Research in Sustainable Intensification in the sub-humid maize-based cropping systems of Babati: Testing performance of integrated past year best-bet component technologies

Africa RISING ESA Project proposal 2013/14

International Institute of Tropical Agriculture (IITA)

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Babati Research Team

Research in Sustainable Intensification in the sub-humid maize-based cropping systems of Babati: Testing performance of integrated past year best-bet component technologies

Description of the intended work plan

Team Leader: IITA – Mateete Bekunda

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Research Team Membership

Name	Institution	Job title	Disciplinary expertise	Qualification	Project role/ responsibility	% time
Job Kihara	CIAT	Agronomist	Soil fertility	PhD	WP1 -PI	20
Dan Makumbi	CIMMYT	Scientist	Breeding	PhD	WP2 -PI	10
Ben Lukuyu	ILRI	Scientist	Animal nutrition	PhD	WP3 & 8 -PI	50
Fen Beed	IITA	Scientist	Plant pathology	PhD	WP4 -PI	20
Adebayo Abass	IITA	Scientist	Food technology	PhD	WP5 -PI	20
V. Afari-Sefa	AVRDC	Scientist	Ag. Economist	PhD	WP6 -PI	5
Fred Kizito	CIAT	Scientist	Water resources	PhD	WP7 -PI	30
Per Hillbur	consultan t	Scientist	Human Geography	PhD	WP9 -PI	20

Note: More research members are given at Work Package level

Summary

This project builds upon results of activities resulting from the implementation of the 2012-13 Research Proposal. Africa RISING promotes an integrated approach that is based on technological innovations addressing context-specific improvements. By design, therefore, the normal progression of activities in the Project should have started with the generation of a baseline situation analysis to allow design and testing of best configured and integrated technologies in the farming communities. This did not happen in 2012-13. Therefore, WPs conducted discipline-specific baseline studies to understand major constraints to improved livelihoods and identify opportunities for targeting research options. The results of these studies have been used in designing studies presented in this proposal.

Several innovations of inputs at the level of crops, livestock and farm technologies were tested or initiated during 2012-13, mainly as potential components of integration during subsequent studies. Lessons learned showed the evident need to integrate tested innovations and led into a merger of some original WPs and re-designed continuing WPs. The re-designed WPs will address (i) crop management efficiency, (ii) livestock and watershed/landscape management, (iii) prevention of mycotoxin contamination along food and feed value chains for maize, (iv) improved postharvest technologies, and (v) dietary diversification through integration of vegetables into maize based systems. New WPs are being included to address (vi) specific needs of mitigating the maize lethal necrosis disease outbreak, (vii) the integrated management of the most common livestock (poultry) in the farming systems, (viii) assess applied integrated crop and livestock treatments' impacts on natural resources, and (ix) introducing innovations related to institutional arrangements (R4D). It is anticipated that results from these studies implemented at different agroecological sites will better define integrated strategies (decision support) that will be the subject of scaling to communities within and outside the study sites. Operationalising these WPs is described later in the proposal. The level of detail in these work packages is much more than that given in other ESA Team Proposals so as to meet IITA's direct funding requirements, given that IITA is the PI Institution.

Project-level research approach

Research approaches and consequent deliverables are more refined under the different work packages. Work packages define levels of responsibility within a research approach that is driven by the integration and adoption hypotheses. In testing these hypotheses, the Research Team proposes an implementation strategy visualised in Figure 1. Research components are layered to inform that products from one form of activity can benefit from or be a resource of another activity. Sometimes such products are "wastes", e.g. vegetable residues are being proposed as a poultry "local feed resource" for 2013-14 research activities, while poultry guano is proposed as a "nutrient resource" for increased vegetable production. In such a scenario, "wastes" are eliminated, farm productivity is increased and natural resources integrity is upheld. The overall increased farm productivity is driven by the markets.

Local farmers will continue to be actively engaged in all farmer-installed and managed trials. For 2013-14, mother-baby and field demonstration approaches will continue to be utilized in the truthing studies as these also allow for implementation of technology dissemination through participating farmers (farmer to farmer) and within farmers' groups. In addition to collecting data related to the applied physical treatments, researchers are committing to compiling household description data that will allow allocation of farmers into typology definitions described under the Farming Systems Analysis studies and will compliment M&E data needs.

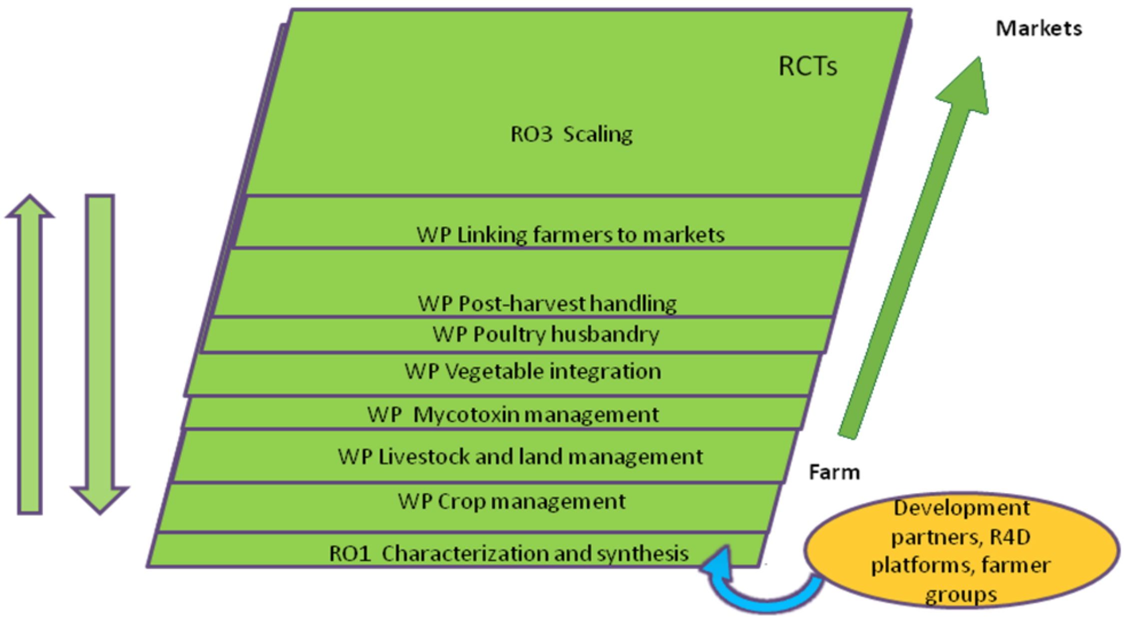

Figure1: A model representation of the implementation strategy showing how different work packages interact and integrate at farm, landscape and market scales.

Communication and dissemination strategies

Several methodologies will be utilized in dissemination (scaling-up) information and technologies. Most of these are integral activities (tools) within the implementation of the research and are not intended to be treated as study cases. A formal study to compare the impacts of some of these approaches on technology uptake within the study sites is in the design process: The methodologies include:

- Conduct of participatory mother-baby and demonstration trials with to farmers in their respective villagers
- Conduct of stakeholders workshops on the project outputs which include success factors
- Utilising R4D and innovation platforms
- Capacity building among extension and researchers partners
- Using websites in sharing information about the project
- Organizing partners' cross-site meetings
- Presentation of results in workshops and conferences
- Production of reports and information leaflets

- Use of electronic and print media such as radio, TV and newspapers

Action Sites

Research will continue to be conducted in the original villages of Long, Sabilo and Seloto (Figure 2). Several activities will be initiated in the villages of Hallu, Matufa and Shaurimoyo.

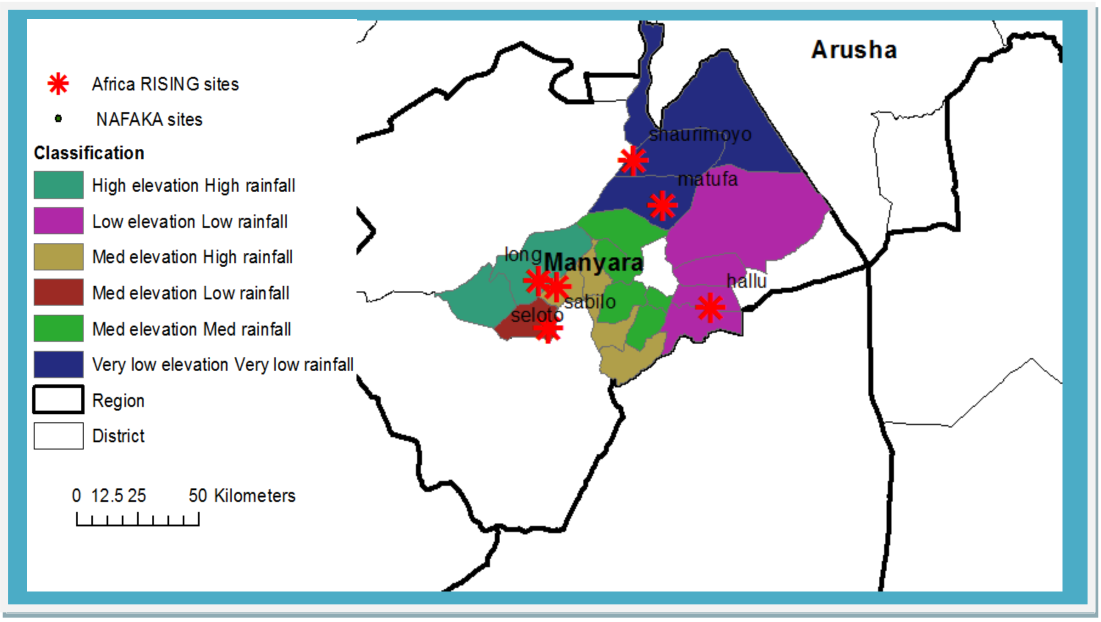

Figure 2. Map of Babati District showing the action villages. Note: There are no NAFAKA action villages in Babati.

Consolidated budget (USD). Details are given under each WP.

Main budget category	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Total
	CIAT	CIMMYT	ILRI	IITA	IITA	AVRDC	CIAT	ILRI	Consultant	
Personnel	73000	50000	17952	49000	30000	35300	30283	12340	46200	
Research	13130	134000	22571	89900	65000	63100	29218	18245	33700	
Training	--	--	23000	5000	5000	--	--	15000	4500	
Other	58296	--	4868	--	20000	--	10799	13037	--	
Overheads	19694	16350	10601	--	--	11871	9543	11629	--	
Totals	164120	200350	78992	138900	120000	110271	79843	70251	84400	1047127

WP1. Crop Management Efficiency: Adaptation of promising crop management technologies to land and production environments in Babati, Tanzania

Work package leader: Job Kihara (CIAT)

Research Team composition

Name	Gender	Institution	Job title	Disciplinary expertise	Highest qualification	Project role/ responsibility	% time
Stephen Dominic Lyimo	M	SARI	Agronomist	Farming systems	PhD	Co-PI	25%
Lulseged Tamene Desta	M	CIAT	Soil Scientist	Landscape ecology	PhD	Landscape analysis support	10%
Jean Claude Rubyongo	M	CIAT	Crop scientist	Seed systems	MSc	Bean trial evaluation	5%
Prosper Massawe	M	SARI	Officer	Soil fertility	MSc	Field operations and data collection	70%
Jetrida C. Kyekaka	F	MAFSCO	DAICO	Horticulturalist	BSc	Advisory and follow-up field operations	10%

1.1Abstract

In this WP, we will (1) determine the effect of land degradation on crop yield, and propose and test potential mitigation management and land use technologies (2) determine N and P nutrient use efficiencies for maize in Babati and (3) conduct further testing of technologies for improving yields of promising bean varieties, including role of P and micronutrients. We will characterize manure quality and enhance farmer knowledge for appropriate handling and integrating use of the manure.

1.2 Research problem and justification

Land degradation is common in Babati, as observed in 2012/13 biophysical characterization study. Soil conditions vary widely from saline water-logged, high pH soils in Matufa to well drained, low pH soils in Long. High erosion prevalence and degradation risk are observed in the studied sites, with high variability within sites. Agronomic survey work conducted in 2012/13 demonstrated a lot of variability in crop yields, but nearly all fell below expected yield levels. Deficiencies of N, P, K, S, Zn and Mg were observed. There are neither systematic analyses done nor data available to relate soil health status and observed yields in Babati, and especially considering farmers management practices. Farmers slowly degrade their soil resource basis without being aware, and continually increase the yield gaps. There is therefore a need to study the impacts of different soil health status and nutrient inputs on yield responses and then promote integrated soil fertility nutrient management (ISFM) and land conservation technologies for improving yields and land resource quality. This goes hand in hand with promoting the use of improved pigeonpea and maize varieties together with local nutrient sources (e.g., farmyard manure, Minjingu mazao) and dozing methods which showed promise during the last season. We shall characterize manure, determine how to improve its quality and raise awareness about the proper use of manure and its benefit in terms of maintaining or increasing soil health and boosting crop yields; knowledge that is currently very low.

1.3 Research Objectives

i. To establish the link between land management, degradation status and productivity nexus
ii. Design and implement test trials offering potential for increased crop and land productivity
iii. Estimate effects of the treatments in (ii) on mitigating climate change impacts on crop productivity

These objectives relate to the integration, adoption and trade-off framework hypotheses of AR in that they will integrate improved varieties, fertilizers and organic resources within established cropping systems and coupled with considerations of affordability. Further, the technologies are tested in varied soil and climate conditions and lessons can be easily applied to other similar contexts (addressing scalability hypothesis).

1.4 Methodology

Activity 1: Assess crop response to limiting nutrients using standard replicated on-farm integrated soil fertility management trials. To address this objective which contributes to integrated systems improvement research output (RO2) of AR, replicated nutrient response trials will be conducted in the 6 AfricaRISING action villages in Babati. The trials (1) will serve as demonstrations/ farmer learning sites not only of good agronomic practices but also to show that fertilizers can increase yields and; (2) help determine agronomical and economically optimum nutrient recommendations and making effort to weigh these against the socio-economic constraints of the farmers ("willingness to adopt"), as well as the involved risks (tradeoff between potentially increased financial risk and increased crop production).

Trial type 1: Nutrient response trials will be implemented in the 6 action villages in Babati (3 different farmer fields in each village representing different soil conditions). There will be 8 treatments for maize-legume intercropping trials, being 4 levels each for N and P and will have 3 blocks (replicates). The strategic replication within different farmer fields is to capture soil variability thus other soil nutrients will therefore be studied as well.

Trial type 2: In testing of manure and P sources, a non-replicated trial will be conducted in each of the 6 villages namely Seloto, Sabilo, Long, Shaurimoyo, Matufa and Hallu, being 6 fields in each village. Four improved maize varieties (3 released and one experimental variety with stress tolerance from CYMMT) identified for best performance (priority ones being SC627, SH 308, PAN691, 4M19 or CKH10038, [in “Long” it will be SC614 (kitale, the green leaf), Pan691 and SC627]) will be used in the trial.. Each maize variety will be intercropped with an improved pigeonpea variety called Mali (a long maturing variety) at the inter-row spacing recommended for each agro-ecozone. Intensification of the system will be done by applying five (5) fertilizer treatments to each maize variety. Farmer’s practice/control will be maize pigeon peas intercropping without any fertilizer. The fertilizer treatments/sources will be: 1) Minjingu Mazao in intercropped system, 2) Minjingu Mazao in soil maize system to assess effect of the pigeon pea on maize yield; 3) Di-Ammonium Phosphate, DAP (18%N, 20%P, 0%K); 4) 3 tons FYM/ha (quite affordable by many farmers in Babati)+ Minjingu Mazao; and 5) 6 tons FYM/ha alone (option for farmers with more manure). The P rates applied from each fertilizer source will be 20 kg/ha at planting. A total of 60 kg N/ha (with supplementation from Urea) will be the target for all the fertilizer treatments. The plot size for each treatment will be 10 m x 10 m. A treatment with 12.5 tons of Gypsum (from Mwanga) will be added in Matufa and Shaurimoyo villages to address high pH of the soils, although we also could test this in 2014/15 (not sure to get gypsum quickly).

Trial type 3: Trials above are based on established intercropping systems and recommendations arising from those can be immediately taken up by farmers. We will conduct a third set where we will test in 9 farmer fields (3 each in Long, Sabilo and Seloto), the response of superior climbing bean variety (Selian 06) to 4 nutrients treatments namely (1) 10 kg P/ha as Minjingu Mazao, (2) 20 kg P/ha as Minjingu Mazao and (3) 20 kg P/ha as DAP plus one control (unfertilized) treatment, as an intercrop with a superior strong-stem maize variety. This will be within Mbili intercropping system. The bean variety being tested was farmers' best choice last year because of its productivity.

Data to be collected in addition to yields (grain [maize, beans, pigeonpeas], stover, biomass of pigeonpeas and at harvests) are:

- Household and Socio-economic data (labor, input costs, produce prices) will be collected to evaluate financial profitability (partial budget) of the tested technologies. Also, Potential farmer adoptability will be assessed by looking at gender- disaggregated labour demands and availability e.g. in the case of FYM application, and household cash-constraints
- Germination, flowering dates, leaf number, plant height at 5 points during the season
- Soil taken at a depth of 0-20 cm and 20-50 cm at planting, if fields were not sampled in the 2012/13 season. A few samples will be taken to 90 cm (in control treatments) as input in modeling activities.
- Grain chemical quality
- Soil infra-Red spectra

Maize varieties that have been selected by farmers as promising and recommended by CIMMYT based on 2012/13 variety testing results will be used (could differ by village). Resistance to nematodes and maize lethal necrosis will be preferred in the variety selection. Trials will be conducted in 2013/14 cropping seasons and 6 (1 in each village) will be repeated during the 2014/15 season. As part of 2014/15 activity, DSSAT model will be used to make fertilizer N and P recommendations based on soil data collected during 2012/13 season, and this will be compared with the recommendations that will be derived from the response trials.

Associated to this activity (activity 1) will be characterization of manure quality for various action villages in Babati and enhancing farmer knowledge of appropriate manure handling/management. To characterize manure quality, 18 representative farmers (3 in each of the 6 action villages in Babati) will be trained on recommended manure handling and manure chemical quality under this and traditional systems will be compared and results used in further training and sensitization of more farmers in the 6 villages. Five months before the onset of the next season (2014/15), the 18 farmers will prepare manure that will be used in testing effect of improved vs traditionally prepared manure on crop yields. Around this activity, a training of trainers session will be organized where extension personnel in Babati will be trained on best practices of manure management.

One field day is planned in each action village during the 2013/14 cropping season, where farmers will assess the tested technologies using participatory tools. These field days should be coordinated with the vegetable work package (wherever possible) who have also planned similar activities.

Activity 2: Link and assess interactions between land management, degradation status and productivity. Spatially distributed soil erosion model will be used to estimate the severity and variability of soil loss across sentinel sites surveyed in 2012/13 period. These will be linked to the existing farmer management practices and observed yield estimates for the study sites. Since sample size for the existing data on observed yields from farmer fields are not sufficiently high (low number of farmers/farms) for a detailed exploration and analysis of this linkage, a follow-up agronomic survey in one site (Long-Seloto-Sabilo) and new survey in another (Matufa-Shauri moyo) site will be undertaken. This will provide a depth of data for relating yields with degradation risk caused by soil erosion in relation to observed management practices and potential suggested options. That is, the data will be integrated in a GIS environment to link the spatial variability of soil erosion and crop productivity (and yield gaps) in farmer fields under their various management practices, and will be compared with performance of the superior best best management practices being tested in field trials in this work package.

Data to be collected include:

- remote sensing derived land use/cover over Babati
- rainfall intensity data or erosivity index from rainfall amount
- soil properties information to derive soil erodibility
- ASTER digital elevation model to derive slope length, steepness and upslope contributing area
- Agronomic survey in two sites for at least 160 farmers (possibly each LDSF plot). The further agronomic surveys will be conducted in the already LDSF surveyed sites and this is to increase data density for better assessment of the land degradation productivity nexus. The names and GPS coordinates of farmer fields surveyed will be provided to WP5 for assessment of pre-/post-harvest losses.
- Include pigeon pea and beans in the agronomic survey. This will enable a complete assessment of farm productivity in several fields and assessment of nutrient balances.
- Assess gender aspects on agronomic practices e.g. gender roles related to beans and pigeonpea production.

Activity 3 (for 2014/15): Determine the possible adaptation strategies based on effect of climate change on crop productivity. Climate change is being experienced by farmers in Babati as observed during focus group discussions by IFPRI. Climate change (specifically temperature, rainfall amount and variability) is one of the major determinant factors of crop-livestock productivity. However, its impacts are not studied in Babati and it is needed to design the appropriate adaptation strategies. Thus, the best-bet technologies implemented in the field trials will be assessed under climate change scenarios, i.e., using current available climate data and projections of future climate based on at least 2 Representative Concentration Pathways (RCPs 4.5 and 8.5) adopted by the IPCC for its fifth Assessment Report. Particular emphasis will be on sensitivity of responses to temperature, elevated CO2, and water limitation and excess. Crop data for this will be derived from trials conducted in activity 1. The DSSAT crop growth model will be used for this activity.
Data to be collected (in 2013/14) in addition to that under activity 1 and 2 are:

- Mineral N in the soil at trial establishments for selected fields and treatments under trial type 1. Others are bulk density, SOM, available P and texture.
- Seasonal climate data including maximum and minimum temperatures
- Soil moisture data in 3 plots (contrasting treatments) in one of the trials in Matufa will be taken.
- Available long-term rainfall and temperature data. This will help assess the trend and temporal variability of temperature and rainfall and to generate future climates under various scenarios
- Soil bulk density
- Plant N and P concentrations

Analysis of soil and plant samples will be in the same labs where AfSIS have been analysed namely the ICRAF lab and Crop Nutrition laboratories in Nairobi. Cutting edge data mining analysis techniques including multivariate analysis, recursive partitioning and regression classifications, geospatial approaches and mixed effects modeling will be used in the analysis of the data, capturing the spatial variability and their implications on responses. Gender disaggregated analysis of technology evaluation data will be undertaken.

1.5 Expected results/deliverables

- 2 manure quality improvement technologies identified and promoted in 6 AfricaRISING villages in Babati
- 6 Extension personnel in Babati will be trained on good practices of manure management
- Nutrient management recommendations for N and P will be revised based on soil and crop responses and profitability assessments.
- Best ISFM practices under different soil conditions will be identified
- Potential adaptation strategies for maize production under climate change scenarios will be identified (2014/15).

1.6 **Others deliverables**

- Capacity building: Farmers will be trained on good agronomic practices, ISFM technologies and appropriate manure management
- Collaboration with SARI will be strengthened
- Refereed journal publications, and presentations in various fora

1.7 **Expected outcomes**

i. Short-term: Awareness created on best soil and crop management technologies
ii. Long-term: Reduced yield gap by at least 25% among participating farmers
iii. Long-term: knowledge gained in engagements with farmers and other scientists in these diverse systems used in designing studies and reducing yield gaps in other places

1.8 Communication and dissemination strategies

i. Besides capacity building among extension and farmers in Babati, results of the research will be presented in scientific forums and published in peer reviewed journals

1.9 Project activity schedule

	O	N	D	J	F	M	A	M	J	J	A	S	O (PP)
Fields identified, prepared and planted	■	■	■	■									
Soil sampling		■	■	■									
soil processing and analysis		■	■	■	■	■							
Plant growth measurements		■	■	■	■	■	■	■	■	■	■		
Manure sampling and analysis		■	■	■									
Trial evaluation with farmers						■	■						
Plant sample processing and analysis									■	■	■	■	■
Trial harvesting									■				■
Data cleaning and analysis								■	■	■	■	■	■
Agronomic survey (+ pigeonpea harvesting)								■	■				■
Climate data collection	■	■	■	■	■	■	■	■	■	■	■	■	■

PP= pigeonpeas

1.10 LOGICAL MATRIX FRAMEWORK				
PROJECT DESIGNATION: Adaptation of promising crop management technologies to land and production environment in Babati, Tanzania				
	Intervention Logic Narrative Summary	**Objectively Verifiable Indicators**	**Sources or Means of Verification**	**Major Assumptions**
Outputs	Output 1: nutrient management recommendations for maize and beans in Babati determined based on standard replicated on-farm integrated soil fertility management trials.	For the key cropping systems and per agro-ecological zone, agronomic and economically optimal nutrient and ISFM options identified. Field days with farmers and community leaders held in all sites to evaluate technologies.	Farmer preferred technologies that will be identified. Scientific publication. Project reports.	Participation of important stakeholders.
	Output 2: Improved land and soil management strategies needed to reduce soil erosion and improve land productivity	Site maps of severity and variability of soil loss across Babati. Database of crop production and linked to land degradation indices.	Maps of soil loss across Babati available for use by partners and stakeholders. Database available for other scientists, decision makers and policy makers (e.g. ELD). Scientific publications Project reports.	Team spirit between landscape ecologist and agronomists.
	Output 3: Improved quality of manure in the action villages in Babati	Training of trainers meetings held 2 times in 2013/2014 Manure samples from the 6 action villages analyzed for chemical quality	Project reports, List of extension personnel trained and farmers trained by the extension personnel.	Trained extension personnel will actively engage in farmer training.

WP2. Integrated approaches to manage Maize Lethal Necrosis (MLN) disease in Tanzania

Principal Investigators: Dan Makumbi (CIMMYT) & Lava Kumar (IITA)

Organization and full address:
International Maize and Wheat Improvement Center (CIMMYT)
ICRAF House, UN Avenue, Gigiri
P.O. Box 1041-00621, Nairobi, Kenya

Research Team composition

Name	Gender	Institution	Job title	Disciplinary expertise	Highest qualification	Project role	%time commitment
Dan Makumbi	M	CIMMYT	Scientist	Breeding	PhD	PI	10%
Mac Jumbo	M	CIMMYT	Scientist	Breeding	PhD	Co-PI	15%
George Mahuku	M	CIMMYT	Senior Scientist	Pathology	PhD	Staff	10%
Lava Kumar	M	IITA	Scientist	Virology	PhD	Collaborator	10%
Susan Njeri	F	CIMMYT	Research Assistant	Breeding	MSc	Field Operations	10%
Joseph Ombaka	M	CIMMYT	Research Assistant	Pathology	MSc	Field Operations	10%

2.1 Abstract

Maize (*Zea mays* L.) accounts for up to 61% of the total calories in the diets as well as 50% of utilizable protein for the majority of the Tanzanian rural population. Legumes mainly pigeon pea (*Cajanuscajan*) and beans (*Phaseolus vulgaris*) are used for household consumption and for the market. In Babati, maize is mainly intercropped with pigeon pea district while some farmers intercrop maize with beans. Maize productivity in Babati like in many parts of Tanzania is low due to a variety of problems including poor agronomic practices, abiotic stresses (low soil fertility and drought), inadequate fertilizer use, pests, and more recently maize lethal necrosis (MLN) disease epidemic. New maize varieties combining high yield potential with tolerance to drought and resistance to major pests have been developed by CIMMYT and the Tanzania National Maize Program. Efforts are in progress to develop varieties resistant to MLN and promising hybrids are available. Several of these hybrids need to be tested to validate their response to MLN in multi-locations.

2.2 Research problem and justification:

The outbreak of maize lethal necrosis disease (MLN) in East Africa is a serious challenge to maize production and poses a big threat to food security for the majority in this region. MLN disease outbreak in East Africa was first reported in Kenya in 2011 (Wangai et al., 2012) where it caused serious yield loses. The disease has since been reported in the neighboring countries of Tanzania and Uganda. MLN is caused by double infection of maize plants by *Maize chlorotic mottle virus* (MCMoV) in combination with any of the cereal viruses in the family *Potyviridae,* such as *Sugarcane mosaic virus* (SCMV), *Maize dwarf mosaic virus* (MDMV) or *Wheat streak mosaic virus* (WSMV). MLN disease causing viruses are transmitted by vectors such as thrips and beetles for MCMV (Nault et al., 1978), and aphids for SCMV and MDMV (Brandes 1920; Pemberton and Charpentier 1969).

During execution of AfricaRISING activities in Babati in 2013, we identified symptoms of the disease in the trials and noted that many of the recently released hybrids and the commercial check were seriously affected by the disease. The varieties preferred by farmers expressed moderate symptoms but these observations can only be confirmed in trials with uniform disease pressure. The most sustainable control option for MLN is host plant resistance in combination with other management options such as good cultural practices. CIMMYT together with its partners from both private and public research organizations have teamed up to work on finding solutions to control MLN. Initial evaluations of several maize inbred lines and hybrids for resistance/tolerance have led to identification of some hybrids and inbred lines with moderate resistance and tolerance to the disease under natural and artificial inoculation (CIMMYT, 2012). Thus it is important to validate the reaction of experimental hybrids identified in Kenya, assess reaction of farmer-preferred hybrids (selected in year 2) and commercial varieties available in Tanzania under hotspot areas in Babati district. Variations in planting time observed in farmers' fields in Kenya have shown that maize crop under delayed planting has often been severely affected by MLN. In view of this, we believe good cultural practices including timely planting would significantly support other control measures to manage this disease and, therefore, needs to be investigated. In addition information establishing the prevalence of the disease in maize growing areas as well as identifying the MLN causative virus strains through surveys, leaf sampling of diseased plants and analysis, is critical in designing appropriate MLN management protocols, as well as determining training and awareness campaign needs targeting affected areas.

2.3 Objectives of the research

1. To identify MLN resistant varieties from available commercial, farmers and experimental maize varieties grown under high disease pressure.
2. Establish the prevalence of MLN and identify causative virus strains sampled from diseased maize plants in Africa RISING research sites in Babati, Kongwa and Kiteto.
3. Assess the effectiveness of different disease management options (cultural practices) in reducing the incidence of MLN for recommendation in target maize growing areas

2.4 Methodology:

i) For objective 1, we plan to set up a trial composed of 140 CIMMYT hybrids already in regional trials, 300 hybrids from advanced hybrid trials, 300 three way hybrids, hybrids grown by farmers and a set of inbred lines. The size of the trial may be reduced depending on land availability. The entries in this trial will be the recently identified MLN tolerant maize hybrids, hybrids commonly grown in Babati, farmer varieties and some experimental hybrids. The trials will be planted at 4-5 hotspot locations (Mara Farm, Seloto and Sabilo) in Babati district under natural infestation. The hot spot areas in Babati have high disease pressure as three of our 2012/13 season trials planted at three of these areas were completely lost to MLN. These hotspot locations were identified during our regular visits in Babati district and during a survey on MLN conducted in 2012 in Tanzania. The experimental design to be used will be the alpha lattice design. Data will be collected on plant stand count, grain yield, days to 50% anthesis and silking, MLN disease severity (scale 1-5, with 1=no disease and 5=100% death due to disease) and MLN disease incidence based on symptoms and diagnostic tests. Data on disease incidence and severity will be recorded at three-week intervals after planting until the end of the grain filling period.

ii) For objective 2, we plan to conduct surveys in farmers' fields around Babati, Kiteto and Kongwa to establish the prevalence of the disease. This will be done two weeks from the time of planting with subsequent monitoring periodically during the crop development till flowering stage. Samples will be taken from diseased plants for laboratory analysis to identify virus strains prevalent in these areas.

iii) Addressing objective 3, we plan to stagger planting, with the first planting done timely with the onset of rains and second planting two weeks after the recommended planting time. Similarly, data will be collected as described in objective 1.

2.5 Expected results/deliverables

- Hybrids and breeding lines with resistance/tolerance to MLN are identified and recommendations made for their utilization: a) in breeding systems (inbred lines), b) for inclusion in national performance trials for fast track release (experimental hybrids), and, c) for upscaling in MLN-affected areas (commercial hybrids).
- Knowledge and information on the prevalence of MLN in target maize based systems is established for utilization in formulating appropriate recommendations on management strategies, determining training needs and designing information packages for public awareness.
- Virus strains associated with MLN identified and measures taken in designing appropriate protocols for managing the disease in the target maize growing areas.
- Effective management options recommended for upscaling in target maize growing areas.

2.6 Others deliverables

- Capacity development
    - Farmers trained on identification of MLN disease symptoms and management strategies.
- Collaboration with other projects, institutions
    - Collaboration will be established with Selian ARI for execution of the trials and farmer preference studies, and DALDOs for farmer selection and training.
    - Collaboration with ILRI on food-feed maize variety identification
    - Collaboration with CIAT on identification of best performing maize hybrids under varying agronomic management options
- Academic, including publications, conference papers
    - Scientific publication(s) in refereed journal(s) and reference bulletins for extension agents and farmers

2.7 Expected outcomes

Short-term

(a) Information on awareness and management of MLN packaged, available and training delivered to stakeholders and farmers on control and management of the disease

(b) MLN stress tolerant hybrids validated and included in national performance trials for variety release consideration.

Long-term

a. Seed of MLN disease tolerant improved maize variety is available to farmers in the Babati action areas.
b. Threat to food security due to MLN in maize growing areas in Tanzania arrested.

2.8 Communication and dissemination strategies

We will engage the communications unit at CIMMYT and IITA to publicize key project activities through print and electronic media.

2.9 Literature references

Brandes, E.W. 1920. Artificial and insect transmission of sugarcane mosaic.*Journal of Agricultural Research* 19: 131-138.

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2.10 Project activity schedule

	2013			2014								
Activity	**Oct/ Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**
Pre-trial site stakeholder and inception meeting	X	X										
Seed multiplication for trials (done in advance using other resources, preparation & Shipment	X	X										
Land preparation and planting	X	X										
1st monitoring visit and initial disease scoring, MLN surveys & trainings		X	X									
Topdressing of trials			X									
2nd monitoring visit and disease scoring, MLN survey			X	X								
Data collection (flowering, disease scoring feed quality), MLN survey				X	X							
3rd monitoring visit					X	X						
Harvest maize						X	X	X				

Data analysis									X	X		
Report write-up and submission											X	

2.11 Logframe of WP2

ROs	Activity	Milestones	Indicators	Key Deliverables
RO2: Integrated systems improved	Evaluate maize varieties for resistance/tolerance to MLNdisease in Babati, Tanzania	Data on key traits collected and analyzed, and resistant/tolerant varieties identified and selected by October, 2014	Number of MLN resistant/tolerant maize identified	1. At least two MLN resistant/tolerant maize varieties identified for target areas
	Establish the prevalence of MLN in target maize growing areas	Knowledge and information on the prevalence of MLN in target maize based systems is established for utilization in formulating appropriate recommendations on management strategies, determining training needs and designing information packages for public awareness.	Knowledge and information generated on MLN prevalence in target maize growing areas	Reports and documentation on MLN prevalence in target maize growing areas
	Identify virus strains associated with causing MLN, formulate measures and design appropriate protocols for managing the disease in the target maize growing areas.	Information on virus strains associated with MLN in the target maize growing areas established & measures taken for designing appropriate protocols for managing the disease	Significant information generated on virus strains associated with causing MLN in target maize growing areas and appropriate control measures put in place	Laboratory analysis reports and documentation on virus strains; recommendations on control measures and protocols for managing MLN
	Determine effectiveness of management options (cultural practices) in reducing MLN disease severity	Effective management options determined and recommendations made for their application in MLN management	Package of cultural measure for controlling MLN determined and recommendations made for their application	Project reports on MLN management, extension leaflets, radio messages
	Develop capacity for monitoring and diagnosis of maize viruses, including MLN	A functional ELISA-based lab established at SARI	Reports on analysis of samples collected during the surveys	Maize virus diagnostic lab at SARI

WP3. Fodder and feed as a key opportunity for driving sustainable intensification of crop livestock systems in Tanzania

Work Package Leader: Ben Lukuyu, ILRI

Research Team composition

Name	Gender	Institution	Job title	Disciplinary expertise	Highest qualification	Project role/ responsibility	% time
Peter Thorne	Male	ILRI	Senior Scientist	Livestock scientist	PhD	ILRI Coordinator	2
Bernard Lukuyu	Male	ILRI	Scientist	Animal Nutrition	PhD	Lead Scientist	10
Festo Ngulu	Male	Africa RISING	Research Assistant	Soil Scientist	MSc.	Field coordinator	20
Alphonce Haule	Male	Babati District	Extension officer	Tropical Animal Production	BSc.	Msc. Student	20
TALIRI, Tanga/	Mixed	NARS	Scientists	Multidisciplinary	Various	Collaborator	40

3.1 Abstract

This proposal details work that will follow up on 2012 - 2013 project activities that sought to introduce appropriate fodder crops into the maize-based farming systems of Babati District as an element of improved land management strategies. The integration of improved forages into smallholder crop-livestock systems is viewed as a means of facilitating the intensification of these systems while mitigating climate change and halting or reversing environmental degradation. Intended outcomes include increased milk production and associated incomes; decreased greenhouse gas emissions per unit livestock product; improved soil fertility and reduced erosion and increased levels of environmental awareness amongst stakeholders.

3.2 Research problem and justification

The current project is motivated by the fact that high human and animal production densities in some areas of sub Saharan Africa, including Tanzania, and the consequent increases in demand for food and livestock feeds have led to permanent cultivation of more land, reduction of grazing and forest lands to expand crop production, and the disappearance of traditional practices that allowed land to lie fallow (Ndikumana and de Leeuw 1996; Walshe et. al., 1998). Nutrient balances are negative in most production systems (Romney et. al., 2003). Organic and inorganic fertilizers are used in insufficient amounts to prevent nutrient mining. Fertilizers and good quality feeds are too costly and not available to poor farmers who do not have access to credit. Innovative crop (food and feed), livestock and soil management technologies that improve productivity and promote efficient recycling of nutrients amongst crops, animals and soil will help to strengthen the low-input, mixed farming systems that dominate throughout much of Tanzania. Forage grasses and legumes are a significant potential contributor to improving efficient in mixed farming systems including those of Babati district. However, information on the most suitable forage crops and the ways in which they can be effectively integrated and used in the system is lacking.

The studies conducted in 2012 - 13 indicate that:

(i) Extensive grazing, with some tethering, is prevalant in lowland areas;
(ii) Pasture are dominated by poor quality grasses;
(iii) Planted forages, especially legumes, are largely absent in the system. This was attributed to lack of forage seed;
(iv) Crop residues such as dry and green maize stover (including strippings and thinnings), bean haulms, pigeon pea residue, sugarcane tops and sweet potato vines are commonly fed to livestock;
(v) Storage, processing and utilization practices associated with these crop residues are poor;
(vi) There is some fodder trading, especially of crop residues, happening at small scale;
(vii) Traditional erosion control methods are not maintained so soil degradation due to overgrazing is evident.
(viii) There is general lack of information on feed technologies

3.3 Objectives or research questions

The major objectives of the proposed project are to:

(i) To establish the suitability of potential forages across the different agro-climates and farming systems found in Babati district;
(ii) To assess the nutritive value of the most important forages and summarise their relative suitability for feeding different classes of livestock;
(iii) To design forage-based feeding strategies that promote the integration of forage and grain legume residues into existing farming practice;
(iv) To introduce and test the potential of a small scale pulveriser to reduce wastage and improve quality of crop residues;
(v) To support the establishment and expansion of local planting material producers (seeds and seedlings) and agribusinesses to overcome the limitations of forage seed supply.
(vi) To evaluate the implications of the improved fodder supply and management systems for green house gas emissions and soil fertility and stability in the longer terms.

3.4 Methodology

The research approach proposed is based on action research using a three strata forage system in which improved forages and fodder trees and shrubs will be integrated into existing mixed crop-livestock systems. The work package will comprise four major tasks:

Task 1: Evaluating and integrating improved forages and fodder trees & shrubs into existing mixed crop-livestock systems (addresses objectives 1, 2 and 3).

This will be done systematically as follows:

i. Promising forages selected from on-station trial plots at LITA Tengeru, Arusha will be planted on two host farms in each of the three selected villages (Long, Sabilo and Seloto). The two farms will serve as data collection and bulking sites for fodder as well as a learning point for selected groups. Yield and quality data will be collected. Farmer participatory evaluation will be conducted. Farmers will be allowed to select at least one forage to plant on their own farms in the second season. A follow up study of the forage opportunities preferred by farmers will be proposed for 2015 - 2016.

ii. Full nutritive value assessments will be conducted on all forage materials used in the research. This information will be presented to participating farmers in a way that is accessible to them and can assist them in selecting the forages that are most appropriate for them.

iii. Based on the lessons learned from the participating farmers, generic fodder integration and management strategies will be identified and promoted for wider adoption.

Task 2. Evaluating the potential for introducing feed processing technologies in Babati district (addresses objective 4).

A small scale commercial residue pulveriser will be introduced and its potential for minimizing wastage and helping to ensure that livestock have access to sufficient quantities of high quality feed all year round will be assessed. The aim of this technology is to strengthen the adoption potential of fodder technologies and allow an evaluation to be made of the potential of this innovation in the small scale feed processing sector in Babati district. The feasibility assessment under this task will also be based on a study of maize stover production (quantity and quality) in Babati district that will be conducted in collaboration with CIMMYT.

Task 3: Enhancing forage seed supply (addresses Objective 5)

i. One plot on each farm will be set aside for screen forage for seed production potential. It will be proposed that promising varieties will be entered for further multi-location seed production trials and farmers participatory variety selection in 2015- 2016.

ii. To improve seed supply and enhance technology adoption by smallholder farmers, partnerships will be established with private agro business seed/planting material dealers to avail seed/planting materials to farmers for purchase. A training course on seed production will be conducted.

Task 4: Evaluate the wider implications of the innovations tested and generate information on recommended feed technologies for wider dissemination (addresses Objective 6)

i. Review the implication of the innovations tested by the project for green house gas emissions and soil fertility and stability in the longer terms.

ii. Develop appropriate extension modules/materials on feeds and appropriate feeding and organize/facilitate their use to develop the capacity of various stakeholders.

3.5 Expected results/deliverables

1. At least two ‘best bet’ improved forage species identified and characterized in each agro ecology and strategies for integrated them into existing systems formulated.

2. The viability of small scale feed processing machines in Babati district determined.
3. Functioning and sustainable private sector seed dealers and small scale agribusinesses created and / or supported.

3.6 Other deliverables

a. At least 100 farmers trained in forage production
b. At least 10 farmers trained on tree seedling production
c. At least one leaflet produced on feed processing technology
d. At least two fact sheets produced on two selected forage varieties
e. A report on the implications of changes in forage production and management practices for green house gas emissions and soil fertility and stability.

3.7 Expected outcomes

Integration of improved forages in crop livestock production systems are expected to increase feed productivity in existing systems. Specific outcomes include the following:

Short term

i) Increased number of farmers planting forages
ii) Increased feed quality in Babati district
iii) Increased awareness on forage technologies and practices amongst farmers

Long term:

i) The feeding and quality of crop residues in Babati district improved
ii) Availability of improved forage seed and planting materials to contribute to sustainable intensification
iii) Improved soil fertility and decreased soil erosion due to planting forages

3.8 Literature references

1. Ndikumana J. and de Leeuw 1996. Sustainable Feed Production and Utilization of Smallholder Livestock Enterprises in Sub-Saharan Africa. Proceedings of the Second African Feed Resources Network (AFRNET), Harare, Zimbabwe, 6-10 December 1993. AFRNET (African Feed Resources Network), Nairobi, Kenya.
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a. Project activity schedule

	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14
Task 1(i)												
Task 1(ii)												
Task 1(iii)												
Task 2												
Task 3 (i)												
Task 3 (ii)												
Task 4 (i)												
Task 4 (ii)												
Reporting												

3.10 LOGICAL FRAMEWORK

Narrative summary	Objectively verifiable indicator (OVI)	Means of verification (MOV)	Lead Institutions
Output 1: Improved forage species identified and characterized in each agro ecology and strategies for integrated them into existing systems formulated.	At least at least two 'best fit' forages being used by participating farmers by September 2014.	▪ Project report ▪ At least 100 farmers trained in forage production ▪ At least 10 farmers trained on tree seedling production	▪ ILRI and TALIRI Tanga
Output 2: The viability of small scale feed processing machines in Babati district determined	At least two pulverisers (choppers) acquired, tested and evaluated by farmers, feed quality and quality measured by October 2014	▪ Project report ▪ Linkage made with a private agro business firm dealing in pulverisers. ▪ At least 2 extension staff trained on pulverisers. ▪ At least 10 farmer trained per sites ▪ A dissemination leaflet produced on feed processing	▪ ILRI and TALIRI Tanga, private agro dealers
Output 3: Functioning and sustainable private sector seed dealers and small scale agribusinesses created and / or supported.	At least two promising, seed producing varieties under Babati conditions identified and in bulking with private sector dealers by September 2015.	▪ Project report ▪ Private agro dealers linked to the project to catalyze seed production ▪ 10 farmers trained on seed production. ▪	▪ ILRI/ CIMMYT/ TALIRI Tanga and West Kilimanjaro

PROJECT MILESTONES

<table>
<tr><td colspan="2">Output 1& 3: Integrating improved forages and fodder trees & shrubs into existing mixed crop-livestock systems and evaluating potential for seed production</td></tr>
<tr><td>1.1 To procure forage seed and planting materials</td><td>▪ Forage seed procured by January 2013 in time for planting by March 2013.</td></tr>
<tr><td>1.2. To quantify forage yields and quality</td><td>▪ Forage yield quantified at Lita Tengeru by February 2014
▪ Forage yield and quality evaluated on farms by scientists from ILRI and TALIRI Tanga and West Kilimanjaro by August 2014
▪ Participatory farmer evaluations conducted farms by scientists from ILRI and TALIRI Tanga and West Kilimanjaro by August 2014</td></tr>
<tr><td>1.3. Train farmers on forage production and seed production</td><td>▪ At least two farmer trainings conducted by August 2013
▪ Produce fact two sheets on selected forages by October 2014</td></tr>
<tr><td>1.4 Evaluate potential for seed production</td><td>▪ At least two ‘best bet’ seeding forages identified by November 2013</td></tr>
<tr><td>1.5 Quantify forage seed production</td><td>▪ Seed production potential quantified by April 2015. Report produced by August 2015</td></tr>
<tr><td colspan="2">Output 2: Evaluating potential of feed processing in crop livestock systems of Babati district.</td></tr>
<tr><td>2.1. To procure feed pulveriser s/choppers</td><td>▪ At least 2 forage pulverisers/ choppers procured by ILRI by April 2014</td></tr>
<tr><td>2.2. Quantify and assess pulveriser performance with farmers. Quantify feed quality and quantity</td><td>▪ The performance of pulverisers measured under farmer conditions
▪ Extended of feed quality improvement quantified by October 2104
▪ Feed wastage saving is measured by October 2014</td></tr>
<tr><td>2.3. Train farmers on feed processing</td><td>▪ At least two training sessions with farmers on feed processing conducted.
▪ At least one leaflet on feed processing produced</td></tr>
<tr><td>2.4. The use of small scale feed processing methods in Babati district assessed</td><td>▪ A follow survey of at least 50 farmers on feed processing conducted in Babati district by July 2015</td></tr>
</table>

WP 4: Evaluation of strategies for prevention of mycotoxin contamination along food and feed value chains in Babati

Work package Leader: Fen Beed, IITA, Dar es Salaam

Research Team

Name	Gender	Institution	Job title	Discipline	Qualification	Project role/responsibility	% time
Fen Beed	M	IITA	Scientist	Plant Pathologist	PhD	Project leadership	20
Martin Kimanya	M	NM-AIST	Lecturer & Chair of Steering Committee for Mycotoxins	Food safety	PhD	Project leadership, laboratory based analysis on diagnostic methods and quantification of mycotoxin in samples, awareness raising	10
Lydia Munuo	F	NM-AIST	Lab technician	Food safety	MSc	Collection, preparation and analysis of samples, Evaluation of optimal detection method for aflatoxin and fumonisin for transfer to ARIs	30
Shabana	M	NM-AIST	MSc student, already recruited	Analytical chemist	MSc		100
Emmanuel Koyano	M	IITA	Research assistant	Research supervisor	MSc	Collection, preparation and analysis of mycotoxin samples, awareness raising	100
Chacha Nyangi	M	SUA- iAGRI	MSc student already recruited	Food Science	BSc	Collection, preparation and analysis of mycotoxin samples and questionnaire data	100
Edgar Lyakurwa	M	SUA- iAGRI	MSc student, from LGA	Social scientist	BSc	Refinement and deployment of awareness strategy	100
Nick Quist Nathaniels	M	Consultant	Media consultant	Communication specialist	PhD	Coordinate development, refinement and deployment of awareness strategy	10
Jocelyn Kaganda	F	TFNC	Communication expert	Nutrition food safety	PhD	Development of awareness raising materials	10
Omari Mponda	M	ARI-Naliendele	Breeder	Mycotoxin specialist	PhD	Development, refinement and deployment of awareness materials for ground-nut	10
Arnold Mushongi	M	ARI-Mbeya	Breeder	Mycotoxin specialist	PhD	Development, refinement and deployment of awareness materials for maize	5
Eunice Temu	F	ARI-Selian	Agronomist	Extension	BSc	Refinement and deployment of awareness strategy	10

4.1 Abstract

This project will identify and deploy control interventions to mitigate mycotoxin contamination in 6 target villages of Babati and hence safeguard the health of people, livestock and realize income generating opportunities through trade (including access to regulated markets where mycotoxin contamination is prohibited). The target for 2014 (and leading eventually to 2016 targets) is to deploy improved aflatoxin management practices to 50 Ha (2500 Ha in 2016) through direct collaboration with 150 farmers, 2 private enterprises, 5 producer organizations (3150 farmers, 50 private enterprises, 125 producer organizations, 5 PPP) and to increase awareness of risks due to aflatoxin (hence increasing likely adoption of control interventions) through training of 300

producers, 38 government staff and 38 private enterprises (7500 producers, 950 government staff and 950 private enterprises by 2016). The key mycotoxin targeted is aflatoxin in maize (produced by *Aspergillus*) but studies also encompass risk due to fumonisin (produced by *Fusarium)* and mycotoxin contamination in beans as this is a key staple that has not been previously studied. However, if results show contamination in food and feed derived from beans is limited then this commodity will subsequently be omitted. Activities in WP4 are linked across all other WPs for Babati and include evaluation of improved; breeding lines, agronomic practices and post-harvest methods, by determining impacts on levels of mycotoxin contamination. Links to ICRISAT led activities in Kongwa/Kiteto; include development, refinement and deployment of awareness raising strategy of mycotoxins and control options, plus testing of diagnostic methods for aflatoxin suitable for transfer to ARIs.

4.2 Research problem and justification

In Tanzania, several indicators allude to high mycotoxin exposure levels among maize and groundnut growing rural households, such as (1) erratic rainfall, high temperature and humidity levels in crop production areas (2) presence of predominantly small farm holdings (85% of maize in Tanzania is grown on less than 1 ha) that produce for informal, local markets and that escape regulation mechanisms and (3) a general lack of awareness about mycotoxins and their effects. Quantification of mycotoxin contamination is a critical first step to address the problem. The jumpstart inception project in 2012 took great strides to address this issue of quantifying mycotoxin levels by surveying all regions important for the cultivation of maize and cassava and analysing samples collected for a suite of mycotoxins (over 250 for each samples). Briefly, 405 cassava and 257 maize samples were analysed. Cassava turned out to be largely unaffected by aflatoxins (86% samples negative; 4% samples above 5 ppb). Maize however has a significant aflatoxin issue: 52% samples negative; 29% samples above 10 ppb (World Food Program limit); 21% above 20 ppb (US-FDA limit); mean 182 ppb – the mean is high because 5% samples had >500 ppb out of which 3.5% had >1,000 ppb; the maximum level found was 9,255 ppb. Babati was found to be one of the districts with the highest contamination levels of maize from the field (although full analysis of data is still continuing) and therefore appropriate for further and more detailed investigation with a focus across the food and feed value chains for crop commodities key to Babati; namely maize and beans. Methods have been optimized to collect representative samples along the food and feed value chain, accompanied by a questionnaire to harness information from farmers, traders/ market vendors, processors, animal feed specialists. For 2012-3 over 1000 samples have been collected from target villages of Seloto, Long and Sabilo and these have been dried, ground and sub-sampled and are currently being analysed to quantify mycotoxin levels. Full integration with WP6 (improved post harvest storage) has led to the development of a sampling strategy which has begun and will continue into the forthcoming year (2013-4) in order to relate mycotoxin levels with traditional compared to improved storage devices as influenced by duration and conditions for raw grain and crop products. Further, for 2013-4 sampling strategy will be expanded to encompass 3 additional villages of Shaurimoyo, Hallu and Matufa (alongside Seloto, Sabilo and Long). Analyses to quantify mycotoxins is being performed using Neogen Accuscan ELISA quantitative reader and Romer labs lateral flow device (LFD) strips specific for total fumonisin or total aflatoxin (calibrated using reference material with known quantities of aflatoxin and fumonisin) and for 2013-4 NM-AIST will lead a comparative analysis of available diagnostic equipment in order to recommend which is most suitable for transfer to ARI-Selian and ARI-Hombolo (to include Neogen Accuscan ELISA, Romer labs LFDs, HPLC, and for a limited number of samples using LC-MS/MS through collaboration with BOKU-IFA-Tulln, Austria and ELISA based system being used by ICRISAT). A major focus in 2013-4 will be to implement and evaluate control interventions to manage mycotoxins in Babati and to achieve this it is recognised that awareness of the potential risks due to these fungally produced chemical poisons must first be carefully explained and messages refined based on the perceptions of stakeholders. In 2012; 545 people received mycotoxin factsheets and in 2012-3 a further 1000 people were recipients and it was clear that there was a need to further enforce awareness through a targeted media campaign.

4.3 Objectives / research questions

1. What is the extent and the distribution of aflatoxin and fumonisin contamination in food and feed from maize (and beans) in Babati
2. To what extent can appropriate intervention strategies mitigate mycotoxin contamination in food and feed?
3. To what extent can raised awareness on the risks (to human and livestock health and trade) due to mycotoxins facilitate the adoption of control interventions?

4.4 Methodology

Information collected in the sample questionnaire will be interrogated and correlated with analysed mycotoxin levels to ascertain which production, processing and storage practices are most directly linked with mycotoxin contamination. These results will be used to justify the strategy for control interventions including geographical hotspots and section of the food and feed value chain most susceptible to contamination by mycotoxins. Should there be no or only limited evidence of contamination in food and feed products originating from beans then no further investigations or control interventions will be performed using beans.

Increasing awareness is of critical importance as a component of any mitigation strategy. This is because mycotoxins and the risks they pose are currently not widely known, and this is why markets are not currently regulated for mycotoxins in Tanzania. We intend to link with Kiteto/Kongwa project to create a similar strategy to raise awareness of the risks due to aflatoxin. Components will include 1) understanding baseline perceptions 2) increasing awareness of mycotoxins 3) increasing awareness of intervention technologies and 4) evaluating impact of intervention technologies. This campaign will involve written material, radio broadcasts, interactive voice messaging services and material will be refined based on the perceptions of stakeholders and shared learning in a participatory and dynamic manner. Services will be recruited of an expert communication specialist; Dr Nick Quist Nathaniels who can provide oversight across commodities and link to the communication capacity inherent within TFNC. Commodity leads will be Omari Mponda of ARI-Naliendele for groundnut, Arnold Mushongi of ARI-Mbeya for maize. Links will also be facilitated to National Steering Committee for Mycotoxins in Tanzania through chair - Martin Kimanya and Jocelyn Kaganda through membership of TFNC. An MSc student will be engaged in these activities who was previously embedded in the extension system in Babati, to evaluate the likely adoption of mitigation technologies and assistance will be provided by ARI-Selian. Control interventions will be linked to other WPs and include the following;

a. Crop varieties that are resistant to the fungi that produce mycotoxins (i.e. *Aspergillus flavus* for aflatoxins) or insect attack that increase entry of these fungi
b. Raising beds where crops cultivated to reduce drought stress (which encourages growth of the fungus - *Aspergillus flavus)*

c. Avoiding drought conditions during crop growth (irrigation, soil amendments with lime and organic supplements)
d. Avoiding insect attack during cropping, harvesting or storage as this facilitates entry of *Aspergillus flavus* and other mycotoxin producing fungi (pesticides)
e. Avoiding rough handling during harvesting or storage as this facilitates entry of *Aspergillus flavus* and other mycotoxin producing fungi
f. Avoiding drying of grain/beans on soil
g. Avoiding wet conditions at harvest – as this promotes growth of *Aspergillus flavus* and other mycotoxin producing fungi
h. Avoiding wet and warm conditions during storage – as this promotes growth of *Aspergillus flavus* and other mycotoxin producing fungi
i. Sorting of grain so contaminated samples are dismissed (and not fed to animals – or processed into products where quality not obvious – flour, beer, spreads, etc.. as these poisoned products will still enter food and feed and cause harm
j. Blanching and binding to treat contaminated crop materials and reduce mycotoxins
k. Indirectly – control through regulation and diagnostics of mycotoxins and this is more likely if awareness increased and if crop products linked to international trade
l. Biocontrol; the application of a biological control agent specifically designed for Tanzania using indigenous and non aflatoxin producing strains of the fungus *Aspergillus flavus* will be considered. This product is ready for testing after screening of different strains was completed by Happy Daudi of ARI-Naliendele at IITA Ibadan at the beginning of 2013 (using funds supplied by USDA-ARS). It is likely that funds for the mass production and preliminary testing of this product will be provided in kind from other donors and through collaboration with the private sector.

4.5 Expected results/deliverables (LOGICAL FRAMEWORK)

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATOR (OVI)	MEANS OF VERIFICATION (MOV)	LEAD INSTITUTIONS
Output 1 Geographical hotspots and susceptible components of maize (and bean) food and feed value chains for mycotoxin contamination determined	At least three hotspots and 3 causal factors identified and reported by May 2014	Project report, GIS map, scientific publication	IITA/ SUA / NM-AIST

Output 2 Intervention measures for prevention of mycotoxin contamination of food and feed determined	At least two control methods identified and plans made for testing across 6 target villages of Babati by September 2014 Different methods for aflatoxin analysis validated at NM-AIST and through collaboration with Kiteto-Kongwa project by July 2014	Project report, plans developed to apply optimal technologies to 50 Ha (through collaboration with 150 farmers, 2 private enterprises, 5 producer organizations) Project report, protocol developed highlighting suitability of different methods for transfer to ARIs	IITA/ SUA/ NM-AIST/ ARIs NM-AIST/ ICRISAT
Output 3 Awareness raising of risks due to mycotoxins and methods for their mitigation created	Strategy developed, refined and implemented to evaluate baseline perceptions and communication tools (written and radio), to increase awareness of risk due to mycotoxins and interventions for their control by October 2014	Project report, awareness increased through training of 300 producers, 38 government staff and 38 private enterprises	IITA/ NM-AIST/ ARIs / ICRISAT

Output 1 **Geographical hotspots and susceptible components of maize (& bean) food and feed value chain for mycotoxin contamination determined**	
1.1 Procure laboratory equipment and consumables	Materials procured by IITA and NM-AIST by December 2013 and July 2014 in timely manner to ensure validity
1.2. Analyse aflatoxins and fumonisins in maize (and beans) food and feeds	Contamination data (based on minimum of 100 maize samples for each of 6 targeted villages) evaluated by scientists working at both NM-AIST and IITA laboratories, by April 2014
1.3. Analyse contamination data and correlate with questionnaire data	Information of contamination risk areas and factors generated by a targeted MSc Student study at IITA by May 2014
Output 2 **Intervention measures for prevention of mycotoxin contamination of food and feed determined**	
2.1. Develop a package of post harvest measures to reduce contamination	Based on correlation of analytical and questionnaire data, an intervention package prepared by September 2014
2.2. Develop an implementation plan for intervention measures to selected areas	At least two new measures are selected and introduced to all the 6 villages by October 2014
2.3. Analyse data on impact of mitigation methods for mycotoxins	The effects of each intervention on mycotoxin contamination measured 2015 (based on minimum of 100 maize samples for each of 6 targeted villages) and documented by May
2.4. Validate laboratory methods	Different methods currently available for aflatoxin analysis validated at NM-AIST by July 2014 and through collaboration with Kiteto-Kongwa project led by ICRISAT

Output 3 **Awareness raising of risks due to mycotoxins and methods for their mitigation created**	
3.1. Recruit staff of LGA and ARI-Selian to participate in awareness raising campaign in framework of MSc program	Candidate selected by December 2013 and integrated into all awareness raising activities in 2014 and registered as iAGRi student at SUA for 2013-4 academic year
3.2. Harmonize messages for raising awareness	Two harmonization meetings conducted in January and April 2014 to develop and refine appropriate messages, linked to National Steering Committee for Mycotoxins in Tanzania and to the Kiteto-Kongwa project and ARIs-Naliendele, Selian and Mbeya
3.3. Conduct a survey of knowledge, attitude and perception of aflatoxins and fumonisins problem	A survey of at least 100 farmers, 10 government staff and 10 private enterprises performed during February and March 2014
3.4 Raise awareness on risks due to mycotoxins and control interventions	Campaign conducted in all the six target villages and completed by August 2014
3.5 Conduct a follow up survey of knowledge, attitude and perception	A survey of at least 300 farmers, 38 government staff and 38 private enterprises performed by September 2014
3.6 Evaluate the influence of public awareness campaigns	Data analysed and evaluation report produced by October 2014

4.6 Deliverables

- 3 MSc students to complete studies:
  1 social scientists embedded at Babati LGA and registered at SUA
  1 Food scientists registered at NM-AIST and 1 embedded at IITA and registered at SUA
- Fate (type, incidence and quantity) of mycotoxins, with focus on aflatoxin and fumonisin, determined along food and feed value chains for maize (and beans)
- Agronomic practices and other factors that increase or decrease aflatoxin and fumonisin contamination in maize (and/or beans) along the food and feed and along value chain
- Relative importance of different factors (using data recorded in questionnaires that accompany each sample) leading to mycotoxin contamination identified; crop type, crop variety, agronomic practices for cultivation and harvesting, threshing and drying methods, storage structures and duration, processing and transport methods, etc..
- Intervention packages developed, based on above understanding, for deployment in 6 villages (based on identified geographical hotspots and practices strongly associated with high mycotoxin contamination)
- Development and evaluation of control interventions on mycotoxin contamination. Methods to mitigate mycotoxin contamination selected from varieties resistant to fungal diseases that produce mycotoxins and to insect attack and abiotic stresses such as drought, harvest when dry and avoid further drying on soil, use of harvesting and transport methods that do not cause physical damage which facilitates infection by mycotoxin producing fungi, use of storage techniques that are dry and airy, and through funding from complimentary projects; Aflasafe product specific to Tanzania

- Development, evaluation and refinement of media materials and campaigns to increase awareness of potential risks caused by mycotoxin contamination for 6 villages to encourage likely adoption of control interventions and regulatory systems to safeguard the health of people, animals and to both safeguard and realise trade opportunities
- Evaluation of diagnostic methods in order to select the most practical, cheap, reliable and precise method to quantify aflatoxins for transfer to ARI stations

4.7 Expected outcomes

In the short term, the risk due to mycotoxin contamination will be determined for food and feed value chains for maize (and beans) in Babati based on analyses of samples from targeted villages. Through correlating contamination levels with data from farmer/market/vendor/processor questionnaires; factors linked to increased contamination will be identified. These will be used to help define the most appropriate control interventions to be deployed across 6 target villages. Acceptance and adoption of control interventions is dependent on increased awareness of the risks mycotoxins pose to public and animal health and hence trade. Therefore, the awareness raising campaign will inform farmers and value chain actors of the potential risks of mycotoxins and methods to mitigate them. Evaluations of the impact of introduced control interventions on mycotoxin contamination and of the acceptance of stakeholders to adopt them, will be harnessed and used to further optimize future intervention and awareness raising strategies. In the long term, this will increase the likelihood of the adoption of intervention methods and justify the need for regulation of food and feed value chains to protect consumers and trade opportunities. This will in part be supported by the capacity transferred to ARI stations to quantify aflatoxin levels using the most appropriate diagnostic method(s).

4.8 Communication and dissemination strategies

To ensure integration with other WPs and to inform farmers of activities and results community meetings have been planned (with the first to be undertaken between 10 and 16th November). There will also be a series of project stakeholder meetings built around the awareness raising campaign. This campaign is of critical importance to sensitise stakeholders of risks due to mycotoxins as a precursor towards acceptance of the need to mitigate them. It is for this reason that a considered effort is being placed into developing an appropriate awareness raising strategy of risk due to mycotoxins and methods for their control. An informed approach will be developed, implemented and refined based on user perceptions and practical experiences gained previously in Tanzania (by an expert communication consultant; Nick Nathaniels and Omari Mponda of ARI-Naliendele). Draft media tools will be developed by Nick Nathaniels through collaboration with Jocelyn Kaganda of TFNC (Nutrition education and training, and also a member of the National Steering Committee for Mycotoxins in Tanzania) and cogent knowledge inputs will be provided through face to face meetings, follow up dialouge, content on voice messaging, on videos, in radio programmes. While there will be a harmonised and common approach to the development of materials across commodities; in order to provide optimal understanding from uniform messages branded in a common and recognisable manner, there will also be a commodity specific approach to highlight control interventions. Omari Mponda will lead this for groundnut and Arnold Mushongi for maize, with inputs from across the WP teams and members of the National Steering Committee for Mycotoxins in Tanzania. The aim is that once the communciation materials are refined, and a strategy recognised for their use developed, to enforce a common understanding, that this can be out and up scaled by the National Steering Committee for Mycotoxins in Tanzania. The impact of this would be to achieve outreach through increased acceptance and adoption of mycotoxin interventions beyond the districts targeted by Africa RISING. Success of this communication and dissemination strategy depends on the combination of funds from the 2 mycotoxin projects, led by ICRISAT and IITA, and the active engagement of the National Steering Committee for Mycotoxins in Tanzania.

4.9 Project activity schedule

	2013		**2014**									
Activity	N	D	J	F	M	A	M	J	J	A	S	O
Proposal development	■											
Sample collection and completion of questionnaires for samples across food and feed value chain for maize (and beans)	■	■	■									
Prepare and analyse samples for mycotoxins acrosss food and feed value chain for maize (and beans)	■	■	■	■	■	■						
Correlation of questionnaire data and mycotoxin prevalence data across food and feed value chain for maize (and beans)				■	■	■						
Report on contamination levels and factors linked to increased mycotoxin contamination across food and feed value chain for maize (and beans)							■					
Procure test kit strips for fumonisin and aflatoxin (for use before expiry)	■	■						■	■			
Develop appropriate package of control interventions											■	
Develop implementation strategy for control interventions for 6 target villages												■
Methods tested for mycotoxin detection and protocol developed									■			
Recruit LGA and ARI-Selian staff for awareness raising activities	■	■										
2 social science MSc students registered for studies at SUA	■	■										
2 intended social science MSc students engaged in awareness raising activities			■	■	■	■	■	■	■	■		
Harmonization meetings to develop and refine awareness raising materials			■			■						
Surveys to identify perception of stakeholders to mycotoxin awareness materials				■	■							
Awareness raising campaign of mycotoxins and methods for their mitigation in 6 villages							■	■	■	■		
Follow up survey of knowledge, attitude and perception in response to mycotoxin media campaign											■	
Data analysis and report, plans for subsequent year												■

WP 5: Improved postharvest technologies for improving household nutrition and income in the maize-based farming system of Tanzania

Work package leader: Adebayo Abass (IITA)
International Institute of Tropical Agriculture; Plot 25, Light Industrial Area, Mikocheni B, Dar es Salaam, Tanzania

Research Team composition

Name	Gender	Institution	Job title	Disciplinary expertise	Qualification	Project role/responsibility	%time commitment
Adebayo Abass	M	IITA	Scientist	Food Technology	PhD	Coordination	20%
Gabriel Ndunguru	M	IITA	Consultant	Food Technology	PhD	Field Research supervision	50%
Badi Mwalimu	M	SRI, Kibaha	Research Officer	Food Technology	MSc	Field Research	50%
Grace Michael	F	IITA	Research Assistant	Food Technology	BSc	Field Research	100%
Christopher Msongore	M	SUA	Student	Agric Economics & Agribusiness	BSc	Student	50%

5.1 Abstract

The important postharvest handling factors in the maize-farming system of Africa RISING project area will be investigated to improve the incomes of smallholder farmers and also provide greater opportunity for increased food production and food security, agro-industry development, development of new products, import substitution and higher incomes to all the rural value chain actors. Mechanized processing and other labor saving technologies will be introduced and compared for efficient processing under varied local conditions. The assessment will be done based on opportunities to increase value addition,, reduce the tiresome and non-ergonomic labor practices, particularly the drudgery operations traditionally assigned to women.

5.2 Research problem and justification

Studies in postharvest handling systems, loss prevention and value-addition are required to design effective interventions for sustainable production systems. A single-focused pursuit of production increases, if successful, would almost certainly lead to gluts at the farm-gate. Glut lowers the prices of farm produce and penalizes producers (IITA strategy, 2012-2020). Therefore, increasing farm-level profitability requires the use of a combination of production and postharvest interventions that reduce food losses, increase the shelf life and market value of farm produce and enhances farmers’ willingness and ability to adopt high yielding crop varieties.

The research undertaken in 2012/2013 identified that food losses occur in the field before harvest, during harvesting and processing, and in storage. During harvesting, postharvest losses of grain and legume crops are between 20 – 40%. Most of this was caused by pre-harvest damages and fungi infection. Factors which cause postharvest losses of food grains include rodents (20%), larger grain borer >90% and weevils 10-25% during storage. Processing losses account for 2% during shelling of maize. The project will introduce postharvest management techniques and nutrition technologies into the maize-based farming systems in order to increase agricultural productivity (Project RO 2)

5.3 Objectives or research questions

It is hypothesized that availability of improved postharvest technologies will increase smallholder farmers' adoption of new crop varieties and improved agronomic practices which are necessary for sustainable intensification, farm-level productivity and market opportunities. Therefore, this study's research objectives are:

1. To develop and test, with farmers, new strategies to reduce postharvest losses and increase food processing in ways that increase market opportunities and increased shelf life for home consumption.

2. To assess postharvest characteristics of newly introduced varieties of food crops in the project sites.

3. To empower women on the production of high protein nutritious foods for nutritional improvement of vulnerable groups in the project sites (children under 5 years of age, pregnant women, people living with HIV/AIDS and the elderly)

5.4 Methodology

OUTPUT 1: New strategies to reduce postharvest losses and increase food processing in ways that increase market opportunities..

In the intervention villages, at least three improved postharvest technologies: (i) mechanized shelling, (ii) improved drying and (iii) storage technologies (hermetic storage and improved crop drying of grains) will be introduced and evaluated for potential to minimize product losses and enhance quality. Technologies i & ii will be tested concurrently. This will be followed by testing of different of storage technologies through on-farm demonstration and co-evaluation with crop growing farmers/farming households. The choice of technologies to test will depend on the predominant crops and extent of postharvest losses.

Pilot processing activities for the most important crops of postharvest loss significance will be initiated in the intervention villages. Farmers' groups will use the processing machines (e.g for threshing of maize, pigeon peas and groundnuts). All the intervention household will be evaluated in order to determine the extent to which improved mechanized postharvest processing technologies (a) reduce postharvest losses; (b) reduce labour inputs and improve health of women farmers; (c) reduce processing time; and (d) increase willingness of men and women farmers to increase on-farm production (intensify) in the intervention villages compared to counterfactual villages. Storage experiments to compare traditional crib storage systems (control) with improved storage techniques will be established to reduce storage loss. Each village will be treated as a block. Households in farmers' cooperatives that have traditional storage facility (cribs) and large quantities of maize will be selected as experimental farmers.

OUTPUT 2: Postharvest characteristics of newly introduced varieties of food crops assessed.
This task involves collaborating with CIMMYT in areas related to the postharvest handling and quality characteristics of the maize and beans new varieties being introduced. In each of the three villages, the newly introduced crop varieties will be characterized on postharvest attributes such as storability, culinary properties nutritional composition and market values. This will involve:

- Cooking time;
- Culinary properties
- Analysis of nutritional composition,
- Suitability for use in different food formulas and

Some analysis will involve farmers in the respective villages while some of them will be assessed at IITA laboratories. Local varieties will serve as controls.
This activity will help the AfricaRising project demonstrate how to reach the goal of improving the nutritional status of the project beneficiaries.

OUTPUT 3: Women groups empowered on the development of high protein nutritious foods for nutritional improvement of vulnerable groups.

Develop food products which are nutritious from locally available crops/livestock.
Groups of women will be trained in the three villages on food product development from locally available crops such as cereals, legumes, oil seeds, livestock products and fish (if available). Nutritional assessment will be conducted in the three villages in order to establish a baseline data information on the nutritional status of the three villages. Women and health workers will be involved in the training program. The products will be fed to the target groups and health workers will monitor the nutritional status of the target groups. The food products will also be subjected to the laboratory analysis and compare results with some of the commercial composite products.

Processing of horticultural crops as strategy of value addition, improvement of nutritional quality, improvement of shelf life and minimizing of postharvest losses.
Three villages grow some horticultural crops such as tomatoes, onions and various types of green leafy vegetables. These crops are perishable and need to be processed into value added products which can store well for a long time with the required qualities. Technologies for processing the various crops will be introduced

in the villages depending on quantities and the types of horticultural crops grown in the respective village. Products such as tomato sauce, chill sauce, dried vegetables and potato crisps will be processed. However the type of product will depend on the activities of WP6, horticultural crops which will be grown by the farmers in the three villages and the interest of the farmers to develop the products.

5.5 Integration (within project collaboration)

a) Mycotoxins are essentially a storage problem. Mycotoxin mitigation project, led by IITA (WP4) looks at factors that increase aflatoxin and fumonisin in maize and bean for food and feed along the value chains. We are conducting storage trials of maize and beans in the same villages of Long, Seloto and Sabilo. We shall therefore collaborate in setting up the trials, monitoring the experiments and in data collection. Data collected will be shared among the two WPs 4 and 5.

b) WP2 on MLND is introducing new maize varieties.T he postharvest handling WP will collaborate with CIMMYT in areas related to the postharvest handling and quality characteristics of the new varieties that will be selected for promotion against MLND.

c) The information generated in this WP will be shared with leaders and policy makers in the local government area, including the District Executive Director, District Agricultural and livestock Development Director, District Commissioner and other policy makers, as well as development partners like NAFAKA, for follow-up, scaling and to increase impact.

5.6 Expected results/deliverables

- In the short term, 3 entrepreneur groups from each village will be sensitized and trained on the use of postharvest technologies. One pilot center will also be established in each village for demonstration of postharvest technologies in this period.
- The following results will be expected during the long term implementation of the project:
  -At least three new strategies will be developed and tested for reducing postharvest losses, increasing food processing and nutritional quality of foods, and to increase market opportunities for the farmers.
  -At least ten new crop varieties of economic and nutritional importance will be evaluated and promoted to increase nutrition and income.

5.7 Expected developmental impacts

- Drudgery and time spent on crop processing especially by women will be reduced, giving farmers more time to engage in other income generating activities.
- Livelihoods of the farmers will improve through increased incomes from value added products

5.8 Environment sustainability

Environmental and food contamination caused by using storage pesticides will incrementally reduce through the use of storage technologies which do not involve pesticides.

5.9 Others deliverables

- Graduate students: A MBA student from SUA has been assigned to work with the project. The graduate student will study the profitability and economic benefits of postharvest technologies being tested.
- Community: The community, farmers, women, youth will be trained in different aspect of postharvest handling.

5.10 Output indicators

- At least 700 farmers and processors, 400 being females from the project intervention villages trained on new technologies for storage and mechanical processing (threshing and shelling) of their crops.
- improved food storage and appropriate processing technologies
- Al least, 75 women trained on production of high protein, nutritious foods based on locally available crops.
- Mechanized shelling of maize, threshing of sorghum, and use of simple oxygen impermeable storage technologies (super grain bags or hermitic metal containers) introduced and tested with farmers.
- One group of entrepreneurs from each of the three villages trained on processing and preservation of foods
- At least 3 new varieties of maize and beans adapted by the farmers of the 3 villages.
- 3 public-private partnerships formed, one from each village as a result of project assistance
- Two types of storage technologies adapted by farmers.
- Two papers published in relevant journals

5.11 Additional info/Forward planning:

New science: Looking forward, the following research areas will be considered within the Postharvest Research Work package up to 2015. The possibility of having postgraduate students to undertake the research would be explored.

I. Investigate the application of Photosensitization (an emerging non-thermal and non-chemical technology) for the control of spoilage fungi (e.g. *Aspergillus*, *Rhizopus*, *Alternaria*, *Mortirella*, *Sporotrichum*, and *Fusarium*), bacteria (e.g. *Listeria monocytogenes* and *Bacillus cereus*) and yeasts (e.g. *Saccharomyces*) in stored foods (In collaboration with the University of Queensland, Australia and a university or research center in Tanzania).
II. Moisture sorption isotherms of Tanzania food crops.

III. Baseline survey to collect information from the key informants on the use of available plant extracts for storage of grains; identify and extract the active ingredients for use against larger grain borer, grain weevils and other storage pests; determine the optimum dosage rate, toxicity against pests (LD50) and biodegradation characteristics of the plant extracts.

5.13 Logframe

Project Outputs: Output 5: Combinations of technologies and interventions evaluated and adapted.	**Objectively verifiable indicators**	**Means/Source of Verification**	**Important assumptions**
	5.5 At least two storage and one processing technologies introduced and evaluated with farmers.	5.5 Scientific publication in peer review journal of high impact factor	Farmers are willing and able to participate
	5.5 At least 5 newly introduced varieties of maize and beans characterized for cooking and culinary properties evaluated	5.5 Scientific publication in peer review journal	The new varieties from the relevant AfricaRising WP/CIMMYT are available.
	5.6 At least 20 women trained on development of high protein nutritious foods.	5.6 Project reports	Village women are willing and able to participate in the training.
Activities	Milestones		
5.5 Evaluate post-harvest approaches that minimize product losses and enhance quality	March 2014: Evaluation of two storage technologies completed		
	Dec 2013: Manuscript for 2013 farmers' survey finalized and submitted to a peer review journal of high impact factor.		
	July 2014: Report of storage experiment completed		
	Sept 2014: Evaluation of processing technologies concluded; manuscript for storage experiment submitted to a peer review		

	journal of high impact factor.
	Oct 2014: New varieties characterized
5.6 Improve and diversify household nutrition	June/July: Report on training of women on development of high protein nutritious foods submitted.

5.14 Work plan 2013/2014 -2014/2015

Activity	2013		2014										2015
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	
Subtask 1: On-farm demonstration of improved postharvest handling technologies through experimentation with farmers*:*	X	X	X	X				X	X	X	X		
Subtask 2: Carryout investigation on the storability, culinary properties, nutritional composition and market value of the crops introduced by other program components.				X	X	X	X	X			X		
Subtask 3:1 Develop food products which are nutritious from locally available crops/livestock	X	X			X	X	X			X	X		
Subtask 3.2: Processi ng of horticultural crops as strategy of value addition, improvement of	X	X			X	X	X		X	X	X		

nutritional quality, improvement of shelf life and minimizing of postharvest losses.													
Monitoring the project	X	X	X	X	X	X	X	X	X	X	X	X	
Evaluation											X	X	

WP6. Dietary diversification: Integration of vegetables into maize based systems of Babati

Work package leader: Victor Afari-Sefa, AVRDC, Arusha

Research Team composition

Name	Gender	Institution	Disciplinary expertise	Highest qualification	Project role	% time
Victor Afari-Sefa	M	AVRDC	Agricultural Economist	PhD	Scientist	5
Tsvetelina Stoilova	F	AVRDC	Genetic Resources	PhD	Scientist	5
Fen Beed	M	IITA	IPM on vegetables	PhD	Scientist	5
Danny Coyne	M	IITA	ISFM	PhD	Scientist	5

6.1 Abstract

While the world is making some progress on poverty reduction, it is having less impact on the growing scourge of malnutrition due to imbalanced diets. More than a billion people are suffering from chronic malnutrition and hunger. An even greater number, accounting for a third of the world's population, are malnourished through imbalanced and excess food consumption resulting in obesity, reduced life expectancy and increased incidence of diseases such as Type II diabetes. Consequently, there is increasing emphasis on the use of food-based approaches to address micronutrient malnutrition. Dietary diversification with vegetables offers a functional, complementary strategy to other food based approaches such as bio-fortification. The goal of this work package is to enable populations of semi-arid areas of Tanzania to capture nutritional and economic benefits from the sustainable integration of vegetables into maize based systems. Consistent with the outcomes envisaged in project year 1, this will involve development of technologies that overcome high pest and disease risks during the wet season and water constraints during the dry season, using adapted and high performing vegetable varieties, improved and robust agronomic practices, and appropriate interventions which promote production in a sustainable and safe manner. Actively integrate and demonstrate vegetable farming and marketing practices to nutrition, health and economic outcomes in order to reduce the vulnerability of indigenous populations of the Babati district.

A scoping study to assess the current status of vegetable production, constraints and opportunities, has been completed. These results will allow for authoritatively informed decisions on which interventions will achieve the greatest impact, particularly the need to explore the optimal rotation or intercropping of vegetables and staples for higher household incomes via system intensification. Results show that on the average, over 50% of non-vegetable farmers who mostly cultivate maize and other staples cultivate more than 2 ha (medium to large farms) compared to over 50% of vegetable farmers who cultivate on less than 2 ha of land. This can be attributed to maize requiring a higher land area to ensure profitability compared to vegetables which have higher farm gate values per unit of land. The dietary diversity score for farmers who have integrated vegetables into their cropping patterns was also higher (7.2) than for farmers who had not integrated vegetables (7.08).

Farmers' most important reason for integrating vegetables into farming systems was for higher income and or income diversification in comparison with other field cash crops such as beans. This was followed by the nutritional importance of vegetables for household dietary needs. The need to optimize land resources for more income from cultivation and sale of vegetables from residual soil nutrient and moisture following harvesting of maize was also a critical determinant why some farmers integrate vegetables into the farming system. Therefore, this work package will utilize information from the study to build on the immediate objectives encompassed by the Africa RISING Program's Research Output 1 (RO1), that will complement baseline and farming systems studies conducted by IFPRI and Wageningen Agricultural university (WUR), and provide guidance on subsequent activities and partnerships. For this study the vegetables targeted are tomatoes, sweet peppers, African eggplant and amaranth. As part of the Research Output (R02), promising vegetables and varieties that are compatible and desirable by farmers and consumers within the existing farming systems will be assessed and explored for their acceptance and suitability through action research with farmers via farmer demonstration plots that were initiated in Project year 1. Research and capacity building aspects under RO2 will additionally work pest and disease management awareness by farmers towards safer and more cost efficient pesticide use and deployment of IPM strategies to manage target pests and diseases. Increased awareness creation of the nutritional importance of vegetables and adoption of adaptable elite vegetable varieties would be promoted under Research Output (R03).

Preliminary results from year 1 activities show that there is scope: (i) to evaluate and promote elite vegetable varieties that will enhance production, (ii) to diversify farm income sources with good agricultural practices in vegetable production and marketing, (iii) enhance nutritional outcomes through promotional activities for increased vegetable consumption at the household level. Preliminary results from the baseline socioeconomic surveys conducted in the district within the period, June-July, 2013 highlighted the potential for inclusion of improved vegetable varieties. The pest and disease incidence survey also highlighted the impact of pests and disease on productivity and the potential for improved production through basic management options, in addition to the need for greater awareness and understanding of pests and diseases and management practices in cereal based farming systems in the districts.

The agronomic, profitability and food safety aspects of the vegetable integration and diversification into existing farming systems will be further investigated in years two and three in an integrated and incremental manner.

6.2 Relevance of work package to Africa RISING Framework

This project has been designed along the Africa RISING principles of: (i) targeting investments and activities at the farm household scale in line with farm typology differences, (ii) applying innovations that sustainably increase output from the same land area, while reducing negative environmental impacts, increasing contributions to natural capital and the flow of environmental services, (iii) evaluating different options of innovations to generate options for intensification in semi-arid zones, (iv) location and design of intervention to identify and test elements of development domains for the target districts, and (v) engaging various R&D partners in innovation to improve relevance and adoption. Using these principles, this work package is designed to experiment/ evaluate diverse options for sustainable intensification of vegetables into crop and livestock productivity in the Babati district. This is followed by targeted evaluation of promising systems integrated innovations using community research and development participatory approaches, and ultimately scaling-up and -out of candidate innovations that promote farm household dietary diversity, while diversifying household income through the high farm gate values accrued from horticultural crops such as vegetables. Improving access to markets through partnerships with the Tanzanian Agricultural Productivity Program (TAPP) will contribute to income outcomes.

6.3 Research Hypothesis

The work package is based on the premise that increased consumption of elite and improved vegetable varieties, produced using improved and safer practices, will contribute to diverse, healthier and balanced diets while increasing farm household income through higher farmgate values of vegetables accrued from their intercropping or rotation with staple cereals such as maize.

6.4 Research Objectives

The specific research objectives are to:

a) **Introduce and evaluate improved varieties of vegetables in cereal based farming systems.** The aim is to validate and disseminate best-bet management packages around the most promising farmer selected new crop varieties suited to semi-arid agro-ecological zones. IN line with the integration hypothesis of the Africa RISING program, this output will contribute to outcome 1 of our intervention and Research Output 2 of the program.

b) **Integrated pest management practices.** This objective will make a direct contribution to safe and sustainable intensification of mutually beneficial mixed cropping systems (objectives 1 and 2 of the Africa RISING program) through a participatory problem analysis and intervention strategy development process involving all stakeholders and research and development actors. Participatory identification and mapping of pest and disease problems, which are a critical bottleneck to vegetable production and marketing for sustainable intensification of horticultural value chains in association with maize in semi-arid targeted districts, can be realized, while providing detailed data for impact analysis in subsequent phases. Results will be used to develop and strengthen key partnerships, responsibilities to deliver a time-bound set of activities, outputs, outcomes and impacts in subsequent seasons to increase the adoption, efficiency and safety of vegetable production and consumer access to safe vegetables. Results from the project can subsequently be adapted to other cereal-vegetable based systems within Tanzania and across East and Southern Africa (Africa RISING program objective 3).

c) **Post-harvest processing and utilization.** This objective will contribute to improving household food and nutrition security among the most vulnerable households and their members, especially women and children. Particular emphasis will be placed on involving women farmers as technical innovators, resource managers and homemakers and developing their capacity, particularly in the area of postharvest handling and processing. This objective will contribute to outcome 1 of our intervention and objective 2 of the program.

6.5 Methodology

This will be an action research, awareness creation and capacity building activity for farmers and Agricultural Extension Agents. It will be conducted in the villages of Matufa, Seloto, Bermi and Gallapo. Bermi and Gallapo villages are originally not part of selected Africa RISING program villages but were included due to their vegetable growing potential (as observed during the site selection exercise), particularly availability of water for irrigation and for the purpose of hastening programme impact in the future. We propose to introduce and evaluate improved varieties of vegetable crops (i.e., tomato, amaranth, sweet pepper, African eggplant) and other promising vegetables in the cereal-based systems to farm households in a manner that complements their on-going farm enterprises and contributes to household nutrition and diversified income outcomes

*6.5.1 Pre-Season Stakeholder meetings for community mobilization***.** The work this year will involve providing feedback on lessons learnt from the 2012/2013 season and share planned work for the growing 2014 season. Effort will be done to mobilize more women to participate in technology validation and experimentations so as to balance gender involvement in our activities.

6.5.2 Implementation and monitoring of community action plans based on sensitization and field demonstrations during 2012/13. 71 farmers comprising of 55 males and 16 females were trained in various aspects of vegetable production using elite varieties via simple demonstration plots. A follow-up visit done few days after the community sensitization and trainings conducted (see technical report on community sensitization and demonstration plot set-up for project year 1) revealed that, some farmers have already established their own garden using the seeds received from AVRDC. Some nurseries that were established earlier during the demonstration sessions had already germinated. During 2013/14, action plans developed in close association with farmers will be reviewed. In collaboration with the district, ward and village Extension officers and other institutions working in the vegetable development sector, activities will be collectively implemented with farmers being tasked to monitor progress regularly with extension officers to ensure the appropriateness of interventions.

Following sensitization of farmers in 2012/13, the demonstration plots for year 2 will involve characterization of selected sites by soil type and testing of the performance of elite vegetable varieties and good agricultural practices (GAPs) vis-a-vis standard farmer practices (control plots).

For fruit vegetables such as tomato, assessment of improved practices will be undertaken by comparing better GAP practices against regular farmer practices (business-as-usual), with farmers acting as replication and using a minimum of 3 farmers per village. Demonstration plots at key sites of elite varieties and improved practices will be established at a prominent site within each target village. On the basis of computed number of replications and entries, the minimum number of degrees of freedom for error must be 10. Planting will be done in a plot size of 2 rows and 6 m long (12 plants per row) at 50cm between plants and 60cm between rows. The demonstration plot would involve a non-replicated plot size of 4 rows of 6 m long (12 plants per row) at 50cm between plants and 60cm between rows. For leafy vegetables such as amaranth, a replicated trial with row and space planting, using a randomized complete block design with a minimum of 2 replications would be set up. Planting could be done in a plot size of 2 rows and 6 m long (24 plants per row) at 25cm between plants and 35cm between rows. For broadcasting, the seed rate of 15g per 6 square meter plot size (6m long and 1m width) is used mixed with sand in a ratio of 1 Seed : 4 Sand proportions. The demonstration plot for leafy vegetables, a non-replicated plot size of 4 rows of 6 m long (24 plants per row) at 25cm between plants and 35cm between rows will be set-up. The plot size of 6m long and 2m width per entry would be employed under manual irrigation using a hose.

In addition, farmers (at least 60% women) willing to provide land for participatory varietal trials, farmer managed demonstrations and community based seed production will be selected with help of village extension officer, village leadership, TAPP and DALCOs for further evaluating the varieties for adaptability by the communities. Gender will be taken into account when assessing for input access (i.e., seed and water access and management including impacts of land tenure on adoption of the proposed technologies) with emphasis placed on involving women for each activity implementation.

*Task 6.5.3. On-farm evaluation of elite vegetable varieties for agronomic adaptability and consumer taste and preferences***.** This is a new area being brought to enhance income diversification and improve nutrition outcomes of the project. A preliminary situational analysis to document current situation surrounding vegetable production, consumption, marketing and related statistics in the 2 districts was undertaken in 2013 to help direct interventions and activities. This analysis will be further developed during the current phase, to help assess the value of interventions and how vegetable production addresses the shortcomings identified in 2013. Additional work includes screening for adapted standard and traditional African vegetables in the target districts using elite and recently released varieties. Further community sensitization on nutritional importance of vegetables and demonstrations for selected vegetables along with improved best bet agronomic practices by vegetable growing farmers, schools and hospital gardens. Best bet practices will be based on use of healthy seedlings and basic improvements in crop production practices which reduce pest and disease incidence and increase production. Demonstration sites will create awareness of these practices, while assessment of their agronomic performance and benefits will be compared with those from standard farmer practice plots as detailed above. Capacity building and or extension advice will include incorporating knowledge of managing other crops other than vegetables (maize, pigeon pea) for better crop rotation practice. This will be done in collaboration with other Africa RISING partners such as IITA and ICRISAT. Cost-benefit ratios would be computed using partial farm enterprise budgeting techniques to collect input-output data over the production season to ascertain farmer uptake of introduced technologies. This will be followed by an assessment of consumer preferences through organoleptic testing of produce with selected cooking recipes for consumer acceptance.

6.5.4 Cost-benefits analyses on integrated intercropping systems for adaptability tested. Elite varieties deployed for adaptability will also be tested for adaptability by intercropping them with staples. Trials will involve intercropping vegetables such as amaranth with maize and/or pigeon pea at varying stages of maturity of the latter and also soon after harvesting of the staple to ascertain the best time of integrating vegetables for optimal yields within the system. To ensure that introduced technologies are widely adopted by farmers, it is again important to undertake a profitability analysis of the incremental changes in existing practices by farmers so as to compare them standard farmer practices. Thus, farmers must be able to visualize the economic benefits of the proposed technologies including vegetable-cereal crop intercropping and crop rotation trials. Partial budgeting analysis approaches would be used to assess the economic profitability of promising technologies and cropping options to enhance adoption.

6.5.5. Soil and irrigation water sampling and nutrients recommendations. Soil and irrigation water samples from the demonstration sites and on-farm trails of various communities will be sampled for analysis. Results obtained on threshold levels of contamination will help improvement of nutrition to crops and vegetable consumers.

6.5.6. Pest and disease management. The 2012/2013 season scoping study recorded the high incidence of pests and diseases when farmers reported wilting, chlorosis, necrosis, viral disfigured leaves and pests as the most prevalent and disturbing in the surveyed regions. Chlorosis was mostly seen in tomato and maize, necrosis common in African eggplant, amaranths, tomato while maize was rarely affected. Viral disfigured leaves mainly affected sweet pepper, tomato, maize and amaranths. Insects/ pests were also evident for all of the crops under question but high incidence in sweet pepper. African eggplant and Amaranths were highly found to be disturbed by necrosis. Herbivores such as *Maasai* pastoralist cattle and wild animals also feed on maize. Pests and disease incidences contributed to the percentage of yield reduction by 47.5% of African eggplant, 20.8% sweet pepper, 19.5% maize, 18.8% tomato and 17.1% amaranths. Results from the 2012/2013 season socio-economic scoping study indicated that merely 40% of vegetable farmers reported to have applied pesticides on their vegetable fields out of which only 17% considered wearing any protection gear when applying pesticides. The time period of pesticides application ranged from 1 to 2 weeks with nearly all farmers who applied pesticides (around 30%) indicating that, they used same water sources used in irrigating their fields to mix the pesticides. Also, majority of respondents (65%) apply pesticide after recognising the pest symptoms on the vegetable field whiles only a smaller proportion reported to apply at the regular interval in a season (15%) while very few (only 2%) reported to apply pesticide after field sampling is done. In essence several knowledge gaps in pest and disease was observed and would have to be addressed in 2013/14 season. Appropriate IPM of vegetable pest and diseases will reduce the misapplication of pesticides that are harmful to human, animal and environmental health. This can be achieved through interventions that focus on the key pest and diseases that were identified in the surveys in 2013. Deployment/demonstration of varieties resistant against the prominent constraints and improved agronomic practices to minimize infection, spread and impact of pest and diseases will be assessed and evaluated. Where pesticides are necessary, guidance will be provided on appropriate products, timing and dose of application (pre- and postharvest).

6.6 Deliverables

The deliverables under this work package for 2013-2014 include:

a. Baseline status of vegetable production and consumption with maize-based farming systems established and basic agronomic practices limiting vegetable production in rotation or relay cropping with maize and other field crops under rainfed and under irrigation documented.
b. At least two adapted elite varieties of selected standard vegetables (i.e., tomato, sweet pepper) and two adapted traditional African vegetables (amaranth or African egg plant) identified for maize-based farming system integration in the target communities.
c. Strategies for engaging women and other village members in community-based seed and seedling production piloted and validated for up-scaling via community sensitization and on-farm farmer managed demonstrations fields.
d. At least 60 farmers engaged in elite AVRDC vegetable variety evaluation for adaptation in target communities of the study area. At least 300 farmers become aware of elite vegetable varieties through community sensitization and on-farm farmer managed demonstration plot assessment.
e. Appropriate IPM interventions using GAP of vegetable pest and diseases to realize the opportunity for vegetables to be integrated into existing maize-based farming systems identified and documented.
f. Diagnostic protocols for pests and diseases identified as common constraints determined and farmer awareness of pests and diseases developed.
g. Tested and validated post-harvest handling practices that add value to produce and improve shelf-life adopted following their exposure and introduction to farm families. This will lead to reduced seasonal gluts and shortages and enhance year-round availability of produce for sale and increased home consumption.
h. Targeted strategies for testing and validation for increased demand creation and promotion of selected elite vegetable varieties and scaling-up of production technologies for increased vegetable consumption within maize-based cropping systems identified for next season.

6.7 Activity schedule

TIME FRAME	ACTIVITIES	LOCATION	RESOURCES	RESPONSIBLE
Dec.,2013	-Follow up in documentation of ongoing activities -Rapid rural appraisal aiming at sensitizing men and women as a strategy to get more women involved in vegetable production activities -Follow up and collection of soil test results before preparation of demo plots*(categorised best practices and normal practices)* in the regions -Site selection for improved vegetable seeds field trials	-Babati -Replicate to other surveyed region	-Car and fuel -Technical staff (incl. specialist in gender and agriculture) -Financial resources	- AVRDC scientist -IITA Scientist -Subject matter specialists at district, ward and village level
Dec., 2013	-Purchasing/collection of inputs for demonstration best practices and field experimental trials(seeds, fertilizers, pesticides e.t.c) -Preparation of farmers friendly training materials *(pamphlets, brochures, posters showing good practices, vegetable diseases/pests symptoms and control measures)*	-Arusha/Babati -Replicate to other selected/surveyed communities	- Vegetable seeds -Technical staff -Financial resources	- AVRDC scientist - IITA
Jan.,-April,2014	-Facilitation establishment of demonstration plots *(nursery and main fields)* categorised best practices and normal practices -Sensitization meeting in progression -Joint field visit(feedback and improvement)	-Surveyed villages in Babati, Kiteto and Kongwa	-Stationeries -Car and fuel -Technical staff -Financial resources	- AVRDC scientist -IITA Scientist -Subject matter specialists at district, ward and village level

	-Field days (about good practices within the district) -Stakeholders meeting(identification of joint activities and networking) -Training of extension agents and farmer trainers(group wise at least 3days per group) -Ongoing practical training in demonstration plots stage by stage crop wise(once per month) -Organize and facilitate stakeholders meeting (one per district)			-Identified stakeholders working in vegetable sector
March-May 2014	-Set-up on farm trials of elite vegetable varieties for agronomic adaptability and consumer taste and preferences. -Sensitization meeting in progression	Surveyed villages in Babati, Kiteto and Kongwa	Stationeries -Car and fuel -Financial resources	- AVRDC & IITA Scientists -Subject matter specialists at district, ward and village level
Jan.,-June,2014	-Follow up/monitoring of ongoing established activities and extension support of the established demonstration plots -Postharvest good practices*(drying, cooling, vegetable handling, vegetable preparation and processing)* -Ongoing practical training in demonstration plots stage by stage crop wise - Food safety awareness campaign and soil and water sampling analysis	-Surveyed villages in Babati, Kiteto and Kongwa	- Car and fuel -Technical staff -Financial resources	- AVRDC scientist -Subject matter specialists at district, ward and village level IITA & AVRDC Scientists -Subject matter specialists at district, ward and village level
July-Aug., 2014	-Farmers and extension agents executions (Study tour to AVRDC and	-Babati -Replicate to other surveyed	- Car and fuel -Technical staff	-AVRDC scientist -Subject

	Lushoto) -Ongoing practical training in demonstration plots stage by stage crop wise and on-farm evaluation (undertake cost-benefit analysis) of elite vegetable varieties for agronomic adaptability and consumer taste and preferences. -Identification of diagonstic protocols for pests and diseases as common constraints	region when resources allows	-Financial resources	matter specialists at district, ward and village level -Selected farmers(TOTs)
Sept,-Oct., 14	-Follow up and extension support of on-going farm field activities -Field *visits (collection vegetable farm data recorded from nursery to and after harvesting)* -Ongoing practical training in demonstration plots stage by stage crop wise - organize and facilitate project feedback meeting - organize and facilitate joint planning meeting for 2015	-Surveyed villages in Babati, Kiteto and Kongwa	- Car and fuel -Technical staff -Financial resources	- AVRDC scientist -IITA Scientist -Subject matter specialists at district, ward and village level

6.8 Logframe

Project Outputs:	**Objectively verifiable indicators**	**Means/Source of Verification**	**Important assumptions**
Output 1: Intervention sites for vegetable integration within maize based farming systems identified at	1.1 4 communities suitable for vegetable farming within the AR sites in Babati district identified by September 2013	1.1 Site selection based on 2013 data and follow up visits using market access, access to irrigation and participatory community rapid assessment approaches conducted 1.2 Work package site selection report	Availability of minimum required biophysical and socio-economic data coupled with expert opinions from DAICOs and various community leaders
Output 2: Production and market constraints of vegetables as intercrop with maize-based cropping system and food safety analysis with vegetable supply chain actors identified	2.1 Documented characterization of maize-vegetable based production sites and consumption patterns of representative rural and urban households in the target region.	2.1. Baseline data reports (socioeconomic and pest and disease incidence assessment surveys)	

Output 3: Best-bet management packages around the most promising farmer selected elite vegetable varieties suited to diverse agro-climatic zones in the project district validated and disseminated	3.1 Inventory of available potential technologies for vegetable integration and diversification	3.1 Community sensitization and field demonstration reports 3.2 Cost-benefit analysis enterprise budgets (spreadsheets) and report on assessment of introduced technologies compared against farmer practice plots 3.3. Field experimental reports on optimal cropping combination of maize-vegetable integration as intercrop and in rotation or relay cropping	Farmers and community leaders will be willing to provide land for setting up demonstration plots and manage trials as per pre-agreed arrangements
Output 4: Appropriate IPM of vegetable pest and diseases to realize the opportunity for vegetables to be integrated into existing maize-based farming systems identified and documented	4.1 Diagnostic protocols for pests and diseases incidence as common constraints on vegetable farms developed	4.1. Study report on identification of appropriate vegetable IPM protocols and packages within maize-based farming systems 4.2 Laboratory assessment reports from on-farm collected samples	
Output 5: Targeted strategies for reducing pest and disease incidence and increased awareness of the importance of vegetables in human nutrition using selected elite vegetable varieties for scaling-up tested and validated	5.1 Community level best bet promotional strategies identified and prioritised	5.1 Community sensitization and demand creation reports from varied activities (e.g., community farmer field days and farmer action plans days) 5.2 Protocol guides for IPM pests and diseases management.	

WP 7: Assessment of farm-scale and landscape level water and nutrient flows, degradation and restoration options under crop-forage systems in Babati Africa RISING (AR) sites

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Research Team

Name	Gender	Institution	Job title	Disciplinary expertise	Highest qualification	Project role	%time commitment
Fred Kizito	Male	CIAT	Scientist	Soil Scientist/ Water Resources Engineer	PhD	PI	30%
Job Kihara	Male	CIAT	Scientist	Agronomist	PhD	Co-PI	15%
Justine Cordingley	Female	CIAT	PD Fellow	Ecologist	PhD	Staff	35%
Kennedy Nga'nga	Male	CIAT	Research Assistant	GIS/Remote sensing	BSc	Staff	20%

7.1 Abstract

This WP will build on the food crop, livestock and landmanagement integration WPs. In this WP, we will (1) assess applied systems' (including fertilized maize, maize-desmodium, and maize pigeon pea and forage intervention treatments) impacts on nutrient loses through leaching and runoff to water ways (2) predict landscape level impacts of degradation on water qualityunder different systems in Babati, and (3) recommend sustainable interventions for crop-livestock systems for purposes of scaling up. The study will combine field scale measurements in farms used for the crop and forages integration WPs, and computer based modeling and scenario generation to guide scaling up of the viable interventions.

7.2 Research problem and justification

While efforts are being made to evaluate and recommend basic productivity components of food and feed crop varieties through selected soil and crop management technologies at farm scale, there is little understanding of the water and nutrient flows and their potential impacts at the landscape level. As observed in the 2012/13 biophysical baseline characterization study, land degradation is common in the Babati area. High erosion prevalence and degradation risk were observed in the studied sites, with high variability within sites. Intensification of crop-based agriculture, such as proposed by other WPs in Babati, has often been associated with a sharp increase in the use of chemical fertilizers, which if not well managed; fertilizer losses could have detrimental environmental impacts. Planting of hedges (fodder)/ grass strips, terraces and potentially trees in the landscapes may have beneficial effects on reducing nutrient losses and water pollution. However, the success of these interventions will depend on informed choices of where to place them in the landscape and with what combination of technologies to yield the best-bet outcome through modeling and scenario generation. Hence understanding these linked processes of change, their feedbacks and synergies has a central importance in managing these human-environment systems. In essence this ushers in new ways of conceptualizing water and nutrient fluxes in a manner that is interdisciplinary, integrative and multi-scalar with particular attention paid to the linkages across scales. As other groups work on quantifying crop responses to specific nutrients, and identifying appropriate forage options for crop-livestock integrated systems; there is an inevitable need to understand systems which present opportunities for enhancing productivity and resource use efficiencies while maintaining environmentally healthy landscapes.

7.3 Relevance of proposal to Africa RISING Framework

With sustainable intensification being the underlying goal of this project and of Africa RISING, the proposed study serves to provide a landscape level perspective on ecosystem condition following implementation of tested crop-forages integration systems. This project plays a unique role in Africa RISING by providing integration between individual work packages while identifying opportunities which exist for enhancing crop and feed productivity without compromising on the ecological stability at the landscape level. The suggested activities provide crucial lessons at the landscape scale issues,which is a core interest of AfricaRISING, especially in progressive years.Considering its integrative nature, this will alsoenhance collaboration between research groups and with farmers.

7.4 Objectives or research questions

iv. Assess crop-forage system (fertilized maize, maize-desmodium and maize pigeon pea) impacts on nutrient loses through leaching and runoff in landscapes to water ways;
v. Conduct landscape level assessment of associated ecosystem responses (including water quality) under different farming (crop-forage) systems in Babati
vi. Provide feasible scenario-based recommendations on sustainable interventions for crop-livestock systems to guide scaling up efforts.

7.5 Methodology

Activity 1**:** Assess crop-forage system (fertilized maize, maize-desmodium and maize pigeon pea) impacts on water and nutrient fluxes through leaching and runoff to water ways. To address this objective which contributes to managing crops and livestock production at landscape levels(RO1) of AR, representative farms used for crop productivity trials and for improved forages will be used for monitoring. These will include a maximum of 4 farms applied with fertilizers, manures, and those planted with fodders and legumes. In each farm, leaching losses will be estimated using tension lysimeters constructed by attaching ceramic cups (SoilMoisture Corp., Goleta, CA) to a 1-1/4 inch diameter polyvinyl chloride (PVC) pipe tube sealed at the end with a rubber stopper.These will be installed in pairs, one at 50 cm and the other at 100 cm depth and placed at upper, mid and lower slopes of the farm. One lysimeter pair will be installed at each distance. Leachate samples will be collected regularly throughout the growing season for measurement of NO_3^- levels. Overland flow frequency will be measured with non-recording overland flow detectors made of PVC tube (24 mm diameter) with a detector section that is perforated on one side and connected at a right angle to a reservoir section (Germer et al. 2010). Overland flow detectors will be monitored following rain events to determine the presence or absence of runoff. Runoff water samples will be collected from the detectors and analyzed for NO_3^- .Soils will be characterized for pH, texture, water holding capacity, bulk density, CEC, and C & N contents. Fertilizer use as well as manure use and quality will also be recorded on a regular basis.

In collaboration with the forages WP, we shall assess root depths and canopy characteristics of the different forage species at plot level to quantify runoff measurements for each plot and how this is influenced by the kind of forage. This will then be scaled up to landscape level through scenario generation on forage land use changesand their associated fluxes i.e. runoff, sediment and water quality.In addition, we shall evaluate the influence of topography (different slope categories) on the fluxes e.g. sloping lands vs flat areas in order to provide a suite of intervention options for the forages WPs for areas with different slope categories in Babati.

Activity 2:<u>*Modelling and Scaling*</u>:

Activity 2a) Modelling**:** Data captured from the different crop and forage systems will form the basis for parameterization of the Soil and Water Assessment Tool (SWAT) modeling platform. We intend to use the APEX (Agricultural Policy Extender) Module within SWAT to inform on smaller scale processes which will in turn help in predicting larger scale nutrient dynamics in the Babati landscape, including N-loading in adjoining water bodies as a result of fertilization and integration of improved forages under different land cover types.

Land use/remote sensing-derived maps (used as inputs for SWAT) will be used to determine spatial patterns from specific areas for measurements of stream water quality based on delineations of predominant landscape level activities. This will cover for example downstream of irrigation areas, grazing lands, high intensity cropping lands and forested areas. Samples will be collected at monthly intervals over the whole year to capture temporal patterns in the cropping calendar and the associated activities. The samples will be analyzed for silt,N load, and common chemicals residues. This activity will thus involve acquisition and analysis of freely available remote-sensing images to derive upto-date land use maps, data collection in the specified locations which serve as pre-requisites for the landscape level water, nutrient and soil flow modeling. This modeling component will also integrate the spatially-defined management data such as the manure application on farmer-fields as captured in the agronomic survey conducted by WP1 last year (and what will be collected this year). We will also utilize rainfall data being collected in the different villages to relate rainfall with erosion prevalence.

Activity 2b: Scaling up and out

We present Figure 1 and Figure 2 as integrative conceptual frameworks that depict farm level and landscape fluxes and their interactions. In Figure 1, water fluxes are the primary regulators of most ecosystem processes through losses and gains to the system and the soil, using the principles from the “soil water bucket” model (Gordon and Famiglietti 2004) serves as a major sink or source. This will permit us to further assess changes in soil water dynamics and responses of ecosystem functions based on differences in human management (See Figure 2).

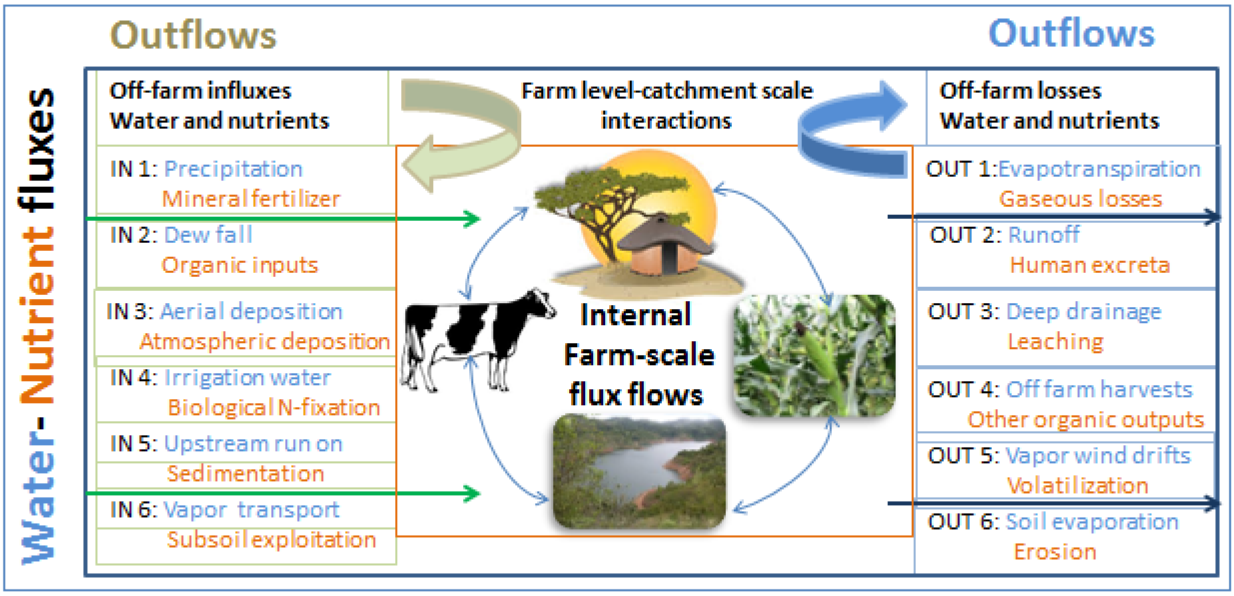

Figure 1: Conceptual representation of water and nutrient flow dynamics that capture the farm-level to landscape scale water and nutrient balance fluxes

Following up on the losses and gains portrayed in Figure 1, Figure 2 exemplifies the scaled processes and management options (as feasible interventions). Linkage analysesof the modeled results that relate the farm level to landscape scale interactions are presented (Figure 2). The fluxes from water movement induce surface runoff, sediment movement and deposition from upslope areas to the subsequent downslope regions (will be quantified by the modeling). In addition, conceptual interventions are proposed (based on scenario outcomes from the modeling) that relate to crop-water-livestock interactions from the farm level to landscape scale (See right side inset panel in Figure 2).

Critical to this process, both biophysical and socioeconomic scales need to be matched for effective uptake and impact. Vertical scaling-up through the extension of ideasand management processes across stakeholder groups (through community level meetings to discuss perceptions) and institutions, as well as policy makers to private sector interests will be explored in coordination with the other work packages. This will be complemented by biophysical-socioeconomic tools (InVEST[1] and RIOS[2]) that incorporate landscape process with stakeholder preferences.

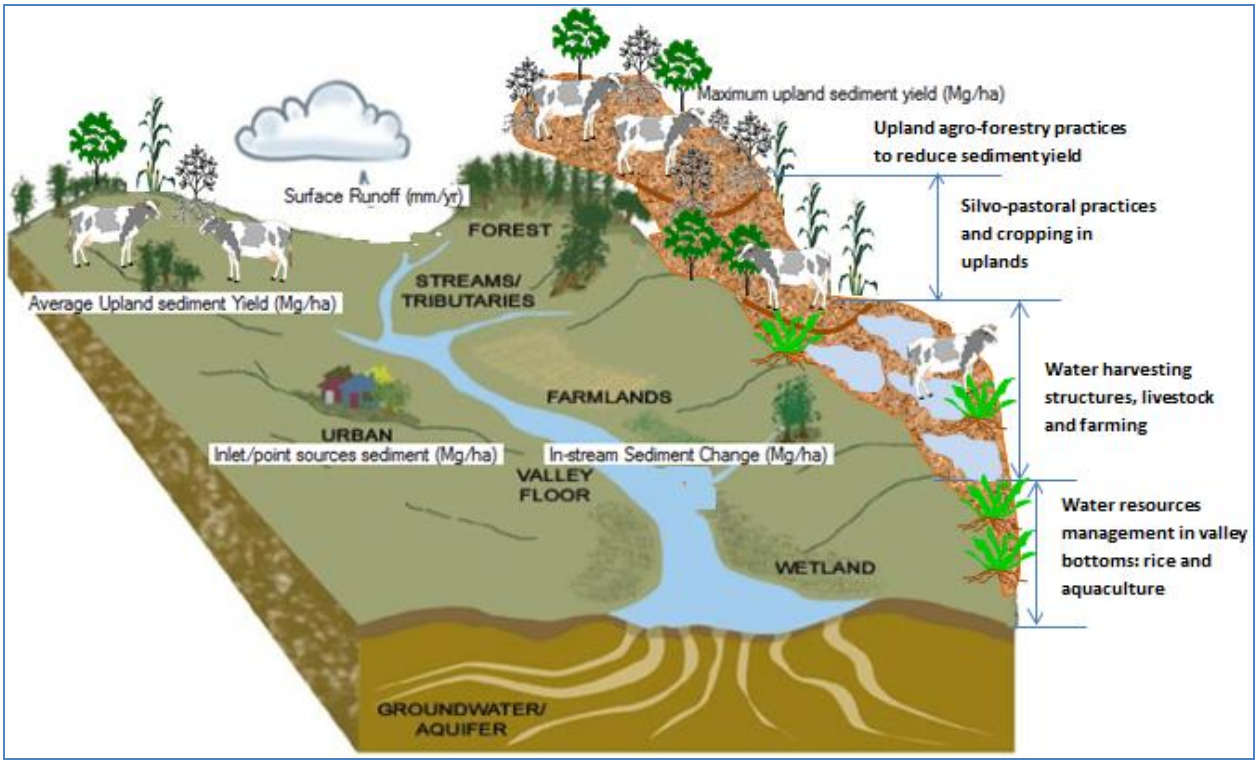

Figure 2. Illustration of farmlevel and landscape fluxes interactions in association with sediment discharge and other landscape management options (after Kizito et al., 2013; Agricutlral Water Management Journal; Submitted)

7.6 Expected results/deliverables

iv. Quantification of water and nutrient fluxes (gains and losses) under crop and forage systems in trials established by WP1 and WP3.

v. Assessment of farm-scale to landscape level condition relating to degradation of water quality(surface and underground) under different farming (crop-forage) systems in Babati.

vi. Provide feasible scenarios for restoration options with recommendations for intensification practices necessary to maintain or improve ecosystem integrity.

7.7 Expected outcomes - short, long term

i. Short-term: understanding of how different crop-forages intensification practices impact on water and nutrient dynamics in farming systems across scales;

[1]**: *InVEST:Integrated Valuation of Ecosystem Services and Tradeoffs***

[2]**: *RIOS:Resource Investment Optimization System***

ii. Long-term: Robust management scenarios for enhancing productivity in integrated systems which maintain ecological integrity in Babati landscapes.

7.8 Logframe

1 Country/Region	Tanzania-East and Southern Africa		
2 Project Title	Assessment of farm-scale to landscape level water and nutrient flows, degradation and restoration options under crop-forage systems in Babati		
Partner Organization	CIAT		
Project Manager	IITA		
Narrative Summary (Intervention Logic)	**Objectively Verifiable Indicators**	**Means of Verification**	**Important Assumptions**
Project Purpose: Provide information on tools and methods that can be used to scale-up and out proven landscape management interventions that have a high potential for increasing productivity	• Increased awareness and conscious management of soil and water resources through inter-linked interventions	• Change in knowledge, attitude and skills of farmers verifiable through training, field activities, IP and value chain activities • Project Reports and Scientific publications	• Political security, and financial environment favorable to stakeholders • Availability of favorable institutional, social, economic and policy conditions for successful adoption of innovations
Outcome: Improved on- and off-farm natural resource management that leads to improve productivity and environmental integrity	• Area maps showing biophysical and socioeconomic factors contributing to degradation processes • Intervention maps that scale to landscape level	• Journal articles • Assessment reports on best management practices	• All stakeholders remain committed to the project • Ecosystem vulnerability to external shocks will necessitate holistic and systems perspectives in resource management
Outputs: 1) Quantification of water and nutrient fluxes (gains and losses) under crop and forage systems in trials established by WP1 and WP3.	• Informed decisions in management options at both farm level and landscape scales	• End of project report appraisals	• Climate change may reduce frequency of rain events thus will require innovative water management interventions
Inputs (ACTIVITIES) 1. Field scale assessments	• Forage treatments may be at very preliminary stages of growth to adequately capture canopy and root depth impacts, in these cases, the variable with greatest weight (Weight of Evidence approach) will be considered e.g. i) Slope of the landscape and the ii) amounts and intensity of rainfall iii) Assess seasonal progression of forage contribution to water and nutrient flux dynamics	• Conduct in-situ field measurements • Progressive field reports • Journal articles	• Population pressure continues to require greater agricultural intensification in Babati • Trained field staff will keep engaging in linking to farmers with project desired goals
2. Soil, water, nutrient modeling at farm scale to landscape level	• Biophysical characteristics quantified based on deployed equipment: water quality, nutrient fluxes (quality and quantity). • Field protocol developed that shows linkages and methodology followed in scaling up.	• 1 Journal article • 1 Field procedures manual for scaling water and nutrient fluxes	• Stability and security prevails in project areas and neighboring regions • Involvement of socio-economic experts to have a more holistic input in the scaling process
3. Scenario generation for feasible interventions	• Well calibrated, functional models that show case processes from farm scale to landscape	• Project Report • Scientific article	• Sufficient data is available to conduct relevant modeling exercise for Babati

WP8. Improving productivity of indigenous chicken through better nutrition and management in mixed crop-livestock farming systems in Babati, Tanzania

Work package leader: Ben Lukuyu, ILRI, Nairobi

Research team

Name	Gender	Institution	Job title	Disciplinary expertise	Highest qualification	Project role/ responsibility	% time
Bernard Lukuyu	Male	ILRI	Scientist	Animal Nutrition	PhD	Field coordinator	20
Leonard Joseph	Male	TALIRI – west Kilimanjaro	Post graduate student		MSc	Student	80

8.1 Abstract

The project purpose is to improve the contribution of local chicken to households' cash income and nutrition by raising the status of this activity from subsistence to a viable economic enterprise. This will be done by developing the scale, management and marketing of local chickens. During the first year initial efforts will be consolidated to generate baseline information on village based chicken production systems, utilization, marketing, opportunities and challenges. Using the information gathered the project will put together an enhanced indigenous chicken production and management package that will include feeding, housing and disease management. Initial efforts will be consolidated to increase production by formulating nutritionally balanced diets based on locally available feed resources and testing them with farmers. The project will also review and test successful indigenous chicken housing models as well as assess the effect on feeding and diseases management strategies under village conditions. Promising feed options and indigenous chickens' production models will be scaled out in the second and third years. The project will simultaneously move to establish market linkages through group formation or strengthening old and new groups formed within the project areas. The project will aim to create opportunities for men and women to establish other businesses, supplying goods and services to chicken farmers.

8.2 Background

The poultry production industry in Tanzania like in other African countries can be divided into a traditional and commercial sector. The traditional sector is part of traditional small-scale farming where the majority of the so-called village or indigenous poultry - in particular chickens - are raised under extensive management conditions. Traditional small-scale poultry production is by far the largest poultry sub-sector and it supplies all poultry meat and eggs consumed in the rural areas in Tanzania (Boki, 2000). For example a recent study by Africa RISING in Babati, Tanzania showed that most (96%) rural households own some indigenous chickens (July 2013). Indigenous poultry has the potential to improve the livelihood of small-scale farmers in rural areas. The indigenous poultry production enterprise has been recognized as one of the pathways out of poverty for the rural small scale farmers because it provides readily available animal sourced proteins (meat and eggs) as well as daily revenue to rural households. This is attributed to the fact that indigenous chickens have a capacity to resist disease, able to utilize low quality feeds and their products are preferred by consumers (Adedeji et al., 2008, Petrus et al., 2011).

The most common indigenous poultry production systems are free-range extensive, the backyard extensive and semi-intensive (Bessei, 1987; Gueye, 1998), The systems are mainly low input systems where the birds are not confined and scavenge for food over a wide area. Rudimentary shelters are provided, and these may or may not be used. The birds may roost outside, usually in trees, and nest in the bush. The flock contains birds (1-10) of different species and varying ages. In backyard systems, poultry are housed at night but allowed free-range during the day. They are usually fed a handful of grain in the morning and evening to supplement scavenging. In addition, the birds are not regularly provided with water and other inputs such as supplementary feeds, houses, vaccination and medication. The poor nutritional profile of the scavenged feed resources (SFR) contributes to the low productivity of the scavenging indigenous chickens.

In the free range system, indigenous poultry obtain their diets mainly from SFR. However, the amounts and availability of SFR are not constant throughout the year (Cummings, 1992). Such feed resources tend to vary with factors such as seasonal conditions, farming activities, life cycle of insects and other invertebrates (Roberts, 1995; Tadelle, 1996; Sonaiya, 2004). Furthermore, previous studies have shown that the nutrient concentrations of feeds scavenged by indigenous chickens is below the nutritional requirements and varies with season, climate and age of birds (Mwalusanya *et al.,* 2002; Rashid *et al*., 2004 and Rashid *et al*., 2005). If the supply and quality of SFR and the seasonal variations are known, efficient strategies for production of scavenging poultry can be developed (Gunaratne, 1999).

Tanzania is well endowed with non-conventional feed resources like soybean, millet and sorghum etc. that could be used by farmers to develop specific feed formulations for indigenous chickens (Mwalusanya et al (2001). With the rising cost of poultry feeds, farmers rearing chickens are increasingly finding it difficult to make profit from poultry keeping. While it is difficult for farmers to formulate feeds for hybrid chickens such as broilers and layers, they can do so for their indigenous chickens or dual-purpose breeds (Gunaratne, 1999). Work by DFID, RIU (2011) showed that there two major areas of knowledge that are requested by farmers. The first is poultry husbandry, which includes vaccination, disease control and feeds and the second is entrepreneurship skills and business management training. This project will therefore seek to work with partners to enhance knowledge on these topics.

8.3 Intergration

- ISFM: The droppings (faeces) can be exploited in soil fertility management to enhance crop production particularly vegetables. The droppings are rich in nitrogen and other nutrients required by plants. The droppings will be easily collected as the chickens will be partially confined for supplementation with feeds to be formulated.
- Post-harvest rejects: Maize and pigeon pea spent grain, and vegetable wastes will be utilized in feed ration formulations, thus reducing leftover losses.

8.4 Objectives and research questions.

Objectives

The overall objective of the project is to develop feeding and management strategies that would help to increase the overall productivity of rural poultry production in Babati district of Tanzania.

The specific objectives are:

a) To identify value chain actors, characterise and quantify different poultry production and management systems of Babati district,
b) To identify, characterise and quantify different and potential scavenging feed resources over seasons, and the constraints to their availability,
c) To formulate and test supplementary poultry feed rations based on nutritional requirements of indigenous chickens and study the effects of supplementation with these rations on growth and egg production in the free-range systems of Babati district. The cost-effectiveness of these feed formulations will be assessed.

Research questions

a) What feed resources and nutrients do indigenous poultry feed on in various households and farming systems at different times (seasons) of the year?
b) What factors affect the quantity and quality of scavenging feed resources (SFR)?
c) Which interventions/strategies could be used to improve SFR availability and quality?
d) What are the supplementary feed requirements (energy, protein, mineral, etc.) of indigenous poultry in Babati district?
e) Which local feed resources can be used as protein and energy supplements to complement scavengeable feed resource base (SFRB) for scavenging chickens?
f) To what extent does supplementation of protein and energy from locally available feed resources and improved management/strategies improve growth and egg production of scavenging chickens in a free-ranging system?
g) What is the cost-effectiveness of the feed formulations aimed at improving productivity of village chickens?
h) How do management interventions (housing) affect nutrition of the chickens?

8.5 **Methodology**

Participatory rural appraisal (PRA).

From each of the 6 action villages of Babati (Figure 2), two farmer groups will be identified. The groups will function as units through which the project will sensitize farmers about the research work and train them on poultry husbandry and other topics. Participatory rural appraisal (PRA) will be conducted with the groups in selected villages. A group of 20 - 30 key informants in each village will be interviewed. The objectives of the PRAs will be to (i) appraise poultry production systems, identify existing and potential scavengeable feed resources available for indigenous chickens and quantify their feeding value, and (ii) to determine the constraints with regard to the availability of these feed resources.

Analysis of nutritive value of locally available feed resources.

Samples of common SFR will be taken from households randomly chosen from the identified farmer groupst in the six villages at 2 month intervals during the year, and subjected to chemical analysis using the Near-Infrared Spectroscopy (NIRS) at ILRI. The feed samples will be analyzed for the proximate components of dry matter (DM), crude protein (CP), Ether Extract (EE), crude fibre (CF) and ash, according to AOAC (1990) procedures and also metabolisable energy ME (MJ/kg). Calcium (Ca), and total phosphorus (P) will determined by atomic absorption and spectrophotometry, respectively. Data from these samples will provide a scientific basis for formulation of the type of feed ration for supplementing the scavenging chicken's diet during the various seasons of the year.

Feed ration formulation for the scavenging chickens

At least four feed rations will be formulated based on the nutritive requirements of scavenging chickens. These rations will be used in an on-farm trial that will comprise of a simple design of comparing improved feeding and farmers practice. Trial treatments will be replicated in all villages, each treatment with 20 birds in a Completely Randomized Design (CRD). Host farmers for mother trials will be selected from within farmers groups. Selection will be done by farmers themselves with researchers as observers. Parameters that will be studied will include (i) growth rates (ii) egg production (ii) Mortality rates (iv) feed intake (v) egg quality, (vi) disease profiling. The cost benefit analysis of different rations will be determined.

Scaling up feed technologies through baby trials

A cluster of about 10-20 farmers from each farmer group in every village will be selected for baby trials. The idea is that each selected individual farmers in a cluster will randomly select and mimic any feed technology tested in the main mother trial. They will technically be equipped with training as a cluster on how to adopt the new technology at their own cost on their farms. Each mothers' trial treatment will have a minimum five baby trial treatments in each cluster for assessment, and other farmers will be allowed to access these to catalyze adoption of new feed technologies.

Introducing improved housing systems

The effect of improved housing will be assessed with farmers by testing successful housing models from other parts of the region. This will be integrated with the feeding study and will comprise a simple comparison of improved vs. farmer practice.

Statistical analysis

Data will be analyzed by using the General Linear Model (GLM) of Statistical Analysis Systems (SAS, 2004). Differences between the treatments means will be separated using Duncan's New Multiple Range Test (Duncan 1955) while analysis of variance (ANOVA) for a CRD will be employed. All the socio-demographic data collected will be coded and analyzed for descriptive statistics for each variable investigated using SPSS programme version 11.0 for Windows 2003.

8.6 Outputs

a. Low cost high quality feed rations for village chickens using local feeds developed and disseminated in rural areas of Babati Tanzania
b. Increased egg and meat production from indigenous chicken in rural areas of Babati Tanzania
c. Improved farmers knowledge on poultry production, disease control and housing in rural areas of Babati Tanzania

8.7 Outcomes

a) Increased food production and income in the rural communities of Babati, Tanzania.

b) Farmers' livelihoods improved in the rural communities of Babati, Tanzania.

c) Wider use of improved appropriate feeding, housing, and disease control strategies in the rural communities of Babati, Tanzania.

8.8 Work plan for major research activities (2013-2014)

Activity	Time frame
Participatory rural appraisal (PRA) and mapping value chain actors	October 2013-March 2014
Analysis of nutritive value of locally available feed resources.	January - May 2014
Feed ration formulation and designing experiments	June – August 2014
On-farm experimental trials and data collection	August 2014 – December 2015
Data analysis	August 2014 – December 2015

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WP9: Integration of socio-economic research and preparations for R4D platforms

Principal Investigator: Per Hillbur, Consultant
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Research Team composition (Second Party)

Name	Gender	Institution	Job title	Disciplinary expertise	Highest qualification	Project role	% time commitment
Per Hillbur	M	Consultant		Human Geography	Associate Professor	Principal Investigator	75 days
Maria Klerfeldt Johansson	F	Gothenburg University	Sida scholarship	Human Geography	BSc	Research Assistant	3 months (scholarship)
Marcus Bengtsson	M	Gothenburg University	Sida scholarship	Human Geography	BSc	Research Assistant	3 months (scholarship)

9.1 Abstract

The project has arisen out of a need for socio-economic research to support the original work packages of the Babati team. In this respect, the aim is to address cross-cutting issues. The project explores the diversity and socio-economic stratification of farm households, which is a basis for proper targeting of beneficiaries of AfricaRISING interventions. Its primary focus is to identify barriers and constraints to adoption of agricultural technologies and practices, but the purpose also goes beyond that by analyzing socio-technical arrangements and opportunities for institutional innovation, including facilitation of an enabling environment for system-oriented approaches. An important outcome for the year 2013/14 is successful preparations for and facilitation of an R4D platform in Babati District.

9.2 Research problem and justification

Reference to 2012/13 research

The complexity of research on sustainable intensification of African agriculture is well documented (see *e g* Pretty et al 2011 and The Montpellier Panel 2013). This proposal aims at addressing some of the research needs for integrating socio-economic and institutional issues to complement the strong agro-ecological focus this far in the Tanzanian sites of Africa RISING. It ranges from situation analysis and collection of socio-economic data to validate planned interventions in terms of social acceptability, integration of local knowledge and identification of proper impact pathways for the diffusion and scaling of innovations.

Reference to farming Systems Analysis

The primary target unit of intervention in Africa RISING is the farm household. It is at this level important decisions are taken on land use, production and marketing issues. The dynamics of the farm household also reflect important aspects of creating livelihoods from farming through labour investments, division of labour between men, women and youth and formation of long-term strategies for agriculture. To address adoption and adaptation to interventions, research is needed to map and analyze demand and incentives for sustainable intensification.

This includes characterization of the six villages in Babati, where the three villages introduced this year represent a dramatic change in profile of activities in terms of agro-ecology, crops and socio-cultural setting. The villages of Shaurimoyo, Matufa and Hallu provide a distinctly new situation for field research in all aspects. New cropping systems include rice, simsim and irrigated farming of vegetables. The livestock situation faces greater difficulties in terms of diseases related to lower lying and water-logged areas. Moving into Mbugwe Division will also include some of the poorest communities in Babati. To take interventions to scale from this diversity calls for identification and validation of a farm household typology that can be used across all research activities.

9.3 Relevance of proposal to Africa RISING Framework

The AfricaRISING action sites in Babati are specifically chosen to provide comparison to sites where interventions are carried out in collaboration with the US government Feed the Future initiative. Babati District is particularly suitable as arena for development of new research methodologies due to the district's rich agro-ecological as well as socio-cultural diversity (Hillbur 1998, 2013a).

The ambition to find appropriate strategies for Africa RISING to introduce and communicate innovations to local communities is another important object of study for this work package. During the first year activities like participatory evaluation, farmer field days, mother-baby trials, demonstration and sensitization are used. The evaluation of the program demands studies on the efficiency of different methods of introduction, training and networking to find reasonable and resource-efficient ways to take the interventions to scale. In addition, the nature of scaling itself (Woodhill *et al* 2012) is an important research issue for the project.

9.4 Research objectives, links to program hypotheses:

Research questions:

(i) Which are the main farm livelihood strategies in the research sites? How are these distributed? Which is the most relevant farm household typology to be used when approaching communities? (Adoption hypothesis, Trade-off hypothesis, Scalability hypothesis)

(ii) What is the relationship between secure tenure (individual certificates for rights of occupancy and/or private ownership) and access to credit? To what extent are local credit institutions (*e g* VICOBAs) used for agricultural intensification? (Impact pathway hypothesis)

(iii) Which are the patterns of fertilizer application in well-established maize/pigeonpea systems in Babati District? Which are the barriers to adoption of integrated soil fertility management (ISFM) in the AR villages? Which are the opportunities to go to scale with local P sources (Minjingu)? What characterizes households involved in contract farming of pigeon peas? Which farm livelihoods? (Integration hypothesis, Adoption hypothesis, Trade-off hypothesis, Scalability hypothesis)

(iv) Which research approaches are the most valid/effective in introducing, communicating and scaling integrated system innovations? Which are the barriers/constraints to different approaches? How is impact measured in respective approach? How can M&E be integrated in scaling approaches? (Adoption hypothesis, Scalability hypothesis)

(v) A. Babati) and B (Kongwa/Kiteto) Which are the success factors for a working R4D platform? How can a local (district level) R4D platform be designed and facilitated to address intended impact in relation to the identified success factors? How can the work of the platform be monitored and evaluated? (All five program-wide hypotheses)

9.5 Methodology

Activity 1: Complementary situation analysis

In addition to the base-line studies, some calibration of methodologies that opens up our understanding of impact pathways is suggested.

Sub-activity 1.1: Target groups/Farm typologies in the six AR Babati villages. The local testing of relevant farm typologies (World Bank 2008, Tittonell 2011) in various socio-cultural environments is essential to target relevant groups. A functioning farm typology will guide planned interventions at both technology and systems levels. Analysis of village profiles, interviews/and wealth ranking at sub-village level will be carried out by help of community representatives/leaders. The activity will be informed by the base-line studies carried out by WP mycotoxins in Long, Sabilo and Seloto and by WUR and IFPRI (all six villages).
Sites: Long, Sabilo, Seloto, Hallu, Matufa, Shaurimoyo.

Sub-activity 1.2: Land tenure, credit and agricultural intensification. The study aims at illustrating a hypothetical (assumed) pathway (tenure-credit-intensification-improved livelihood). The study involves document studies and interviews on land titling at village level as well as individual smallholders certificates. With this as a background, interviews are carried out with 20 vicobas/SACCOs/banks in Babati District to analyze the role of credits in agricultural intensification. The study is informed by sub-activity 1.1 on farm typologies, and will be carried out by an MA/MSc student and /or a skilled enumerator under supervision of the principal investigator.
Sites: Land tenure data from the six AR sites. Relevant credit institutions/VICOBAs are selected in relation to this to reflect intensification in the six sites.

Sub-activity 1.3: Adoption of ISFM in maize/pigeon pea production. The activity is carried out in collaboration with WP 1 (integrated crop production) and the private/public partnership with Export Trading Group (ETG). The aim is to focus on a potential scaling activity (soil fertility/intercropping) from a well-established situation to frontier areas. This includes a background survey on adoption of fertilizer use/ISFM in the established maize/pigeon pea corridor in Babati, as well as identification of barriers/constraints to adoption of P application/ISFM to support introduction of integrated practices in action sites. Furthermore, a survey/analysis of contract farming households under ETG will be carried out in Babati District. The study is informed by sub-activity 1.1 on farm typologies.
Sites: Background study in the established maize/pigeon pea corridor as reference for the six AR sites. Randomly selected ETG farmers in Babati District. The analysis and interviews will be carried out by an MA/MSc student and /or a skilled enumerator under supervision of pigeon pea scientist (Lyimo) of WP 1 and the principal investigator.

Sub-activity 1.4: Impact of research approaches to introduce, communicate and scale integrated systems innovations. This study focuses on the efficiency of different methods of introduction, training, networking and scaling of integrated systems innovations. The range of methods and ways to communicate in complex systems need particular attention (Leeuwis and Arts 2011). The study includes an investigation of the legacy of previously used approaches in Babati, such as *e g* participatory evaluation, participatory land use management, farmer field schools, farmer groups and mother-baby trials. The results will support a future discussion on design of interventions and how these are brought to scale. The study is undertaken as review of documents and literature, interviews with key informants and field assessment of long-term impact of previous interventions at farm and landscape level. The activity will also seek integration between activities of AfricaRISING and recent and on-going interventions in Babati District.

Activity 2: Establishment of R4D platforms for sustainable intensification in Babati

Multi-stakeholder platforms for introduction and scaling of systems innovations are increasingly common in Africa (see *e g* Adekunle and Fatunbi 2012; Tenywa et al 2011), although evidence of their efficiency are still not clear. Systematic research on their impact is therefore needed (Hillbur 2013b). The conditions for trying the concept of R4D platforms are ideal in Babati. The activity aims at making preparations (involvement and validation of stakeholders) in November-December 2013 for a two-day's workshop for stakeholders in April 2014.

Preparation and facilitation of an R4D platform in Babati during 13/14. Identification, active recruitment and validation of stakeholders. Testing of methodology for establishment of R4D platforms. Training of local capacity to initiate, facilitate and evaluate impact of R4D platforms. *Duration*: Interviews, recruitment and validation of participants, 2 weeks Nov/Dec 13. Preparation of material, training and facilitation of first meeting, 2 weeks April 2014. Monitoring and evaluation. *Preliminary setup*: Recruitment and validation of participants according to the following structure: >10 participating farmers (>5 women); 5 private sector participants, 5 extension and NGOs (relevant), relevant policy makers from district, regional and national level, researchers (5-10 covering WPs). The R4D platforms will be performed in Swahili, documentation in Swahili and English.

9.6 Expected results/deliverables

Expected results/deliverables	Expected developmental outcomes	Impact on gender	Environmental sustainability
1.1 Functioning farm household typology for AR ESA project; adapted wealth ranking methodology	Analysis of census data and village profiles	Gender disaggregated data on socio-economic stratification and livelihood strategies	Analysis of existing village profiles (perspective 2020). Awareness of mycotoxins (with WP4)
1.2 Evidence on the role of credit for sustainable intensification	Increased knowledge on local use of credits for development	Gender-disaggregated data on tenure security and access to	Improved understanding on links between tenure security and sustainable land use

	purposes	credit	
1.3 Adoption patterns for integrated system innovations (maize/pp/ISFM)	Support to WP 1: Increased productivity, income and nutrition	Gender-disaggregated data on adoption patterns and contract farming	Support to WP 1: improved soil conditions and NRM
1.4 Evidence on relative efficiency of methods for introduction and scaling of interventions	Improved understanding of efficiency of development interventions	If possible, gender analysis of previous interventions	Analysis of long-term effects on the landscape by methods of interventions
2 Successful preparations and facilitation of local R4D platform in Babati	Integration of research and development needs	Gender-balanced participation in priorities setting and evaluation of interventions	How is the environment represented in an R4D platform? Stakeholder?

9.7 Others deliverables

Other deliverables	Capacity development; Graduate, community	Collaboration with other projects; institutions	Academic; publications, conferences	Equipment	Staffing
1.1	Community participation in wealth ranking, two Swedish graduate theses	WUR, IFPRI, Gothenburg University	Published thesis (2 students) Published paper on farm typologies (2015); Conference paper on wealth ranking	-	-
1.2	Agricultural economics graduate?	Local Vicobas, SACCOs, banks	Concept paper on impact pathways		
1.3	See interventions for WP1	Export Trading Group (ETG), Selian ARI	Paper on adoption of ISFM; paper on contract farming	See interventions for WP1	See interventions for WP1
1.4	Option for local team on landscape change	Locally present NGOs, extension service	Published paper on legacy of methods for intervention and landscape change (2015)		
2	Increased skills in analysis, priorities setting and leadership among all participants	Farmers and their organizations, research partners, policy makers, private sector, NGOs,	Academic papers; printed material (updates) for wide communication to community; responsibilities of stakeholder		*Local coordinator?*

		etc	representatives		

9.8 Expected outcomes

Expected outcomes per sub-activity	Short term	Long term
1.1	Targeting of improved livelihoods of smallholders	Targeting support improvements for resource-weak households
1.2	Improved understanding of the role of agricultural credit	Strengthening of credits for agricultural purposes
1.3	Increased adoption of ISFM in maize/pp systems	Improved soil fertility and NRM; improved livelihoods for maize/pp farmers
1.4	Improved awareness on link method of intervention – adoption – long-term landscape change	Improved implementation of project interventions in terms of social acceptability and landscape transformation
2	Established R4D platform with relevant and wide representation	Widely recognized forum for promotion of sustainable intensification

9.9 Communication and dissemination strategies

Activity	Communication and dissemination strategies
1.1	Aggregated typology and ranking results in participating (sub-)villages; Concept paper on farm typologies for all work packages and rest of AR/ESA project and R4D platform; Conference/workshop presentation of wealth ranking
1.2	Communication of results on the role of credits to the R4D platform
1.3	Communication of results on adoption to the R4D platform; dissemination of ISFM through extension and ETG; academic papers
1.4	Communication of results on intervention design and landscape change to the R4D platform; academic paper; dialogue with locally present NGOs
2	Hub of priorities setting on interventions and of communication and

	dissemination strategies; monitoring and evaluation

9.10 Monitoring and Evaluation

Monitoring and Evaluation	Research outputs (suggested)	Program hypotheses (PH)
Activity		
1.1	RO 1 – target improved livelihoods	PH 2: Adoption PH 3: Trade-off PH 5: Scalability
1.2	RO 2 – Impact pathways for systems improvements (productivity, income and natural resource status)	PH 4: Impact pathway
1.3	RO 1: Situational analysis for adoption of best-bet technologies RO 3: Institutional innovations (contract farming) that lead to scaling while improving livelihoods	PH 1: Integration PH 2: Adoption PH 3: Trade-off PH 5: Scalability
1.4	RO 1: Design of interventions based on previous experiences RO 2: Test and validation of interventions at farm systems level RO 3: Identification of efficient methods for scaling interventions	PH 2: Adoption PH 5: Scalability
2	Integrating research outputs; one of primary tasks: RO 1: Ensuring bet-fit innovations RO 3: Scaling and delivery of integrated innovations Integrating research outputs; one of primary tasks	PH 1: Integration PH 2: Adoption PH 3: Trade-off PH 4: Impact pathway PH 5: Scalability

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9.12 Project activity schedule

Activities	Oct-Dec 13	Jan-Mar 14	Apr-Jun 14	Jul-Sep 14
1.1	*preparations*	*preparations*		
1.2				
1.3		*preparations*		
1.4		*preparations*		
2.1				