Technical Report

Sustainable Intensification of Key Farming Systems in East and Southern Africa

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The Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development (R4D) projects supported by the United States Agency for International Development (USAID) as part of the U.S. Government's Feed the Future (FtF) initiative.

Through action research and development (R&D) partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three projects are led by the International Institute of Tropical Agriculture (IITA) in West Africa and East and Southern Africa, and the International Livestock Research Institute (ILRI) in the Ethiopian Highlands. The International Food Policy Research Institute (IFPRI) leads an associated project on monitoring, evaluation, and impact assessment.

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Summary

Africa RISING aims to create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition and income security, particularly for women and children, and conserve or enhance the natural resource base. In order to be considered successful, sustainable intensification should increase the productivity of agricultural systems but also reduce pressure on ecosystem states and processes, safeguard equitable relations among societal groups and support the economic viability of households, enterprises and communities[1]. 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 ESA Project should have started with the generation of a global baseline situation analysis to allow design and testing of best configured and integrated technologies in the farming communities.

The baseline situation analysis in the intervention countries (Tanzania and Malawi) has been initiated. Concurrently, however, several discipline-specific baseline studies have been conducted to understand major constraints to improved livelihoods and identify opportunities for targeting research options. These were also aimed at providing more information for defining the challenges identified during the 2012-2013 Annual Review and Planning Meeting, and have been the guide in designing the 2012-2013 implemented activities. These were complemented with information generated from participatory workshops held with farmers prior to the cropping season. Farmers identified and prioritized technologies based on their capability to source required inputs and for implementation management.

This report, therefore, presents considerable information on Research Output 1. The report is still fragmented at the disciplinary level and in many cases incomplete because many activities are ongoing and data analysis from the just completed seasons has not yet been finalized. The need to integrate and synthesize these activities and the production of a coherent baseline report during 2013-2014 is recognized.

On Research Output 2, several innovations of inputs at the level of crops, livestock and farm technologies were tested, mainly as potential components of integration during subsequent studies. Partial results are described in this report because some of these studies are ongoing, dictated by their position in the value chain sequence. The implementation approach of testing on-farm and in the communities allows the spread of information to larger scales, contributing to the indicators required of the Feed the Future projects.

Training was conducted of extensionists, farmers and students on different topics. This creates a reserve of personnel who may be called upon to perform these functions for future Africa RISING and other similar activities. Through Memoranda of Understanding, partnerships with USAID-supported development projects in Tanzania and Malawi have been formalized. Agreement has been achieved about collaboration with the USAID Mission-funded SIMLEZA project in Zambia. Several publications resulting from the research carried out are under preparation. A presentation of the Africa RISING farming systems analysis has been given at an international symposium in China.

[1] Pretty, J., Toulmin, C. and S. Williams, 2011. Sustainable intensification in African agriculture. International Journal of Agricultural Sustainability, 9(1) 2011, pp. 5–24.

Partners

ADD	Agriculture Development Division, Malawi
ARI-Naliendele	Agricultural Research Institute, Naliendele, Tanzania
ARI-Hombolo	Agricultural Research Institute, Hombolo, Tanzania
AVRDC	The World Vegetable Center
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
DAICO	District Agriculture, Irrigation and Cooperative Offices, Tanzania
DALDO	District Agriculture and Livestock Development Offices, Malawi
ETG	Export Trading Group, Tanzania
ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INVC	Integrating Nutrition in Value Chains
IRA	Institute of Resources Assessment, University of Dar es Salaam, Tanzania
LUANAR	Lilongwe University of Agriculture and Natural Resources, Malawi
MSU	Michigan State University
MAFC	Ministry of Agriculture, Food and Cooperatives, Tanzania
NAFAKA	Tanzania Staples Value Chain
NM-AIST	Nelson Mandela African Institute of Science and Technology, Tanzania
SIMLEZA	Sustainable Intensification of Maize-Legume Systems in Eastern Province of Zambia
SUA	Sokoine University of Agriculture, Tanzania
SFHC	Soils, Food and Healthy Communities, Malawi
TALIRI	Tanzania Livestock Research Institute
	Tuboreshe Chakula, Tanzania
UDOMA	University of Dodoma, Tanzania
UNRALS	University of Natural Resources and Applied Life Sciences, Austria
WU	Wageningen University, The Netherlands

1. Introduction

The U.S. Agency for International Development (USAID) is supporting the East and Southern Africa project of the Africa RISING program, a multi-stakeholder agricultural research project to sustainably intensify key farming systems as part of the U.S. Government's Feed the Future initiative to address global hunger and food security issues. Africa RISING is also a way of bringing regional focus to the CGIAR Research Programs (CRPs) on Integrated Systems, especially the CGIAR Research Programs on Dryland Systems (CRP 1.1) and Humidtropics (CRP 1.2).

Africa RISING started in October 2011 and is expected to be implemented over a total of five years. It is organized around 4 research outputs (RO) that are logically linked in time and space:

1: Situation Analysis and Program-wide Synthesis
2: Integrated Systems Improvement
3: Scaling and Delivery of Integrated Innovation
4: Integrated Monitoring and Evaluation

In Tanzania, activities are being implemented in two different agroecological environments that define specific agricultural potentials (Figure 1): (i) the sub-humid areas of Babati District (currently 6 villages) and (ii) the semi-arid area stretching across Kongwa and Kiteto Districts (currently 5 villages). Each village has a minimum of 200 households (Figure 1, Table 1).

In Kiteto, farming of annual crops is the most important livelihood activity for smallholder households, with an average planted area of 3.6ha per household, followed by livestock keeping (30% of the rural households). Despite sub-optimal conditions, maize is the dominant crop grown in Kiteto District. Other major crops are sorghum, sunflower, beans and pigeon peas. Farming is entirely rainfed. Soil erosion is a widespread problem.

Similarly in Kongwa, the mainstay of the majority of the population is crop farming, sometimes in combination with livestock. Major crops grown are maize, sorghum, sunflower, groundnut, millet and tomatoes. Soil erosion occurs widely. The district has a distinct rural character, with few urban areas. The markets along the Dodoma-Morogoro/Dar es Salaam road, cutting through the center of the district, are however lively, particularly the "international" market in Kibaigwa, which is a major crop/cereal market for Tanzania.

Babati District, in recent history, attracted people from different parts of Tanzania – and even beyond – for the availability of fertile land. The shifting landscape and growing conditions allow a wealth of different crops to be planted, ranging from maize and rice to sorghum, sunflower, beans, pigeon peas, sesame, chickpeas and cotton. Pressure on arable land is high with planted land of about 1.3ha per household. A large number of farms (38%) experience soil erosion. Cattle are the dominant livestock followed by goats, sheep and pigs.

In Malawi, activities are ongoing in a total of 25 villages in four Sections in Dedza and Ntcheu Districts, representing three agro-ecologies from semi-arid to sub-humid (Figure 2, Table 2). Maize-based production systems dominate both districts which have unimodal rainfall from November to April. Farm sizes range from 0.5 to 1.5ha, characterized by crops growing on ridges. Soil fertility is generally low. Farmers do not own significant livestock numbers to produce adequate manure for soil fertility replenishment.

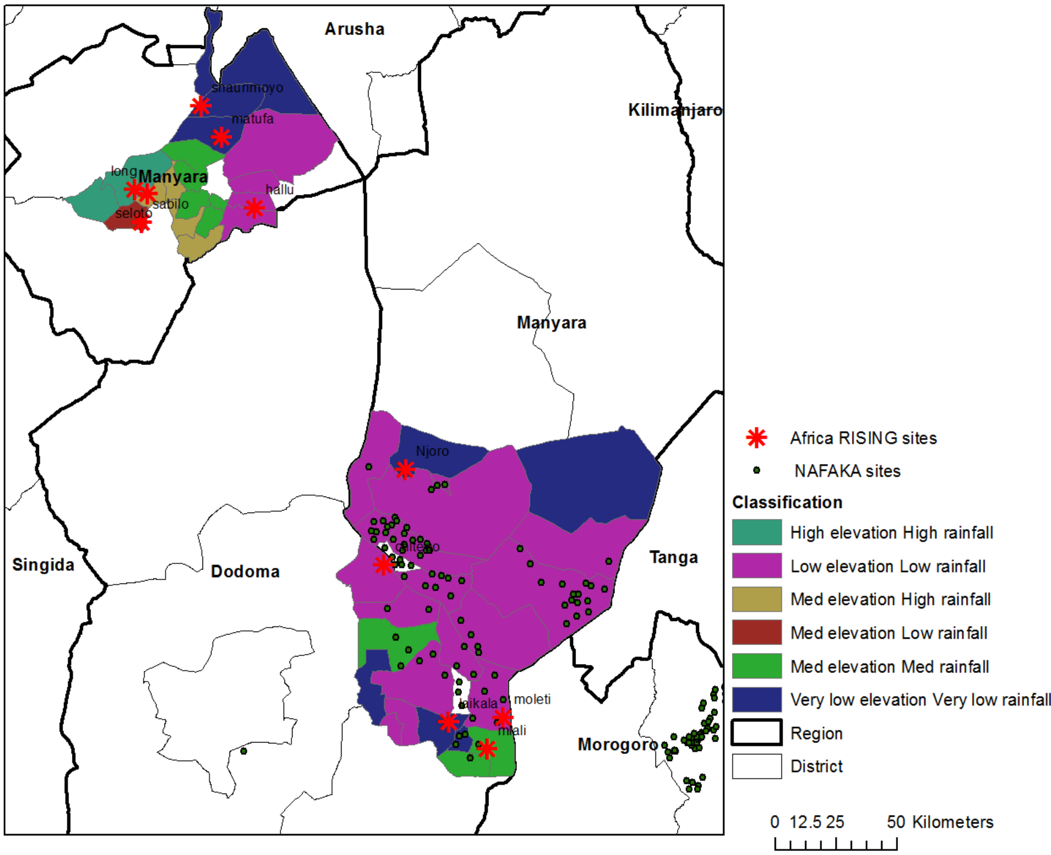

Figure 1: Africa RISING intervention villages in Tanzania.

Table 1: Africa RISING intervention sites in Tanzania.

Tanzania Africa RISING Action…		
Region (=2)	**District (=3)**	**Village (=11)**
Manyara	Babati	Long, Sabilo, Seloto, Hallu, Matufa, Shaurimoyo
	Kiteto	Njoro
Dodoma	Kongowa	Chitego, Moleti, Mlali, Laikala

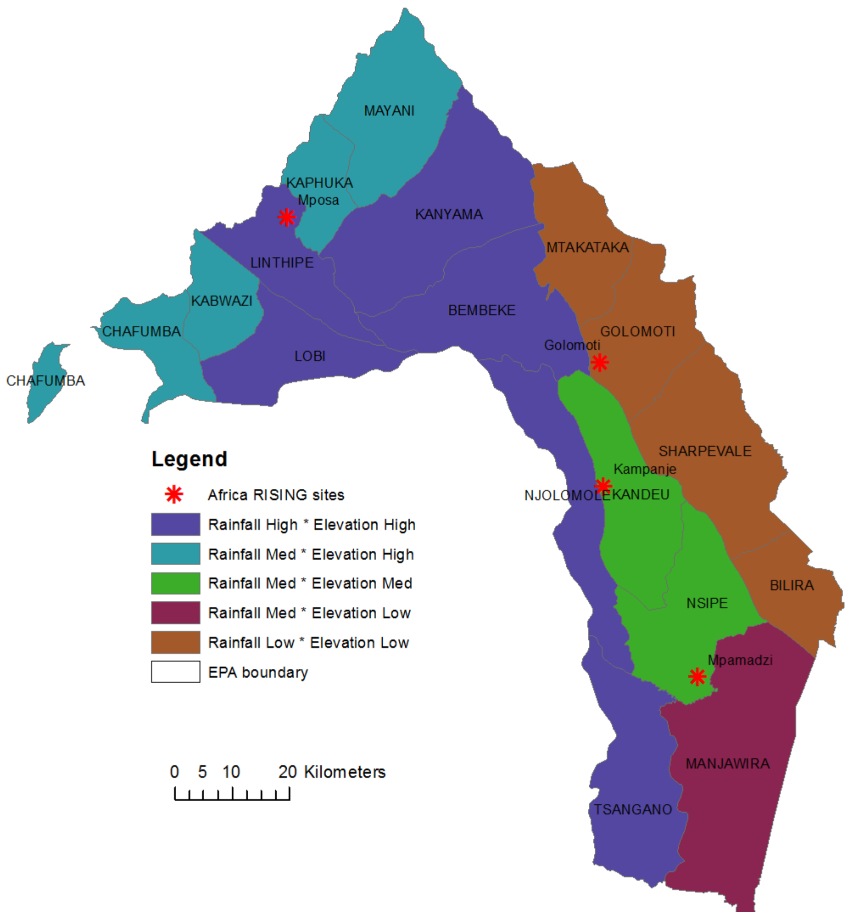

Figure 2: Sections in Malawi with Africa RISING intervention villages.

Table 2: Intervention sites in Malawi.

Malawi Africa RISING Action…			
District (=2)	**Extension Planning Area (=4)**	**Section (=4)**	**Village (=25)**
Dedza	Golomoti	Golomoti Centre	Kalumo, Msamala, Pitala, Wilson
	Linthipe	Mposa	Chibwana, Mbidzi, Mkuwazi, Ng'anjo, Phwere
Ntcheu	Kandeu	Kampanje	Kasese, Zoyoyama, Kampanje Center, Kanjusi, Kazputa, Darika, Gonde, Koneba, Sereman, Mitchi
	Nsipe	Mpamadzi	Amosi, Champiti, Gwauya, Hiwa, Malaswa, Nzililongwe

2. Implemented work and achievements per Research Output

Research Output 1 (RO1): Situation analysis and program-wide synthesis

Baseline studies: A meeting between Research Team members from the region and IFPRI held in Dar es Salaam from 28-30 January 2013 developed a standardized tool for M&E data collection across ESA Project sites and disciplines through harmonization of existing survey tools. This tool has formed the basis for the global qualitative and quantitative commissioned baseline surveys that started in Malawi during July 2013 and will be initiated in Tanzania later in the year. The results of the studies will, in this case, come later than the agronomic and other studies, but are still desirable in describing responses obtained in current research activities and useful in designing subsequent field studies. Discipline-specific baseline surveys conducted prior to or concurrently with agronomic and livestock research (Research Output 2) are reported in the following sections.

Soil health and characterization surveys: Different approaches were used in the study sites, the most comprehensive one being that conducted in Babati District and in Malawi. Procedures developed by the Africa Soil Information Service, AfSIS (www.africasoils.net), were adapted; 2 sentinel sites and 16 clusters were surveyed in Babati District and Malawi action sites, respectively. Soil sample characterization and data analyses are yet to be completed. Preliminary information on soil erosion, as an indicator of land degradation, shows that erosion prevalence in Babati is moderate, but with Matufa sentinel site having higher erosion prevalence compared to the Long-Seloto-Sabilo site (Figure 3).

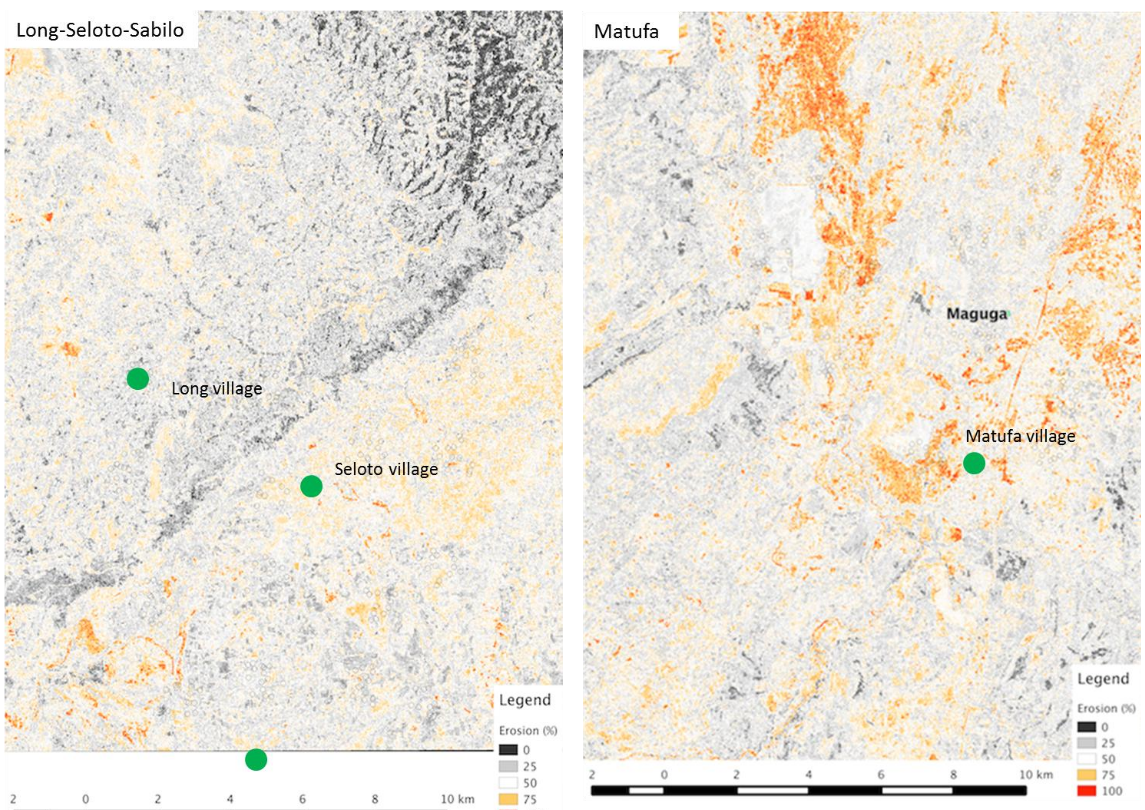

Figure 3: Erosion prevalence in the Long-Seloto-Sabilo and Matufa sites.

In Malawi, erosion prevalence estimate shows about 55% probability of observing erosion, the highest being at Nsipe (70%) and the lowest at Linthipe (30%) (Figure 4, left). Erosion prevalence also shows variability within sites (at cluster level, Figure 4, right). These observations provide a basis for targeting landscape-level interventions; areas with high erosion prevalence need to be better managed with physical soil and water conservation measures.

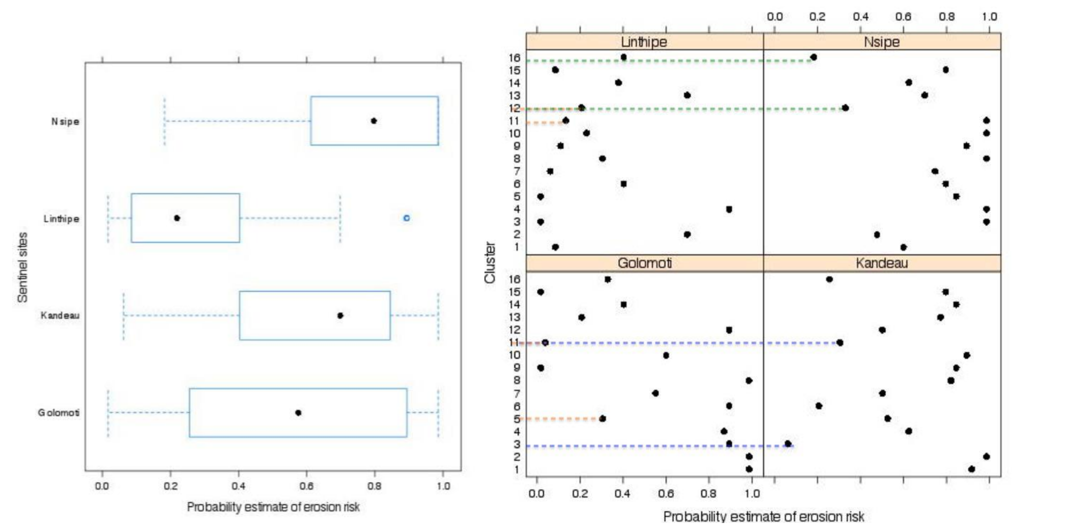

Figure 4. Erosion prevalence estimates showing (left) between site, and (right) within site variability. The dotted lines in the right figure show clusters corresponding to the intervention areas.

For Kongwa/Kiteto action site, one sentinel block of $10 km^2$ has been identified for landscape assessment of soil and vegetation using the land degradation surveillance framework, the results of which will be reported during the 2013-2014 research year.

Agronomic surveys: In Babati, these were conducted to estimate actual maize yields obtained by farmers under their own practices and identify management practices that limit production. One hundred and seventeen farmer fields in Babati (Tanzania) and 160 in Linthipe (Malawi) were marked out and the history of their management and production estimates taken. Harvest data given in Figure 5 show huge deviations from the potential yield for some selected varieties. Varieties used by farmers were variable. In Babati, they included SC 627 (39% of farmers), H614D (8.5%), Local variety plus some mixed varieties (19%), DK 8031 (11%), Pioneer (7.7%) and other hybrids such as Pannar 691, SC403, SC513, and H628 (12.8%), while recycled hybrid seeds were used by 1.7% of the sampled farmers. Most of the hybrids show an exploitable yield gap of at least 3t ha^{-1} for the majority of the farmers. Clearly, strategies are needed to reduce these yield gaps while still addressing sustainability issues of the production base.

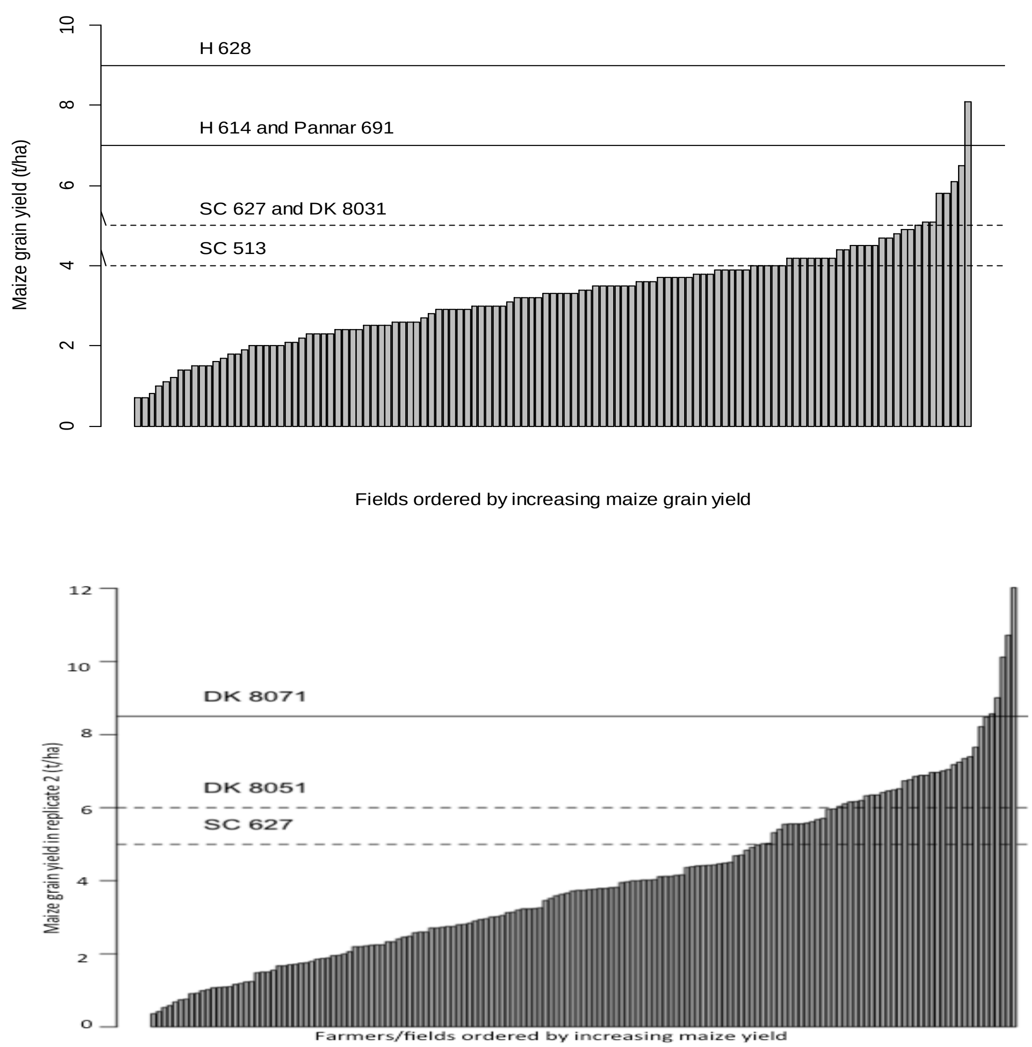

Figure 5: Maize grain yield observed in Babati, Tanzania (top) and Linthipe, Malawi, in the 2012-2013 cropping season. Horizontal lines indicate the potential yield of the hybrid varieties grown by farmers. Broken lines indicate the lower potential where data provided was a range.

Factors contributing to the yield gap were many and variable (examples are italicized in this paragraph). Despite the fact that over 81% of the farmers use hybrids, only 3% applied fertilizers on maize as foliar fertilizer called "Booster". As a consequence, the majority of the farmer fields had negative nutrient balances (at least 74% for N, 66% for K) indicating *mining of the soil*. The Classification Tree used to attribute the magnitude of different factors to the yield gap (Figure 6) shows that crops with *plant density* above 24,000 plants per hectare had 900kg ha^{-1} more grain yield than those whose density was lower. *Slope category* influenced the yields where fields on the higher degree slopes (steep and gentle slopes) have suppressed yields (by 800kg ha^{-1}) compared to fields on flat or on very gentle slopes, for fields with harvest density of >24,000. For all tree branches, *homestead proximity* of fields showed consistently more yield for fields closer than for fields farther away from the homestead. For the more flat fields that were away from the backyard, yields were 800kg ha^{-1} higher in fields with frequent *manure application* (at least twice in 5 years) than those with less frequent application. *Within field variations* were also evident.

Yields from samples replicated 7 meters apart within the same field showed differences averaging 50%, and even doubled in at least 15% of the cases (Figure 7a). Uneven implementation of *agronomic practices*, such as variable planting density (Figure 7b) and uneven weeding, as well as *inherent differences in soil fertility* were the main contributing factors. In Malawi, mixed effect modelling results show that *variety*, *manure application*, *fertilizer use*, *intercropping with legumes*, *weeding time and frequency* and *plant spacing* are the major determinants of yield gaps.

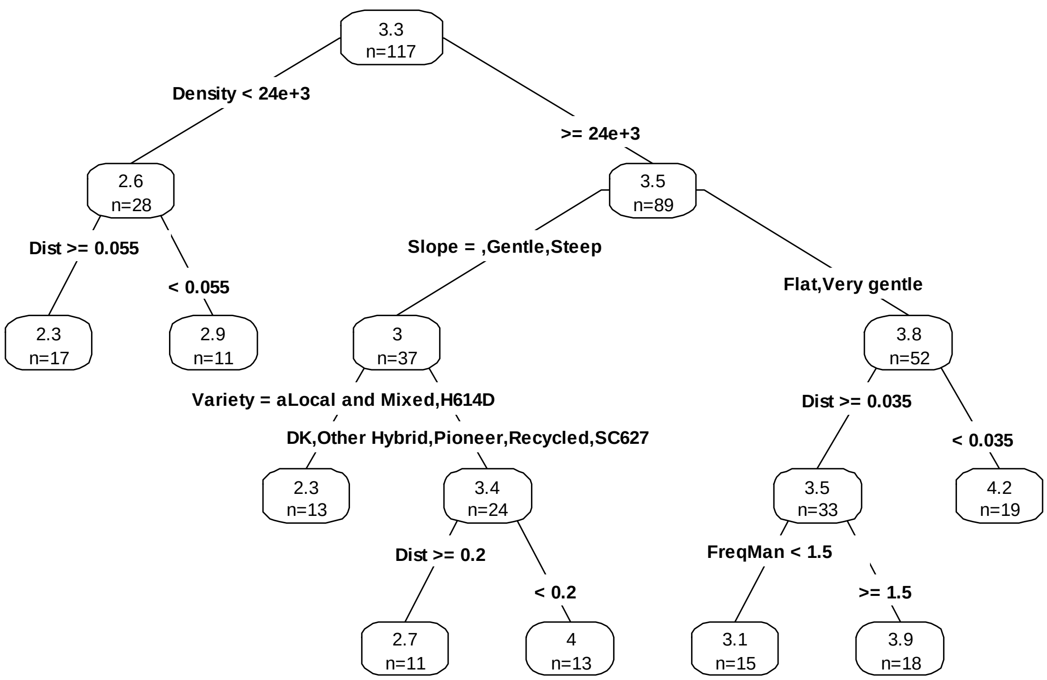

Figure 6: Influence of key production parameters on maize grain yields observed from various farmers' fields in Babati (n=117).

The different impacts of these factors is consistent with the Program's Trade-off Hypothesis which advocates for targeting better tailored interventions that suit the context specific environments (physical and socio-economic). These and other results not reported here are being developed into a manuscript for publication (Kihara et al., *Agronomic yield estimation in Babati, Tanzania: the why, what and how)***.**

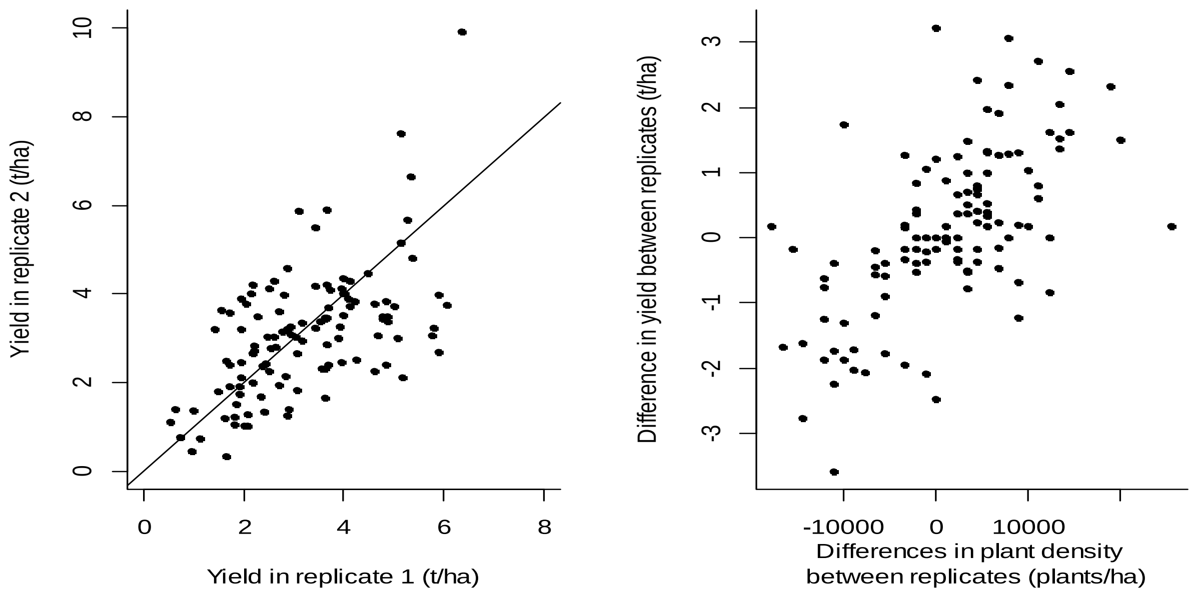

Figure 7: Yield variations between the replicates in the farmer fields surveyed (a) and relationship between replicate differences in observed maize grain yield and plant density at harvest (b) in Babati, northern Tanzania. A 1:1 line is shown. Similar results were obtained in Malawi.

Characterizing livestock production systems, feeds and feeding systems: A desktop mapping showed that farming systems across Babati are all mixed crop-livestock in nature (Figure 8a) only differing in degrees of intensity and nature. A scoping study identified the common types of livestock as being local breeds of cattle, sheep, local goats, local chickens and donkeys. Their functions include savings (social capital), draught power, source of manure, and milk production mainly for home consumption. Pigs were occasionally spotted. Dairy goats are common, having been introduced through the FARM Africa project.

Common livestock production systems in the highlands are based on free-grazing, tethering and in some cases confining (zero-grazing). Extensive grazing is dominant in the lowlands. This system is also likely dominant in the semi-arid Kongwa and Kiteto. Other common feed resources are crop residues, being dry maize stover, green maize stover (strip, thinnings), bean haulms, pigeon pea residue, sugarcane tops and sweet potato vines. Planted forages, especially legumes, are largely absent from the system. Using the Feed Resource Assessment Tool (FEAST), it was estimated that the combined feed sources at best meet up to 65% of feed during the wet season (mainly grazing) and only 12-30% during the dry season (mainly crop residues) (Figure 8b). The results of the scoping study indicated the need to introduce improved grasses and forages so as to increase feed system productivity and quality, which could also concurrently improve the landscape quality, especially by controlling erosion and introducing nitrogen to the soils through biological nitrogen fixation.

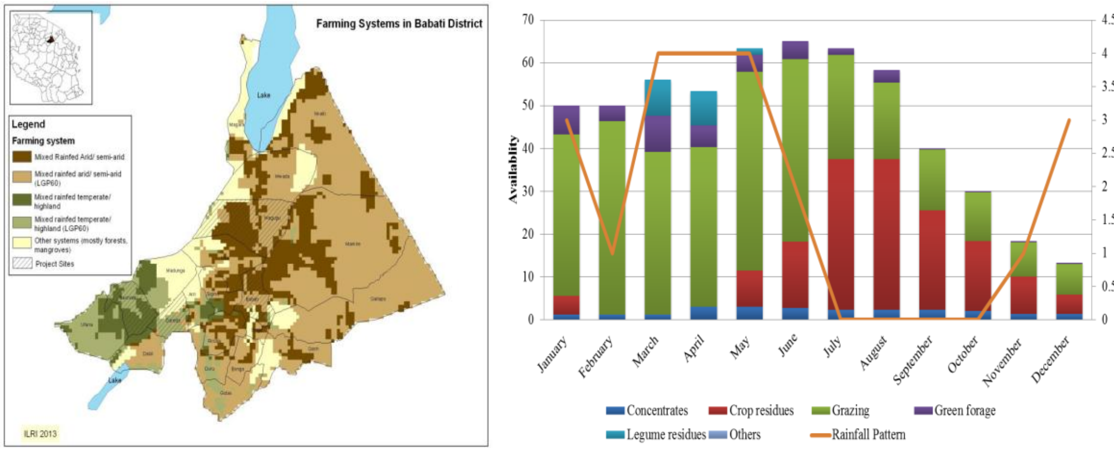

Figure 8: Map of livestock production systems for Babati District (a) and an illustration of livestock feed availability during a calendar year (b).

Factors contributing to high postharvest losses: Postharvest loss assessment was done through focus group discussions and household interviews in Long, Seloto and Sabilo villages in order to establish the factors that contribute to high postharvest losses. At least 60 individuals were interviewed during the focus group discussions and 360 households were interviewed using a structured questionnaire. Assessments of the household processing and storage infrastructure/capacity were also conducted during the surveys. Data collected are being compiled for analysis, after which a project intervention strategy report will be produced. The postharvest yield loss profile (Figure 9) shows several ways in which farmers reported experiencing food losses in the field, during harvesting and processing and in storage. Most farmers lack access to modern methods for harvesting, processing and storage. Local storage structures were dilapidated and ineffective against storage pests. Weevils, confused flour beetles and larger grain borers damaged stored crops. Adverse weather contributes to low farm outputs, high food losses and food insecurity. Literature shows that these factors can lead to harvest losses of over 50%[2]. Identifying best practices and innovative arrangements for increasing agricultural productivity must go hand in hand with improving postharvest management systems because minimizing food losses would, in equal measure, reduce inadequacy of food supplies. The data generated in this study are being compiled into a manuscript for publication (Abass et al., *Postharvest food losses in a maize-based farming system in semi-arid savannah area of Tanzania*).

[2] Obeng-Ofori, D., 2011. Protecting grain from insect pest infestations in Africa: Producer perceptions and practices. Stewart Postharvest Review, 7, 3:1-15.

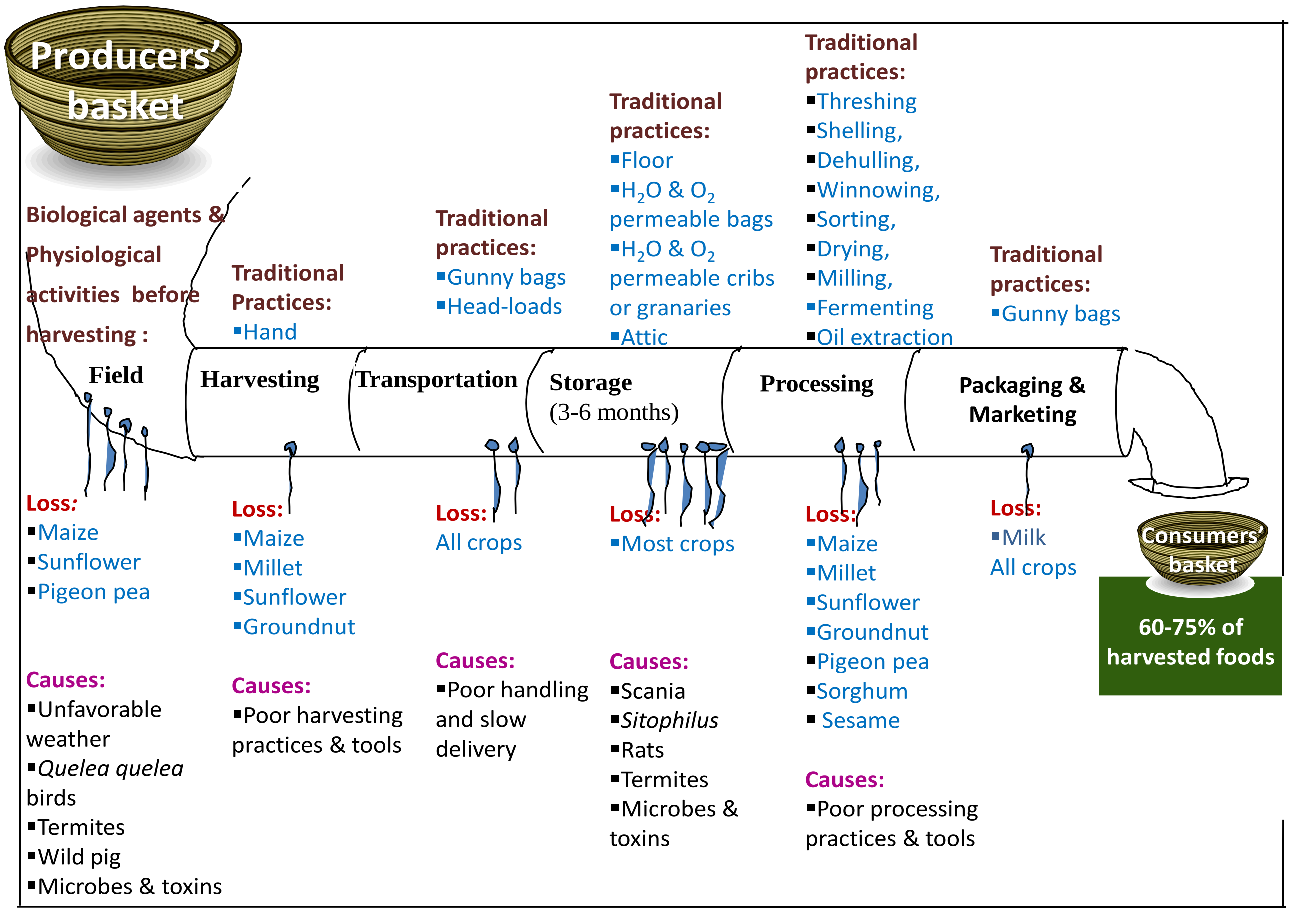

Figure 9: Postharvest loss profile in the maize-based system of the semi-arid areas of Tanzania.

Mycotoxin contamination: Two household surveys involving 460 households in three villages of Babati District, namely Seloto, Long and Sabilo, have been completed. The surveys produced 448 and 390 geo-referenced maize and bean samples respectively, which will be used to establish the association of certain demographic, socioeconomic and agricultural practices as documented in farmer questionnaires with contamination levels of aflatoxin and fumonisin as shown by ELISA analysis. Samples are collected along the food and feed value chain, with those already collected originating from the field and recent storage, and those still to be collected from stores, markets, processors and supplies of animal feed. Results generated from these studies will help to clearly define risk and in particular identify hotspots for control intervention studies.

Preliminary results from Kongwa and Kiteto Districts show that only 19% of the farming households are aware of aflatoxin, yet its incidences and levels are very high (Table 3). Most of the crops analyzed for aflatoxin contamination contained ≥4ppb and ≥20ppb, the respective permitted thresholds for the EU and USA, the largest markets for various food products. No aflatoxins were detected on beans, pearl millet or pigeon peas. Creation of awareness appears to be an important pre-condition for the introduction of aflatoxin management technologies.

Table 3: Incidences and levels of aflatoxin in grain of different crops grown in Kongwa and Kiteto Districts.

Crop	**Number of samples**	**Aflatoxin incidence and levels**
Groundnut (household samples)	163	18%,20 to 4000ppb
Maize (household samples)	366	2%, 20to 340ppb
Bambara	78	10%, 20 to 411ppb 33%, 1 to 20ppb
Pigeon pea	29	100%, 0ppb
Beans	4	100%, 0ppb
Pearl millet	35	100%,0ppb
Sorghum	64	11%, 1 to10ppb
Sunflower	143	13%, 20 to 293ppb
Groundnut (market samples)	28	57%, 20 to 504ppb
Maize (market samples)	23	26%, 1 to 10ppb

Integration of vegetables into maize based systems: This project was supported much later than the others. So far, a household socioeconomic characterization survey of production and consumption patterns of 300 respondents has been conducted in 10 villages across Babati, Kongwa and Kiteto Districts. Data are currently being processed for analysis; the results will establish the baseline status of household socioeconomic characteristics, vegetable cultivars, farm input usage, production practices and constraints, vegetable farming profitability, knowledge and training needs of vegetable farmers, marketing channels, household welfare indicators and vegetable consumption levels within the maize-based production systems. The analysis will build on the jumpstart observations obtained from Kilombero District which show that: (i) promotion of elite vegetable varieties will enhance production; (ii) good agricultural practices in vegetable production and marketing will diversify farm income sources; and (iii) promotion of activities for increased vegetable consumption at the household level will enhance nutritional outcomes.

Assessment of new research challenges: The *Plant Disease and Pest Monitoring Survey* aims to provide up-to-date information on the abundance and distribution of important pests and diseases of maize and common bean in the Africa RISING project action areas, with specific attention to new diseases or pests such as maize lethal necrosis (MLN). The outputs are expected to be reliable and accurate pest and disease distribution data, an update of crop pest and disease occurrence lists, and an identification of priority pests and diseases of economic significance for formulating research on integrated management approaches. The main study conclusions were:

- Aphids and pod borer on maize, whiteflies and aphids on beans are common pests.

- MLN, maize streak, bipolaris leaf blight, curvularia leaf spot and turcicum leaf blight are common diseases on maize.
- Bacterial blight, angular leaf spot, anthracnose, ascochyta blight and viral diseases were the most common diseases on beans.
- A wide variety of nematodes were also detected in all the fields assessed.
- Emerging threats to maize included MLN disease, observed in most of the maize production zones in Babati, and *Striga*, detected in Kongwa District; black bean beetle in Long in Babati was found to be a new threat to bean.
- MLN disease was found to be widespread in Babati District, but disease incidence was relatively low.
- From this study it can be concluded that drought, pests and disease are the major limitations to maize and common bean production in the surveyed sites in Tanzania. The incidence and severity of pests and diseases varied between sites. Indigenous and less tolerant varieties were being grown by most farmers. The perception towards use of Integrated Pest and Diseases Management options to manage pests and diseases was generally weak to moderate.

A low-cost enzyme-linked immunosorbent assay (ELISA) was developed for the detection of Maize chlorotic mottle virus (MCMoV), one of the two viruses involved in causing MLN in maize, for use in epidemiological surveys and in screening germplasm for host resistance.

- MLN is a newly emerging disease in East Africa caused by synergistic interaction between Maize chlorotic mottle virus (MCMoV), a virus new in Africa, and the Sugarcane mosaic virus (SCMV). Single infection of MCMoV or SCMV is difficult to diagnose by symptoms alone.
- In this study, a rabbit polyclonal antiserum was produced against the recombinant MCMoV coat protein and these were used in developing an ELISA for MCMoV detection. This assay is simple to perform and low-cost, and handy for use in monitoring the spread of MCMoV.

The survey was intended to include groundnut and pigeon pea. However, partners could not make the required technical teams available at the appropriate development stage of the crops.

Economic, social and institutional constraints to adoption of agricultural technologies and institutional innovations in project areas: A socio-economic survey in Malawi showed variable tendencies in adoption of different technologies farmers were exposed to (Figure 10). Generally, farmers seem to prefer adopting inorganic fertilizer, perhaps because of an opportune environment created by the government. Malawi's targeted fertilizer and seed subsidy has resulted in clear positive effects on household maize production and self sufficiency[3]. In general, more farmers are dis-adopting technologies in Linthipe than in Nsipe. Larger dropouts of more than 20% are observed in 7 of the 10 technologies. Among the ten technologies observed, mulch, lime, fallow, compost and agroforestry are adopted by few farmers and/or are being dis-adopted by a large number of farmers. Based on the semi-structured interview of about 320 households, the major reasons for the lower adoption and/or dis-adoption of technologies in the two sites include lack of technical know-how and high labor demands. The major reasons, however, vary between the two sites. The results show the challenges of disseminating and adopting some interventions such as mulching and fallowing when local circumstances of farmers, e.g. availability of land, do not allow.

[3] S. Holden and R. Lunduka, 2010. Impacts of the fertiliser subsidy program in Malawi: Targeting, household perceptions and preferences. Noragric Report No 54, UMB, Aas, Norway.

In Tanzania, a desktop study supported by limited field meetings with district representatives and stakeholder organizations (and complemented with a few village and farm visits) showed that the most important constraints to farming (e.g. cultivation equipment, access to land and extended dry spells requiring irrigation support – Table 4) are best addressed at the institutional level because they require a lot of investment and other support services. These, then, should be overcome first if "complimentary" agricultural intensification technologies are to be practiced and adopted. This points to the importance and the potential roles of R4D platform partners – in sum, to reduce farmer uncertainties. Consequently, the study identified potential membership (categories and existing representative institutions) for the district-level platforms at each of the action sites. The categories include farmers and farmer organizations, input suppliers, market agents, financial institutions, policymakers, extension institutions, research institutions and development (grant) partners.

Table 4: Constraints to farming in Kiteto, Kongwa and Babati Districts of Tanzania[4].

Most important constraint	**% of households in**		
	Kiteto	**Kongwa**	**Babati**
Poor soil cultivation equipment	24.4	21.0	15.6
Access to land	19.0	15.8	18.1
Access to potable water	12.1	-	-
Access to improved seed	8.4	-	-
Extended dry spell	6.3	22.2	19.4
Access to credit	5.7	5.4	-
Soil fertility	-	5.4	12.6
Cost of inputs	-	4.7	18.8
Access to off-farm income	-	4.7	-
Ownership of land	-	-	7.4

[4] Adapted from: United Republic of Tanzania, 2012. National sample census of agriculture 2007/2008. Volume Vu: Regional report – Manyara Region. National Bureau of Statistics, Dar es Salaam.

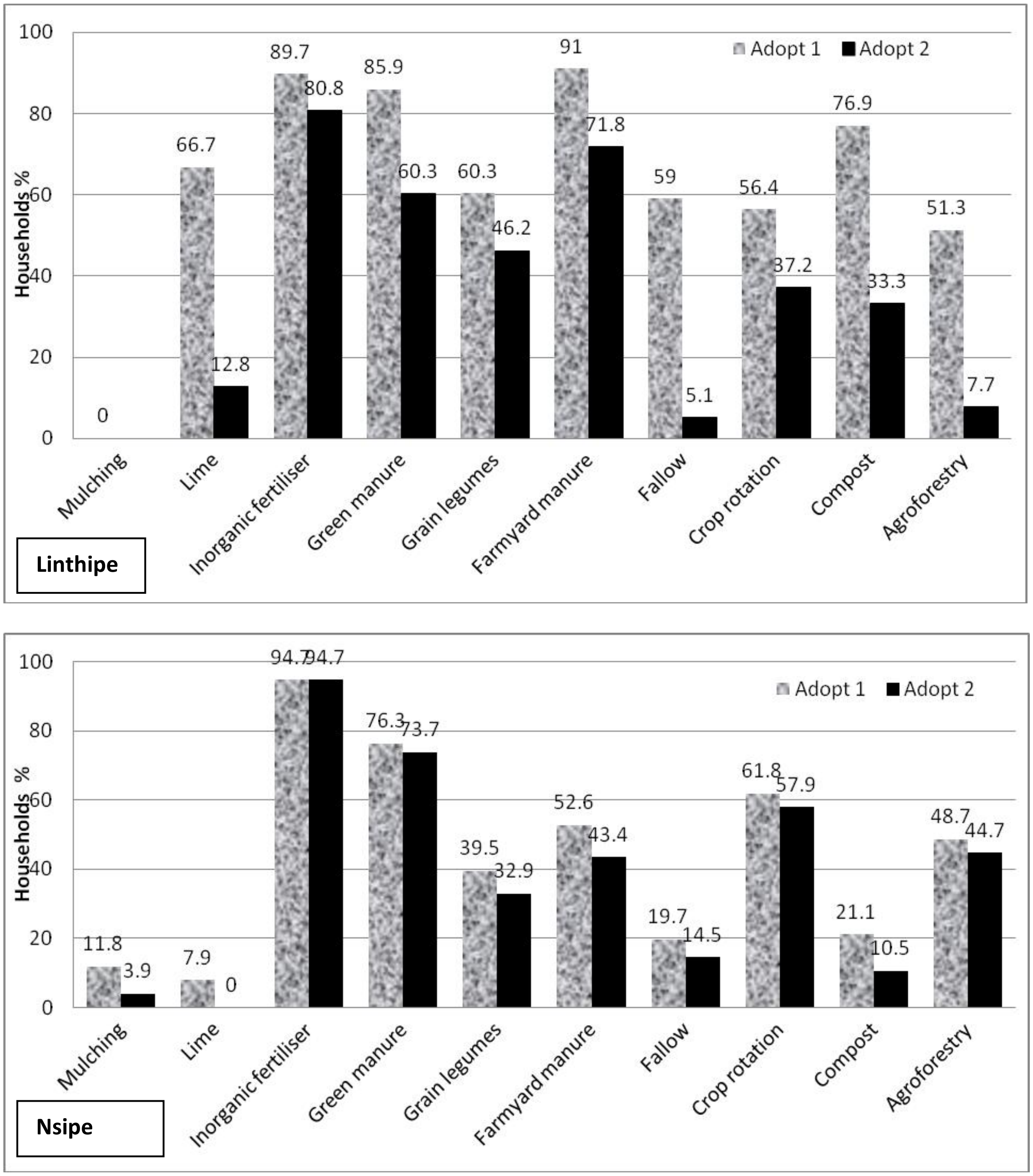

Figure 10: Proportion of farming households that have ever used (adopt 1) and are still using (adopt 2) ISFM technologies in (i) Linthipe and (ii) Nsipe EPAs.

Construction of farm household typologies: A Farming Systems Analysis study was initiated with the aim of characterizing farming households so as to derive a farm typology from which representative farms will be selected for detailed diagnosis and exploration of promising innovations. Farm surveys were conducted in 16 villages in Tanzania (Babati, Kongwa and Kiketo Districts) and 8 villages in Malawi (Dedza and Ntcheu Districts). At the village level, 10 farms were selected using a spatial Y-shaped sampling frame to avoid sampling bias while obtaining information on spatial correlation.

Results of the preliminary analysis of these data were presented at the 4th International Farming Systems Design Workshop in China. A large diversity in household and farm sizes was observed within and between regions. Farms in Tanzania are larger than in Malawi, in particular in the Kongwa region where 50% of farms exceed 5ha (Figure 11a). On the farms in Malawi the labor input per unit of farm area was considerably higher than in Tanzania (Figure 11b). Farmers suggested a large range of potential attention points and innovation needs for their cropping systems during survey sessions (Table 5). In Malawi the emphasis was on crop diversification and solving land shortages, whereas in Tanzania a broader range of desired improvements was mentioned. These suggestions will be elaborated and evaluated for feasibility in the subsequent exploration phase.

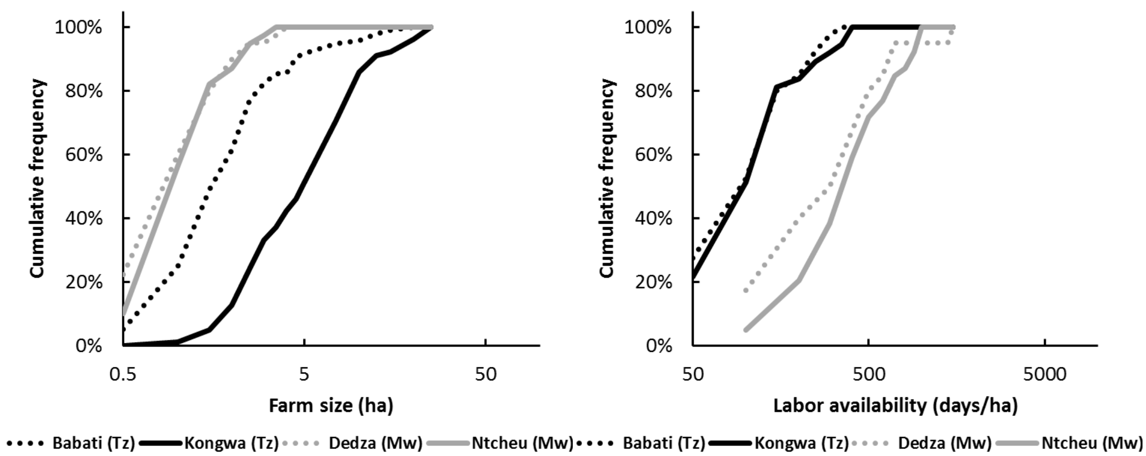

Figure 11: Cumulative frequency of farm sizes (a) and labor intensity (b) (both on a logarithmic scale) in villages of four case study regions in Tanzania (Tz) and Malawi (Mw).

Table 5: Fraction of farmers mentioning desired improvements in cropping systems in Tanzania (Tz) and Malawi (Mw).

Proposed improvement	Babati (Tz)	Kongwa (Tz)	Dedza (Mw)	Ntcheu (Mw)
New crops, cultivars, processing	0.43	0.60	0.88	0.74
Land availability	-	-	0.23	0.13
Advice, education and research	0.23	0.13	-	-
Technologies and machines	0.17	0.33	-	-
Inputs (fertilizers, seeds)	0.25	0.31	0.38	0.23
Improved farm management	0.22	0.06	-	-
Natural resources (soils, manures)	0.14	0.14	-	0.03
Economic resources	0.07	0.15	0.20	0.26
Subsidies	0.02	0.05	-	-

Social initiatives, groups	0.01	-	-	-

Research Output 2 (RO2): Integrated Systems Improvement

Several innovations of inputs at the level of crops, livestock and farm technologies were tested, mainly as potential components of integration during subsequent studies. This was emphasized at the Lilongwe [2012-2013 Annual Review and Planning Meeting] (3-5 September 2013), where the Research Team from Babati presented an integration illustration model (Figure 12). Components are layered to emphasize that products from one form of activity can benefit from or be a resource for another activity. Some such products are "wastes" – for example, vegetable residues (WP 7) are being proposed as a poultry local feed resource for 2013-2014 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 environmental integrity is upheld.

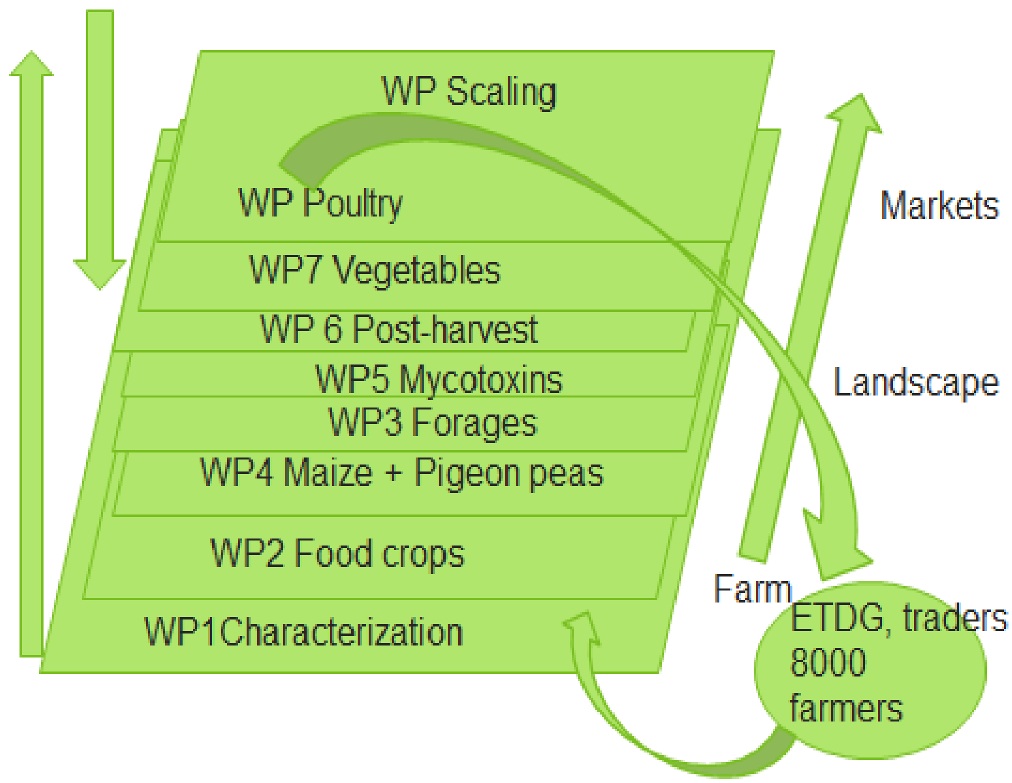

Figure 12: A model representation of the integration implementation strategy showing how different work packages interact at farm, landscape and market scales.

Participatory evaluation of new and promising food and feed crop varieties: Several activities introduce potentially high yielding and marketable food and feed crops from neighboring countries or other regions, as well as from national research institutions. Multidisciplinary research team members at national and international research institutions selected materials of specific adaptive characteristics to the target biophysical conditions and market needs. Standard crop evaluation protocols (phenotypic and post-harvest characteristics) were used to identify the most site-specific suitable varieties. The selected varieties will become the primary component in the research integration sequencing.

Maize. In Babati, nine stress tolerant maize hybrids were planted at three locations to identify adapted varieties that will be used in intercropping trials and for release in subsequent years. These were compared with a "local" check (SC627) which is an earlier introduced improved variety. Figure 13 shows consistent site differences; highest yields were always in Sabilo and lowest in Seloto. Yields of the new hybrids were not very much different from the local check and, during the participatory variety selection exercise, the majority of farmers (37%) preferred SC627 over the new varieties. The next best hybrid selected was CKH10038, preferred by 27% of the farmers. Seasonal limitations did not permit implementation of similar work planned for Kongwa and Kiteto.

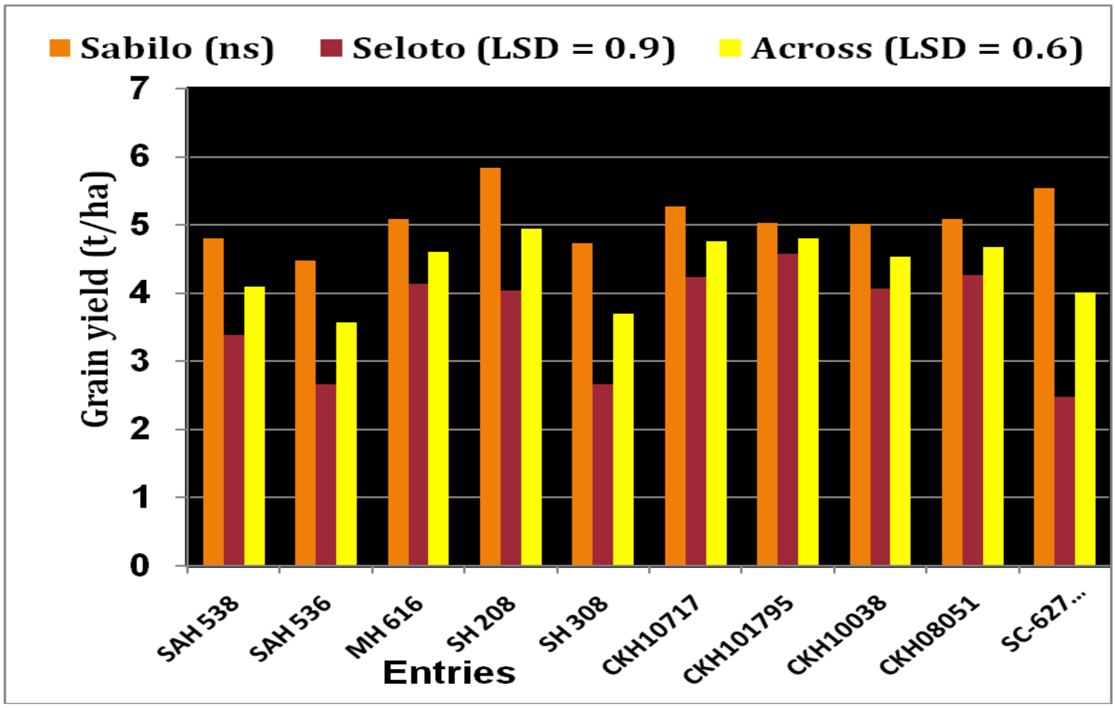

Figure 13: Maize variety selection in Babati District.

Beans. The beans activity introduced into Babati one highly marketable and micronutrient rich mid-altitude climbing variety and 5 drought tolerant bush-types. These were grown under different fertilizer regimes. Figure 14 shows that responses to fertilizer were site specific; Minjingu Mazao performed better at Long and Seloto while DAP performed better at Sabilo (results not shown here). This lays further emphasis on the importance of targeting innovations. Only Selian 06, the climber, just about reached its yield potential (4-6.5t ha^{-1}) at Long and was most popular during the evaluation sessions. Other varieties barely reached half of their potential yield, an indication of the existence of other limitations that need to be overcome and to be addressed during the next research phase.

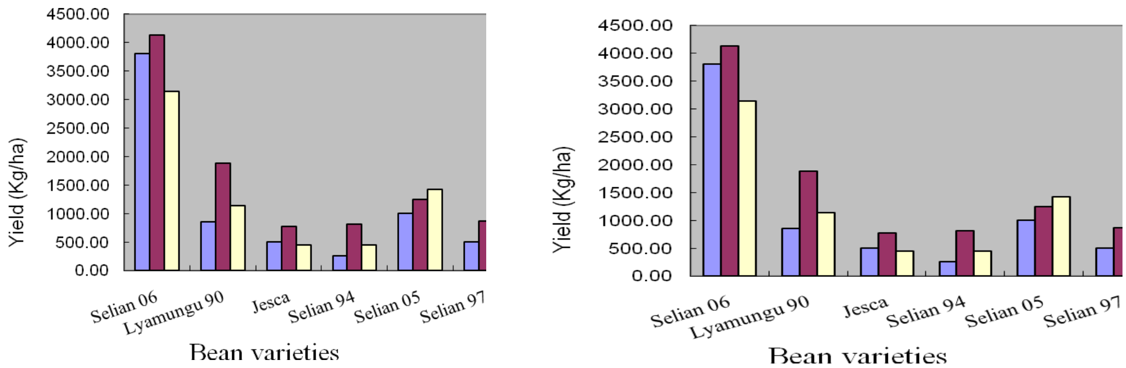

Figure 14: Yield performance of bean varieties against different fertilizers (blue = control; purple = Minjingu mazao; yellow = Diammonium phosphate) at Long and Seloto villages.

Pigeon pea. Performance of three improved pigeon pea varieties under farmer field conditions for adaptation (yield, resilience to pests, diseases and drought, farmer preference etc.) and agro-forestry needs was evaluated using participatory variety selection approaches at a few representative locations in Kongwa and Kiteto. This crop is late maturing and data are still being collected; analysis of the data will be used to inform adoption and promotion strategies for the improved pigeon pea varieties.

Groundnut. Various improved varieties were evaluated under field conditions in Kongwa and Kiteto for yield, resilience to rosette and drought and farmer preference. Results will be presented in the next report.

Fodder species. Forage materials were sourced, cleared by respective government authorities and imported to Tanzania for on-station bulking at Tengeru Livestock Research Station in Arusha (Plate 1). The main reason for this is to have enough vegetative planting materials and seed for subsequent distribution to participating farmers in project sites in the second rain season, for integration in the crop livestock production systems. The second reason is to 'ground-truth' highly promising forage varieties in terms of yield and drought/cold tolerance. Tengeru Station was appropriate because of the irrigation facilities that enabled bulking even during the dry spell.

Materials under bulking are improved Brachiaria varieties – Brachiaria hybrid (CIAT 36087 cv. Mulato), *Brachiaria brizantha* (CIAT 26024) and *Brachiaria brizantha* (CIAT 26110 cv. Toledo) from Rwanda Research Organisation, Kagarama Station, Rwanda and *Brachiaria decumbens* from ILRI Addis Ababa. Other grasses are *Panicum maximum* cv. Giant Panicum, smut-resistant *Pennisetum purpureum* cv. Kakamega 1, high-yielding *Pennisetum purpureum* (ILRI 14984), *Pennisetum purpureum* (ILRI 16803), *Pennisetum purpureum* (ILRI 16786), *Pennisetum purpureum* (ILRI 16835) and *Pennisetum* *purpureum* (ILRI 16837), all sourced from the Kenya Agricultural Research Institute (KARI), Muguga, Kenya.

The legumes, *Lablab purpureus* (CIAT 22759), *Stylosanthes guinensis* (CIAT 11995), *Canavalia brasiliensis* (CIAT 17009) and *Lucaena diversifolia* (K780) were sourced from CIAT, Columbia. *Desmodium uncinatum* for both medium and highland areas, dual purpose cowpea for lowland areas, *Stylosanthus scabra*, and Vetch for highland areas were sourced from ILRI, Addis Ababa. Other forages for integration in selected niches of the farming systems included two species of fodder trees *Lucaena pallida* and *Sesbania sesban* for highland areas, *Panicum maximum*, and Brachiaria cv. Mulato.

Plate 1: Forage multiplication in Tengeru.

Participatory evaluation of combinations of technologies: Several technologies that have been proven as successful options by the research team (Malawi) or with potential (Tanzania) for sustainable intensification and climate smart agriculture were identified and implemented as adaptive optional experiments with farmers. These included cereal-legume rotations, cereal-legume intercrop and doubled-up legumes; and with complementary technologies that included addition of different types of fertilizers at different rates and methods of application, and integration with in-situ water harvesting and conservation technologies. Some of these technologies were implemented across the three mega-sites (although not in a uniform systematic manner) in which case a comparative synthesis will be desirable when all data are in. Others were applied to specific sites.

Among the legume-based technologies, Malawi farmers consistently ranked groundnut, soybean and cowpea as good across all sites, but had reservations on long duration pigeon pea varieties that required more labor to guard against animal damage after the main harvest period. Information from these reflection and farmer feedback workshops has already been factored into the new work plans for year 2013-2014.

In Tanzania, the intercropping trials were maize-pigeon pea, and the pigeon pea was still in the field at the time of this report. In Babati, Minjingu Mazao was the most preferred P fertilizer source for maize followed by Minjingu Phosphate rock (PR-granular) and then Diammonium phosphate (DAP) during the farmers' assessment. Reasons given by farmers were: 1) prices for the Minjingu fertilizers were lower compared to DAP, even if the latter gave higher (but not significantly so) yields; 2) easy access; and 3) multi-nutrient composition of Minjingu Mazao. Treatment yield differences (Table 6) support the farmers' choice.

Table 6: Fertilizer micro-dosing of a maize/pigeon pea intercrop and maize yields at Sabilo.

Treatment	Yield (t/ha)
DAP	4.618 a
Minjingu Mazao	4.149 ab
Minjingu PR-granular	3.853 b
Farmer's Practice	0.71 c
LSD (n=9)	0.62
CV %	19.3

In Kongwa and Kiteto, optimum P rate for maize was established at 30kg P ha^{-1} for a yield range of between 4-5t ha^{-1}, but maize response to N fertilizer was poor, suggesting the existence of other compounding factors. Deep tillage improved yields; ox-ripper and ox-ridger tillage increased yield by 25% and 30% respectively. Higher yields were obtained with tractor drawn implements. Detailed results will be presented with the next report.

Research Output 3 (RO3): Scaling and Delivery

No research activity has been designed or implemented to achieve this output. However, scaling activities/processes have been ongoing by virtue of the tools used in the participatory evaluation of technologies and deliberate awareness campaigns. Mother-baby adaptation, demonstration and multi-location research tools have been utilized in the introduction and evaluation of technologies described above. Information has reached communities during the needs assessment meetings, focused group discussions, household surveys, technology assessment sessions and awareness creation campaigns. Table 7 shows the type of partnership engagement in Babati that allowed scaling of technologies and information. It is estimated that 560 farmers were involved in field days and direct training in the Kongwa/Kiteto action site, while 450 farmers directly experimented with different sustainable intensification technologies in Malawi. Assessment of these approaches on the broad spectrum of adoption and impact has been considered a subject for future research.

Table 7: Partner engagement in Babati District. Associate farmers are those reached through training, interviews, group discussions, field days, factsheets and news media.

Work Package (WP)	WP Leader & Institution	Partner Research Institutions	Research Farmers (%F)	Associate Farmers (%F)
Biophysical production constraints	Job Kihara, CIAT	SARI, DAICOs	320 (sampled plots)	480 (?)
Improved food & feed crop varieties	Dan Makumbi, CIMMYT	CIAT, SARI, IITA, DAICOs	Maize: 8 (13) Beans: 24 (54)	Maize: 272 (17) Beans: 424 (41)
Fodder species for land management	Ben Lukuyu, ILRI	CIAT, TALIRI, IITA, DAICOs	On-station	-
Intercropping & micro-dosing with Minjingu PR	Stephen Lyimo, Selian ARI	IITA, ICRISAT	28 (?)	634 (27) 20m thru TV & radio
Mycotoxin contamination	Fen Beed, IITA	NM-AIST, MAFSIC, SUA	Not applicable	545
Postharvest technologies	Adebayo Abass, IITA	SUA	8(?)	428 (?)
Integration of vegetables	Victor Afari-Sefa, AVRDC	IITA, University of Dodoma, DAICOs	Not applicable	300 (150 veggies & 150 non-veggies)

3. Capacity building

Training was conducted at different levels and for different purposes (Table 8). This creates a reserve of personnel who may be called upon to perform these functions for future Africa RISING and other similar activities.

Table 8: Training activities conducted in the ESA region during the 20123-2013 research season

Type of Training	Participant category	Number of trainees
Agroecology and participatory research	Extensionists	38
Visual diagnosis of nutrient deficiencies, and agronomic surveys	Extensionists	7
Nutrient deficiency identification (maize-doctor)	Farmers	478
Land Degradation Surveillance Framework	Extensionists	13
Enumeration: Farming systems analysis, baseline surveys, protocols for crop pests & diseases surveys	Variable	29
Nutrition workshops	Female farmers	168
Fertiliser management and intercropping	Farmers	43
Post-harvest management technologies	Farmers	172
ToT on Integrated soil fertility management	Extensionists	23
MSc in partnership with iAGRI	Students	2

4. Partnerships

New institutional partnerships are forming teams with Africa RISING to address specific interests; they are Tuboreshe Chakula (USAID-supported) on nutrition with the Kongwa/Kiteto Team, and the private Export Trading Group (ETG) with the Babati Team for linking farmers with profitable markets, especially for pigeon pea.

Memoranda of Understanding were signed with the Integrating Nutrition in Value Chains (INVC) Project, supported by the Malawi USAID Mission, and Tanzania Staples Value Chain (NAFAKA), supported by the Tanzania USAID Mission.

Africa RISING entered into partnership with the USAID Zambia Mission-funded Sustainable Intensification of Maize-Legume Systems in Eastern Province of Zambia. At a first exploration meeting held in May, common areas of interest were explored. These were further developed at a workshop in September. The parties, including the USAID Mission, have agreed on a range of activities that will be carried out in mutual interest and benefit. Africa RISING will invest US$350,000 in this new collaboration in the season 2013-2014. An amendment to the existing SIMLEZA proposal has been prepared and submitted to IITA.

5. Lessons learned and implementation issues

Integrated research in Africa RISING demands engagement from partners who have other commitments, especially at their institutional levels. This is a particular challenge for CGIAR partners not present in the countries. They face problems monitoring the experiments. NARS can be reliable partners but are curtailed by serious lack of resources to contribute to initiatives. Understanding these, and careful activity planning to ensure that the research scientists' incentives and satisfaction are met within the limited resources, is essential in building strong partnerships.

Co-learning approaches that integrate farmers and extension workers in the research process appear to attract buy-in from farmers more readily. Experiences have shown that there is need to concurrently strengthen the capacity of inputs dealers to more effectively ensure delivery of quality inputs on a reliable basis when farmers start demanding the desired technology inputs.

Farmers in Babati, having a clear knowledge of their problems, are very eager to try out solutions together with researchers. Meetings for farmer training became very nice forums for farmers to discuss the problems they are facing, and these will be invaluable inputs in the planning of next year's interventions/activities.

In Tanzania, the baseline survey has not yet been carried out, and there is no clear information on when it will be done. In Malawi, the survey has just been completed but data will not be available to inform next season's planning.

Challenges were faced in getting seeds of experimental maize hybrids (drought tolerant and protein enriched) into Tanzania due to restrictions on seed movement imposed as a precaution against maize lethal necrosis (MLN) disease. When a permit for research purpose was received from the Quarantine Service, moisture content of soils was low and germination of the seeds poor. Thus, the experiments did not yield useful results and need to be carried out again in the coming season.

Progress has been made towards better integration of all national and international implementing partners. Good team spirit is noticed at meetings. However, when returning home from the meetings, attitudes often change. Many partners do not respect the agreements signed between IITA and their organizations. Non-compliance with reporting deadlines makes it difficult for IITA to report on time to the donor and to disburse funds to partners as planned during workplan development. Efforts have been made to improve on reporting discipline but these are so far minimally successful. While it is understandable that some smaller national partners do have capacity problems to comply with the reporting requirements, it is not acceptable that the CGIAR partners are failing to report on time. The Coordinator and Chief Scientist continue appealing to the partners to comply with obligations in the interest of the success of the project.

6. Publications

Jeroen C.J. Groot, Lotte Klapwijk, Carl Timler, Mateete Bekunda, Tom van Mourik, Katrien Descheemaeker, Pablo Tittonell, Ken Giller, Sieglinde Snapp, Bernard van Lauwe (2013). Rising to the challenge of sustainable intensification of agricultural production in Africa – farming systems design to support action research for development. Proceedings 4th International Symposium for Farming Systems Design. 19-22 August 2013, Lanzhou, China, 167-169

7. Success stories