Africa Research in Sustainable Intensification for the Next Generation

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-in-development projects supported by the United States Agency for International Development (USAID) as part of the U. Government's Feed the Future initiative.

Through action research and development partnerships, Africa RISING is creating 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 regional 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 the program's monitoring, evaluation and impact assessment.

Africa RISING appreciates support from the American people delivered through the USAID Feed the Future initiative. We also thank farmers and local partners at all sites for their contributions to the program.

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Partners

ADD	Agriculture Development Division, Malawi
AGRA	Alliance for a Green Revolution in Africa
ARI-Naliendele	Agricultural Research Institute, Naliendele, Tanzania
ARI-Hombolo	Agricultural Research Institute, Hombolo, Tanzania
ARI-Selian	Agricultural Research Institute, Selian, Tanzania
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
DALDO	District Agriculture and Livestock Development Officers (Malawi)
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
LUANAR	Lilongwe University of Agriculture and Natural Resources, Malawi
MSU	Michigan State University
MAFC	Ministry of Agriculture, Food, and Cooperatives, Tanzania
MERU- AGRO	MERU-AGRO Seed Co
MMFL	Minjingu Mines and Fertilizer Co
NAFAKA II	Cereals market system development (Tanzania)
SAIOMA	Strengthening Agricultural Input and Output Markets
SFHC	Soils, Food, and Healthy Communities, Malawi
TLC	Total Land Care (Zambia, Malawi)
UDOM	University of Dodoma, Tanzania
ZARI	Zambian Agriculture Research Institute
WU	Wageningen University, The Netherlands
WorldVeg	The World Vegetable Center

Summary

Documentation of the legacy of its achievements, mainly as journal publications, has continued to be the ESA Project's main activity during this reporting period. Twelve papers were published or accepted for publication, 10 were submitted, and 32 are under development. Documentation is making use of data collected from studies implemented during past years, with some complemented by survey data generated during this reporting period. Our handbook, whose main audience are scaling institutions, was published by CABI and may be accessed here http://dx.doi.org/10.1079/9781800621602.0001.

Continued interest in the maintenance of long-term projects led to their continued support for field activities. There have been several publications based on data generated from these experiments and more are expected. Data collection is continuing. Long-term on-farm conservation agriculture (CA) trials were successfully re-established in 16 target communities of Malawi and eastern Zambia. They have regularly been monitored and both early and mid-season evaluations have been done by partners. Promotional activities were initiated by our development partners, the Ministry of Agriculture, and NGO staff. We have also maintained six long-term trials in Malawi. The objective is to create a platform for evaluating the long-term effects of rotating legumes with maize and other nutrient management options and establish the potential for soil organic carbon sequestration and other biodiversity indices.

In the Babati district of Tanzania, 20 farmer groups are implementing Mbili-Mbili as an integrated practice with stripping and topping. This is more of a close-out activity on Mbili Mbili technology implementation uptake. The learning sites have only one ½ acre plot of the Mbili-Mbili technology with the integrated practices. There was joint laying out, planting, and managing the demonstrations by members of the groups, and likewise will be harvesting. Additionally, field days are planned to bring together members of the different farmer groups. One hundred and fifty farmers are targeted to participate in the field days. Focus group discussions will capture group challenges and learnings in implementing the Mbili-Mbili system and accompanying practices.

Capacity building operations have been scaled down. Most short-term training used to utilize field trials as learning centers; indeed, the training reported on relates to the field experiments that were supported. Similarly, partnerships for scaling have reduced and the backstopping intensity of existing ones has reduced. Researchers are preparing technology labels, farmer manuals, and extension guides to be available during country-level project close-out activities and beyond.

Africa RISING ESA project action sites

The East and Southern Africa (ESA)-wide geo-referenced sites are shown where Africa RISING was implementing either research activities or technology dissemination over the project time, updated to the current reporting period (Figure 1).

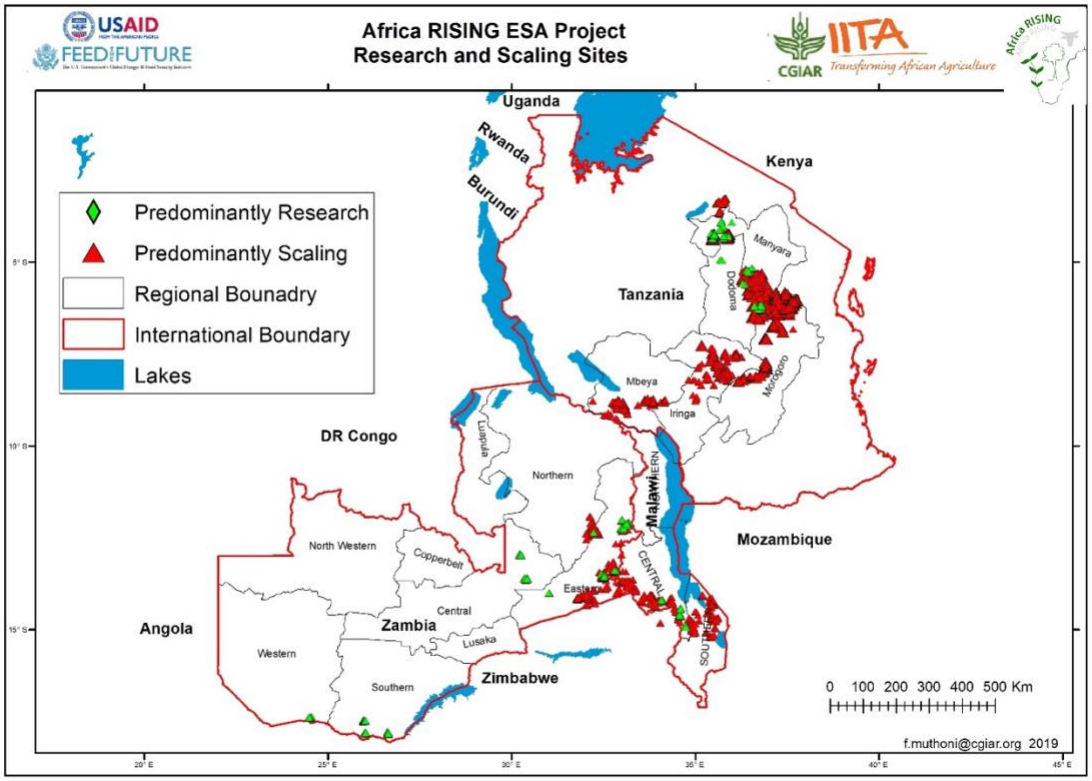
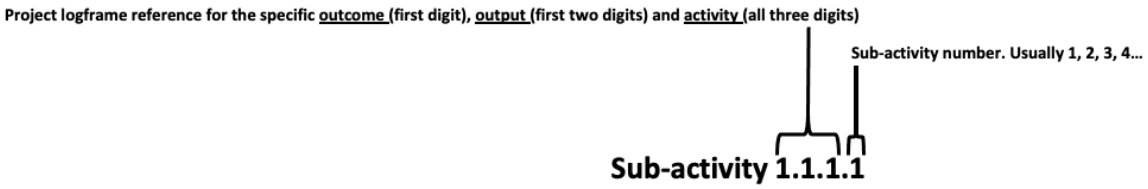


Figure 1. Locations where the Africa RISING–ESA Project has conducted research (green diamond) and scaling (red triangle).

Implemented work and achievements per research outcome

Each sub-activity in the report is preceded by a label code meant to help the reader gain context about its alignment with specific outcomes, outputs, and activities within the project logframe - https://hdl.handle.net/10568/82852. This label code is interpreted as shown below.



Outcome 1. Productivity, diversity, and income of crop–livestock systems in selected agroecologies enhanced under climate variability

Output 1.1 *Demand-driven, climate-smart, integrated crop–livestock research products (contextualized technologies) for improved productivity, diversified diets, and higher income piloted for specific typologies in target agroecologies*

Activity 1.1.1*: Assess and iteratively improve resilient crop-crop and crop-livestock integration systems*

Sub-activity 1.1.1.1: Validation of drought-tolerant maize (DT) hybrids under on-farm conditions in central Tanzania

Two manuscripts have been developed based on 18 Drought Tolerant (DT) and 8 Quality Protein Maize (QPM) hybrid trials conducted in the 2019/2020 season. From these, four best DT hybrids were selected for yield and agronomic performance and the two best performing QPM hybrids were allocated to Meru Agro Seed Company for commercialization. The manuscripts have been reviewed for the second time, recommendations are being addressed, and a new submission date of June 2022 (for both) is proposed. The manuscript working titles are:

1. GGE biplot and stability analysis of drought-tolerant Quality Protein Maize hybrids evaluated under semi-arid conditions in Tanzania.
2. GGE biplot and stability analysis for grain yield and agronomic traits of drought tolerant-three-way maize hybrids in Tanzania.

Sub-activity 1.1.1.2: Investigations of the medium to long term impacts of SI technologies on crop productivity in multi-locational fields

Twelve (12) long-term on-farm cereal-legume rotation experiments, some dating back to the 2012/2013 cropping, were maintained for (a) investigating the medium to long-term impacts of SI technologies (i.e., improved soil fertility management, ISFM), improved germplasm, crop combinations, and nutrient and water management) on crop productivity on multi-ecology field sites; and (b) as a source of data for "water-limited yield potential" study, required for the Case Studies' SI analyses on the Africa RISING impact—investigated under sub-activity 5.1.1.4. We

expect significant future investments around these trials from the Excellence in Agronomy (EiA) initiative, which has expressed interest. Two manuscripts were published during the last reporting period.

We implemented the 2021/2022 season cropping activities as planned. During 2022, we have maintained only six trials, two each in Linthipe, Kandeu, and Golomoti Extension Planning Areas. The main objective is to create a platform for evaluating the long-term effects of rotating legumes with maize and other nutrient management options and establish the potential for SOC sequestration and other biodiversity indices. The trials are currently being harvested. Results, in manuscript form, will be available for reporting during the next reporting period.

Sub-activity 1.1.1.3: Determining the productivity of groundnut as a function of seed generation × variety × density interactions in two contrasting agroecologies, and rotational benefits to maize

The objective of this work was to evaluate the effect of groundnut seed quality and plant density on groundnut productivity and quantify the rotational benefits to a subsequent maize crop in high and low potential agricultural zones in central and southern Malawi, respectively. Jester Kalumba successfully defended his MSc thesis "*Effect of seed generation, rhizobia inoculation and plant density on productivity and seed quality of soybean [*Glycine max *(l.) Merril] and groundnut [*Arachis hypogea *(l.)] in Dedza and Machinga districts of Malawi"*. The thesis abstract was given in the last report. A manuscript based on the research has been drafted, with June 2022 set as the target date for publication.

Sub-activity 1.1.1.4: Exploring productivity of goats under controlled breeding and feeding regimes among young breeding female goats in the crop–livestock system in Malawi

This sub-activity was completed with the main products being an MSc thesis of Charles Mkchutche, and a published manuscript (http://www.lrrd.org/lrrd33/1/dmase3302.html), whose abstract was presented in the last report.

Sub-activity 1.1.1.5: Determining the productivity and resilience benefits of Gliricidia-based cropping systems

This study has focused on assessing drought resilience and long-term productivity of *Gliricidia sepium*-based cropping systems. Fieldwork was completed in 2021. The main activities conducted during 2021/2022 include processing and analysis of the experimental data, and writing manuscripts, technology labels, and a success story. The work is still progressing with the development of manuscripts, an agroforestry manual, and medicine labels. Two PhD students attached to agroforestry work have submitted their thesis for examination. A success story titled "Farmers leading transfer of agroforestry technologies in Dodoma, Tanzania" has been published online (yet to be branded and uploaded under Africa RISING). Two manuscripts were published during this reporting period. The abstract of one (https://doi.org/10.1186/s13705-021-00310-8) was presented during the last report. The abstract of the other (https://doi.org/10.3390/su14010053) is presented below.

Profitability of Gliricidia-Maize System in Selected Dryland Areas of Dodoma Region, Tanzania **(**M. Swamila et al., 2022**)**

Abstract

"Declining soil fertility and climatic extremes are among major problems for agricultural production in most dryland agro-ecologies of sub-Saharan Africa. In response, the agroforestry technology intercropping of Gliricidia (*Gliricidia sepium* (Jacq.)) and Maize (*Zea mays* L.) was developed to complement conventional soil fertility management technologies. However, diversified information on the profitability of the Gliricidia-Maize intercropping system in dryland areas is scanty. Using data from the Gliricidia and maize models of the Next Generation version of the Agriculture Production Systems sIMulator (APSIM), this study estimates the profitability of the Gliricidia-Maize system relative to an unfertilized sole maize system. Results show significant heterogeneity in profitability indicators both in absolute and relative economic terms. Aggregated over a 20-year cycle, Gliricidia-Maize intercropping exhibited a higher Net Present Value (NPV = Tsh 19,238,798.43) and Benefit-Cost Ratio (BCR = 4.27) than the unfertilized sole maize system. The NPV and BCR of the latter were Tsh 10,934,669.90 and 3.59, respectively. Moreover, the returns to labour per person day in the Gliricidia-Maize system was 1.5 times those of the unfertilized sole maize system. Sensitivity analysis revealed that the profitability of the Gliricidia-Maize system is more negatively affected by the decrease in output prices than the increase in input prices. A 30% decrease in the former leads to a decrease in NPV and BCR by 38% and 30%, respectively. Despite the higher initial costs of the agroforestry establishment, the 30% increase in input prices affects more disproportionally unfertilized sole maize than the Gliricidia-Maize system in absolute economic terms, i.e., 11.1% versus 8.8% decrease in NPV. In relative economic terms, an equal magnitude of change in input prices exerts the same effect on the unfertilized sole maize and the Gliricidia-maize systems. This result implies that the monetary benefits accrued after the first year of agroforestry establishment offset the initial investment costs. The Gliricidia-Maize intercropping technology, therefore, is profitable with time, and it can contribute to increased household income and food security. Helping farmers to overcome initial investment costs and manage agroforestry technologies well to generate additional benefits is critical for the successful scaling of the Gliricidia-Maize intercropping technology in dryland areas of Dodoma, Tanzania".

Work on deliverables planned for the second half of 2021/2022 is progressing and the delivery dates are given below.

Targeted deliverables for 2020/2021 and status on achievements

Deliverables (2021/2022)	Delivery dates
Manuscript on the nutritional interactions and resource-use efficiency in *G. sepium* intercropping	Target submission date: April 2022
Risk analysis of *Gliricidia sepium*-Maize intercropping under semiarid conditions	Target submission date: June 2022
Manuscript on the adoption and socio-economic impacts of agroforestry technologies	Target submission date: April 2022
Extension manual on validated agroforestry technologies	To be developed & produced by June 2022.
Two flyers on "Productivity and Economic benefits of maize-*Gliricidia* intercropping" and "Integration of agroforestry and the efficient cooking stove. Under drafting.	Final versions to be produced by May 2022.
Two technology labels	Final versions available May 2022

Sub-activity 1.1.1.6: Assess the yield, economic, and BNF benefits of innovative approaches addressing the pigeon pea and common bean productivity within maize-based cropping system and variable weather

This study aimed to determine the effects of different crop spatial configurations on the productivity of pigeonpea and beans within the three eco-zones of Babati district, Tanzania, and assess the uptake and adaptations of Mbili-Mbili technology by farmers in the same district. The fourth season field experiments were implemented successfully; data analysis and manuscript development are ongoing. Being a possible last year of Africa RISING in the study sites, it was considered important to deliver this technology to existing farmer groups as a minimum close-out activity during 2021–2022. The approach was to work with 20 farmer groups and demonstrate the Mbili-Mbili technology as an integrated system with other system practices (stripping and topping).

During this reporting period, 20 farmer groups were identified in 10 villages of Babati district (two each in Sabilo, Long, Gallapo, Hallu, Endadosh, Orgadinda, Qash, Riroda, Endanachan, and Duru) of Babati district, and a demonstration of the Mbili-Mbili technology installed with each farmer group. Training was done for all farmer group members (see Capacity Building Section), who were later engaged during the establishment of the demos. The establishment of the demos was affected by weather, with planting dates spread from December 2021 to early March 2022. In all villages, except Long, maize was intercropped with beans and pigeon pea. In Long, pigeon peas were substituted with potato, a key adaptation of Mbili-Mbili in the highlands.

Field days will be conducted at the physiological maturity of maize between the month of April and June. During this period, focus group discussions will also be conducted where learning insights on group implementation of Mbili-Mbili will be recorded. Deliverables for the second half of 2021/2022 are described below.

Two manuscripts have been developed and are ready for submission; (i) Agronomic *performance and economics of legume-legume and cereal-legume intercropping systems in Northern Tanzania* to be submitted to Field Crops Research, and (ii) *Socio-economic factors influencing farmer perceptions and their level of knowledge in sustainable intensification innovations in Babati, Tanzania* to be submitted to Heliyon.

Sub-activity 1.1.1.7: Monitoring the impact of weather and climate variability on the productivity and resilience of maize–legume cropping systems of Kongwa and Kiteto, Tanzania

The collection of monthly weather datasets from automated weather stations in Kongwa and Kiteto districts in Tanzania has continued. The datasets were shared with partners on Dataverse. This responsibility has now been assigned to TARI – Hombolo replacing SUA because of the weather stations' proximity to TARI. Preparation of a manuscript out of a survey to establish farmers' perception of weather variability and associated crop production was initiated. Progress has not been submitted by the PI for the second successive reporting period. Accordingly, we consider the sub-activity closed.

Sub-activity 1.1.1.8: Explore, document, and assess the sustainable intensification pathways of 3 farming system case studies in Tanzania to inform scaling potential.

This study was to be driven by compiling existing data on three farms that hosted different researchers and filling data gaps where identified. At the end of 2020, a household survey was conducted in Tanzania (focusing on the adoption of postharvest technologies) in which the three original farms were included. Progress on the three farm case studies has not been provided as the researcher is on intermittent sick leave.

Sub-activity 1.1.1.9: Assessing the impacts of Africa RISING technologies on the performance and resilience of multi-location and differentially exposed farming systems case studies in Malawi.

In an activity that started in 2020, it was hypothesized that crop productivity in mother trials typically represents water-limited yield potential for the different agroecologies. Crop yield for these trials would be used as benchmarks to assess the level of intensification at the farm-scale for other farmers' groups (mother trial host farmers' fields, baby trial farmers, and farmers not directly participating in Africa RISING activities). Mother trial farmers are more likely to adopt more technologies as they more closely interact with a range of SI technologies in the mother trials. The objectives of this sub-activity are to (i) determine the adoption and impact of SI technologies for the differentially exposed farming systems; (ii) predict different farming systems' performance when subjected to scenarios of shocks; and (iii) identify the contribution of Africa RISING technologies to shock resiliency. The FarmDESIGN modeling framework was proposed to be used for analysis. The MSc work addressing the first objective was completed and a thesis submitted (see the report of April-September 2021). A report of progress on the other two research questions has not been provided by the PI, who is on intermittent sick leave.

Activity 1.1.2: *Evaluate and implement pathways that are effective at improving access to seeds and clonal materials of modern varieties of legumes, cereals, vegetables, forages, and livestock*

Sub-activity 1.1.2.1: Assessment of the benefits of management technologies on the performance of improved vegetable varieties

The closing action in this sub-activity was to conduct end-line household surveys to assess the knowledge, attitudes, and practices of vegetable production for improving household nutrition and income in action and control villages. The survey was conducted in March 2022. Data cleaning and analysis are ongoing and a manuscript on the impact of improved vegetable management practices is targeted for publication by August 2022.

Output 1.2 *Demand-driven, labor-saving, and gender-sensitive research products to reduce drudgery while increasing labor efficiency in the production cycle piloted for relevant typologies in target areas*

Activity 1.2.1: *Support local partners through training on appropriate drudgery-reducing technology delivery.* ***No sub-activity was planned for 2019-2020.***

Activity 1.2.2: *Co-adapt existing mechanization options with target communities*

Sub-activity 1.2.2.1: Use of tractor mounted ripper tillage implement for enhancing soil water infiltration and moisture conservation in semi-arid areas of Kiteto

This study was initiated during the 2018/2019 cropping season to determine the potential benefits of rip tillage (RT) in semi-arid agroecologies of Central Tanzania. The collection of data was continued during the 2019/2020 season. Analysis of the two seasons' data contributed to the manuscript titled "*Factoring labor in the comparison of in situ rainwater harvesting technologies for semi-arid areas of Central Tanzania*" submitted to Soil & Tillage Research Journal and is currently under review. The draft manuscript abstract was presented in the April–September 2021 report.

Output 1.3. *Tools (including ICT-based) and approaches for disseminating recommendations in relation to the above research products, integrated into capacity development*

Activity 1.3.1*: Conduct extrapolation domain analysis based on GIS, agroecology, and crop model-generated information to establish the potential of technologies for geographical reach*

Sub-activity 1.3.1.1: Farmer/Extension messaging (forage production and use, crop residue processing and use, and feed rations) using the MWANGA ICT-Platform

MWANGA ICT – Messaging Platform has been described in previous reports. During 2021–2022, the plan is to broaden the use of Mwanga to more farmers beyond the key groups within a specific research activity, as has been the case, at least to double the numbers of farmers currently being reached. We plan to bring in agro-dealers and seed companies to have their buy-in and communicate through this platform. From a scientific perspective, it's important to understand to what extent the ICT messaging with Mwanga is benefiting farmers and how the farmers perceive them.

During this reporting period, updating and expanding the farmer contact database for Mwanga were undertaken. Farmers with non-functional cell phone contacts were removed from the database and new contacts (obtained from the previous agronomic survey conducted in Babati and others obtained from the MKilimo platform) were added. The new farmer database is available. To date, 22,232 SMS (agronomic and postharvest) have been sent to 1744 farmers. Some of the messages are targeted at specific farmers practicing relating technologies. Ongoing activities will result in deliverables to be completed by August 2022 and presented in the next report, including:

1. A report on an evaluation study regarding the utilization of Mwanga, covering those farmers who have been receiving the messages. The report will cover farmers' sentiments, preferences, and whether there is a change in their knowledge, attitude, skills, and aspirations as a result of accessing ICT services.
2. A report on the training of agro-dealers, seed companies, and development partners on the potential for utilization of Mwanga for communication.

3. A success story on village-level feedback and results from delivery meetings.

Sub-activity 1.3.1.2: Produce regionally relevant extrapolation domain maps for validated conservation agriculture (CA) practices

The major work implemented involved the revision of a manuscript submitted to Agriculture and Forest Meteorology titled 'Remote sensing and machine learning identify where and when conservation agriculture increases maize yield in Southern Africa,' whose details were presented in the last report. Main revisions include the following:

i) Further cleaning of conservation agriculture trials database from CIMMYT, including matching tillage treatments with digitized field polygons. Three more years of conservation agriculture trials data were incorporated into the analysis to cover a 16-year time series.

ii) Remote sensing variables have been incorporated in the random forest model, including fraction of photosynthetically active radiation (FPAR), anomalies for temperature, evapotranspiration, and enhanced vegetation index (EVI), seasonal cumulative EVI, and coordinates (latitude and longitude). Variables related to soil chemical properties (nitrogen, zinc, boron, and magnesium) were removed since they change within a short period. But physical properties were maintained.

iii) A VSURF (ensemble of ensemble) procedure was applied to eliminate variables that did not improve the model accuracy.

A manuscript titled 'Spatiotemporal modeling and prediction of maize yield at farm-scale in South-East Africa (2007–2020)' is in preparation, with a target submission date of August 2022. The plan is to develop the manuscript from a study on the application of an ensemble machine learners to predict the spatial variability of the maize grain at a field scale (30 m) for convectional (CP) and conservation agriculture (CA) tillage systems. The agronomic data was obtained from agronomic management practices for 16 growing seasons (2004/2005 to 2019/20). An ensemble of three ML algorithms, i.e., the random forest (RF), eXtreme Gradient Boosting (XGboost), and spectral vector machines (SVM), will be evaluated together with a spatial-temporal cross-validation procedure to train the ensemble ML models. A spatial feature selection will be employed to eliminate variables that do not lead to better spatial predictions of maize grain yields beyond the training sites. The robustness of the spatial predictions of maize yields is to be evaluated using the concordance correlation coefficient (CCC).

Sub-activity 1.3.1.3: Produce regionally relevant extrapolation domain maps for validated soil and water conservation practices

During this reporting period, we aimed to finalize research papers focusing on the magnitude of land degradation and its drivers in the East and South Africa (ESA) region (the first published manuscript, https://www.mdpi.com/2072-4292/13/9/1754, was at local scale – Kongwa district of Tanzania).

The first research paper focused on validating the gridded monthly precipitation products; it is titled "*Assessing the skill of gridded satellite and re-analysis precipitation products over an altitudinal gradient in East and Southern Africa" and* was submitted to Atmosfera Journal. We evaluated the skill of three gridded precipitation products (GPPs) in estimating the gauge observations and compared the precipitation trends derived from these products across the east and southern Africa region. Taylor diagrams and Kling-Gupta Efficiency (KGE) were used to assess the accuracy. We evaluated the skill of three gridded precipitation products (GPPs) with

varying spatial resolution in estimating the observations from the gauge network and compared the long-term precipitation trends derived from these products. Validation results revealed that the three GPPs had varied performance over temporal and altitudinal ranges. The skill of the three GPPs at a monthly scale, was generally high but showed lower performance at high elevations over 1500 m, especially during the OND season. At 501–1000 m and above 1500 m elevations, CHELSA-v2.1 had lower skill than the other two products that caused over-estimation of the annual and seasonal precipitation trends over mountainous terrain and large inland water bodies like Lake Victoria. Our results further reveal that new or higher resolution precipitation data is not always the most accurate since an update of the algorithms can introduce artifacts or biases.

The second research paper is in preparation, targeting August as its publication date. It's focus is on determining the trends and drivers of vegetation productivity as an indicator of land degradation.

Sub-activity 1.3.1.4: Ex ante impact assessment with Trade-off Analysis Model for Multidimensional Impact Assessment (TOA-MD) for regional relevance of Africa RISING technologies.

As presented in the last report, progress toward producing a manuscript as the target deliverable is again not reported on. The PI is on intermittent sick leave.

Outcome 2. Natural resource integrity and resilience to climate change enhanced for the target communities and agroecologies

Output 2.1 *Demand-driven research products for enhancing soil, land, and water resource management to reduce household/community vulnerability and land degradation piloted in priority agroecologies*

Activity 2.1.1: *Characterize current practices in ESA through identifying formal and informal arrangements for access to and use of water and land resources*

Sub-activity 2.1.1.1: Assessing buffer and adaptive capacity to harness resilience of different farm types

Two new MSc students started their research in November 2021, contributing to systems synthesis activities in Tanzania and Malawi. This follows successful completion of studies by two other MSc students whose theses summary were presented in the last report. The new students are conducting analyses on how selected Africa RISING beneficiary farmers perform against multiple dimensions of the SIAF framework relative to other farmers in the community. In Tanzania, the focus will be on positive deviant farmers in terms of SIAF indicator performance, and farmers who implement various Africa RISING technologies and packages. The student is using a dataset of a survey among 579 farmers. The subject of the thesis is "*Holistic impact assessment of project promoted sustainable intensification technologies at farm level in Tanzania*". In Malawi, farmers involved in mother and baby trials will be compared to non-participating control farmers using recently collected panel data. The subject of the thesis is "*Holistic impact assessment of project promoted sustainable intensification technologies at farm level in Malawi".* Theses completion is expected in June 2022, and journal articles will be generated from the theses.

Output 2.2 *Innovative options for soil, land, and water management in selected farming systems demonstrated at strategically located learning sites*

Activity 2.2.1: *Set up demonstration and learning sites in target ESA communities*

Sub-activity 2.2.1.1: Lessons from long-term on-station Conservation Agriculture (CA) trials in Zambia

Long-term on-station trials were successfully completed by the end of June 2020 and four manuscripts have already been published (see report of April–September 2021). One manuscript titled "*Short-term gains versus long-term sustainability - evidence from long-term CA research in Southern Africa*" has been published in Agriculture Ecosystems and Environment https://bit.ly/38Ab6IV. The proposed "Economic assessment of Zambia CA systems" manuscript could not be further pursued as we did not generate sufficient data for its development.

Sub-activity 2.2.1.2: Assessing the benefits of nutrient and water management for climate resilience in Malawi

Experiments on nutrient and water management were implemented in southern Malawi, where there is a high risk of droughts. Although these trials have now been terminated, they have generated useful data to inform how 'Climate Smart' it is to capture more rainfall water through tied ridging. We used the trials to consolidate action learning with farming communities, hugely exposed to high seasonal rainfall variability, often making fertilizer investments unattractive. Simple approaches, such as tied-ridges, that buffer farmers against soil moisture stresses were therefore promoted. These in-situ rainwater storage practices increase residence time for rainwater to infiltrate, as tropical storms often have rainfall intensity that exceed soil water infiltration several times. We have largely facilitated the institutionalization of approaches that enhance resilience within the Malawi extension services, as these trials were used by extension as climate-smart interventions field day platforms.

Data from this work has now been published in different formats:

Regis Chikowo, John Olwande, Maria Wanzala, Mary Lubungu, Hambulo Ngoma, Pedro Sanchez. 2021. Opportunities for Building Resilience of African Farming Systems. In: *AGRA Africa Agriculture Status Report. A Decade of Action: Building Sustainable and Resilient Food Systems in Africa (Issue 9)*. Nairobi, Kenya: Alliance for a Green Revolution in Africa (AGRA). Pp 68-92 (https://agra.org/wp-content/uploads/2021/09/AASR-2021-A-Decade-of-Action-_Building-Sustainable-and-Resilient-Food-Systems-in-Africa.pdf)

Fred Kizito, Regis Chikowo, Anthony Kimaro, Elirehema Swai. 2022. Chapter 5: Soil and water conservation for climate resilience. In: *Bekunda, M., Hoeschle-Zeledon, I., & and Odhong J. (Eds). A handbook of approaches in sustainable agricultural intensification for farmers in East and Southern Africa.* Pp 62-79. CABI (. http://dx.doi.org/10.1079/9781800621602.0001*)*.

Sub-activity 2.2.1.3: Climate-smart farming practices (soil water micro-catchments, weather-informed varieties, cover crops integration [cowpea]) for increasing productivity of the maize-legume system under variable weather conditions.

The study ended in 2020/2021. It tested options of utilizing weather forecasts' information to decide on planting dates, integration of *in situ* water harvesting, cover crops, improved fertilizer management, and the combined application of these technologies. The generated data have been analyzed and used to inform/draft the ISFM system-level manuscript (see Sub-activity 4.1.1.3 re-submitted manuscript).

Sub-activity 2.2.1.4: Integration of fodder trees and grass forages in dryland farming

This is a closed sub-activity. Data generated from this activity was used to support three publications presented in earlier reports.

Sub-activity 2.2.1.5: Evaluation of land rehabilitation benefits of shelterbelts and contours

This is a closed sub-activity, but with no documented deliverables.

Sub-activity 2.2.1.6: Validation of residual tied ridging as a labor-saving technology in the semi-arid areas of central Tanzania

During the current reporting period, activities implemented were to complete and submit one manuscript for publication and draft a second one for submission to a journal. The abstract for the draft manuscript *"Factoring labor in the comparison of in situ rainwater harvesting technologies for semi-arid areas of Central Tanzania"* was presented in the last report. It has been submitted to the journal Soil & Tillage Research. A second manuscript "*Effect of induced water stress on maize performance under in situ rainwater harvesting techniques in semi-arid areas of Central Tanzania*" is being prepared for submission in June 2022.

Outcome 3. Food and feed safety, nutritional quality, and income security of target smallholder families improved equitably (within households)

Output 3.1 *Demand-driven research products to reduce postharvest losses and improve food quality and safety piloted in target areas*

Activity 3.1.1: *Conduct packaging and delivery of postharvest technologies through community and development partnerships with an iterative review, refining, and follow-up*

Sub-activity 3.1.1.1: Impact of nutritional messaging on household nutrition, knowledge, attitude, and practices

With the easing of the COVID-19 pandemic restrictions on the movement and gathering of people, the end-line survey to generate the impact data was, at last, implemented in March 2022 in Karatu District of Tanzania, where Africa RISING is conducting a scaling partnership with the development partner, Islands of Peace. Two manuscripts will be prepared and submitted for publication by August 2022. One will be on "*The impact of nutritional education on farmers' nutritional knowledge, attitude and practices, income, and nutrition status"* and the other on "*the impact of improved production technologies on vegetable yield and profitability*".

Sub-activity 3.1.1.2: Validating hermetic storage structures and the environment on physical and economic loss abatement in produce

The field component of this study was concluded in 2019. Data collected in an impact survey in mid-2020 were processed and a manuscript titled "*Adoption and impacts of improved post-harvest technologies on food security and welfare of maize-farming households in Tanzania: A comparative assessment*" was prepared and submitted to the journal Food Security in January 2022. The abstract of the draft paper was presented in the April-September 2021 report. Another manuscript on the role of social capital and networking in relation to the speed of postharvest technology adoption will be completed by June 2022.

Sub-activity 3.1.1.3: Nutritional value, safety, and processing quality of produce during storage and utilization by households

This is a closed activity as reported in the April–Sept 2021 Report. One manuscript was published (https://doi.org/10.1016/j.jspr.2020.101723).

Output 3.2 *Nutritional quality due to increased accessibility and use of nutrient-dense crops by farmers improved*

Activity 3.2.1: *Promote and deploy nutrient-rich crop varieties and livestock food resources in target communities*

Sub-activity 3.2.1.1: Pathways to sustainable adoption of nutrient-dense diets in rural communities of central Tanzania

The sub-activity addressed drivers of food choice focusing on new pearl millet and pigeonpea varieties promoted by Africa RISING. In the last report, we presented a link to the manuscript addressing drivers of pearl millet consumption was published (https://www.frontiersin.org/articles/10.3389/fsufs.2021.694160/full), and also the summary of results and conclusions of the draft manuscript addressing drivers of pigeon pea consumption. This too was published in January 2022 as "*Drivers of Pigeon Pea Consumption Among School-Aged Children in Central Tanzania"* and may be accessed on the link https://www.frontiersin.org/articles/10.3389/fsufs.2021.726404/full.

Sub-activity 3.2.1.2: Promoting farmer production of nutrient-dense (Zn, Fe) NUA45 and drought-tolerant SER83 bean varieties in Malawi

Activities under this sub-activity were concluded. A published manuscript and a technology label were presented in the April-Sept 2021 report.

Sub-activity 3.2.1.3: Determining quality and safety of locally produced legume grain-derived complementary foods and adoption in Dedza District

Building on the introduction of nutrient-dense common bean varieties (sub-activity 3.2.1.2 above), this study was designed to introduce farmers to alternative methods of incorporating nutrient-dense common bean varieties in menus as part of their diets, especially to demonstrate how these foods would protect children from undernutrition. Because this is a community--engagement activity, its progress was limited by the COVID-19 pandemic. Approval for community-engagement activities was granted only in September 2021, and this work is planned to be implemented during 2021–2022.

Sub-activity 3.2.1.4: Assess the contribution of the farming systems interventions in narrowing the food and nutrient gaps in Kongwa and Kiteto, and the probability of smallholder farmer production to meet them

This study aimed to determine how an integrated delivery of productivity-enhancing technologies (targeting Africa RISING promoted crop and livestock technologies) can increase the probability of meeting dietary diversity and nutrient adequacy of family household nutrition dietary needs. The survey was only implemented in September 2021, the delay being due to logistical challenges linked to the escalation of the COVID-19 pandemic in the region. Data analysis and manuscript development are being implemented. The target submission date of the manuscript to a journal is June 2022.

Outcome 4. The functionality of input and output markets and other institutions to deliver demand-driven sustainable intensification research products improved

Output 4.1 *Access to profitable markets for smallholder farming communities and priority value chains facilitated*

Activity 4.1.1: *Conduct a comprehensive value-chain analysis with a specific focus on SI technologies*

Sub-activity 4.1.1.1: Conduct value chain analysis (VCA) for (quality protein) maize seed in Kongwa and Kiteto

Results of this study were merged with those of sub-activity 4.1.1.2 to produce one stronger manuscript (see progress report under 4.1.1.2).

Sub-activity 4.1.1.2: Value chain analysis of groundnut seed and design of operation enhancement strategies for semi-arid ecologies of central Tanzania

A working abstract of the manuscript "*Analysis of the Maize and Groundnut Seed Value Chains in Central and Northern Tanzania"* was presented in the April-September 2021 report. The draft manuscript is in the final round of review after inputs by the subject matter specialist, and will be submitted in April 2022. The target journal is Outlook on Agriculture.

Sub-activity 4.1.1.3: Assess how livelihoods of farmers are affected by the implementation of ISFM practices as a result of Africa RISING activities in Babati

This is a survey and synthesis activity whose data have been used to draft manuscripts for publication (the deliverable). A summary of the findings was presented in the last report. The generated manuscript titled "*Analysis of organic resources transfers and interactions with landscape positions influence crop yields among smallholder farmers in Northern Tanzania*" was submitted to the journal Field Crops Research. It was rejected with good reviewer comments. These have been addressed and the article resubmitted. It is now under peer-review. Another manuscript titled "*Participatory action research, social networks, and gender influence soil fertility management in Tanzania*" has been approved by all the co-authors for submission to a journal.

A farmer and extension guide on ISFM (rework of the 2019 version) is available with the Communications team for publishing.



Soil Fertility Management in Bab

Sub-activity 4.1.1.4: Assess how livelihoods of farmers are affected by the implementation of ISFM practices as a result of Africa RISING activities in Kongwa and Kiteto

This study is like sub-activity 4.1.1.3, but is implemented in the semi-arid areas of Kongwa and Kiteto districts of Tanzania, where water harvesting drives ISFM. Data collected during the last reporting period were reviewed and were considered incomplete due to the lack of a proper control group. Focus has now changed toward a repeat of the whole survey through a new tool designed to capture all the necessary data required to show the impact of ISFM on food security and income. This will ensure that a control group is in place, and this will help us tease out the impact of the Africa Rising awareness campaign on the intensity of ISFM use. We have already requested TARBES data with identifiers to include the original baseline farmers where possible. A sample of 300 (for the treated) and 300 (placebo/control) is targeted. The new survey is targeted for April/early May (following crop harvest) and a manuscript for publication by August 2022.

Sub-activity 4.1.1.5: Value chain analysis of nutrient-dense common bean varieties in Malawi

Studies that analyze value chains of crop varieties with unique attributes, such as bio-fortified varieties in the context of many other established varieties of that crop, are very rare. Based on the implemented field trials, NUA45 productivity was comparable to mainstream varieties grown in central Malawi. It was, therefore, hypothesized that its high nutrient density would be an incentive for widespread adoption. To better understand this, at least five years after introducing two nutrient-dense common bean varieties in Central, we carried out a value chain analysis of common beans in central Malawi. We aimed to map different players in the bio-fortified common bean value chain and analyze the opportunities and constraints that exist along the bio-fortified common bean value chain to facilitate the development of a value chain enhancement strategy for bio-fortified common bean. We interviewed 174 farmers from seven villages, carried out focus group discussions with participants purposively selected from bean growers, and 101 traders from local markets. Key informants, with vital information on common bean markets, were also interviewed. The Herfindahl Hirscham Index (HHI) was used as a measure of the level of specialization. Marketing margins, a measure of the difference between one point in the marketing chain and another as a reflection of marketing costs, were computed.

Survey results showed that there was no specialization—bio-fortified beans are sold to traders who act as wholesalers and retailers for several varieties. There was no premium price attached to the bio-fortified varieties, with the morphological differences between the bio-fortified and normal varieties so similar in some cases that differentiation was practically nil. The unrecognized/uncelebrated "quality" of bio-fortified beans is a significant impediment to their wider adoption. A manuscript titled "*An analysis of the performance of nutritionally superior common bean varieties five years after introduction in central Malawi"* is being prepared for publication by June 2022.

Activity 4.1.2: *Conduct a value chain stakeholder analysis (stakeholder mapping)*

Activity 4.1.3: *Develop a value chain enhancement strategy (including collective action approaches, contractual arrangements, and standardization)*

Sub-activities under Activities 4.1.2 and 4.1.3 are addressed by the relevant value chain sub-activities presented under Activity 4.1.1.

Activity 4.1.4: *Identify and evaluate existing mechanisms that inform farmers about dynamic market needs*

Sub-activity 4.1.4.1: Exploring ICTs for linking farmers to markets

The continuing activity with the MWANGA Platform is merged with and reported under sub-activity 1.3.1.1.

Activity 4.1.5: *Analyze the existing baseline survey data and supplement them with qualitative surveys from target regions*

Sub-activity 4.1.5.1: Identify the most profitable market channels and welfare effects of participating in the maize, groundnut, and pigeon pea markets in Malawi, Tanzania

This is a concluded sub-activity, with a published manuscript "*Welfare impacts of smallholder farmers' participation in multiple output markets: Empirical evidence from Tanzania"* that can be accessed at https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0250848. The manuscript abstract was presented in the April-September 2021 report.

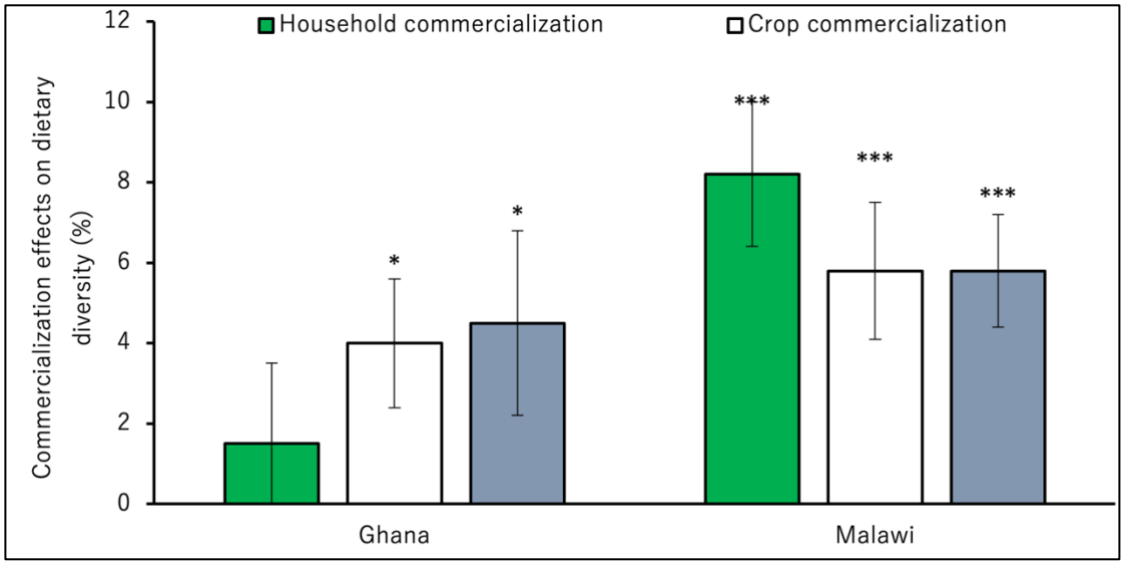
Sub-activity 4.1.5.2: Impact of smallholder Agricultural commercialization on household income and nutrition in Ghana and Malawi

This is a new sub-activity driven by the observed mixed literature results when linking agricultural commercialization with household economics, nutrition, and dietary quality. The study is testing the hypothesis of a positive correlation between commercialization and dietary diversity, food security, and child nutrition, taking advantage of the panel and quasi-experimental data from some districts in Ghana and Malawi. Drafting the manuscript for publication is complete and in the process of submission to the Food Policy Journal in April 2022. It is titled "*Linkages between agricultural commercialization and nutrition in Ghana and Malawi.***"**

In summary, the study results indicate that commercialization is associated with higher HDDS (household dietary diversity score) by about 8% on average in Malawi, while in Ghana, the results are statistically insignificant (Figure 2). We also analyzed associations between crop and livestock commercialization and HDDS separately in both countries. Crop commercialization is associated with improved household diets by 4.0% and 5.8% in Ghana and Malawi. Livestock commercialization is also related to improved diets in both countries, ranging from 4.5 to 5.8%. This implies that crop and livestock commercialization interventions would improve dietary diversity in both countries. We also found that crop commercialization is associated with improved household food security by 5.3% and 11.1–30.7% in Ghana and Malawi. Finally, the results on child nutrition as measured by the height-for-age Z-scores showed that livestock and farm commercialization was negatively correlated with nutrition in Ghana but not in Malawi.

Several factors might explain these results. First, possibly household income from commercialization is spent on non-food items, non-nutritious foods, or both. Second, in

subsistence economies where most households sell food items meant for their consumption, the commercialization of such commodities might trigger limited access to nutritious foods. Finally, some nutritious foods such as legumes and livestock are often produced for the market and not for their consumption. Overall, the results point to the need to improve market infrastructure to enhance commercialization to improve farmers' welfare in more remote locations of sub-Saharan Africa.



Notes: The dependent variable in all the regression models' is household dietary diversity score (HDDS). All models are estimated by a Poisson panel data regression model. Coefficient estimates are drawn from correlated random effects (CRE). Marginal effects of commercialization on dietary diversity are shown with standard error bars. ** p < 0·05, *** p < 0·01.

Figure 2. Association between farm commercialization and dietary diversity

Sub-activity 4.1.5.3: Eliciting willingness to pay for quality maize and beans: Evidence from experimental auctions in Tanzania

This is another new sub-activity that is funded by the Policy, Institutions, and Markets (PIM) CRP and Africa RISING. A manuscript titled "*Eliciting willingness to pay for quality maize and beans: Evidence from experimental auctions in Tanzania*" is near ready for submission. A summary is below.

Introduction. Food safety hazards are associated with illness and loss of human life, food and nutritional insecurity, impose costs on the food economy and public health system, interrupt international trade, and reduce disability-adjusted life years (DALYs) (Hoffmann et al., 2019[1]; Jaffee et al., 2019[2]). These problems are often worsened in developing countries because food safety issues, such as aflatoxin and chemical contamination, coupled with weak enforcement of regulations against selling unsafe food are unobserved. But evidence showing the economic benefits or how consumers value these quality aspects is thin, yet they constitute an essential part of quantifying the demand for different food products. The difficulty lies in that it is not

[1] Hoffmann, V., Moser, C., Saak, A., 2019. Food safety in low and middle-income countries: The evidence through an economic lens. World Dev. 123, 104611. https://doi.org/10.1016/j.worlddev.2019.104611

[2] affee, S., Henson, S., Unnevehr, L., Grace, D., Cassou, E., 2019. The Safe Food Imperative: Accelerating Progress in Low- and Middle-Income Countries, The Safe Food Imperative: Accelerating Progress in Low- and Middle-Income Countries. https://doi.org/10.1596/978-1-4648-1345-0

easy to value the quality aspects mentioned above. Some benefits are not visible to consumers or traders and valuing them may also be subjective. This study was guided by the question—if high-quality maize and common beans were differentiated from the unsorted maize and common beans, are consumers willing to pay a premium through sorting and food safety labelling?

Methodology. Using the incentive-compatible Becker-DeGroot-Marschak (BDM) mechanism, we estimated the willingness-to-pay (WTP) for different quality maize and beans grades in four districts of Tanzania (Babati, Kilolo, Kongwa, and Mbozi) using data from a household survey and experimental auctions involving 555 participants. Specifically, we estimated consumers' observable and unobservable quality premiums on the different types of maize and beans. We consider three types of maize and beans quality grades;(1) unsorted and unlabeled; (2) sorted and unlabeled grade; and (3) sorted and labeled.

Results

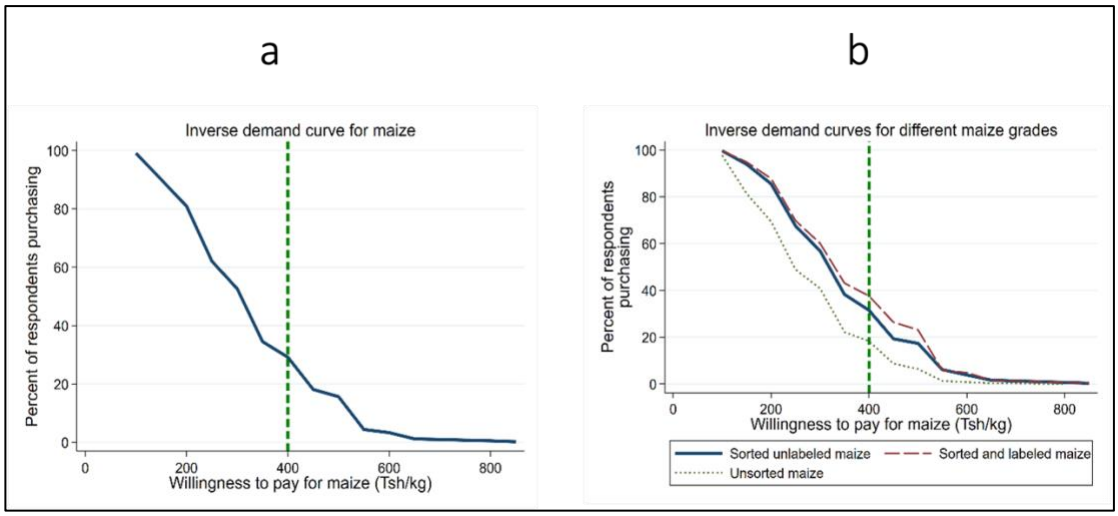
Demand for maize and beans. Demand curves were estimated as the share of households whose bid was greater than or equal to the price of maize and beans. Figures 3a and 4a display the inverse demand curve for all participants in the WTP auctions regardless of the different grades. The demand curves disaggregated by the different quality grades are shown in Figures 3b and 4b. We did not account for any of the respondents, households, or farm characteristics in plotting the demand curves.

The WTP, regardless of the quality grades, ranges from Tanzania Shillings (TZX) 50 to 1200, with the median price for a kg of maize that individuals are willing to pay being TZX 300. The median price is close to the average market price of maize of TZX 400 across the four districts[3]. At the average price of TZX 400, the proportion of farmers WTP for maize is about 30%; those willing to pay TZX 500 are only 18% translating into a 12% reduction in demand of the farmers who are willing to pay with a corresponding TZX 100 increase in the price. The vertical distance between any two curves in Figure 1b depicts the quality premium that farmers are willing to pay a discount or a premium for the different quality maize grades. The difference encompasses the unobservable and observable quality premiums. It is apparent that most of the auction participants place a premium on the sorted and labeled maize compared to the unsorted maize, with demand curves of the two quality grades lying to the right of the unsorted grade. The premium that farmers are willing to place on the unobservable quality at lower and higher prices is not very apparent because the vertical distance between the sorted and the labeled maize is minimal.

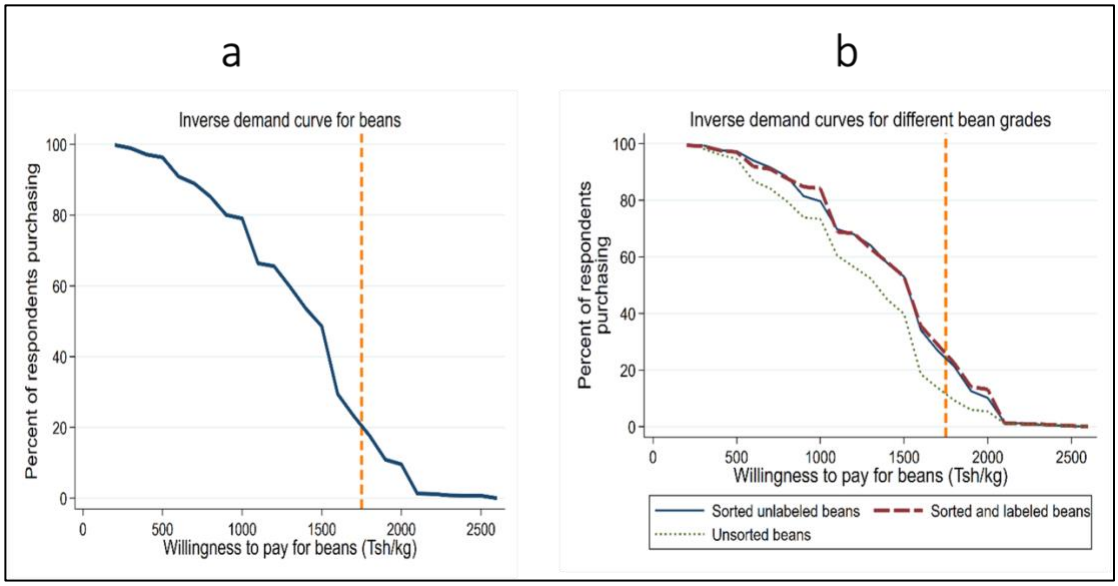
Considering that common beans is a cash crop, the WTP is unsurprisingly higher than that of maize. As with the maize, farmers' WTP for beans decreases with price, ranging from TZX 100 to 2500 and a median price of TZX 1400 (Figure 4a). The average market price of beans between January and July 2021 is TZX 1750, and only 11% of the farmers were WTP for the unsorted beans at this price, 24% for the sorted, and 25% for the labeled beans (Figure 4b). The vertical distance between the unsorted curve and those of the sorted and labeled grades is quite significant while that of the sorted and labeled is not, pointing to the importance the farmer's

[3] This average is based on the average prices from January to July 2021. This is a relatively lean period hence the prices are higher than during the harvest period when the study was conducted.

place on the visual attributes of the different grades of beans as opposed to the unobservable characteristics.



Figures 3a and b. Inverse demand curves for all maize and different quality maize grades



Figures 4a and b. Inverse demand curves for all beans and different quality beans grades

***WTP for observable and unobservable maize and beans quality attributes*.** Results indicate that auction participants are WTP more for observable quality attributes by TZX 73 (25%) and TZX 191 (14%) over the unsorted maize and beans grades (Table 1). The constant indicates the amount auction participants were willing to pay for the unsorted grades implying that the participants were willing to pay TZX 364.36 and TZX 1569.37 per kg for the sorted grades of maize and beans, respectively. Table 1 also indicates that participants value observable more than unobservable quality attributes, with a TZX 12.865 difference between the sorted and labeled maize grades. At the same time, that of beans is TZX 23.243 (although not significant). Generally, the results underscore the importance of aflatoxin testing and postharvest processing (i.e., sorting) to enhance food safety and security.

Table 1. Observable and unobservable quality premiums for maize and beans

Variable	(1) Maize WTP	(2) Beans WTP
Sorted maize	72.97***	
	(7.25)	
Sorted and labeled maize	85.84***	
	(7.93)	
Sorted beans		191.17***
		(17.52)
Sorted and labeled beans		214.41***
		(18.32)
Constant	291.39***	1378.20***
	(6.89)	(20.95)
Observations	1665	1665
Number of unique bidders	555	555
Observable quality premium (β_1)	72.973***	191.171***
Unobservable quality premium ($\beta_1 - \beta_2$)	12.865*	23.243
F-test: Observed quality premium = unobserved quality premium	F = 3.61*	F = 2.12

Note: Participant cluster robust standard errors reported in parenthesis
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Outcome 5. Partnerships for the scaling of sustainable intensification research products and innovations

Output 5.1 *Opportunities for the use and adoption of sustainable intensification technologies identified for relevant farm typologies*

Activity 5.1.1: *Farmer participatory experimentation with crop and soil management and integrated crop-livestock technologies in on-farm situations*

Sub-activity 5.1.1.1: Continued experimentation in six target communities of Eastern Zambia and nine target communities in central and southern Malawi with already established clustered CA trials

This study aims to demonstrate the best options available for the management of drought-tolerant maize varieties and CA practices in 16 target communities of Malawi and Zambia. This year's implementation was strongly affected by a delayed onset of the cropping season. Most farmers in Malawi and Zambia could only seed their trials after Christmas and towards the beginning of January 2022 (Figure 5). Then rains started heavily, leading to floods in some parts, nutrient leaching, and waterlogging in others. Finally, this was followed by a long dry spell in February 2022, which affected the whole region. Farming, in general, has become very difficult and complex under such unpredictable weather conditions.

Partners managed to establish all on-farm long-term trials as planned. We are proud that 96 trial replicates in all 16 Target communities were established and all the required data collection is

currently taking place. The implementation teams have also received all data sheets, so the routine data collection continues as in previous years. TLC has put a dedicated extension officer in the program who collects the data, which is likely to be very beneficial for the program. Soil sampling in Malawi on LT trials was initiated in March/April to capture additional long-term data. These samples will be put together and sent to MSU for further analysis.



Figure 5. CA mother trials with doubled-up legume systems in their early stage (left) and large-scale adoption of CA systems in Mwansambo (right), February 2022. Photo Credit: CIMMYT/Thierfelder

Sub-activity 5.1.1.2: Explore the productivity domains of selected legumes and cereals to elucidate their best fitting cropping system at the community/landscape level and their dissemination

This study was designed to validate the adaptation of selected technologies in three sub-ecology domains (low, moderate, and high potential) identified during the 2018-2019 cropping season. In the 2019-2020 season, we identified the best-fit cropping systems, management, and planting patterns for each of the three sub-ecologies. Preliminary observations were presented in the April–September 2021 report. The two proposed manuscripts are about 80% complete and still within the targeted April 2022 period for submission to a journal. The manuscripts' working titles are:

1. Yield Advantage of Elite Cereal and Legume Genotypes in Varying Potential Agro-ecologies of Central Tanzania
2. Participatory Variety Selection (PVS) as a tool for variety development: A case study for the Africa RISING Project in Tanzania and McKnight CCRP Project in Malawi.

Technology labels on resilient sorghum and pearl millet varieties for the arid and semi-arid areas and a sorghum-pigeon pea intercropping technology have been developed. They reflect the importance of cropping systems characterized by water stress in semi-arid areas.

Sub-activity 5.1.1.3: Engage development partners to identify livestock management technologies of interest for partnership dissemination

The sub-activity was terminated due to poor performance.

Sub-activity 5.1.1.4: Case studies: Application of SI technologies use among farmers interacting with Africa RISING at different intensities (MSU/CIMMYT partner study)

In this sub-activity, we quantify the farm-scale impact of engaging farmers at different Africa RISING technology access intensities. The hypothesis and methodology have been described in previous reports. The partial summary of the paper under development and titled "*Does the intensity of interaction between researchers and smallholder farmers over a five-year horizon matter? Evidence from Central Malawi*" is given below.

In many cases, agricultural research-for-development projects work with farming communities, and eventually assess the impact of interventions based on the conventional "treated and counterfactual" design. In central Malawi, Africa RISING engaged farmers through the mother-baby technology transfer action research model for at least five years. This resulted in a multi-tiered farmer reach intensity 1) mother trial host farmers intensively reached, 2) baby farmers with intermediate association with researchers; 3) local control farmers with no direct Africa RISING project support but supposedly benefitting from the 'Africa RISING' effect in the community; and 4) distant control farmers who are at best remotely associated with Africa RISING. With their proximity to researchers, we hypothesize that mother trial host farmers are more likely to adopt and implement SI technologies at the farm scale. Therefore, the main objective was to determine differentials in farm-scale uptake of SI technologies as a function of the intensity of exposure to agricultural research and development. Four mother trial host farmers and four farmers each from baby farmers, local and distant controls were selected across six communities for 96 households.

A survey was implemented in three Modules between February and August 2021 and will be repeated for Modules 1 and 2 between March and May 2022. The objectives were to 1) characterize the farms, 2) determine crop productivity, and 3) determine the socioeconomic impact of farmer association with Africa RISING. Preliminary results suggest variable farm sizes but within the 0.4–1 ha range. The soil fertility status of fields that farmers perceived as "low and high" fertility was not different among farm categories (Table 2), indicating that there was no bias in farm selection. The differences in crop productivity were not always maintained for the total farm production variable due to differences in farm sizes and cropping profiles.

More data synthesis is in progress, and the new target submission date is August 2022.

Table 2. Soil fertility differentiation among farmer groups and low and high fertility fields within farmer groups.

	SOC (%) for low and high fertility fields		Clay content (%) for low and high fertility fields		pH for low and high fertility fields	
Farmer Category	**Low**	**High**	**Low**	**High**	**Low**	**High**
Mother farms	0.874	0.999	23.3	26.94	5.62	5.67
Baby farms	1.012	1.017	26.08	28.42	5.45	5.59
Distant control	0.957	0.958	24.8	26.42	5.6	5.57
Local control	0.946	0.991	26.33	26.76	5.64	5.6
Average	0.956	0.988	25.35	27.15	5.573	5.596
p-value	0.734		0.839		0.29	

Sub-activity 5.1.1.5: Panel survey, soils processing, and meta-analysis studies for maize-grain legumes sequences and implications for sustainability

This study aims to present evidence from a uniquely designed multi-year and multi-site study, representing a gradient from marginal to mesic environments (Mungai et al., 2016). Key determinants of yield response to fertilizer are assessed through detailed socioeconomic and biophysical data based on over 1,200 observations from more than 500 fields in Central Malawi. Africa RISING began collecting data in the Central Region in August 2014, with 278 farmers in the original sample providing detailed household and demographic information. By 2018, the latest period of data used here, 277 of the original 278 farmers and 538 of the original 553 plots were still annually monitored.

One manuscript has already been published (https://doi.org/10.1002/saj2.20263), and the abstract was presented in the last report. A second manuscript titled "*In marginal environments, legume diversified systems nutritionally superior: A meta-analysis*" is under development, targeted for publication in August 2022. This meta-analysis uses data generated across multiple sites and years to inform models for crop mixtures and cropping specialization for yield stability and household nutrition.

Activity 5.1.2: *Use farm trial data to apply crop simulation models and assess performance over space and time, including assessment of climate-smart technologies to establish the potential for adaptation and mitigation*

Sub-activity 5.1.2.1: Apply the APSIM crop simulation model to assess changes in resource use efficiencies, productivity, and profitability of the different cropping systems in Kongwa, Kiteto, and Iringa in Tanzania.

The study's objective is to use APSIM modeling to assess the long-term implications of SI options on climate, market risks, and resource use efficiency of smallholder farms in central Tanzania and Malawi. A manuscript titled "*Long-term implications of sorghum-pigeonpea intercropping systems on productivity, resilience, and profitability among smallholder farmers*" targeted for publication in March 2022 is delayed; a new publication target date is set for June 2022.

Sub-activity 5.1.2.2: Evaluating potential contributions of integrated soil fertility management around the five SIAF domains with emphasis on Africa RISING interventions in Tanzania

This synthesis activity aims to assess system-wide effects of ISFM on indicators within the five domains of SIAF in Tanzania. Two manuscripts have been submitted to journals for publication:

Participatory action research, social networks, and gender influence soil fertility management in Northern Tanzania has been accepted for publication in the journal Systemic Practice and Action Research. Findings showed that participatory action research (PAR) was associated with early adoption of inorganic fertilizers among medium and high-resource farmers but with a reduction in incorporating crop residues among poor-resource farmers. Bridging social capital in terms of information access and diversity in the sources spurs fertilizer use and early adoption of new varieties, especially among high-resource farmers. In contrast, cooperatives, farmer groups, and farmer-farmer local networks support soil and water conservation, especially among low resource farmers. Among the high resource farmers, increased women's bargaining power for farm inputs supports fertilizer and manuring, while livestock resources support crop residue incorporation and vice versa. Both act as deterrents. The likelihood of practicing ISFM is constrained by the age of decision decision-makers and more dependants, but this is countered by education level and farm sizes. In the resource-constrained, with low extension and technical support, and men-dominated patrilineal farming systems, the study highlights the significance of PAR, information networks, and gender inclusivity in improving soil fertility management.

Contributions of Integrated Soil Fertility Management (ISFM) to various sustainable intensification impact domains: A meta-analysis has been re-submitted to Agricultural Systems. The analysis was based on the context that implementation of integrated soil fertility management varies widely among farmers, from none to full ISFM, with multiple computations in between. Therefore, the intensity of ISFM is influenced by the number of ISFM components (improved germplasm, crop associations, organic resources, fertilizers, and local adaptations, e.g., soil and water conservation) used in a specific plot of a farmer's field. The findings show that the intensity of ISFM is higher in the sub-humid (1 to 4) than in the semi-arid ecozone (0 to 3). Except for SWC applied by 40% of farmers in both ecozones, the proportion of farmers using intercropping (91%), improved seeds (95%), and manure (55%) in the sub-humid ecozone is more than double those applying these ISFM components in the semi-arid ecozone. Productivity and economic benefits increase with the number of ISFM components at the expense of higher labor demand unless practices for drudgery reduction are employed. Differential access to resources and decision-making and control rights drive the choice of the specific ISFM components and the intensity of their application.

Africa RISING has achieved success with fertilizer microdosing, lablab and cowpea as cover crops, water harvesting, new varieties, Mbili-Mbili, toppings and strippings, extension services and demonstrations, and partnerships with the private sector. During 2021/2022, action under this sub-activity is to develop these successes into specific stories and district-wide policy messages (in English and Swahili) and communicate those through various media, specifically district-level key stakeholder/policy forums, etc. Progress is as follows:

Compendium of success stories in English and Swahili. A compendium of nine success stories has been developed. The stories have been enriched with farmer voices and scientific agronomic data generated from field trials and household surveys conducted in Babati since 2013. Once

refined, the success stories will be translated to Swahili and published on the Africa RISING website for ease of access.

YouTube videos communicating key stories and findings. Video shooting of farmers who have successfully adopted ISFM and Mbili-Mbili technologies was successfully conducted (Figure 6). Rich video material was captured. Video editing, script writing, and translation are in progress.



Figure 6. Scenes of video capture of farmers' success stories in Babati District, Tanzania. Photo credit: Job Kihara/CIAT.

Farmer and extension guide in English and Swahili. The field guide on soil fertility management in Babati has been improved from the earlier version developed in 2019. The English version has already been translated to Swahili. Designing of the English version is at its final stages, while the Swahili version has already been laid out and is undergoing design. Finalized guides will be launched during the district-level key stakeholder/policy forum, which will be held between May and July 2022.

Activity 5.1.3: *Establish adaptive field experiments with mineral and crop/animal-derived organic manure*

Sub-activity 5.1.3.1: Rainfall-responsive nitrogen fertilization strategies: in search of increased nitrogen use efficiency by smallholder farmers under rainfed conditions in Malawi

This study aimed to identify financial risk reduction based on formulating innovations around N fertilizer use by smallholder farmers guided by rainfall conditions. One manuscript (https://doi.org/10.1080/2150704X.2021.1938733) was published (see April–September 2021 report) and the sub-activity closed.

Sub-activity 5.1.3.2: Assessing the effect of residue quantity and quality, and water conservation on maize productivity and nitrogen dynamics on smallholder farms in Malawi

Challenges in managing crop residues on the farms have been documented. The trade-offs are rarely used in informed decision-making. They indicate that high-quality residues must be preserved for soil fertility gains instead of the easy pathway of land preparation through burning the residues. While the knowledge of N dynamics, following the incorporation of different

residue qualities, is fairly documented, what is not clear is the interaction between crop residue quality, quantity, and soil water management on maize productivity, which is the target of this study. In addition to the PhD thesis and one publication that were completed in 2020, a manuscript titled "*Crop residue quality and quantity and water management interactions on smallholder farms in Malawi*" is under development for submission in June 2022.

Sub-activity 5.1.3.3: Assessing the integrative effect of in-situ rainwater harvesting and fertilizer micro-dosing on crop yield, water, and nutrient use efficiency in Kongwa District

The sub-activity has ended because no reports have been received for the last three consecutive periods.

Activity 5.1.4: Demonstrate the use and impact of crop residues, forages, and other organic resources as animal feed and nutrient resources

Sub-activity 5.1.4.1: Test the effect of feeding Napier grass and Maize stover supplemented with bean haulms at different levels on milk yield under smallholder farmer conditions

Sub-activity 5.1.4.2: Demonstrating the of effect home-made feed rations based on Gliricidia sepium *and vegetable waste on the productivity of selected strains of chickens*

Both sub-activities ended in 2020 following the non-submission of two consecutive reports even after no-cost contractual extensions were awarded.

Activity 5.1.5: *Use crop-livestock models for trade-off analysis*

No proposal was submitted to conduct research under this activity during this reporting period.

Activity 5.1.6: *Disseminate best-fit integrated crop-livestock technologies to reach and have an effect on small-scale farmers in a landscape context*

Sub-activity 5.1.6.1: Small-scale piloting of FarmMATCH – a framework for typology-based targeting and scaling agricultural innovations. (Matching Agricultural Technologies to Farms and their Context)

Africa RISING has established that sustainable recommendation domains (SRDs) can be used to target scaling specific technologies (Muthoni *et al.* (2017[4]). But the effectiveness of the suitability assessment can be further refined as long as the features of individual farms are considered and directly related to technology characteristics during the targeting phase. This study proposes using the FarmMATCH approach to fill this knowledge gap (i.e., facilitating the matching between agricultural technologies to farms and their context).

Existing Africa RISING GIS+ARBES data for Tanzania are used in this study. Relational databases have been constructed and a prototype app to test targeting has been developed. The testing dataset has been uploaded into Dataverse. A journal article is being drafted, with a target submission date the end of June 2022.

[4] Francis K. Muthoni, Zhe Guo, Mateete Bekunda, Haroon Sseguya, Fred Kizito, Fredrick Baijukia, Irmgard, Hoeschle-Zeledon, 2017. Sustainable recommendation domains for scaling agricultural technologies in Tanzania. Land use policy 66: 34-48.

Activity 5.1.7: *Conduct cost-benefit and gender analysis coupled with other socio-economic analyses to identify and quantify adoption constraints and opportunities for different farmer contexts*

Sub-activity 5.1.7.1: Socio-economic studies on cost/benefits of CA systems, labor, nutrition, and gender in target communities of Malawi and Zambia

5.1.7.1 is merged with sub-activity 5.1.1.1.

Sub-activity 5.1.7.2: Farmer application of SI principles in CA long-term trials in Malawi and Zambia, and Sub-activity 5.1.7.3: Socio-economic studies on nutritional benefits of SI practices

These are now presented as Case Studies under sub-activity 5.1.1.4.

Sub-activity 5.1.7.4: Assess the effect of tied ridging, residual tied ridging and rip tillage on maize productivity, net crop returns, household income, and food security

A summary of the study's progress was presented in the last report and an abstract of the conference paper "*The average and distributional impacts of soil and water conservation technologies on the welfare of smallholder farmers in Tanzania* (https://ageconsearch.umn.edu/record/314992)". A manuscript "*The income and food security impacts of soil and water conservation technologies in Tanzania"* adapted for journal publication was submitted to the *World Development Journal* and is currently under review.

Sub-activity 5.1.7.5: Determine the effect of the joint adoption of improved maize varieties and maize-legume rotation on maize productivity and crop incomes in Malawi

In Malawi, the Africa RISING project has been testing and promoting sustainable intensification practices (SIPs) to improve soil fertility, maize, and legume productivity, among others. However, estimating the returns from SIPs is dependent on the accurate measurement of production and cultivated plot size. In most cases, smallholder self-reported plot size and output are usually plagued with measurement errors, resulting in over or underestimating crop yields and incomes. The measurement error may be systematic and correlated with the adoption of SIPs (also correlated with the plot size), resulting in biased estimates of crop yields and incomes. Current studies have shown that measuring plots using Global Positioning Systems (GPS) and crop cuts for production can overcome some of these problems (Carletto et al., 2017[5]).

Using unique plot-level longitudinal survey data, this study examines the impact of adopting a combination of improved maize varieties, maize-legume intercropping, residue retention, and organic fertilizer on the total value of maize productivity (TVMP) in Malawi. Unlike most studies that use farmers' self-reported farm sizes and production, we use GPS measured plots and crop cuts to measure productivity, reducing errors with either under-or over-estimating productivity. Of particular interest in this study was the empirical examination of the relationships between temperatures (minimum and maximum), rainfall, and the adoption of SI practices.

In the April–Sept 2021 report, we presented a summary of findings based on the analysis of the data available then, and a manuscript was to have been submitted by February 2022. We, however, identified problems with the data and estimation procedures which have since been

[5] Carletto, C., Corral, P., Guelfi, A., 2017. Agricultural commercialization and nutrition revisited: Empirical evidence from three African countries. Food Policy, 67, 106–118

sorted. The results are currently being updated after obtaining additional data and modifying the analysis procedure. The new date for submitting the manuscript is June 2022.

Sub-activity 5.1.7.6: Determine Africa RISING research on household welfare and return on investment

Africa RISING ESA project has been testing, validating, and promoting improved SI technologies to sustainably increase agricultural productivity, food, and nutrition security and reduce poverty. Despite these achievements, rigorous impact evaluation has not been done to investigate the impact of these interventions on the return on investment (ROI) and household welfare. This study is vital in assessing whether changes in a particular outcome are due to AR project intervention and not to other factors. Secondly, research requires some substantial investments. Therefore, to justify funding for research, it is imperative to show the return on investment. A manuscript on the "*Impact of AR investments on ROI, productivity, food security, and poverty*" has been drafted in collaboration with ACDI-VOCA and is currently under review by co-authors, with a targeted submission date of May 2022. Some preliminary results were presented in the April–September 2021 report.

Output 5.2 *Strategic partnerships with public and private initiatives for the diffusion and adoption of research products*

Activity 5.2.1: *Map and assess relevant stakeholders to establish dialogue for the exploration of mutual synergies for scaling delivery of validated technologies*

Sub-activity 5.2.1.1: Engage able and willing partners to develop a strategy and implementation framework for scaling up intensification technologies in semi-arid ecologies of central Tanzania

To support scaling of technologies via improved seed, the project continued to work with DASPA and KFC-community based seed production and grain marketing associations whom we entered into MoU in2021. Breeder seed to support the production of foundation seed was procured and supplied to DASPA. The seed production initiative is guided by the seed roadmap developed in 2021 (Table 3).

Table 3. Seed roadmap for groundnut and pigeonpea seed production by DASPA for the next 3 years

			Year: Production in kg					
Seed class	**Crop type**	**Variety**	**Year 1: (2021/22) Breeder Seed input**	**hectarage**	**Year 2: Foundation seed production**	**hectarage**	**Year 3: Certified seed production**	**hectarage**
Breeder	Groundnut	Naliendele 2016	500	5	0	0	0	0
Foundation	Groundnut	Naliendele 2016	0	0	5000	50	0	0
Certified	Groundnut	Naliendele 2016	0	0	0	0	40000	400
			Seed multiplication rate: Breeder to foundation = 1:10. Foundation to certified= 1:8					
Breeder	Groundnut	Nach 15	50	0.5	0	0	0	0
Foundation	Groundnut	Nach 15	0	0	500	5	0	0
Certified 1	Groundnut	Nach 15	0	0	0	0	4000	40
			Seed multiplication rate: Breeder to foundation = 1:10. Foundation to certified = 1:8					
Breeder	Pigeon pea	Mali	50	5	0		0	
Foundation	Pigeon pea	Mali	0		7500	750	0	
Certified	Pigeon pea	Mali	0		0		112500	11250
			Seed multiplication rate: Breeder to foundation = 1:150. Foundation to certified = 1:150					
Breeder	Pigeon pea	Ilonga M2	50	5	0		0	
Foundation	Pigeon pea	Ilonga M2	0		5000	500	0	
Certified	Pigeon pea	Ilonga M2	0		0		5000	5000
			Seed multiplication rate: Breeder to foundation = 1:100. Foundation to certified = 1:100					

Notes: To reinforce seed production and sustainability, a three-year seed road map has been developed to guide DASPA operations. ICRISAT has provided the early generation (breeder) seed to be used for this purpose. The focus crops are two groundnut two varieties (Naliendele 2016 and Nach 2016) and two Pigeonpea varieties (Mali and Ilonga M2). It is projected that in the next 3 years that 44,000 kg and 117,500 kg of groundnut and pigeonpea improved seed will be produced from an estimated 440 ha and 16,250 ha, respectively. The multiplication rate of groundnut is 1: 10 and 1: 150 for pigeon pea.

Sub-activity 5.2.1.2: Summary of other partner engagements

- CIAT is still working in partnership with private institutions SEED-CO, Dekalb Seed Company, and Minjingu Fertilizer Company. These companies contributed some inputs to be used in the demos and would later be involved during farmer field days. Tanzania Agricultural Research Institute - Selian and Babati District Council are our key national contacts expected to scale-out technologies and knowledge generated during and beyond the Africa RISING project period.
- CIMMYT has maintained a partnership with most organizations previously involved with the work (ZARI, TLC, Governmental extension services in Malawi and Zambia) and continues the alliance with the Sustainable Intensification for Smallholder Farmers in Zambia (SIFAZ) project led by FAO. The implementers are CIMMYT, the Ministry of Agriculture, the Africa SOIL project, and the University of Edinburgh. Monitoring visits and field tours in Zambia this year have been conducted jointly (Figure 7). The SIFAZ project has maintained six additional target communities (40 mother trials and 1000 baby trials) in Eastern Zambia, which follows similar research ideas and the successes and experiences gained through Africa RISING.
- The NORAD-funded ACASA project jointly implemented by IITA and CIMMYT has conducted further socio-economic research on CA systems in Malawi and Zambia and will add new insights on the research questions on why CA systems, although so beneficial, are not widely adopted.



Figure 7. Joint annual field and study tour between Africa RISING and SIFAZ projects in Hoya, Eastern Zambia. Photo credit: Christian Thierfelder/CIMMYT.

- TARI Hombolo continued to collaborate with LEAD Foundation to roll out Fanya juu/chini terraces in two districts (Manyoni and Ikungi) of Singida Region, Tanzania.
- Africa RISING has continued its partnership with the Kilimo Endelevu project of Iles de Paix (IDP) to scale best bet technologies in Karatu. Other partners include Mtandao wa Vikundi vya Wakulima Tanzania (MVIWATA) and Research Community and Organizational Development Associates (RECODA).
- WorldVeg has linkages with the Mboga na Matunda (MnM) project and TAHA in Zanzibar and Arusha, respectively. These projects have benefited from nutrition materials and scaling technologies validated during Africa RISING Phase 1 in Zanzibar.

Activity 5.2.2: *Leverage/link and integrate (engagement and outreach) with existing initiatives, including Government extension systems, to support and encourage the delivery pathways*

Sub-activity 5.2.2.1: Engage with seed companies to accelerate QPM seed scaling in Tanzania

In the last report, we presented two new developments that have delayed the implementation of national performance trials (NPTs). They are (i) a change of procedure for seed companies to access new breeding products and (ii) access new products by seed companies through the institutional (CIMMYT's Product Allocation Committee - PAC) stage-gate process rather than through the researcher. The PI left the CIMMYT office in Nairobi after handing over to the PAC.

The update we have received from CIMMYT Nairobi is that some of the Africa RISING hybrids can be presented to the Director as a special case for consideration, specifically for Tanzania. What is required is:

1. A list of the hybrids (should not be more than two to have a chance during the discussion with the Director)
2. The performance data for the Kongwa and Kiteto sites where they were tested
3. A list of the interested seed companies

The PI, even after transfer to ICRISAT Zimbabwe, has agreed to provide the information.

Sub-activity 5.2.2.2: Support the Ministry of Agriculture and NGO Extension in scaling CA-systems in Eastern Zambia and Malawi

Africa RISING research partner CIMMYT has maintained working relationships with most scaling organizations over time (ZARI, TLC, CRS, and Governmental extension services in Malawi and Zambia). Due to the late onset of rains, some promotional and scaling activities have shifted from March to April and will be reported on in the next report. However, some of the field days have already happened in Southern Malawi and Eastern Zambia. A complete list of events and participating farmers will be provided in the next Report.

All trial sites were visited during the annual field and study tours in February 2022. Sister projects and their personnel joined us in Zambia (here we collaborate with the EU -funded SIFAZ project) and in southern Malawi (here we collaborate with the Africa SOIL project). These joined tours help us expose more extension personnel to the trial locations, their objectives, and technologies. As a very interesting development, there is a Technology Release Team now active in Zambia and they commented on technologies that we have been promoting and trialing in Eastern Zambia. Some of these technologies have truly advanced and have been mainstreamed

in the Zambian agriculture system. In that sense, Africa RISING has supported the institutionalization of technologies.

We have initiated the development of a farmer guide for technology extension for farmers in Malawi, building on an existing Farmer Manual for Zambia. The aim is to leave behind legacy products for further use by the farming communities after Africa RISING has ended.

Sub-activity 5.2.2.3: Support to CRS in scaling and marketing GMCC and grain legume intercropping strategies, and sub-activity 5.2.24: Support to Total LandCare in scaling CA systems in Malawi

These were merged with and are reported under sub-activity 5.2.2.2

Sub-activity 5.2.2.5: Partnership with Islands of Peace for increasing the adoption of postharvest products

As reported before, the backstopping support by Africa RISING ended during 2020 with resounding success and the IoP was to continue scaling the postharvest technologies on their own, having gained confidence in their scaling capacity.

Sub-activity 5.2.2.6: Partnership with Islands of Peace for increasing the adoption of good agricultural practices in vegetable production and improved nutrition

This sub-activity is largely on building capacity for the implementing staff of the IoP consortium. Africa RISING is partnering with the Kilimo Endelevu Project of IoP to scale best bet technologies in Karatu. Other partners are Mtandao wa Vikundi vya Wakulima Tanzania (MVIWATA) and Research Community and Organizational Development Associates (RECODA).

On 25 October 2021, Africa RISING participated in the final evaluation of the Kilimo Endelevu program in Karatu District, where the evaluation findings were shared. The research/scaling partnership was highlighted, and its continuity emphasized.

Africa RISING co-organized a local seed and food fair with IoP partners in Karatu from 25 to 27 November 2021, attended by more than 700 people. A report can be found at https://africa-rising-wiki.net/KaratuSeedFair2021. Suggestions for follow-up were that researchers should (i) develop a mechanism to monitor and backstop the application of technologies learned from the event by farmers and (ii) document good practices demonstrated by farmers (success stories) capacitated through Africa RISING and IoP initiatives.

Sub-activity 5.2.2.7: Partnership with LEAD Foundation to take to scale soil and water management technologies in erosion-prone areas of Central Tanzania

The partnership between Africa RISING and LEAD Foundation has continued to bear fruits. During this reporting period, (i) Twenty demonstrations were installed with Fanya juu/chini terraces, (ii) 7ha of land owned by champion farmers were installed with Fanya juu/chini terraces and this work is still in progress (Figures 8 & 9), and (iii) District Agriculture Irrigation and Cooperative Officers (DAICOs) were consulted in respect of their training on the application of Fanya juu/chini technologies, and periods agreed for the training were April and May 2022.



Figure 8. Facilitators from Africa RISING and LEAD Foundation pose for a group photo after installing Fanya chini terraces, being first defense terrace, on a lead farmer's (Amandus Fredrick Mbua) land in Ikungi District. Photo credit: Eliehema Swai/TARI.



Figure 9. A lead farmer (Mohamed Shabani Selemani) at Ighuka village, Ikunga District, standing in his field installed with Fanya juu terrace. Photo credit: Eliehema Swai/TARI.

Output 5.3 *Gender-sensitive decision support tools for farmers to assess technology-associated risk and opportunities used by partners*

Activity 5.3.1: *Identify and communicate gender-sensitive decision support technologies in the context of different farm typologies*

Sub-activity 5.3.1.1: Gender implications of the introduction of soil and water conservation technologies in the semi-arid Kongwa and Kiteto districts of Tanzania

Research on gender dynamics related to the rip tillage technology in Kiteto district (Tanzania) included two MA students from the University of Dodoma (UDOM). Both students submitted their final theses with research results at the end of 2021. One student graduated and submitted her thesis to IITA (abstract below), while the second student was instructed by his evaluators to make further amendments before resubmission. The title of the thesis to be revised is *"Evaluating soil and water conservation with a gender lens: a case of maize rip tillage in Kiteto district, Manyara, Tanzania*."

Completed thesis

Student: Zamaradi Said Islahi

Title: Understanding gender dynamics of mechanization: the case of rip tillage in Kiteto district of Manyara Region, Tanzania

Abstract

The study examined the gender dynamics of agricultural mechanization drawing its references from the rip-tillage technology in Kiteto District of Manyara Region in Tanzania. It specifically explored gendered access to the implements necessary for rip-tillage (tractor and other tillage implements), the interaction between rip-tillage technology and a gendered division of labor at the household level in addressing the labor-intensive demands in the field of agriculture, the interaction between the adoption of the rip-tillage technology and gendered income decision-making. At the community level, the study explored men's and women's perceptions of collective actions. A mixed-research approach was applied with a sample of 40 participants, who included 24 men and 16 women. Data were collected through Focus Group Discussions, Matrix Scoring and Documentary Review. Thematic Coding Approach was used to analyze the qualitative data analysis as suggested by Terre Blanche, Durrheim and Painter (2006). The analysis revealed that most men-headed households positioned men to access information, training, and technology on the rip tillage first. However, in the female-headed households, women were the first to access the same. The introduction of rip-tillage technologies did not completely address labor demand in farming since manual labor is still required in various stages of farming. Women appeared to provide most of the labor compared to men and their gender-biological role overlap with farming responsibilities. Further, temporary migration affected labor availability where the workload falls on women. Children are also engaged in farming activities to support household members. It was found that in the Male Headed Household, the income from maize is controlled by men or joint decisions, while the income from residues was solely under men. In Female Headed Household (FHHs), the income decisions on both maize and residues are solely made by women. Both men and women participated in group use of one rip-tillage driven tractor and group farming practices in the demonstration farm's set-up. Farmers perceived collective work as a good practice since it simplified their work but was challenging during weeding time as many prioritized their farms over others. Farmers in Njoro were perceived to be marginalized, while women in Kiperesa were believed to be less prioritized in receiving rip-tillage service. Therefore, it is concluded that unclear mechanisms to address

gendered access to technology and lack of gender awareness among farmers hindered equal chances of men and women benefiting from the introduction of rip tillage technology. It is recommended that research institutions consider well-established gender-responsive mechanisms for information sharing, and technical support, including training, and ensure the availability of affordable technology and services to provide meaningful support to the agriculture sector.

Sub-activity 5.3.1.2: Role of gender from farm-to-fork and grain markets of legumes and dryland cereals in Kiteto and Kongwa

The main output of this sub-activity is a thesis with the working title *"Women empowerment and impact on maternal and child nutrition outcomes."* The thesis write-up has not progressed because the student's continued illness caused her discontinuation. However, data were analyzed and the drafting of the manuscript is underway. Additional data was collected (August-September 2021) and will be combined with previous data sets to strengthen the gender empowerment and nutrition components of the manuscript, "*Gender empowerment and associations with maternal and child nutrition outcomes in rural Tanzanian households*.. We target to submit the manuscript to a journal by June 2022.

Sub-activity 5.3.1.3: Identify and communicate gender-sensitive decision support tools in the context of different farm typologies

Technology testing in Malawi and Tanzania has been accompanied by gender evaluations based on the Sustainable Intensification Assessment Framework (SIAF). However, an important question has not yet sufficiently been addressed, namely how household decision-making and technology adoption interact. Output 5.3 (Activity 5.3.1) in the logframe for Africa RISING East and Southern Africa stipulates an investigation of this question with an action research approach. The research combines elements from household methodologies (Gender Action Learning System, GALS) with farmer exchange visits. The technological focus is on soil and water conservation technologies and legume-maize integration. During this reporting period, the following have been implemented:

1. Data collection for both Tanzania and Malawi took place between November 2021 and March 2022. This included two three-day workshops with men and women farmers in Ntcheu/Malawi and Kongwa/Tanzania and evaluation workshops with the research teams in both countries.
2. All data (qualitative and quantitative) have been processed (transcribed, entered, cleaned) and are ready for analysis and write-up. Submission of the manuscript is scheduled for June 2022.
3. Household methodology manuals titled *Integrated socio-technological decision-support tools for Malawi and Tanzania* have been tested and revised and are almost complete (last round of revisions is pending).

Output 5.4: *A technology adoption, monitoring, evaluation, and learning framework for use by the project team and scaling partners released [led by IFPRI and used by project partners]*

Activity 5.4.1: *Monitor and modify the progress of technology adoption process towards scaling*

Sub-activity 5.4.1.1: Populate the Beneficiary and Technology Tracking Tool (BTTT) Tanzania, Malawi, and Zambia with information about AR technologies applied, and farmers/households engaged in validating the technologies

During this reporting period, the population of the Beneficiary and Technology Tracking Tool (BTTT) with information about project technologies applied, and farmers/households engaged in validating the technologies (direct beneficiaries) in Zambia was completed. The list of all 1000 farmers that were not updated in Zambia is now in the BTTT. The number remains at 2287, being 104% of the target. This activity was already completed for Tanzania and Malawi (Dropbox (IFPRI)\AR BTTT & FtF Data- shared M&E officers\M&E Tools\BTTT\UPDATED-2022)).

Sub-activity 5.4.1.2: Populate the technology scaling tool with detailed information on scaling data for Tanzania, Malawi, and Zambia

The results of this activity will be presented in the next report.

Sub-activity 5.4.1.3: Design simple research a rack-up database and populate it with research rack up data for Tanzania, Malawi, and Zambia)

Research rack-up data compiled from researchers was reviewed, verified, and compiled for entry into USAID web-based research rack-up database. A total of 42 technologies were entered for this reporting period; 17 were categorized as plant and animal improvement research, 19 as production systems research, and six as social science research.

Sub-activity 5.4.1.4: Conduct data quality assessment (DQA) to verify the number of direct beneficiaries reported against those verified in source data for the selected sites

This activity was suspended due to COVID travel restrictions during 2020/2021 and discontinued for 2021/2022.

Sub-activity 5.4.1.5: Provide additional capacity building to and work with ESA research partners to ensure timely (and complete) submission of FTF indicators data for FY 2021, research rack-up data, country narratives, IM performance narratives, compliance with the AR Data Management Plan

The M&E officer continued to work with researchers to ensure quality submission of FtF indicator data, IM activity performance narratives, research rack-up data, and datasets onto Dataverse. A guide provided to AR scientists assisted them in reducing the gaps encountered during the submission of FY 2020 data. By 12th November 2021, all required data on FtF, activity performance narratives, and research data had been compiled and entered into the USAID's Development Information Solution (DIS) and Dataverse platforms.

Capacity building

Table 4. Short- and long-term training and field days offered during October 2019–March 2020.

Subject of training/Field Day	Lead institution	Venue	Dates	Participant Category	Number of participants	Percentage of women
Short-term training and Field days						
Mbili-Mbili integrated system demonstrations	CIAT	Babati District, Tanzania	09 Dec 2021 – 25 Feb 2022	17 Farmer groups	275	45
Local seed and food fair	WorldVeg & IoP	Karatu District, Tanzania	25-27 Nov 2021	>700 variable stakeholders	> 50	51
Graduate training						
Graduate internship in GIS	IITA	IITA Arusha	November 2020 to September 2021	Graduate Intern, (Francis Msangi)	1	0
Graduate Research (MSc)	University of Bonn	University of Bonn	July 21 to March 2022	MSc. Graduate Research Fellow (Robin Cramer)	1	0
Undergraduate Industrial attachment (BSc. Geoinformatics)	ARDHI University Tanzania	IITA Arusha	14/09/2021 to 20/11/2021	Internship (Jovin Vicent)	1	0
Undergraduate Industrial attachment (BSc. Geoinformatics)	ARDHI University Tanzania	IITA Arusha	14/09/2021 to 20/11/2021	Internship (Darren Mbaga – ARDHI University Tanzania)	1	0
Cases studies expanded framework	MSU/LUANAR	LUANAR	November 2020; ongoing	MSc, Chifuniro Kalawang'oma	1	0

Subject of training/Field Day	Lead institution	Venue	Dates	Participant Category	Number of participants	Percentage of women
Graduate internship - GIS	IITA	Arusha	November 2020 to June 2022	Francis Msangi	1	0
Case studies: Application of SI technologies among farmers	CIMMYT, MSU	LUANAR University of Zimbabwe	November 2019 to August 2020; Granted extension	MSc students, Isaac Mavhiko and Tinashe Taringa, Chifunilo	3	33
Gender analysis of RT technology	IITA	University of Dodoma	2019 to 2021	MA students, Julius Anatory and Zamaradi Said	2	50
Profitability of *Gliricidia*-based cropping system	ICRAF/IITA	Sokoine University of Agriculture	October 2019 to June 2022	PhD student, Martha Swamila	1	100
Modelling cooking-related demand and on-farm supply of fuelwood	ICRAF	Humboldt University	October 2020 to December 2021	PhD student, Johaness Hafner	1	0
Agronomy	CIAT	Kenyatta University	2019 to 2022	PhD student, Michael Kinyua	1	100
Holistic impact assessment of project promoted sustainable intensification technologies - Tanzania	WUR	WUR	2021-2022	MSc student, Sergi Domenech-Carbo	1	0
Holistic impact assessment of project promoted sustainable intensification technologies - Malawi	WUR	WUR	2021-2022	MSc student, Alessandra Cossu	1	100

Table 5. Short-term capacity building activities led by CIMMYT in Malawi and Zambia

SUMMARY OF TRAININGS, MEETINGS, FIELD DAYS AND ROAD SHOWS 2021/22 SEASON

Id. No.	Title of Training/Meeting	Country	Venue	Date (s)	Trainee Category	Men	Women	Total	% Women
1	Conducting preparatory meeting to plan for the 2021/22 season	Malawi	Machinga ADD	14.10.2021	Staff	8	4	12	33
2	Conduct protocol and datasheets review meeting	Malawi	Machinga ADD	20.10.2021	Staff	8	4	9	44
3	Conducting preparatory meeting to plan for the 2021/22 season	Malawi	Lemu	25.10.2021	Farmers	4	2	6	33
4	Conducting preparatory meeting to plan for the 2021/22 season	Malawi	Herbert	26.10.2021	Farmers	7	11	18	61
5	Conducting preparatory meeting to plan for the 2021/22 season	Malawi	Malula	27.10.2021	Farmers	4	2	6	33
6	Conducting preparatory meeting to plan for the 2021/22 season	Malawi	Matandika	28.10.2021	Farmers	3	3	6	50
7	Conducting preparatory meeting to plan for the 2021/22 season	Malawi	Songani	28.10.2021	Farmers	0	6	6	100
8	Conduct early & mid season evaluations	Malawi	Lemu	24.01.2022	Farmers	16	31	47	66
9	Conduct early & mid season evaluations	Malawi	Malula	25.01.2022	Farmers	12	22	34	65
10	Conduct early & mid season evaluations	Malawi	Herbert	26.01.2022	Farmers	28	19	47	40
11	Conduct early & mid season evaluations	Malawi	Matandika	26.01.2022	Farmers	14	33	47	70
12	Conduct early & mid season evaluations	Malawi	Songani	08.02.2022	Farmers	20	30	50	60
13	Conduct Late season evaluations	Malawi	Lemu	07.03.2022	Farmers	53	121	174	70
14	Conduct Late season evaluations	Malawi	Malula	07.03.2022	Farmers	62	88	150	59
15	Conduct Late season evaluations	Malawi	Herbert	08.03.2022	Farmers	76	93	169	55
16	Conduct Late season evaluations	Malawi	Matandika	09.03.2022	Farmers	87	122	209	58
17	Conduct Late season evaluations	Malawi	Songani	10.03.2022	Farmers	74	86	160	54
18	Conduct Field days	Malawi	Songani	26.03.2022	Farmers	72	118	190	62
19	Conduct Field days	Malawi	Matandika	22.03.2022	Farmers	49	73	122	60
20	Conduct Field days	Malawi	Lemu	25.03.2022	Farmers	67	72	139	52
21	Conduct Field days	Malawi	Herbert	24.03.2022	Farmers	68	101	169	60
22	Conduct Field days	Malawi	Malula	23.03.2022	Farmers	73	116	189	61
23	Conduct Field days in babies	Malawi	Malula Babies	28.03.2022	Farmers	260	377	637	59
24	Conduct Field days in babies	Malawi	Herbert Babies	29.03.2022	Farmers	275	396	671	59
25	Conduct Field days in babies	Malawi	Lemu Babies	30.03.2022	Farmers	384	429	813	53
26	Conduct roadshows	Malawi	Balaka	31.03.2022	Community/Farme	454	704	1158	61

27	Conduct roadshows	Malawi	Machinga	01.04.2022	Community/Farme	460	648	1108	58
28	Conduct roadshows	Malawi	Zomba	04.04.2022	Community/Farme	446	750	1196	63
29	Conducting preparatory meeting to plan for the	Zambia	Chanje	05.11.2022	Farmers	6	4	10	40
30	Conducting preparatory meeting to plan for the	Zambia	Hoya	15.11.2021	Farmers	5	1	6	17
31	Conducting preparatory meeting to plan for the	Zambia	Kapara	14.10.2021	Farmers	8	4	12	33
32	Conducting preparatory meeting to plan for the	Zambia	Kawalala	13.11.2021	Farmers	7	8	15	53
33	Conducting preparatory meeting to plan for the	Zambia	Mtaya	04.11.2021	Farmers	4	3	7	43
34	Conducting preparatory meeting to plan for the	Zambia	Vuu	18.12.2021	Farmers	84	40	124	32
35	Conducting Early season evaluation for the 2021/22	Zambia	Chanje	04.02.2022	Farmers	14	13	27	48
36	Conducting Early season evaluation for the 2021/22	Zambia	Hoya	09.02.2022	Farmers	7	10	17	59
37	Conducting Early season evaluation for the 2021/22	Zambia	Kapara	27.01.2022	Farmers	12	18	30	60
38	Conducting Early season evaluation for the 2021/22	Zambia	Kawalala	25.01.2022	Farmers	8	13	21	62
39	Conducting Early season evaluation for the 2021/22	Zambia	Mtaya	22.01.2022	Farmers	6	6	12	50
40	Conducting Early season evaluation for the 2021/22	Zambia	Vuu	27.01.2022	Farmers	15	7	22	32
41	Conducting Mid season evaluation for the 2021/22	Zambia	Chanje	07.03.2022	Farmers	14	21	35	60
42	Conducting Mid season evaluation for the 2021/22	Zambia	Kapara	10.02.2022	Farmers	17	18	35	51
43	Conducting Mid season evaluation for the 2021/22	Zambia	Kawalala	21.02.2022	Farmers	8	13	21	62
44	Conducting Mid season evaluation for the 2021/22	Zambia	Mtaya	24.03.2022	Farmers	4	8	12	67
45	Conducting Mid season evaluation for the 2021/22	Zambia	Vuu	02.03.2022	Farmers	28	6	34	18
46	Conducting Fied day for the 2021/22 season	Zambia	Kawalala	31.03.2022	Farmers	34	30	64	47
47	Conducting Fied day for the 2021/22 season	Zambia	Mtaya	06.04.2022	Farmers	19	21	40	53
48	Conducting Fied day for the 2021/22 season	Zambia	Vuu	29.03.2022	Farmers	431	494	925	53
	TOTALS					3815	5199	9011	58

Challenges and actions taken

1. For *Mbili-Mbili* technology trials in Babati district of Tanzania, shifts in dates for the normal rainfall onset were a major challenge encountered during this season. This had adverse effects on the bean crop, which was affected by high rainfall in March resulting in high yield losses. However, farmers were able to identify the potential of Mbili-Mbili and its capability to cushion total legume losses, considering the presence of pigeonpea as a second legume.
2. The late onset of rains also happened in Malawi and Zambia. This has caused delays in conducting field days, evaluation meetings, roadshows, and other promotional work; these will be implemented and reported in the next report.
3. Capacity building for farmer groups was affected by land ownership. Farmer groups did not have their own group fields so members had to select a farmer who would host the demos. Considering that the selected fields would only be used as learning sites by group members, their full involvement in running all activities was limited. To achieve our objective, we encouraged group members to ensure they devote some good time to learning within the demos and, if possible, replicate the lessons in their own fields.

Communications and knowledge sharing

The main communication channels supported during the reporting period were:

- Wiki internal workspace: http://africa-rising-wiki.net/Program
- Project updates on the program website: https://africa-rising.net/
- A Yammer network with internal updates
- Photos: https://www.flickr.com/photos/africa-rising/
- Repository: https://cgspace.cgiar.org/handle/10568/16501

The stories listed below were published and disseminated to stakeholders concerning project activities and outputs.

- Tanzania's agriculture minister lauds achievements of five-year technology scaling program backstopped by Africa RISING (18 January 2022)
- Francis Muthoni talks to Radio IITA about the value of applying GIS tools in agricultural research (22 November 2021)
- Animal Traction-Based Conservation Agriculture Offers Multiple Benefits for Smallholder Farmers in Zambia (17 November 2021)
- Africa RISING ESA partners make plans to shore up project's sustainable intensification legacy at 10th review and planning meeting (17 November 2021)
- Africa RISING–Islands of Peace partnership: A portrait of success from a Tanzanian smallholder's point of view (2 November 2021)
- BRIEF FOCUS: Animal traction-based maize–legume conservation agriculture (27 October 2021)

The following meetings and events were held during the reporting period. The communications team supported some of these meetings and events through materials preparation, facilitation etc.

- 8 April: Brainstorm meeting for AR End-of-Program event
- 25-27 November 2021:Karatu Local seed and Food Fair - Karatu, Tanzania
- 8 November 2021:ESA Project partners update meeting - virtual via MS TEAMS
- 8 October: PCT organized interactions between select Global and Regional Initiatives and the SI-MFS Initiative
- 7 October 2021: ESA Project partners update meeting - virtual via MS TEAMS

Selected reports and publications

The following peer reviewed journal articles and reports were published by the project team during this period.

Peer reviewed journal articles

The following peer reviewed journal articles and reports were published by the project team during this period.

- Mhlanga, B., Pellegrino, E., Thierfelder, C. and Ercoli, L. 2022. Conservation agriculture practices drive maize yield by regulating soil nutrient availability, arbuscular mycorrhizas, and plant nutrient uptake. Field Crops Research 277: 108403
- Swamila, M., Philip, D., Akyoo, M., Manda, J., Mwinuka, L., Smethurst, P., Sieber, S. and Kimaro, A. 2022. Profitability of Gliricidia-maize system in selected dryland areas of Dodoma Region, Tanzania. Sustainability 14:53.
- Thierfelder, C. and Mhlanga, B. 2022. Short-term yield gains or long-term sustainability? – a synthesis of Conservation Agriculture long-term experiments in Southern Africa. Agriculture, Ecosystems & Environment. 326: 107812
- Peter, B.G., Messina, J.P., Carroll, J.W. and Chikowo, R. 2021. A case for green-based vegetation indices: Plot-scale sUAS imagery related to crop chlorophyll content on smallholder maize farms in Malawi. Remote Sensing Letters 12(8):778-787.
- Thierfelder, C., Paterson, E., Mwafulirwa, L., Daniell, T., Cairns, J., Mhlanga, B. and Baggs, E. 2021. Toward greater sustainability: How investing in soil health may enhance maize productivity in Southern Africa. Renewable Agriculture and Food Systems
- Giller, K.E., Delaune, T., Silva, J.V. et al. 2021. Small farms and development in sub-Saharan Africa: Farming for food, for income or for lack of better options?. Food Security 13: 1431–1454
- Burke, J.W, and Jayne, T.S. 2021. Disparate access to quality land and fertilizers explain Malawi's gender yield gap. Food Policy 100
- Chikowo, R., Olwande, J., Wanzala, M., Lubungu, M., Ngoma, H., and Sanchez, P. 2021. Opportunities for Building Resilience of African Farming Systems. IN: AGRA. (2021). Africa Agriculture Status Report. A Decade of Action: Building Sustainable and Resilient Food Systems in Africa (Issue 9). Nairobi, Kenya: Alliance for a Green Revolution in Africa (AGRA)
- Nkhata, W., Shimelis, H. and Chirwa, R. 2021. Productivity of newly released common bean (Phaseolus vulgaris L.) varieties under sole cropping and intercropping with maize (Zea mays L.). Frontiers in Sustainable Food Systems 5:741177.

Reports, training material, and briefs

- Manda, J.,Tufa,A., Mutungi, C., Alene, A., Manyong, V. and Abdoulaye, T. 2022. Eliciting willingness to pay for quality maize and beans: Evidence from experimental auctions in Tanzania. Poster prepared for the IITA Social Science Group Virtual Meeting, 7 December 2021. Ibadan, Nigeria: IITA.
- IITA. 2021. Africa Research in Sustainable Intensification for the Next Generation: Sustainable intensification of key farming systems in East and Southern Africa: Technical report, 1 April 2021 – 30 September 2021. Ibadan, Nigeria; IITA.

- Thierfelder, Christian. 2021. Animal Traction-Based Conservation Agriculture Offers Multiple Benefits for Smallholder Farmers in Zambia. Blog Post. Washington DC: Agrilinks.
- Joseph JE, Rao KPC, Ngwira AR, Swai E, Rötter RP, Whitbread AM. 2021. Analysis of rainfall variability and trends for better climate risk management in the major agro-ecological zones in Tanzania. CCAFS Working Paper no. 363. Wageningen, the Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)