Technical Report

Sustainable Intensification of Key Farming Systems in East and Southern Africa

01 October 2013 to 31 March 2014

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

Through action research and development 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 (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads an associated project on monitoring, evaluation and impact assessment.

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Content

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	International Center for Agroforestry Research
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
Malmo University	Sweden
NAFAKA	Tanzania Staples Value Chain Activity
NM-AIST	Nelson Mandela African Institute of Science and Technology, Tanzania
SUA	Sokoine University of Agriculture, Tanzania
SFHC	Soils, Food and Healthy Communities, Malawi
SIMLEZA	Sustainable Intensification of Maize-Legume Systems for the Eastern Province of Zambia
TALIRI	Tanzania Livestock Research Institute
Tuboreshe Chakula	Improved Food Processing for Nutrition and Value Addition, Tanzania
UDOM	University of Dodoma, Tanzania
UNRALS	University of Natural Resources and Applied Life Sciences, Austria
WU	Wageningen University, The Netherlands

Summary

During the period from 1 October 2013 to 31 March 2014, activities addressing Research Output 1 (Situation analysis and program-wide synthesis) progressed on different fronts; baseline surveys were completed in Malawi, have been initiated in Tanzania and were in planning phase for Zambia. Disciplinary generated survey data were or are being analysed in preparation for publications. The set of data generated from post-harvest surveys were used to produce a publication in a refereed journal.

First phase Farming Systems data analysis were completed and are expected to guide future studies that will be conducted by a PhD student yet to be identified. The study performed, among others, (i) Model-based exploration of trade-offs and synergies within the farms, which resulted in set of alternative farm configurations that perform differently in productive, economic and environmental performance indicators; and (ii) Selection of desirable farm configurations, as identified by the farmer and other relevant stakeholders on the basis of the performance indicators, for fine-tuning and redesigning the case study farm. Six critical constraints and ten research entry points were identified and analysed in the ESA Region.

The period also presents a second phase of Research Output 2 (Integrated Systems Improvement) field experiment installations, building upon results of last year's field activities. Disciplinary integration has continued to strengthen as some of the work packages installed activities on same plots so as to determine the genetic, ecological, environmental and economic or livestock feed impacts of treatments, or on the same sites to enable co-learning. New partners were brought on board to address these additional requirements. All the villages identified during the site selection process at the early stages of the project were brought on board this season. The original (2012/2013) mother/demonstration trials are now being used to evaluate treatment residual or rotational effects. The original baby trial farmers are being evaluated for innovation and adaptation. In Babati, R4D activities are being conducted at 308 sites of which 54 are demonstration in nature and the rest are the technology adaptation evaluations. In Kongwa/Kiteto, 20 researcher managed sites and 140 farmer managed baby plots have been established in the five villages. On-station trials exist at the research stations of Hombolo and Makutopora for new unreleased material of pearl millet, bambara nuts and sorghum. In Malawi, there are 16 mother sites and more than 1000 baby trials.

A new partnership with the SIMLEZA (Sustainable Intensification of Maize-Legume Systems for the Eastern Province of Zambia) project was born at the partnership meeting from 6-7 September 2013 in Malawi. Since then, the SIMLEZA Team has conducted farmer training and meetings with stakeholders and re-established demonstration plots – both on-station and on-farm. Some 408 farmers were trained during the period, including 57 new farmers identified and trained to host on-farm agronomy trials such as soybean agronomy, nutrient management, maize-legume intercropping and doubled-up legumes under conservation agriculture (CA). Establishment and/or activation of on-farm and on-station trials were conducted before the onset of the 2012/2013 planting season and inputs distributed as required.

Following the successful participatory evaluation and ranking of technologies from last year's demonstration studies in Tanzania, one integrated technology and one new bean variety have been elevated to the next stage in the technology proofing process through facilitating their practice by wider and randomly selected households to assess technology impact and variability in adoption and adaptation, based on typology. In the broad sense, this is a complimentary adaptation procedure to the baby trials being implemented in Malawi.

Preparations for the establishment of a R4D Platform were initiated in Babati District. The platform will be launched in April. The role of the platforms is to set priorities and give feedback to activities initiated by research and, in the long run, to stimulate learning and innovation to improve livelihoods in terms of productivity, income generation and nutrition. Platforms will also serve as vehicles for

scaling innovations within and beyond the district. In Zambia, an Innovation Platform (IP) meeting was held in November with the objective of strengthening collaboration between farmers, farmer groups, extension services, researchers and the private sector. A total of 21 people from the various stakeholder groups participated in the meeting. In February 2014, an IP was launched in Kongwa-Kiteto. The meeting drew 38 participants from 6 different categories of R4D users in the Kongwa-Kiteto area. The meeting prioritized areas for research over the next two years for the team and partnerships to explore.

Mentoring capacity at degree training has improved. In Tanzania, the number of PhD students conducting research with Africa RISING has grown to 3; there are 4 on-going MSc studies, and arrangements to receive a new cohort of 5 iAGRI-supported students are in advanced stages. Two undergraduate (BA) students from the University of Gothenburg started conducting their 5-month studies on Africa RISING research sites in Babati. Sites in Malawi are hosting 2 PhD and 4 MSc research students.

For the first time, a scientists' exchange visit was implemented aimed at knowledge sharing between Research Teams and research design harmonisation. The Malawi Research Team hosted 16 researchers from Zambia and Tanzania from 5-8 March 2014. The visitors were taken on a tour of the action research sites in Dedza and Ntcheu Districts, where they interacted with farmers, local extension partners and our district R4D actors. Participants generally appreciated the initiative. They were most impressed by the well-functioning mother-baby trial approach as a way of promoting new technologies to different farmer types; the doubled-up legume systems; and the strong engagement of the farmers in the field research. Some criticism has been raised regarding logistics and pre-visit information on the trials and sites. The experience will be used by the management team to better prepare for future exchanges.

Several papers have been prepared and published and presentations given at conferences and meetings.

ESA Action Areas

In Tanzania, there are two ecologically distinct research sites: (i) Babati District in Manyara Region which includes the intervention villages of Long, Sabilo, Seloto, Hallu, Matufa and Shaurimoyo; and (ii) Kongwa-Kiteto Districts, with Kongwa District being in Dodoma Region and including the villages of Chitego, Moleti, Mlali, and Laikala, and Kiteto District with Njoro village belonging to Manyara Region (Figure 1).

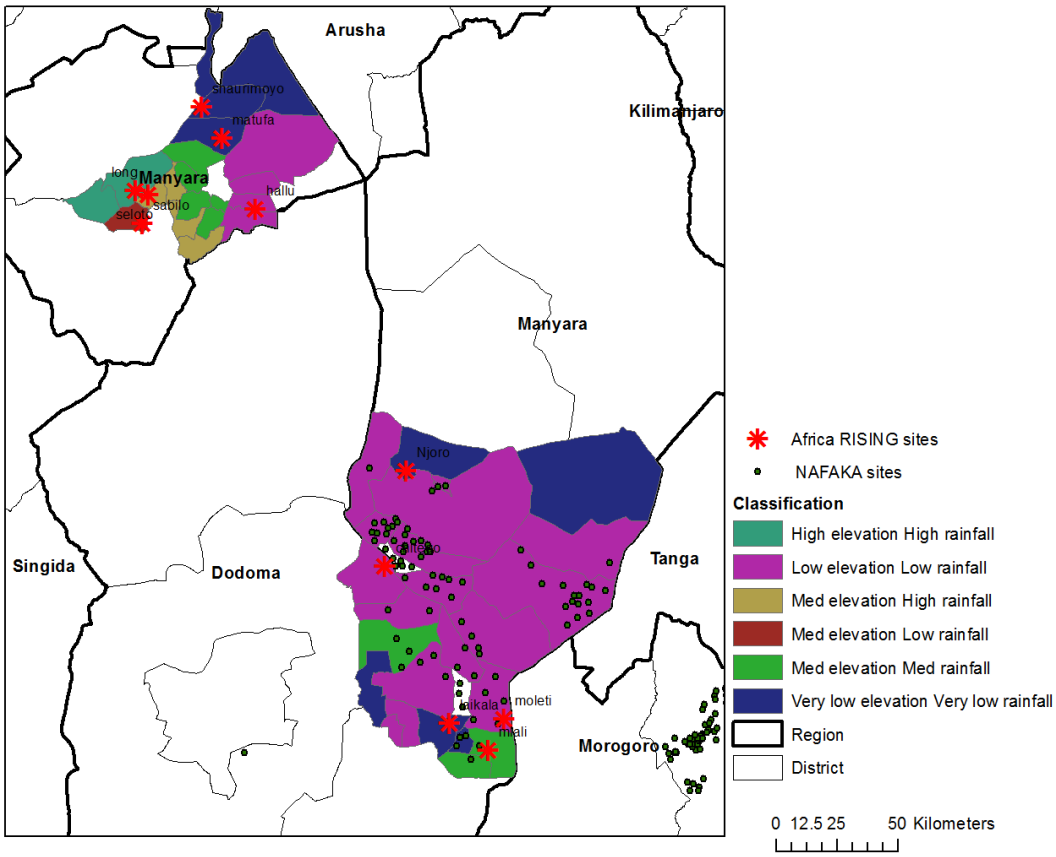

Figure 1: Africa RISING intervention villages in Tanzania.

In central Malawi, Africa RISING is implemented in (i) Dedza District, Golomoti EPA, Golomoti Center Section, and Linthipe EPA, Mposa Section; (ii) Ntcheu District, Kandeu EPA, Kampanje Section, and Nsipe EPA, Mpamadzi Section (Figure 2).

The new joint SIMLEZA-Africa RISING field intervention sites in Eastern Province of Zambia are in the Mthaya, Kapara and Chanje Camps of Chipata District, and Kafumbwe and Kawalala Camps of Katete District. Msekera Research Station in Chipata District also hosts on-station trials (Figure 3).

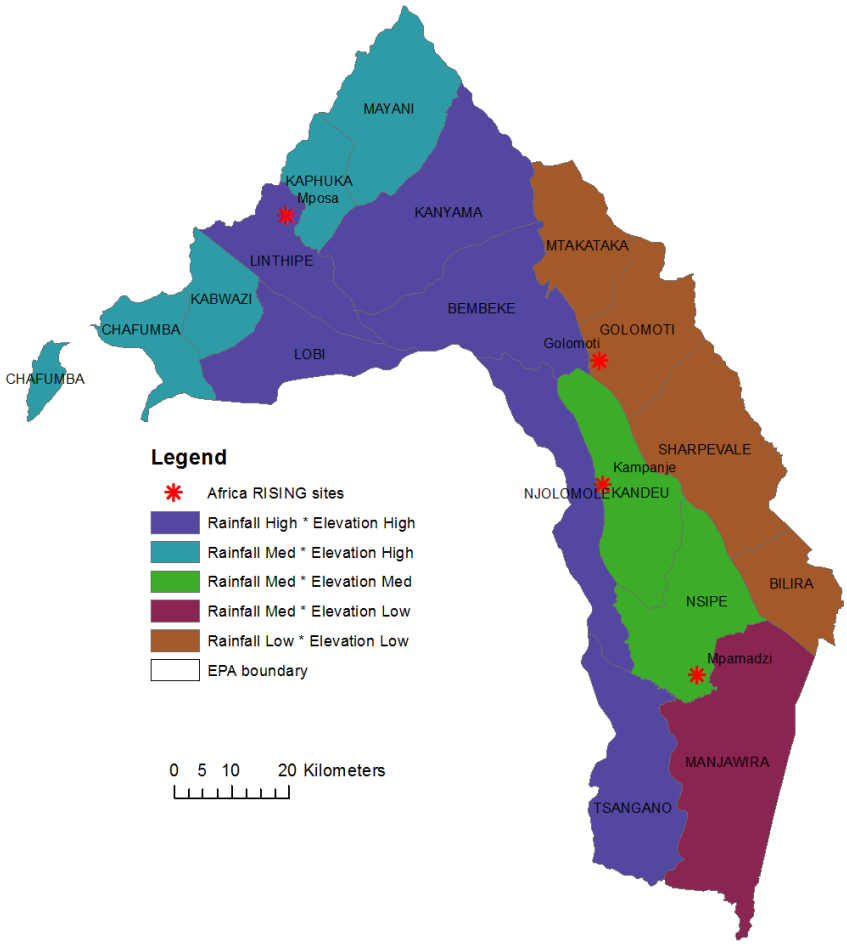

Figure 2: Sections in Malawi with Africa RISING intervention villages

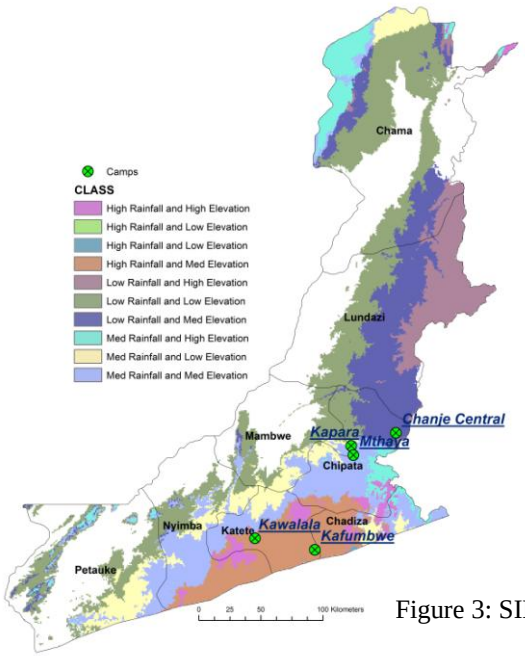

Figure 3: SIMLEZA-Africa RISING intervention sites in Zambia (camps)

Implemented work and achievements per Research Output

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

Baseline surveys: Surveys to generate data for baseline information were conducted by IFPRI in Malawi from August to October 2013, covering 1100 households. Those in Tanzania started on 24th February 2014, and are expected to last until mid-April and to cover 900-odd households. Ongoing discussions with the SIMLEZA partners in Zambia will determine the detail of involvement in surveys to supplement available data. Sorting and analyses of data generated from the surveys in Malawi are due in the first semester of 2014.

Farming Systems Analysis: The Department of Plant Sciences of Wageningen University and Research Centre (The Netherlands) performed the Farming Systems surveys and data analysis during the period from April 2013 to March 2014. The final report indicates differences between countries, e.g. in farm size, livestock density, number of cultivated crops and female headed households. However, countries share some similarities in terms of farming constraints and potential research entry points (Table 1). Ongoing R4D activities are already addressing many of these identified items, having been informed by own disciplinary surveys.

Table 1. Prioritized farming constraints and research entry points by country

Constraints/Entry points	Tanzania	Malawi
Constraints		
Low crop and livestock productivity	X	X
Changing climatic patterns	X	
Crop pests and diseases	X	
Poor animal nutrition and husbandry	X	X
Poor manure and crop residue management	X	X
Reliance on subsidised inputs (fertilisers)		X
Entry points		
Farmer education	X	
Pest and disease management	X	
Product processing and marketing	X	
Diversification of agricultural activities	X	
Improved livestock feeds	X	
Improved manure and crop residue management	X	X
Doubled up legumes		X
Securing seed		X
Livestock intensification		X
Separation of cropping and livestock land		X

Vegetables: A baseline socioeconomic, pest and disease incidence survey was conducted in Babati and Kongwa/Kiteto to identify promising and optimal alternatives for introducing vegetables as high value crops into maize-based cropping systems while ensuring increased farm household consumption of safer vegetables. Results from descriptive statistics show that farmers who integrated vegetables into maize-based systems received slightly higher crop income than farmers who cultivated only maize (Table 2). The dietary diversity score also shows marked, but statistically insignificant, differences between maize-vegetable based households in comparison with sole maize-based households. An ensuing peer reviewed manuscript entitled "Does cropping diversity contribute to dietary diversity? Evidence from maize-vegetable systems in Tanzania" has been accepted for oral presentation at the 88th Annual conference of the Agricultural Economics Society (AES) scheduled for 9-11 April 2014 in Paris.

Table 2. Cost and Returns among adopters and non-adopters

Production Characteristics	HH	Adopters	Non-Adopters
Male households	210	53%	47%
Female households	90	43%	57%
Mean Amount Received (TZS)		906430	817248
Mean Total Variable Cost (TZS)		240610	189102
Mean Net Income (TZS)		665820	628146
Mean Net Income (USD)		**416.1**	**392.6**

Mapping Soil Constraints: Further analysis of the soil samples collected from the Babati area has shown several constraints including high pH in some cases and low exchangeable bases (Figure 4). Such observations will be guiding specific location of nutrient limiting and alleviation studies in future.

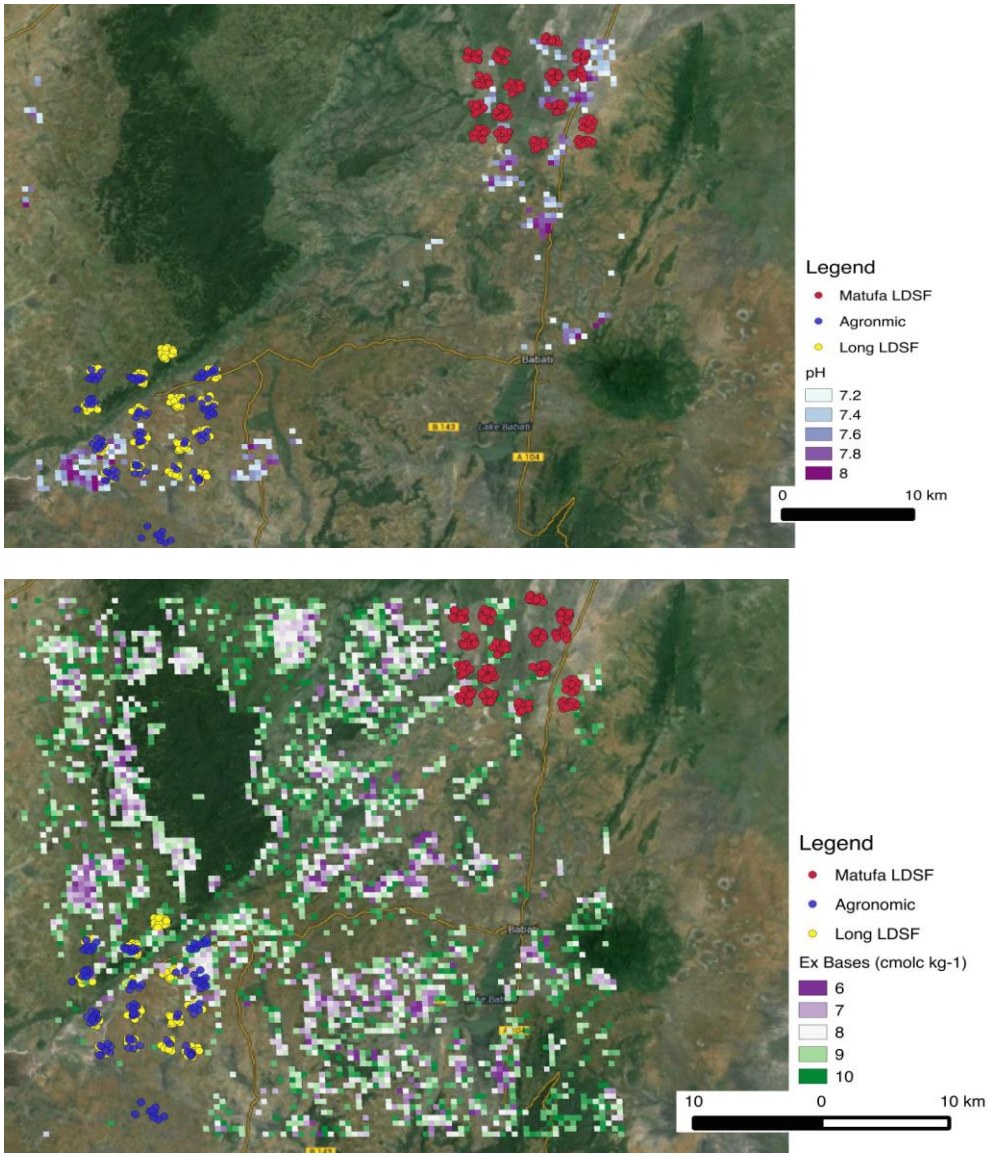

Figure 4: Hotspot map of constraints. Locations where pH values are greater than 7.2 (top) and exchangeable bases are less than 10cmolc kg^{-1}(bottom). LDSF: Land Degradation Surveillance Framework. Points indicted sampling sites. Agronomic: shows locations where production survey was conducted in individual farmer field

Analysis of maize-legume value chains: Data collection instruments were designed and pre-tested by the SIMLEZA Team. They included structured questionnaires for input supplies, processors and output buyers to identify constraints, investment opportunities and institutional innovations for increased adoption of improved technologies (such as seed, integrated soil fertility management [ISFM] and conservation tillage). The main actors and their roles in the maize legume seed value chain were identified.

Research Output 2 (RO2): Integrated Systems Improvement

The reporting under this section is organized under thematic "technology-driving" systems within which the ESA Teams have identified one or more base technologies as the entry points for driving integration activities. The thematic drivers are (i) natural resource management (NRM) based on crop ecology; (ii) NRM based on ISFM; (iii) landscape; (iv) livestock feeds; (v) postharvest management; and (vi) commissioned studies representing emerging challenges. All experiments were installed during this reporting period and have not reached the data generation stage.

NRM technologies driven by crop ecology

The doubled-up legume technology in Malawi: A total of 16 mother trials, each with at least 10 treatments, were (re)established in Dedza and Ntcheu Districts between November and December 2013. These experiments are testing different sustainable intensification technologies. The original 8 mother trials that were mostly in the legume phase have now entered the rotational phase, in which residual effects are being tested. During the current cropping season (as from November 2013) 8 new mother trials were established in the project's four EPAs, but expanding to new villages. The number of baby trial farmers has more than doubled from 450 during the 2012/13 cropping season to >1000 during the 2013/14 cropping season. The original baby trial farmers are already demonstrating innovations, and are able to elaborate on the knowledge and benefits that are accruing as a result of Africa RISING interventions. In addition to the 16 'systems' mother trials, CIAT is also implementing 4 mother trials investigating the potential for intensification of field beans for improved nutrition of diets.

The research team has been collecting data across all research sites, with the mother-baby trials approach as the main methodology for co-learning with farmers about sustainable intensification options. The collected data include agronomic performance of different crops (grain legumes and maize) under different cropping systems (sole cropping, cereal-legume intercrop, doubled-up legumes) and fertilization regimes. During early March 2014, the research team embarked on an ambitious exercise collecting hundreds of plant samples across the research sites to estimate biological N_2-fixation of different legumes under different soil fertility and agro-ecology domains. Samples are already being processed and isotopic methods will be used to determine the proportion of legume N originating from biological N_2-fixation. The project has expanded the research team to now include the Animal Science Department and the Nutrition and Food Sciences Department from LUANAR. Our R4D partners continue to actively participate in project activities, including spearheading field based learning through field days.

The Conservation Agriculture technologies in Zambia: During the period, the SIMLEZA Team re-established four CA trials at Msekera Research Station for the 2013/14 cropping season. These are (a) Long-Term trial, (b) Weed Management Strategy trial, (c) Crop Residue Level trial and (d) Expanded Step trial (quantifying the contribution of (i) surface residue retention, (ii) rotations and (iii) minimum tillage to sustainable NRM). The first 3 trials have been running since 2011/12. At the same time, on-farm conservation agriculture trials were pegged in November 2013 before seeding started in December 2013 and stretched into January 2014 due to a delay in onset of the rains.

Three new on-farm sites hosting the Africa RISING-initiated new Doubled-up Legume trial were established at the onset of the 2013/14 cropping season. The sites are located in Chanje, Kapara and Mthaya camps of Chipata District. Soil samples were collected in December 2013 for the initial characterisation of physical and chemical properties while a detailed description of the soil profile at Msekera Research Station was conducted in November 2013.

Early season farmer and IP stakeholder evaluation of on-farm CA technology trials was completed in January 2014 and data are being compiled by the socio-economic scientists involved in the project. Mid-season evaluations were still in progress at the time of compiling this report. Technology evaluation tools developed by CIMMYT scientists are being used during the evaluation process at each stage of the cropping season. A number of parameters are being measured on each of the 4 trials established at Msekera Research Station and these will enable quantitative evaluation of the technologies that are being tested. One Master's student registered at University of Zambia is using the Long-Term trial for her study as she evaluates the effect of CA on soil properties.

Cereal-based intercropping: The Research Team in Kongwa/Kiteto is testing and confirming new technologies identified and/or prioritized in the 2012/13 season as part of the genetic intensification strategy that will underpin the ecological strategies being investigated under ISFM and intercropping. Crop diversification efforts include pigeon pea and groundnut in Laikala and Chitego; pigeon pea varieties ICEAP 00554 and ICEAP 00557 and groundnut varieties ICGV-SM 02724 and Mnanje have been confirmed for integration. Other variety diversification trials planted in December 2013 are 7 pearl millet and 7 sorghum lines each in Laikala, a very drought prone environment. Field trials have been planted for participatory variety selection (PVS) using the 5 candidate lines for evaluation under farmer field conditions in selected villages of Kongwa and Kiteto. Crop combination technology trials, mainly involving spatial cereal-grain legume arrangements, were established in Mlali, Moleti, Chitego, Laikala and Njoro villages during December 2013, and data collection is ongoing. Instruments for the cost-benefit analysis tool to be applied to different treatments have been developed and initial data collection for validation of the tool is on-going.

Results from the previous season's evaluation of improved groundnut varieties in Kongwa and Kiteto for yield, resistance to rosette virus disease and farmer preference could not be obtained from the partners in time for this report and will be included in the next report.

NRM technologies driven by ISFM

The 4R principles of nutrient use efficiency: Research Teams in the ESA Project are using the 4R principles in designing and implementing NRM technologies driven by ISFM. Application of the 4Rs (right source, right rate, right time and right place) improves nutrient recovery and contributes to improved agronomic efficiency. In several trials, these treatments have also included the crop variety variable.

In Babati District, agronomic trials to test response of four maize varieties to inorganic fertilizer and manure, and Seedco maize variety 627 to different inorganic fertilizer levels and combinations, have been established. Trials have been installed in Hallu, Long, Matufa, Sabilo, Seloto and Shaurimoyo, to demonstrate to farmers the positive effects of good agronomic practices (spacing, seed and fertilizer placement), with field layouts designed to clearly show treatment differences. Minjingu phosphate rock, triple superphosphate (TSP) and urea are the main sources of nutrients used in the studies. Integrated soil fertility and crop combination trials were also installed in Mlali, Moleti, Chitego, Laikala and Njoro villages of Kongwa and Kiteto Districts, planted in December 2013.

Landscape driven technologies

***In-situ* water harvesting:** Integrated crop, water and erosion management trials have been established in Mlali, Moleti, Chitego, Laikala and Njoro villages. In Njoro the focus is on the *in-situ* water harvesting technologies of ripping and ridging. Water runoff trials are also being conducted in Mlali to determine the impact of the treatments on soil, water and nutrient flows. Fanya juu erosion control structures (terraces constructed by digging ditches and heaping the soil, forming bunds on the upper sides of the ditches) have been established in Mlali, to test landscape level interventions for scaling. In the same village, dual-purpose fodder trees and fast growing wood trees have been planted as shelterbelts for evaluation of efficacy in control of wind erosion. Experiments were installed in December 2013. These technologies will have significant effects if practiced by several farmers constituting a landscape. They need support of local policy and by-laws for effect. To this end, the DAICOs of each district are involved to help promoting the technologies. The Innovation Platform is also part of the envisaged adoption strategy starting at local level and gradually including high level district officials.

Livestock driven technologies

Livestock forages and feeds: Dual-purpose forage legume *Glyricidia sepium* has been planted in Chitego and Mlali villages of Kongwa District, either as fodder bank or as intercrop with cereals. In one treatment *Glyricidia* is treated as doubled-up legume with groundnut in a maize crop. The slower growing *Glyricidia* is planned to offer fodder during the drier part of the year. The *Jitegemee* Farmers Group, whose fields shall act as field schools for R4D, is raising fodder seedlings.

In Babati, the integration of improved forages into smallholder crop-livestock systems is planned to facilitate the intensification of mixed crop-livestock systems, mitigate climate change and reverse environmental degradation. In one of the treatments, forages (*Napier* and *Leucaena*) are being grown on bunds to strengthen fields against soil erosion and retain sub-surface water from crops (efficient water use). In this arrangement, the opportunity cost of land is minimal. Other sets of treatments are *Napier* grass intercropped with a fodder legume for a fodder bank, and the second one is testing the productivity of maize-fodder legume intercrops. These treatments are being replicated in the three villages of Sabilo, Seloto and Long.

Postharvest and nutrition technologies

Product storage: The ESA project is currently engaged in introducing and evaluating improved postharvest processing and storage methods together with the farmers, and increasing their technical know-how on postharvest management, beginning in Babati. The specific introduced postharvest technologies are:

a. ***Collapsible dryer cases*** which are a low cost solution for safe, effective and convenient drying of a vast range of crop harvest products. They use solar energy, allow grain drying on almost any flat surface, are durable and are easy to repair, maintain and transport. In case of anticipated rain or during the night they can be covered instantly, providing water resistance and protecting commodities from moisture re-absorption (Figure 5).
b. ***Triple layer oxygen-water impermeable Super Grain Bags (SGBs)*** are a multi-layer polyethylene storage technology that provides penetration resistance to pests during storage of products in bags. They are gas- and water-tight, which further increases mortality of spoilage pests. Preliminary results of the ongoing study show that recovery of maize stored in SGBs could be up to 100% compared to 5% in conventional polypropylene bags after eight months storage (Figure 6).
c. ***Motorized shelling machines*** have been introduced to reduce labor and time inputs into maize shelling, particularly by women. The mechanical sheller is compact, efficient (1500kg/hr) and with

low breakage rate. The technology is being validated in three villages of Babati and will be further tested in eight villages during the next harvest season (Figure 7).

Figure 5: GrainPro Collapsible Dryer Case, A. Abass (IITA)

Figure 6: Maize grain stored in GrainPro Super Grain Bag, E. Koyano (IITA)

Figure 7: Motorized maize shelling machine, A. Abass (IITA)

Mycotoxins: Studies are being done to determine the (i) prevalence, extent and distribution of fumonisin and aflatoxin contamination in staple foods and feeds; (ii) influence of farmer practices on contamination levels; and (iii) geographical hotspots and vulnerable components of the value chain. Working with the storage experiments, the Mycotoxins Research Team in Babati is determining the extent of appropriate intervention strategies to mitigate aflatoxin and fumonisin contamination in food and feed during storage. The team plans to raise awareness of risks due to aflatoxin and fumonisin and how to control them.

Integrating elite vegetables into maize-based cropping systems: This was the first identified step toward improving nutrition of households based on increasing the variety of foods eaten. In Babati, AVRDC has initiated a "seed-kit" approach that can be easily adopted by farmers through visual learning and practice, and involves three components: (i) introduction of elite seed varieties, (ii) adoption of healthy seedlings and (iii) integrating pest management practices. The setup allows for a comparison of the business-as-usual scenario (control) with the main demonstration plots showing good agricultural practices depicted by these three technologies. The purpose is to create awareness and information exchange through discovery learning. In collaboration with the Postharvest Team, plans are being drawn to address losses of up to 10% of vegetable products occurring as a result of physical, physiological and poor postharvest handling skills.

Formulation of high nutrient foods from locally grown crops: This activity is being planned with development partners, notably with the Tuboreshe Chakula project in Tanzania, in order to increase the nutritional quality of foods. Processing and preservation investigations will utilize products from the new crop varieties introduced by other work packages.

Emerging challenges

Maize lethal necrosis disease (MLND): MLND (Figure 8) is an emerging viral disease which poses serious challenges to maize production and is a big threat to food security for the majority in Eastern Africa. MLND outbreak in East Africa was first reported in Kenya in 2011, and has since been

reported in the neighboring countries of Tanzania, South Sudan, Ethiopia, Rwanda and Uganda. Studies focused on understanding the MLND epidemiology and finding appropriate interventions to mitigate disease impact in affected areas, and prevention of further spread.

Figure 8: MLND symptoms, L. Kumar, IITA

Understanding MLND epidemiology: MLND is a disease manifested by synergistic interaction between Maize chlorotic mottle virus (MCMV), a new virus in Africa, and the Sugarcane mosaic virus (SCMV), occurrence of which is known for several decades. However, a new strain of SCMV was detected co-infecting MCMV in the 2011-12 epidemic in Kenya. Surveys conducted in 2013 (Mar-Apr) in the Africa RISING project sites in Babati, Kongwa and Kiteto Districts identified occurrence of MCMV and SCMV in all the districts. Incidence of single infection of MCMV (64%) was much higher compared to single infection of SCMV (22.5%) and mixed infection of SCMV+MCMV (21.5%). Nucleotide sequencing of MCMV and SCMV genomes confirmed that virus isolates in Tanzania are very similar to those detected in the Kenyan outbreak. New diagnostics tools were developed for the detection of MCMV. In 2014, surveys will be conducted for disease incidence and understanding the diversity of MCMV and SCMV isolates, and a one week training course will be organized on MLND diagnostics and control in Tanzania particular for Africa RISING project stakeholders and partners during the second quarter of 2014. FAO and BMGF expressed interest to co-sponsor the event to bring participants from East African countries affected by MLND, which is accepted. An MSc student, Mr Allan Mariki (Tanzanian), has been recruited under the iAGRI scheme to work on a project topic 'Studies on distribution and epidemiology of maize lethal necrosis disease in Tanzania'. The student is currently doing his course work at Makerere University, Uganda, and will initiate research work from October. Outputs from epidemiology studies will contribute to disease control efforts. Training course and graduate student training will enhance diagnostic capacity and control among the national partners. Purchase of lab equipment to establish serological diagnostics capacity at Selian Agricultural Research Institute is underway.

Control options: The most sustainable control option for MLND is host plant resistance combined with good agronomic management and crop husbandry practices. Trials have been installed at suspect hotspot areas, including places outside of the Africa RISING intervention villages. The Babati

Research Team is conducting evaluations of several maize inbred lines and hybrids for resistance/tolerance. Several experimental maize hybrids (over 270 entries) whose parental lines have shown moderate tolerance/resistance have been planted in 36 trials as follows: 5 in Seloto, 7 in Matufa, 18 at Mara farm in Kiru Valley village (all in Babati District) and 6 in Karatu District. The trials at Matufa were planted on 23 and 24 December 2013. The trials at Mara farm and Seloto were planted during the last week of January 2014. At Karatu, the 6 trials were planted on 22 March 2014. Another set of trials will be planted during the second week of April at Mara farm to determine if late planting has influence on MLND occurrence. Symptoms of the disease have already been observed in many maize fields this season at Matufa and Seloto villages. Data to be collected include plant stand (number of plants in a row or plot), disease score (scale of 1-5), disease severity, agronomic characteristics and grain yield. If promising hybrids are identified from these testing efforts, plans to fast-track for release and commercialization will be initiated. A survey is also to be conducted across the district during this cropping season to establish the prevalence of the disease, as well as identify the virus strains in the diseased plants.

Research Output 3 (RO 3): Scaling and delivery

Research teams in the ESA Region are using action and co-learning research models (mother-baby and demonstration) through which farmers in the intervention villages and beyond can start to pick up technologies they find most suited to their needs. This is assisted by planned farmer field days and participatory technology selection days during which development partners and electronic and print media are invited to participate for wider dissemination. Planning for these activities is ongoing.

In Babati, two of the selected technologies from last year were randomly assigned to a larger number of farmers using the coupon approach and were installed during the current season to enable evaluation of technology impact on livelihoods and to identify the adoptive and adaptive capacity by farmers with different resource endowments. The improved maize seed plus Minjingu phosphate rock technology package was extended to 240 farmers across different agro ecologies in Babati District, while a new climbing bean variety was extended to 50 farmers in the highland village of Long where it is most suitable to grow. This approach will be applied to new identified technologies every year.

Research teams have also put in place, or are planning for, Innovation and R4D platforms at district level whose roles are to set priorities and give feedback to activities initiated by research, while the long-term goal is to stimulate learning and innovation to improve livelihoods in terms of productivity, income generation and nutrition. They also serve as vehicles for scaling innovations within and beyond the district. In Chipata, an IP meeting was held in November 2013 with the objective of strengthening collaboration between farmers, farmer groups, extension services, researchers and the private sector. A total of 21 people from the various stakeholder groups participated in the meeting. In Kongwa/Kiteto, the IP was launched on 27 February 2014 involving 38 people from six different categories of users of research products. The R4D Platform in Babati will be launched from 10-11 April 2014.

Multidiscipline (largely expressed as work packages in the 2013/14 work plans) technology integration

This report has been presented at thematic rather than work package (WP) levels, reflecting the gradual integration process between disciplines. Themes are being proposed based on indications of how work package activities are building upon (using outputs of) or implementing with each other (example from Babati; Table 3). WP1, for example, offers opportunities to test the treatment effects on (i) MLND, recorded during the life of the study; (ii) mycotoxins incubation in soils – soils in different treatments have been samples for this purpose – and consequent effects on grain; (iii) grain

quality in respect to postharvest handling and storage; and (iv) soil, water and nutrient cycles – the entire WP7 studies will be conducted on WP1 sites (and WP3 and WP6 sites in future). Fodder crops have been included as intercrops with crop management experiment installation on boundaries of fields hosting WP1 treatments.

Table 3. Matrix showing how the Babati Research Partners relate to each other in the execution of their discipline-led research. Note that relating to each other (integration) is time-bound; some are *in-situ* (black shade – concurrent implementation), others are *ex-situ* (blue – making use of or following upon products), and some cut across both phases (pink).

	WP1	**WP2**	**WP3**	**WP4**	**WP5**	**WP6**	**WP7**	**WP8**	**WP9**
WP1: Crop management									
WP2: Managing MLND									
WP3: Livestock and land management									
WP4: Mycotoxins management									
WP5: Postharvest management									
WP6: Vegetable integration									
WP7: Water and nutrient flows									
WP8: Poultry husbandry									
WP9: Platforms and social research									

Capacity building

Short-time training: A one-day pre-season training of Ministry of Agriculture and Livestock and Total Land Care (TLC) extension officers and community volunteers participating in the SIMLEZA-Africa RISING project was conducted on 7 November 2013. Participants were drawn from 7 agricultural camps spread across Chipata, Katete and Lundazi Districts. The training was attended by 2 female and 17 male Extension Officers from the Ministry of Agriculture and Livestock, and 7 male community volunteers. The topics covered were conservation agriculture (CA), soybean agronomy, participatory variety testing and community seed production.

In Babati, 32 farmers were trained on good agronomic practices including plant spacing and fertilizer applications. Four extension officers were trained on soil sampling and design and layout of agronomic trials. Three extension personnel were trained on greenhouse gas measurements at field level.

Graduate Training: Table 4 shows an encouraging trend of building a graduate student cadre that will hopefully better appreciate the conduct of integrated systems research.

Table 4: Undergraduate and graduate students conducting research on Africa RISING Action sites and being mentored by research partners

Student	Sex	Country of Origin	Country of Research	Africa RISING Supervisor	University	Degree	Period
Semeni Ngozi (iAGRI)	F	Tanzania	Tanzania	Per Hillbur	Egerton Univ, Kenya	MSc	May 14 - May 15
Marco Sanka (iAGRI)	M	Tanzania	Tanzania	Per Hillbur	Makerere, Univ, Uganda	MSc	Nov 14 - Aug 15
Maria Klerfelt Johansson	F	Sweden	Tanzania	Per Hillbur	University of Gothenburg, Sweden	BA	Mar 14 - Sept 14
Marcus Bengtsson	M	Sweden	Tanzania	Per Hillbur	University of Gothenburg, Sweden	BA	Mar 14 - Sept 14
Christopher Alex Msongore	M	Tanzania	Tanzania	Adebayo Abass	SUA, Tanzania	MSc	2013 - 2014
Chacha Nyangi (iAGRI)	M	Tanzania	Tanzania	Fen Beed	SUA, Tanzania	MSc	2013 - 2014
John Joseph Malley	M	Tanzania	Tanzania	Fen Beed	SUA, Tanzania	MSc	2014 - 2015
Leonard Joseph Marwa	M	Tanzania	Tanzania	Ben Lukuyu	SUA, Tanzania	PhD	2014 - 2017
Alphonse Haule	M	Tanzania	Tanzania	Ben Lukuyu	SUA, Tanzania	MSc.	2014 - 2015
Mawazo Shitindi (iAGRI)	M	Tanzania	Tanzania	Mateete Bekunda	Tuskegee, USA	PhD	2013 - 2016
Gregory Sikumba	M	Zambia	Tanzania	Ben Lukuyu	University of Nairobi, Kenya	PhD	2013 - 2016
Michelle Hockett	F	USA	Malawi	Robert Richardson	MSU, USA	MSc	2013 - 2014
Alex Smith	M	USA	Malawi	Sieg Snapp & Regis Chikowo	MSU, USA	MSc	2013 - 2014
Edward Mzumara	M	Malawi	Malawi	Regis Chikowo & Wezi Mhango	LUANAR, Malawi	MSc	2013 - 2014
Soflet Mwafulirwa	F	Malawi	Malawi	Agnes Mangwela	LUANAR, Malawi	MSc	2013 - 2014
Erin Anders	F	USA	Malawi	Sieg Snapp & Regis Chikowo	MSU, USA	PhD	2013 - 2016
Justin Chipomho	M	Zimbabwe	Malawi and Zimbabwe	Regis Chikowo & Sieg Snapp &	University of Zimbabwe	PhD	2013 - 2016
Anita Kaleba	F	Zambia	Zambia	Christian Thierfelder	UNIZA, Zambia	MSc	2013 - 2014
John Banda	M	Zambia	Zambia	Christian Thierfelder	UNIZA, Zambia	MSc	2013 - 2014
Frederick Mwansa	M	Zambia	Zambia	Christian Thierfelder	UNIZA, Zambia	MSc	2013 - 2014

Lessons

Farmers have a clear knowledge of their problems and are very eager to try out solutions together with researchers. Establishment of demonstrations, both diagnostic and descriptive, have provided opportunities to showcase a set of yield enhancing technological options to farmers, being at different levels of crop intensification and integration. For example, farmers are able to identify better responses of maize to DAP than to Minjingu phosphate rock in the areas with early season water

stresses, but also noted that on degraded sites without P application, P deficiency symptoms are manifested by purple leaves. Introduction of forages in cropping systems as a means of improving livestock feeding has been roundly appreciated by livestock keepers. Co-learning approaches that integrate farmers and extension workers in the research process appear to attract buy-in from farmers more readily.

Partners appreciate that Africa RISING multi-stakeholder project design and implementation involves complex institutional and operational relationships, but that a negotiated approach is the best to avoid institutional conflicts. There is hope that instituting Innovation and R4D Platforms will facilitate better project design through stakeholder-prioritized action areas.

Challenges

Establishing and operating multi-site trials has meant extra work and more time at critical times of the year such as at planting and harvesting. Due to rains occurring at different times in different villages, teams had to make several trips to establish the demonstrations and ensure capture of the first rains. Partner farmers are not necessarily patient with the scientists, who may not be available on time to establish the trials, and may consider these as poorly executed actions. To manage on the available budget, the teams have had to focus on limited representation if travel needed does not involve a key data collection activity.

With respect to genetic intensification, prolonged dry spell and extensive heat stress have affected the crops in some sites. Although trials seem to still hold, continued dry spells may lead to complete crop failure, and this may require further testing of new germplasm for these adverse environments.

The procurement of field equipment has been a hassle, especially because the trials have already been established. It takes a long time to get the equipment after placing orders because of transportation and border customs bureaucracies. Measures taken included using faster courier services, but this had economic implications.

Data from baseline surveys to be carried out by IFPRI were not available to inform the planning and setup of this season's field trials.

We have not been able to attract research partners in critical cross-cutting disciplines of marketing, gender and social science. Team members are expressing the need to link farmers to input and output markets in order to achieve larger scale impact, as well as the need to research on social issues that affect scaling. The recent recruitment of an agricultural economist should bring some relief in future with regards to socio-economic data collection and analysis.

The communication specialist employed in November 2013 to serve the two regional projects in ESA and WA resigned and will leave mid-April 2014. It has been decided that for this position a highly qualified internationally recruited communication specialist will be sought to address the growing communication needs.

Building partnerships with outreach and development partners has been equally challenging. They need readily available and proven technologies to take on board, but these have not been readily available in the early SI implementation stages. The platforms being instituted may help in bringing parties to appreciating the convergence zone of the different disciplines.

Heavy responsibilities on partner individuals has, in some cases, led to slow and late implementation of activities, right from the development and submission of proposals to execution of field activities.

Publications

Oral presentations:
Mhango W, Snapp S, Chikowo R. 2014. Shrubby Pigeon Peas Transform Malawi Farming: 1st-Generation Perennial Grain Legumes: For Session Perennial Grains for Food Security in a Changing World: Gene to Farm Innovations. 13-18 February 2014, Hyatt Regency, Chicago, USA

Snapp S, Mhango W, Chikowo R. 2014. Next Steps and Research Needs in Perennial Grain Development: For Session Perennial Grains for Food Security in a Changing World: Gene to Farm Innovations. 13-18 February 2014, Hyatt Regency, Chicago, USA

At the CGIAR Consortium Board meeting in March 2014 in Dar es Salaam, Tanzania, the Africa RISING ESA project was presented by B. Lukuyu, ILRI. http://africa-rising.wikispaces.com/east_southern_africa

Papers:
Abass A, Ndunguru G, Mamiro P, Alenkhe B, Mlingi N, Bekunda M. 2014. Post-harvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania. Journal of Stored Products Research 57; 49-57. http://www.sciencedirect.com/science/article/pii/S0022474X1300101X

Snapp S, Bezner Kerr R, Smith A, Ollenburger M, Mhango M, Shumba L, Gondwe T, Kanyama-Phiri G. 2013. Modeling and participatory farmer-led approaches to food security in a changing world: A case study from Malawi. Secheresse 24; 350-358. DOI: 10.1684/sec.2014.0409
Chikowo R, Zingore S, Nyamangara J, Bekunda M, Messina J, Snapp S. 2014. Approaches to reinforce crop productivity under water-limited conditions in sub-humid environments in Africa. In Climate Change and Agricultural Intensification (Lal R, Mwase D, Hansen D, Eds). Springer. In press.

Chikowo R, Zingore S, Snapp S, Johnston A, Bruno G. 2014. Farm typologies, soil fertility variability and nutrient management in smallholder farming in Sub-Saharan Africa. Accepted in *Nutrient Cycling in Agroecosystems*.

Multimedia:
DVD, Africa RISING Malawi, 'In Search of Sustainable Intensification of Farming Systems' http://youtu.be/r6EyXsdgznM

2 DVDs on Weed Management in Rice: http://africarice.org/warda/guide-video.asp
Posters:
Two posters were presented at the World Congress on Agroforestry, 10-14 February 2014, Delhi, India
http://wurl.cc/4c2; http://wurl.cc/4c3
A poster on 'Intensification of Maize-legume Based Systems to Improve Farm Productivity and Conserve Natural Resources in Semiarid Tanzania' was presented at the CGIAR Consortium Board meeting in March 2014 in Dar es Salaam, Tanzania. http://bit.ly/1odgDG5

Submitted Abstracts for Tropentag 2014, 17-19 September 2014, Czech Republic:
Snapp S, Chikowo R, Mhango W, Anders E, Smith A, Hockett M, Morrone V, Richardson R, Bekunda M, Hoeschle-Zeledon I. Doubled up legumes in Malawi: an innovation for sustainable rain-fed cereal production in developing countries.

Hillbur P. Rururbanization – a threat to agricultural intensification and food security?

Success story

Turning over a new leaf: Amaranth in Africa

Mrs. Ephraim Lukumay, a farmer in Bermi village, Dareda ward, Babati District of Tanzania, didn't think too highly of amaranth a few years ago. "We did not know the nutritive importance of this vegetable," she said. Today she grows amaranth to consume at home and to sell to neighbours and at markets. She is a participant in the Africa RISING East and Southern Africa Project, an initiative to improve agricultural production knowledge and access to modern technologies, such as high performing vegetable varieties in the sub-region. As part of the project, Mrs. Lukumay and 70 other farmers learned good production and post-harvest practices and farm record-keeping skills during training sessions hosted by AVRDC – The World Vegetable Center's Eastern and Southern Africa office in September 2013. To get them off to a good start, participants also received seed of improved tomato, amaranth, African eggplant and sweet pepper.

Proud Mrs Lukumay in her amaranth field.
Photo: Inviolate Mosha, AVRDC

Now about 85% of the trained farmers are growing amaranth as well as other crops. "Before we did not have good quality seeds, such as what we have now in our fields," said Mrs. Lukumay. "We are not using any pesticide; the crop is fast-growing and very palatable. I grow amaranth in my home garden, and I am confident that I can now contribute some money to solve some family problems and not only depend on my husband to provide us with everything."

'Madira 1', the amaranth variety distributed by AVRDC, grows well in the local environment. "We can harvest for a long time by cutting the leaves—about six months if we manage it right," said Mrs. Lukumay. She described her production method: "I harvested amaranth from my plot of 3 by 15 meters for over 10 weeks since the first week of October 2013. The first harvest was by thinning; then I left the other plants in a spacing of about 20 by 30 centimetres and then continued to cut the leaves after every vegetative growth."

Mrs Lukumay with her daughter explaining how they dry amaranth seeds for sowing in the coming season using a direct solar dryer.
Photo: Inviolate Mosha, AVRDC

Her family of five consumes about 0.5kg of amaranth every day, and she sells more than 10kg every week. “Many people like the amaranth variety we grow from AVRDC seed,” she said. “It tastes good and it is very nutritious.

Most of my customers are pregnant mothers and families with children under five. When they visit pre-natal clinics, the nurses tell them to eat more amaranth!”

Mrs Lukumay handing over to daughter Nembris the revenue of the day’s sales of amaranth. Photo: Inviolate Mosha, AVRDC

Mrs. Lukumay’s 13-year-old daughter, Nembris, is the family cashier. Nembris attends Dareda Secondary School in Babati from Monday through Friday from 7.00am to 4.30pm, then assists her mother in the vegetable garden for one hour after school and almost 2 hours on Saturdays. “We have TZS 20,000 cash in hand as at now,” Nembris said. “When we began selling amaranth I didn’t keep record but now I do, and we made TZS 50,000 during the last two and half months.” Nembris has advised her school mates to grow amaranth to improve the nutrition for their family and to make money to be able to cover some of their needs in school.

Mrs. Lukumay said she appreciated the opportunity to enhance her vegetable production skills through the AVRDC training course. “This training made us aware of the benefits of amaranth,” she said. “This crop is now very attractive to us as farmers, because of the income it can bring, and the nutrition it provides.”

Nembris keeping record of income from amaranth sales.
***P**hoto: Inviolate Mosha, AVRDC*