technology to consistently exceed costs, and how to minimize risks
- lack reliable and affordable access to relevant information, resources and technologies

The proposed research is based on two premises: (1) sustainable intensification of agriculture production requires improved soil fertility management in which legumes are an integral part of cropping systems (Bezner-Kerr et al. 2007; Snapp et al. 2010; Kapkiyai et al. 1999; Kumwenda et al. 1996), and (2) addressing soil-related constraints requires not simply increasing access to fertilizers or use of other soil amendments, but - fundamentally – enhancing smallholder farmers' capabilities in diagnosing and finding solutions to important yield constraints (Bursh et al. 1997). Farmers often have extensive knowledge of adaptive strategies to reduce stress on their crops (Miruka et al. 2012).

Improved management capabilities will have four important short- and long-term benefits: (1) Empower farmers (especially women) to take an active role in identifying problems and solutions in bean production; (2) Improve household income through sale of increased bean production; (3) Provide higher volume of beans for traders along the value chain within the country as well as in cross-border trade; (4) Ensure greater availability of nutritious beans and less dramatic seasonal price fluctuations for net consumers (other rural households and urban consumers).

The project will contribute directly to achieving four of the six strategic goals ('focal areas') in USAID's Feed the Future (FTF): inclusive agriculture sector growth, gender integration, climate-smart development, and research and capacity building (see section 'B. Alignment with USAID Feed the Future Goals and Strategic Research Objectives' below for further details). Within the Legume

Innovation Lab program, we address SO2 (Transforming Grain Legume Systems and Value Chains) through improved smallholder production management decision-making.

Project activities will take place in key bean production regions in two important FTF focus countries – in Uganda (where maize, beans and coffee are promoted through FTF projects in 62 districts in southwest and central regions) (FTF 2011b) and in Mozambique (FTF priority provinces are Nampula and Zambézia; priority crops are oilseeds, cashews, fruits, beans) (FTF 2011a). In Uganda, beans are grown in a wide range of ecosystems in two seasons per year, but only one season per year in Mozambique in higher elevation and higher rainfall ecozones (Wortmann 1998).

Increasing bean productivity can help reduce poverty. FTF currently supports strengthening of value chains that increase cash income as well as improving nutrition. In both countries, common beans are grown for household consumption and income. As a significant source of protein, beans can help address poor nutrition, a major health problem among poor rural households in both countries. In Uganda, beans are the most important legume crop, and fifth crop overall (UBOS 2005). In Mozambique, beans are a cash crop for 35% of producing households (Anon. 2012); the country is the largest informal exporter of maize and beans in southern Africa, with a 50% share of regional exports in both (FTF 2011a).

However, in both countries extension systems are weak (Bategeka, Kiiza & Sasirye 2013). Agriculture is predominantly low input/low output (bean yields are 1/3 of those achieved with improved inputs and practices) (FTF 2011a, 2011b), with production increases driven primarily by larger areas planted rather than higher productivity. In Uganda, bean yields have been declining during the past decade. In Mozambique, most (78%) households do not belong to any rural institution, limiting access to crop technologies, inputs and credit to informal systems (Woldemariam et al. 2012). In both countries, poor soil fertility has been identified as a major factor in reduced bean yields (FTF 2011a, 2011b).

2. Objectives

To contribute to widespread and sustainable improvements in bean productivity and soil fertility management, our research objectives are to:

1. Characterize farmers' motivations, current knowledge and practices, problem diagnoses and solutions, and livelihood and risk management strategies;
2. Develop and refine models about farmers' decision making;
3. Develop and validate appropriate diagnostic and decision support aids;
4. Develop and assess the effectiveness of innovative approaches for dissemination of information and decision support aids, training, and follow-up technical support; and
5. Enhance institutional research capacity relative to grain legumes.

3. Approaches and Methods

This project seeks to develop 'tools' (methods and procedures) that enable smallholder farmers with varying levels of education to better diagnose soil-related production constraints, and make improved site-specific crop system management decisions that contribute to higher productivity (including grain legumes) in the short term as well as improvements in soil fertility in the long term. It will also assess the effectiveness of innovative communication approaches and technologies to engage farmers with diverse characteristics and other key stakeholders in widespread dissemination and adoption of diagnostic and decision support aids in different agroecological contexts. The project team consists of researchers with expertise in fields that are critical to the success of this endeavor: soil science, integrated cropping systems, economics, sociology, and communication. Moreover, all team members view multidisciplinary applied research as essential for understanding complex problems and identifying appropriate solutions, and have extensive experience in such collaborative efforts.

Obj. 1 - *Characterize Smallholder Farmers' Motivation, Current Knowledge and Practices*

Our specific sub-objectives are:

1a - Conduct state-of-the-art reviews of literature and relevant management practices in Africa

1b - Collect and analyze primary data in research communities

1c - Characterize farmers' agricultural motivations, knowledge, practices, problem diagnoses and solutions

Crop production and soil fertility improvement are complex knowledge management processes that occur within a dynamic context of livelihood resources and priorities. Integrating local and scientific knowledge, some of which may be gender-specific, is essential for improving bean productivity in a sustainable manner. The team will establish a base understanding of smallholder farmers' motivation, current knowledge and practices in maize-bean cropping systems, problem diagnoses and solutions adopted – especially pertaining to soil fertility management - in Masaka District, Uganda, and Gurué District, Mozambique. This effort will begin with a state-of-the-art review of available country-specific reports and publications to characterize farmers' practices of field selection and preparation, crop and variety selection, planting methods and spacing, use of various types of inputs, intercropping and rotation patterns, problem identification and solutions attempted by farmers to date. It will also cover post-harvest use of beans - consumption, market sales, storage.

A Participatory Rural Appraisal (PRA) will initiate the community level research process in each country to create a multifaceted understanding of smallholder farmers' current knowledge, practices, motivations, experiences and conditions in selected communities. Researchers and facilitators will draw on an array of methods and techniques, including semi-structured key informant interviews, focus group discussions and situation analysis at community and farm level (Chambers 1994). The research team and community will expand their knowledge of priority problems and available resources, as well as important bases for stratification within the community that may influence the research process and its long-term implications (Mukherjee 1997).

Contextual elements that will be considered for their relevance include:

- Agroecosystem features (terrain, rainfall, soil nutrient/physical properties, diseases, pests)
- Resource availability, accessibility and affordability
- Species and varieties of legumes grown, seed sources and systems (private-public)
- Typical length of food shortage period in the community
- Market development and access

PRA meetings with 10-15 community members will help identify 2-3 innovative farmers cultivating land in each of the 2-3 predominant soil groups within each research community (3 in each country). Soil samples from fields managed by these and other farmers will be analyzed and compared for key physical and chemical factors known to influence bean production. Building on the information obtained through the PRAs, a baseline household survey of practices and conditions will be conducted, in coordination with the Impact Assessment project (SO4.1). A stratified random sample of 50 farmers in each community will be interviewed regarding sources and use of information about management of beans, maize and other key crops, and soil fertility; problem diagnoses and solutions adopted; decision making practices and risk management strategies. Gender-related factors will be incorporated into selection of PRA participants, core research farmers, survey interviewees, and impact assessment. Similar procedures will be utilized in Masaka and Gurué Districts. The information obtained will form the basis for the multidisciplinary researcher team, drawing on methods from both the natural and social sciences, to observe and learn how farmers can build on their existing knowledge and locally available resources with scientific knowledge and external resources to improve their conditions. The combined socioeconomic and soils data will then be used to develop hypotheses regarding constraints to bean production in farmers' production systems.

Obj. 2 – *Develop and Refine Models about Smallholder Bean Farmers' Decision Making*

Our specific sub-objectives are:

2a - Characterize access to resources required for bean production

2b - Characterize farmers' livelihood goals, resources, strategies and success through analysis of household survey data

2c - Develop models to characterize farmer decision making

2d - Assess influence of institutional factors

2e - Pilot test, evaluate, and revise models

To understand the social dimensions and dynamics of farmer decision making, a key starting point is recognizing that farmers have greatly varying production and livelihood goals, knowledge, abilities, and assets. Farmers' holistic view of crop-soil health and decision making processes are embedded within ecosystem dynamics and an array of factors cutting across the biophysical, socioeconomic, political and cultural domains (Vanlauwe 2004). This is useful for understanding farmers' experiences and differentiated local knowledge regarding soil ecology and soil fertility change, revealed in local taxonomies and language, and local methods of monitoring and evaluating their own experiments (Ramisch 2004). This is also important for success in filling in 'knowledge gaps.' Taking into account key social characteristics can help explain existing patterns of soil fertility and facilitate better targeting of recommendations and decision support advice. For example, that women and men have different priorities and reasons for using various nutrient sources reflects differences in access, affordability, impact, and benefits derived. Women typically place greater emphasis on risk, vulnerability, labor, and immediate contribution to household well-being. That noted, women are as likely as men to engage in innovative behavior in agriculture (Reij & Waters-Bayer 2001).

To address the elusive success for decision support interventions in agriculture, an additional level of understanding involves considering the roles of social structure and social dynamics in complex processes of change. The shift from conventional approaches has been leading researchers to engage farmers in processes that create a continuous community learning environment to determine their own actions. Instead of the traditional fixation on individual 'adoption rates' that reflect compliance with externally created technologies and criteria, sustainable agricultural development requires genuine empowerment involving changes in beliefs, knowledge, behavior and social relationships (Bartlett 2008). A key element in empowerment is collective action. Groups and social networks play important roles in experimentation and adoption of new management practices and technologies (Sseguya et al. 2009, 2013). Mechanisms of social cohesion are effective in transforming beliefs and subjective knowledge when people have real opportunities to learn together in social situations characterized by trust and respect for each other, ask questions and seek answers, and make sense of each other's experiences and knowledge alongside scientific knowledge; it truly reflects a 'community of practice' (Morton 2011). This process of 'sensemaking' enables people to devolve new 'mental maps,' set their own goals and outcomes, experiment, evaluate, collectively frame and legitimize a preferred 'way forward,' develop a sense of efficacy and pride, encourage each other and subsequently persuade others to take similar actions (McCown 2005; Morton 2008). Such an inclusive process can also prevent the too common fear of envy - and actual sabotage and theft - that stifles agricultural innovation (Adhiambo & Tatalović 2011; Reij & Waters-Bayer 2002).

Analysis of the PRAs and the baseline household survey of practices and conditions will provide a detailed community-wide profile regarding farmers' practices of field selection and preparation, crop and variety selection, planting methods and spacing, use of various types of inputs, intercropping and rotation patterns, problem identification and management practices utilized by farmers to date, consumption, market sales, and storage. In order to understand flows of resources within and outside the community, GPS coordinates will be recorded for households surveyed and key institutions, both formal and informal. Network analysis will be conducted to understand flows of key resources – information, production materials, labor, food, money, etc. These baseline data will

serve as the reference point for monitoring changes in knowledge, attitudes, practices and conditions over time. Potential gender and literacy differences will be taken into account. Our approach to working initially with small groups of innovative farmers will develop the nucleus of successful and motivated farmers who can subsequently promote engagement by others and adoption of new management practices and technologies (Critchley 2002).

Key social, cultural, economic, institutional and contextual factors which shape farmers' decision making – individually and collectively - that will be considered include:

Resources

- Resources required for production and marketing (natural, physical, financial, human, social)
- Factors that influence land allocation, especially for legumes, and investment in farm inputs
- Social relationships and economic costs of accessing / controlling each type of resource
- Resource constraints (material, labor, etc.)

Livelihoods

- Livelihood goals and priorities
- Income sources, including off-farm, and level
- Social identity (ethnicity, religion, roles in the community)
- Group and social network size and strength
- Risk management arrangements, safety nets
- Food security/shortage experience
- Nature and extent of vulnerability, resilience
- Progress toward livelihood goals
- Risk assessment/tolerance

Decision Making

- Sense of self-efficacy
- Stimuli to critically reevaluate existing assumptions and practices
- Perceived indicators of problems
- Awareness, availability, accessibility, and affordability
- Criteria (factors considered and the relative importance of each)
- Information base (nature, sources, credibility)
- Gender and other roles (who makes or negotiates which types of decisions)
- Decision processes (timing, stages, sequencing)
- Evaluation of previous experiences (own and others')
- Adjustments over time (responding to changes in both internal and external factors)

Institutions

- Community-based organizations
- Farmers organizations
- Collective action for enhancing access to vital resources
- Extension services
- Governance

These factors may influence current knowledge, attitudes, practices, and subsequently processes of information dissemination, training, utilization, and support to stimulate and sustain widespread implementation. Project researchers will incorporate the set of most influential factors, and potential interactions among them, in design and application of decision support aids that will be developed in collaboration with participating farmers, with special attention devoted to gender- and literacy-related barriers to implementation of improved management practices and technologies.

Obj. 3 - *Develop and Validate Diagnostic and Decision Support Aids*

Our specific sub-objectives are:

3a - Determine soil fertility constraints for improved bean production for selected farmers/sites

3b - Develop diagnostic aids

3c - Conduct participatory farmer assisted research to test the effect of using the diagnostic aid on resulting bean productivity

3d - Determine effects of participatory farmer assisted research interventions

To improve soil management decision making, diagnostic tools will be developed with and for farmers who have varying levels of education, based upon field-observable soil classification characteristics in diverse agro-ecologies in two target bean production regions in Uganda and Mozambique. Utilizing farmer experience and input from soil scientists and systems agronomists, and drawing on the global knowledge base of appropriate practices and technologies, soil and cropping systems management strategies and options appropriate for various smallholder farm systems will be identified. To continue the process of determining soil-related factors that limit bean productivity, a missing element study using representative soils from each district studied will be conducted to determine nutrient deficiencies (Deenik & Yost 2006). This technique has been used successfully to identify the important soil factors that limit crop productivity in areas lacking adequate databases on soil physical and chemical properties. Once these constraints are identified, management strategies appropriate for smallholder farmers can be determined and developed. Additionally, strategies can be tested at researcher-managed sites to determine validity of identified management strategies, particularly if solutions are untested in previous research. Diagnostic aid development will be in part based on results from the missing element studies. Equally important, participatory identification of problems and promising solutions, on-farm trials, and assessment are essential to foster local ownership of the research process and its results, which are key to sustainable implementation of recommended management practices and technologies that emerge.

Farmer assisted research studies will be conducted in each district comparing current farmer practices with those developed through using a diagnostic aid which will include indicators that farmers themselves can monitor over time. Researchers will also convey results of scientific analyses using readily understandable visual methods. Given inherent precipitation, soils, and other differences between Masaka and Gurué districts, we have the opportunity for a robust comparison of our overall methodology. Management options may include simple interventions such as use of soil amendments (compost, manure, lime, phosphate fertilizer, etc.) to fundamental long term changes in the system (cover, inter- and relay cropping, limited tillage, integration of livestock, etc.) (EC-JRC 2013). These decision support aids will provide farmers with information on a 'basket' of technologies and improved management practices to achieve particular objectives, and enable farmers to weigh 'trade-offs' among alternatives. Normally, two or more growing seasons are required for farmers to gain sufficient experience with diagnostic aids for sustainable continuation of practices. Farmers will be interviewed annually after each cropping cycle to determine impacts of diagnostic aid use on bean productivity, soil quality, influence on subsequent crop(s) - especially maize, and potential for sustainable adoption.

Obj. 4 - *Assess Effectiveness of Innovative Approaches for Dissemination, Training, and Support*

Our specific sub-objectives are:

4a - Assess existing information dissemination systems about bean production and soil fertility

4b - Work with existing institutions and organizations to identify and develop messages to provide farmers with critical information to make decisions about beans and soil fertility, and pathways that could provide information in an effective, efficient, and sustainable manner

4c - Based upon prototype message development and testing, develop and launch information packages through viable providers and pathways to farmer decision makers

4d - Evaluate information packages

Dissemination of field tested management options for farmers is necessary for sustained increases in bean productivity. However, smallholder farmers often have poor access to information necessary for improved decision making in management of production systems. In Masaka, Uganda and Gurué, Mozambique, literacy – especially among women - and the percentage of households with electricity are low, making use of conventional written publications and mass media dissemination less effective than in more developed regions. The development of effective and efficient dissemination pathways and materials is critical for long-term enhancement of farmer decision making capabilities (Ngaka et al. 2012). We expect farmers to derive significant benefits through short-term training, especially women who are more commonly involved in producing beans (in both female- and male-headed households), are members of farmer groups, and provide leadership in those groups.

The project will engage the core groups of farmers, women and men, in developing and testing innovative communications approaches and technologies for learning and sharing information about new options for sustainable improvement in increased yields and soil fertility. Given limited extension system resources in Uganda (1:24,000) and Mozambique, horizontal peer-to-peer learning (field days, exchange visits, local community based organizations) and network dissemination will be important initial methods. Building on insights from work on objective 2 above, the role of groups and social networks in experimentation and adoption of new management practices and technologies will be integrated with approaches to fostering individual behavioral changes.

To benefit those with low literacy skills – especially women, communication approaches and technologies that may be used include: print materials, participatory radio campaigns in local languages, portable and multifunctional MP3 recorder radios that can record and replay broadcasts, text and audio SMS messaging, on-air call-outs to farmers and to experts, 'smart' phones, and visual decision aids - including farmer recorded videos and animated videos (Scientific Animations Without Borders, SAWBO – see Bello-Bravo & Pittendrigh 2012; Sseguya et al. 2012; Martin & Abbott 2011; Digital Green 2010). The 'Lifelong Learning for Farmers' project in Uganda, based at Makerere University, successfully piloted an information sharing platform for farmers using mobile phones, radio, website, open and distance learning materials for development (Tenywa 2013).

Optimum levels of training and follow-up support will be determined to identify efficient use of resources (extension personnel, material, financial); this will facilitate development projects being able to utilize our research results for scaling up and achieving widespread impact (Friis-Hansen & Duveskog 2012), particularly in non-contiguous communities and areas. Emphasis will be placed on communication approaches and technologies that maximize sustainable use of available resources.

Monitoring and evaluating the impacts of project activities will involve collecting and analyzing data at baseline and at regular intervals. Methods for documenting outcomes in terms of increased productivity will involve one-time and some repeated measures using mobile phone-based surveys and other locally effective methods (Brian 2013). Emphasis will be placed on frequent small-scale assessments that help guide correcting/enhancing activities. Data accumulated over time can be linked to provide a dynamic view of project progress, and can help focus summative evaluation activities.

Obj. 5 - *Enhance Institutional Research Capacity relative to Grain Legumes*

A key element in institutional research capacity building will be training three graduate students in academic programs in U.S. institutions and research activities in Uganda and Mozambique. Their research foci and methods will contribute directly to achievement of our project objectives:

- one M.S. student from Uganda will study Sustainable Agriculture at Iowa State University and conduct research on agronomic and livelihood aspects of smallholder farmer decision making
- one Ph.D. student from Mozambique will study soils/crops at the University of Hawaii and conduct research on management influences on soil C and N pools

- one M.S. student from Mozambique will study Communication at Iowa State University and conduct research on innovative socio-technical approaches for dissemination of information and decision support aids

In addition, one M.S. student studying Agronomy, supported by a stipend and tuition scholarship from Iowa State University, will conduct M.S. thesis field research in Uganda as part of this project. This work will test the validity of management strategies identified through participatory research to enhance bean productivity and soil fertility management in replicated, scientist-managed research.

At Makerere University, three Ugandan graduate students will receive training in M.S. degree programs of study and research that will also contribute directly to project objectives:

- one student will study soils/crops and conduct research on limiting nutrients (omission of elements) and lime requirements
- one student will study geography at Makerere University and conduct research on socioeconomic factors influencing decision making in crop and soil fertility improvement
- one student will study soils/crops at Makerere University and conduct research on assessment of suitability of decision support aids for different soils

One research technician in each country will gain experience in multidisciplinary research activities and specific skills in processing and analysis of soil and crop samples. Short-term training that is needed for project work will be identified once project research activities are initiated.

4. Collaboration with Host Country Institutions

In Uganda, two agricultural research institutions play important roles in project design, implementation, and ensuring long-term impact. For Makerere University, our research project is well aligned with the research themes and strategic plan of the University (2008/09 to 2018/19). Scientists in the Department of Crop Production in the College of Agricultural and Environmental Sciences have extensive experience in multidisciplinary applied research in various regions of the country, and widely recognized expertise in development of simple methods, techniques and kits for analysis of soil characteristics.

Uganda's National Agricultural Research Laboratories, in particular its Soils and Agro-meteorology Unit, conducts research to diagnose soil-related constraints and identify appropriate interventions. Its scientists combine information on biophysical, economic and social factors with available technologies to enable farmers to manage soil resources and the entire landscape in a sustainable manner. It involves local government authorities in the implementation of activities including trainings, demonstrations, sensitization workshops and field days at district level.

Agricultural innovations for sustainable development are the central focus of the 2011-2015 master plan of the Institute for Agriculture Research of Mozambique (IIAM). IIAM strives to become a center of excellence in agricultural research, contributing to improved food security, poverty alleviation, and sustainable use of natural resources. This research project can add value to IIAM's efforts to address fundamental problems of low agricultural productivity and poor soil fertility in the context of climate change and variability. IIAM recently initiated a collaborative project with CIAT investigating interactions among soils and bean breeding and varietal development. Our project will collaborate with them by including selected soils in the nutrient omission and lime requirement studies and exchanging soils data; CIAT and IIAM personnel will provide selected bean germplasm for our studies in Gurué.

Scientists in all participating research organizations have participated extensively in articulation of project objectives, selection of field sites and methods, and in development of the Workplan, Milestones, Performance Indicators, and Impact Pathway. The project's Box.com website for file sharing and storing, along with email, have greatly facilitated our collaboration. We will all participate extensively in development of protocols for data gathering and analysis. Research activities will necessarily involve collaboration of all organizations in activities to achieve the project's four research

objectives. Scientists in multiple institutions will contribute to mentorship of graduate students in the U.S. and Uganda, thereby enhancing institutional capacity for research on grain legumes.

5. Coordination with other International Grain Legume Research Programs/Projects

This project complements the CGIAR research program on grain legumes which employs cutting-edge genetic approaches to address soil fertility problems. Our focus addresses a critical 'technical gap' in CRP 3.5 by developing and validating diagnostic and decision tools for sustainable implementation of management practices and technologies, especially by women. The project team will learn about relevant existing and emerging conservation agriculture approaches and technologies from WOCAT's global network of scientists, and explore opportunities to collaborate and coordinate research efforts with CGIAR scientists through CRP 3.5, the AGRA Soil Health Program, IFDC, CABI, McKnight Foundation which has programs with an integrated multi-functional intensification emphasis, Africa RISING which focuses on maize-legume based systems in the Eastern Highland of Africa, and the Bill and Melinda Gates Foundation. Project researchers will continue to explore bases for collaboration with two African based networks under PABRA (the Pan-African Bean Research Alliance): the Eastern and Central Africa Bean Research Network (ECABREN) and the Southern Africa Bean Research Network (SABRN).

The AGRA investment plan covers four strategic areas: seed systems, markets, policy, and soil health. Soil health projects in Mozambique address critical soil improvement related issues for increasing crop productivity which include: (1) promoting sustainable fertilizer use within an ISFM framework and development of knowledge products for different target audiences; (2) developing response curves for selected crops in different agro-ecological zones of Mozambique; (3) building site-specific decision making tools for assisting farmers in optimizing the return of fertilizer use; and (4) improving soil health information management and sharing. This Legume Innovation Lab complements on-going IIAM led soil health initiatives.

One specific way in which significant synergies will be possible with other projects and programs concerns creative and efficient use of existing and new information technologies to improve both pathways and methods of communication among farmers and between farmers and information sources. Educational packages using animation have been developed by SAWBO and are already integrated into several legume-oriented projects in Africa. Small portable pico projectors, smart phones and other video devices are being used in other projects both to collect information from farmers as well as communicate to them. Group information delivery methods involving these devices are now being used in Uganda and other countries. The Africa Farm Radio Research Initiative has significantly increased the ability of radio programs to effectively draw in farmers and provide participatory forums for learning relevant agricultural topics.

6. Outputs

Project activities are expected to produce the following outputs:

- Characterization of smallholder bean farmers' agricultural motivations, current knowledge and practices, problem diagnoses, and livelihood and risk management strategies (by 2015)
- Models of farmer decision making strategies that reflect influences of social, cultural, economic, institutional and contextual factors are developed and refined (by 2016)
- Innovative diagnostic aids using observable characteristics that enable farmers to make site-specific management decisions are developed and validated (by 2016)
- Process for identifying alternative strategies and management practices for improving cropping system productivity and soil fertility is developed (by 2017)
- Effective and efficient methods and media for information dissemination to intermediate and end users are developed and assessed (by 2017)
- Capacity building through applied research-based training is conducted (2013 onwards)

- Research results published in peer-reviewed literature and at the Legume Innovation Lab website hosted by the Management Office at Michigan State University (2015 onwards)

The Project's Impact Pathway Worksheet provides details of outputs, uses, and steps to achieving our vision of success.

7. Capacity Building of Partner Host Country Institutions

Research support in this multidisciplinary project is an opportunity for Ricardo Maria (IIAM), a young Mozambican soil scientist, to strengthen his knowledge and skills in systems analyses. Working and learning together with PIs from US higher education institutions and with farmers will provide a unique opportunity for integrating local knowledge on soil quality indicators and management with scientific knowledge. He expects to improve his capabilities in statistical analyses. Acquired scientific knowledge will be used to develop decision support aids suitable for illiterate and resource constrained farmers that will improve their capacity to make decisions on fertilizer use within the context of an Integrated Soil Fertility Management framework. For Ugandan soil scientists Moses Tenywa and Onesimus Semalulu this project will help improve their understanding of current knowledge about decision making for crop and soil fertility improvement, outstanding challenges and how to overcome them. Short-term training at ISU and/or Hawaii will enable them to sharpen skills in analytic procedures and in using models for decision making for soil fertility improvement.

B. Alignment with USAID Feed the Future Goals and Strategic Research Objectives

Regarding strategic goals in USAID's Feed the Future, the project will contribute to inclusive agriculture sector growth (improving agricultural productivity, expanding markets, and increasing the economic resilience of vulnerable rural communities), gender integration (enhancing women's access to key productive resources, the productivity of their agricultural activities, and their empowerment, agency and inclusion), climate-smart development (effective, sustainable and equitable resource management and adaptation to environmental challenges), and research and capacity building (focused on sustainable intensification of agricultural production systems while reducing adverse impacts on natural resources and the environment, and ensuring food security) in two important focus countries - Uganda (maize, beans and coffee promoted through FTF projects in numerous districts across agroecosystems) and Mozambique (FTF priority provinces are Nampula and Zambézia, beans and three other crops promoted). In the Legume Innovation Lab, it addresses SO2 (Transforming Grain Legume Systems and Value Chains) through improved smallholder production management decision-making.

Project researchers will conduct all activities in a gender equitable and inclusive manner. This will begin with selection of farmers with aptitude for innovation in agricultural practices, identification of crop production constraints, participation in field experiments, development of diagnostic and decision support aids, pilot testing of these aids, development of information for dissemination, and evaluation of project intervention impacts. In both countries, men and women have distinct roles in bean production systems. Overall, women do most agricultural work, with men responsible for land preparation and assisting in planting and weeding; harvesting is mainly women's activity. Men tend to be interested in selling most/all of the harvest, while women prioritize household consumption and nutrition (Anon. 2012). To improve decision making systems, methods must be found to include all participants in the agricultural cycle to maximize the ability to define problems and identify a full range of alternative actions. Thus, attention to women's roles at various stages of the process merits attention. Special focus will be placed on dissemination activities to ensure that all partners in bean production and soil fertility are represented.

USAID Mission Engagement

In Mozambique, project PIs from U.S. and Ugandan universities and from IIAM met with the USAID Mission Director and Feed the Future staff on May 29th in Maputo. This provided a tremendous

opportunity for sharing information about USAID programs in Mozambique and the Legume Innovation Lab program. In-depth discussion of our project and the expertise of research team members revealed several key points of significant interest for Mission staff. These included soil test kits, animated videos about management practices, and use of agricultural technologies. In Uganda, the project Lead PI has met regularly since 2004 with USAID Mission agricultural development staff, and will continue to do so during future travel there to communicate the focus and approach of project activities and explore bases for collaboration. Once the Project Technical Description is finalized and approved by the Technical Management Advisory Committee, it will be shared with key staff in the Mission in Kampala. After communication is established with Mission staff regarding details of the project, the PI and Co-PIs will seek to establish ties with Mission development partners. We will be pleased to respond when the Missions express interest in an Associate Award that would enable us to provide technical assistance and access to grain legume technologies.

C. Impact Pathway Plan (*attached* with other project documents)

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Feed the Future Innovation Lab for Collaborative Research on Grain Legumes

Impact Pathway Worksheet

Name of your Legume Innovation Lab Project (Shorter version):	**Farmer Decision Making Strategies for Improved Soil Fertility Management in Maize-Bean Production Systems**
Lead PI:	**Robert E. Mazur**

		STEP 1	**STEP 2**		**STEP 3**	**STEP 4: Program Logic (identify steps to reach next users and final users to achieve the vision of success) add columns if needed. For each step specify the timeline and identify action plan your project will undertake over the next 4.5 years**				
ID#		**List Project OUTPUTS Expected by FY 17**	**Next Users of project Outputs**	**Final Users of project Outputs**	**Vision of Success**	**Step 4.1**	**Step 4.2**	**Step 4.3**	**Step 4.4**	**Step 4.5**
1	Vision of Impact pathway	Models of farmer decision making strategies that reflect Influences of social, cultural, economic, institutional & contextual factors developed and refined	Project research team	Development organizations, farmers' associations, extension, researchers	Increased effectiveness & efficiency in determining constraints & solutions for sustainably implementing investments in bean productivity & soil fertility in Uganda & Mozambique	Understand strenghts and limitations of leading and emerging models	Understand effects of relevant social, cultural, economic, institutional and contextual factors	Existing models refined for application to crop and soil fertility improvement	Model(s) pilot tests generally successful	Model refined and ready for widespread use
	Timeline -- when to be achieved? (Fiscal year)	2015			2017 +	2013	2014	2014 in Uganda, and 2015 in Mozmabique	2016	2017
	Strategies and Action Plan					Complete state-of-the-art review of literature	Conduct & analyze participatory rural appraisals & household surveys in Uganda & Mozambique	Reinterview farmers; develop and refine decision-making models for Uganda and Mozambique	Reinterview farmers; use these models in application of decision support aids	Reinterview farmers; further refine these models for subsequent dissemination
2	Vision of Impact pathway	Diagnostic aids using observable characteristics that enable farmers to make site-specific management decisions are developed and validated	Project research team	Farmers, extension agents, agriculture ministry staff, farmers' associations, development organizations	Widespread use by farmers of diagnostic and decision support aids to solve problems - in Uganda and Mozambique, in Africa, and in other developing countries	Understand strenghts and limitations of existing diagnostic and decision support aids	Understand farmer-identified constraints and soils characteristics	Diagnostic aid developed for smallholder maize-bean production in research districts	Diagnostic aid refined	Diagnostic aid ready for dissemination through networks of farmers & development organizations
	Timeline -- when to be achieved? (Fiscal year)	2016			2017 +	2013	2014	2015	2016	2017
	Strategies and Action Plan					Complete state-of-the-art review of literature	Conduct and analyze PRAs; collect and analyze soil samples; initiate fieldwork with selected innovative farmers	Develop diagnostic aid based on field observable soil characteristics in diverse agro-ecologies	Refine diagnostic aid based on feedback from farmers after their use	Finalize diagnostic aid
3	Vision of Impact pathway	Process for identifying alternative strategies and management practices for improving cropping system productivity and soil fertility developed	Project research team	Farmers, extension agents, agriculture ministry staff, farmers' associations, development organizations	Widespread use by farmers of diagnostic and decision support aids to solve problems - in Uganda and Mozambique, in Africa, and in other developing countries	Learn about farmer strategies for identifying and addressing bean production constraints	Have comprehensive analysis, local and scientific, of production constraints and options to address them	Have synthesized analysis of bean production constraints	Process for developing locally-appropriate diagnostic aids for improving productivity and soil fertility under field testing	Process for developing locally-appropriate diagnostic aid ready to disseminate through research & development networks
	Timeline -- when to be achieved? (Fiscal year)	2016			2017 +	2014	2015	2015	2016	2017
	Strategies and Action Plan					Work with smallholder farmers on identification of constraints, solutions attempted to date	Combine insights from scientific analyses of soil physical & chemical properties with local characterizations	Combine insights from scientific recommendations for addressing soil fertilty deficiences with local solutions	Pilot test solution strategies in farmers' fields	Solution strategies in farmers' fields ready to disseminate through networks of farmers & development organizations

		STEP 1	STEP 2		STEP 3	STEP 4: Program Logic (identify steps to reach next users and final users to achieve the vision of success) add columns if needed. For each step specify the timeline and identify action plan your project will undertake over the next 4.5 years				
ID#		List Project OUTPUTS Expected by FY 17	Next Users of project Outputs	Final Users of project Outputs	Vision of Success	Step 4.1	Step 4.2	Step 4.3	Step 4.4	Step 4.5
4	Vision of Impact pathway	Effective and efficient methods and media for information dissemination to intermediate and end users are developed and assessed	Project research team	Farmers, extension agents, agriculture ministry staff, farmers' associations, development organizations	Widespread use by farmers of diagnostic and decision support aids to solve problems - in Uganda and Mozambique, in Africa, and in other developing countries	Assess past use of diagnostic and decision support aids by projects and organizations; initiate PRA and interviews	Complete PRA and interviews; document current providers and pathways for dissemination	Develop and field test prototypes and methods to improve dissemination; test alternative pathways	Monitor initial prototypes and pathways; revise as needed; launch 2nd wave info. packages	Work with providers and pathways to strengthen sustainability of diagnostic and decision support aid packages
	Timeline -- when to be achieved? (Fiscal year)	2017			2017 +	2013	2014	2015	2016	2017
	Strategies and Action Plan					Review literature and relevant management practices; plan for initiating PRA and household interviews	Conduct PRA and interviews in Uganda and Mozambique; in-depth interviews with information providers	Work with providers & pathways to develop dissemination packages for decision support aids in Ug. & Moz.	Monitor info. prod. & pathway delivery via interviews in Uganda & Mozambique; evaluate alter. & revise	Training for providers and channel staff to develop and deliver future packages in Uganda & Mozambique
5	Vision of Impact pathway	Capacity building through applied research-based training conducted	Project research team	Makerere; NARL; IIAM; farmers assoc.; students trained at ISU, Hawaii, and Makerere Univ.	Partner country researchers collaborate with farmers to identify viable solutions to productivity constraints in maize-bean cropping systems - Uganda & Mozambique, Africa, & other developing countries	Researcher team collaborates in guiding formation of graduate students' research projects	Researcher team mentors graduate students in data collection methods, analysis, and report writing	Graduate students learn value of participatory, farmer assisted research; publish research results	Graduate students participate in pilot application of refined diagnostic & decision support aids in new farming communities	Graduated students conduct research as employees of national institutions (gov't, NGO, private sector)
	Timeline -- when to be achieved? (Fiscal year)	2017			2016 +	2013	2014	2015	2016	2017
	Strategies and Action Plan					Initiate graduate training of Ugandan student in Sustainable Agriculture (MS, ISU)	Initiate training Mozambicans in soils (PhD, Hawaii); Communications (MS, ISU); Ugandan in soils (MS, Makerere)	Initiate training Ugandan student in geography (MS, Makerere)	Train 2nd Ugandan student in soils (MS, Makerere); pilot train farmers in diagnostic and decision support aids in Uganda and Mozambique	Initiate training of farmers in other communities in Uganda and Mozambique
6	Vision of Impact pathway	Results of research produced in various formats for array of stakeholders	Project research team	Farmers, extension agents, agriculture ministry staff, farmers' associations, development organizations, researchers, scientists	Results of research project utilized in various formats by array of stakeholders - in Uganda and Mozambique, in Africa, and in other developing countries	Review of relevant research reports from Uganda and Mozambique, and relevant scientific literature	Communicate research priorities and approach to peers via program website and meetings	Preliminary research results shared with peers in research organizations; constructive discussion fostered	Research results drafted in various formats for key stakeholders in Uganda and Mozambique	Research results presented in various formats for an array of stakeholders (researchers, develoment organizations, funders)
	Timeline -- when to be achieved? (Fiscal year)	2017			2016 +	2013	2014	2015	2016	2017
	Strategies and Action Plan					Identify, collect, and analyze relevant literature	Identify and summarize knowledge gaps, research priorities and approach	Produce research briefs to stimulate discussion of preliminary results and early findings	Produce reports to communicate research findings to potential users; receive feedback	Produce reports in various formats and of varying length for practitioners, policy makers, researchers