Improved postharvest technologies for promoting food storage, processing, and household nutrition in Tanzania

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

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

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

Introduction

In developing countries, lack of appropriate grain storage technologies leads up to 20-30% losses, particularly due to postharvest pests. As a result, smallholder farmers end up selling their grain soon after harvest, only to buy it back at an expensive price just a few months after harvest, falling in a poverty trap. The potential impact on poverty reduction and greater livelihood security will not be realized if farmers are unable to store grains and sell surplus production at attractive prices. Postharvest losses, also have an impact on environmental degradation and climate change as land, water, human labor and non-renewable resources such as fertilizer and energy are used to produce, process, handle and transport food that no one consumes. Apart from causing quantitative losses, pests in stored grain are also linked to aflatoxin contamination and poisoning.

Agricultural intensification projects aim at identifying best practices and innovative arrangements for increasing agricultural productivity in ways that improve income and nutrition of farm households. However, an increase in land productivity without corresponding increases in storage, processing and preparation of nutritious foods from the excess harvest may heighten postharvest losses at a greater magnitude than 40%. Therefore, there is debate whether or not agricultural intensification will improve or worsen food insecurity and poverty of households who lack the capacity to preserve excess production; majority of smallholder are in this category. A possible higher cost of intensification and less revenue caused by higher postharvest losses may further aggravate poverty. Hence, improving the capacity of smallholders' to process and store farm outputs and also produce nutrient-dense foods for household consumption is a precondition for reducing poverty, hunger and malnutrition among intensifying farming communities.

This report focuses on adding value to Africa RISING through knowledge and institutional innovations that increase food and nutritional security of the poor and vulnerable groups in FTF sites. The approach included developing the value chains for priority crops within a diverse farming system by enhancing the rural agro-processing sector and building the capacity of farmers, mostly women, to produce nutritious food for home consumption and for the market.

Purpose

The purpose of the project was to test new approaches for reducing postharvest losses of food, improve food security and increase nutritional value of food crops in an intensifying maize-based farming system of Tanzania.

Objectives:

1. Improve scientific knowledge for developing strategies that will expand agro-processing sector
2. Improve post-harvest storage and food processing knowledge of households
3. Create awareness on postharvest loss reducing technologies among stakeholders

Outputs:

1. Factors that contribute to high postharvest losses and general food insecurity in project areas understood and strategies for expanding agro-processing sector suggested.
2. Appropriate post-harvest handling technologies and processing techniques demonstrated and promoted
3. Awareness created and information on postharvest technologies generated and disseminated, networking among stakeholders created

Partners:

1. Dr. Abass Adebayo, Food Technologist (IITA) – Coordination;
2. Dr. Tadele Tefera, Postharvest Entomologist (CIMMYT)-Coordinator
3. Dr. Peter Mamiro, Food Scientist (Sokoine University of Agriculture) -. Data analysis and writing of technical reports;
4. Mr. Bamidele Alenkhe, Agro-processing Engineer (IITA) – Machine design;
5. Dr Gabriel Tito Ndunguru, Food Scientist (True Foods) – Project consultant: Field research activities, technology demonstration and training of farmers.
6. Dr Peter Matowo, Agronomist, Selian Agricultural Research Institute (SARI), Arusha, Field data collection, demonstration of grain storage technology.
7. Mr Charles Makalanga, entomologist, SARI- Framers selection, setting up demos

Implementation strategy

NARS partners (see above) were identified based on their experiences and capacity in postharvest project implementation. The project objectives explained to the partners; roles and responsibilities of partners defined and research agreements were signed between partners and IITA and CIMMYT. In this exercise, meetings were held with local partners, including the national research programs and universities; the local partners identified target communities and intervention plan was jointly designed. Best-bet intervention technologies were identified, and tested with farmers. In general, the project objectives were guided and technically supported by CIMMYT and IITA research teams; whilst local implementation was executed by local partners.

Achievements against plan

Objective 1: Improve scientific knowledge for developing strategies that will expand agro-processing sector

Output 1: Factors that contribute to high postharvest losses and general food insecurity in project areas understood and strategies for expanding agro- processing sector suggested.

Postharvest loss assessment study to establish the factors that contribute to high postharvest losses *(100% achievement)*: The study was done through focus group discussions and household interviews in 14 villages of Dodoma region (Kondoa district), Kilimanjaro region (Hai, Siha and Moshi districts), Manyara region (Babati and Mbulu districts) and Arusha region (Arusha, Meru, Karatu, and Monduli districts) in order to identify factors contributing to high postharvest losses of food. Two hundred and seventy individuals were interviewed during the group focus discussion and 633 households were interviewed. Data from the field was analysed and draft report is available. Maize postharvest losses due to storage pests appeared very high (over 25%).

Post-harvest losses were viewed by the respondents as being caused by bad weather which checked the final harvest of the crop. Insect pests, rotting by fungus, termites, rodents, wild animals, theft and birds including chicken were observed by most respondents (Fig1). Losses in storage were accelerated by late preparation of storage structures, late harvesting, poor storage facilities, storage bags with very low life span from the market, the bags are also easily punctured by rats. These problems led to most farmers disposing their products early which succumbed to being paid low uneconomical prices.

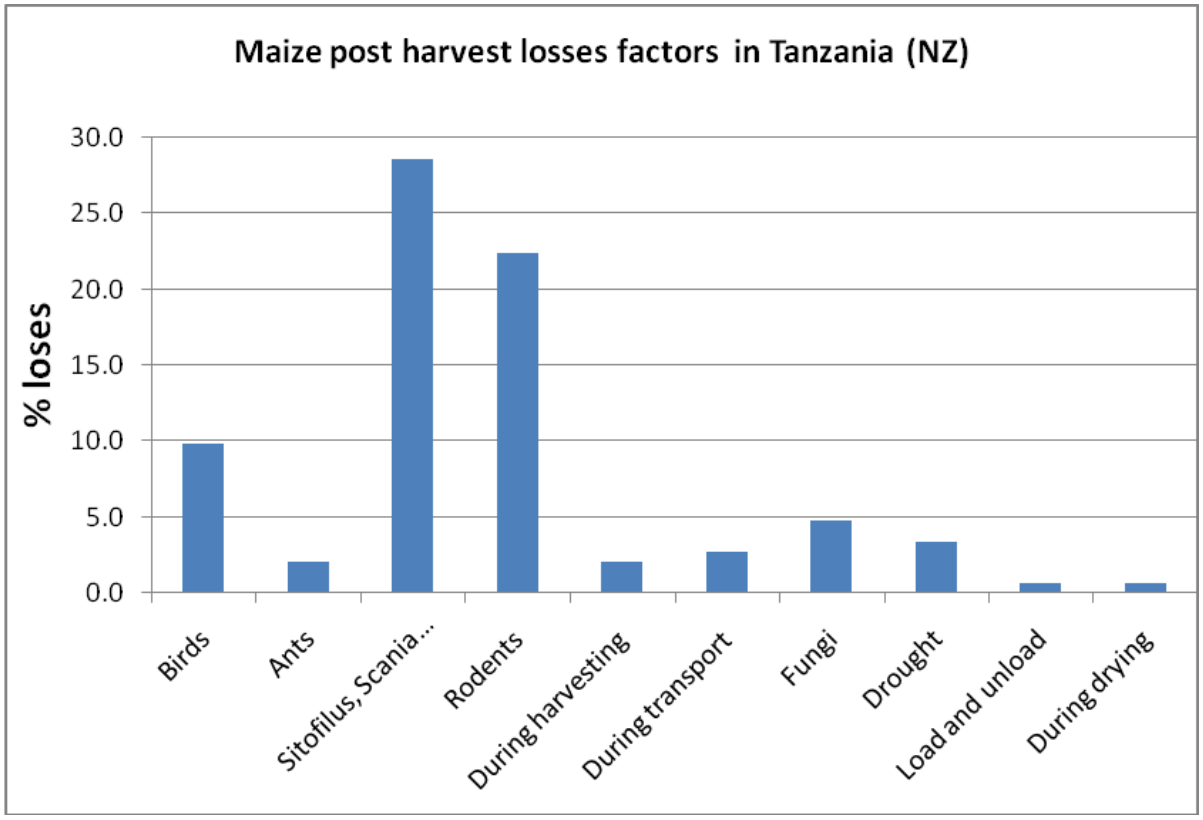


Fig 1. Maize postharvest losses in Tanzania.

Postharvest losses by insects are as indicated in Figure 2 below . The highest losses of 0-20% were reported in Dodoma, followed by Arusha, Kilmanjaro and Manyara while in 20-40% region were reported in Kilimanjaro followed by Arusha and Dodoma.

Postharvest losses by insects are as indicated in Figure 2 . The highest losses of 0-20% were reported in Dodoma, followed by Arusha, Kilmanjaro and Manyara while in 20-40% region were reported in Kilimanjaro followed by Arusha and Dodoma.

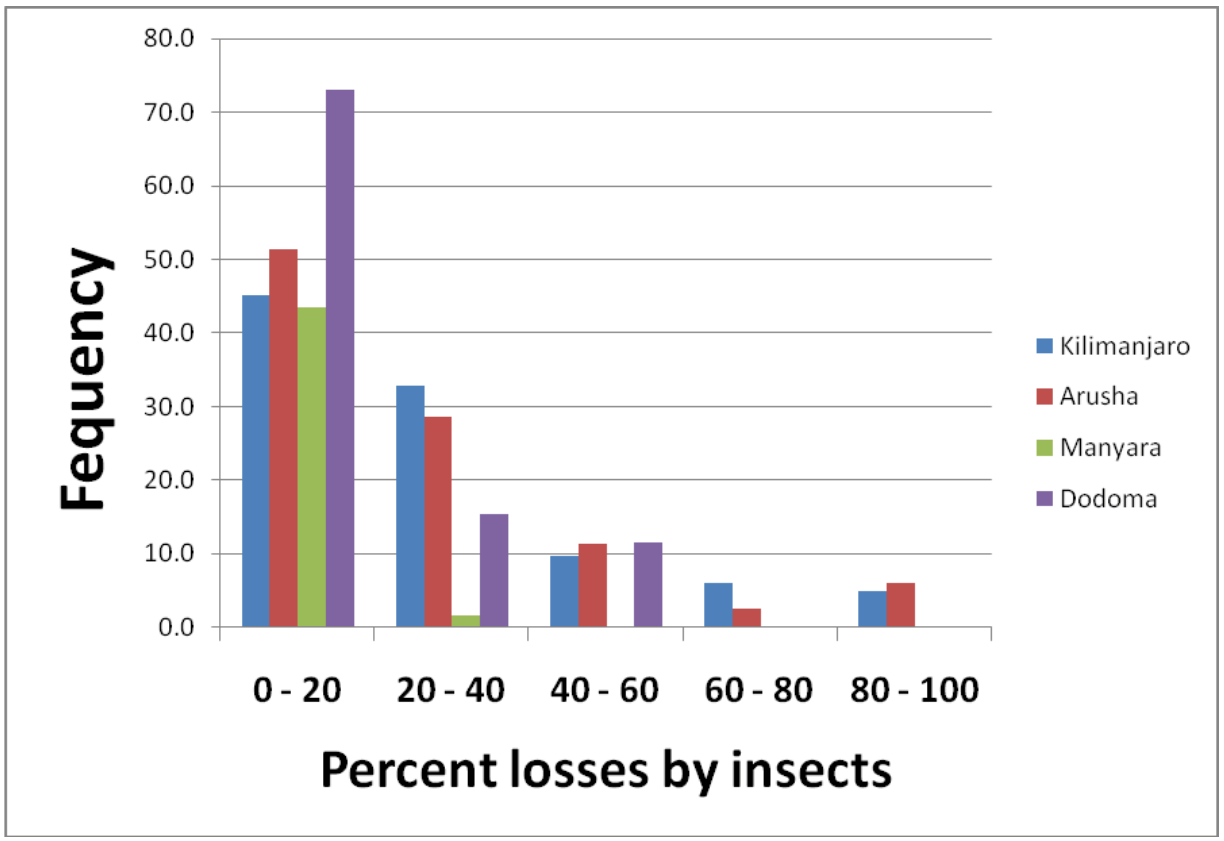


Figure 2. Per cent grain loss by insects.

One of the factors leading to high postharvest losses of grains in Tanzania is lack of improved storage facilities. Farmers are using traditional storage facilities which are prone to pest invasion (Fig 3).

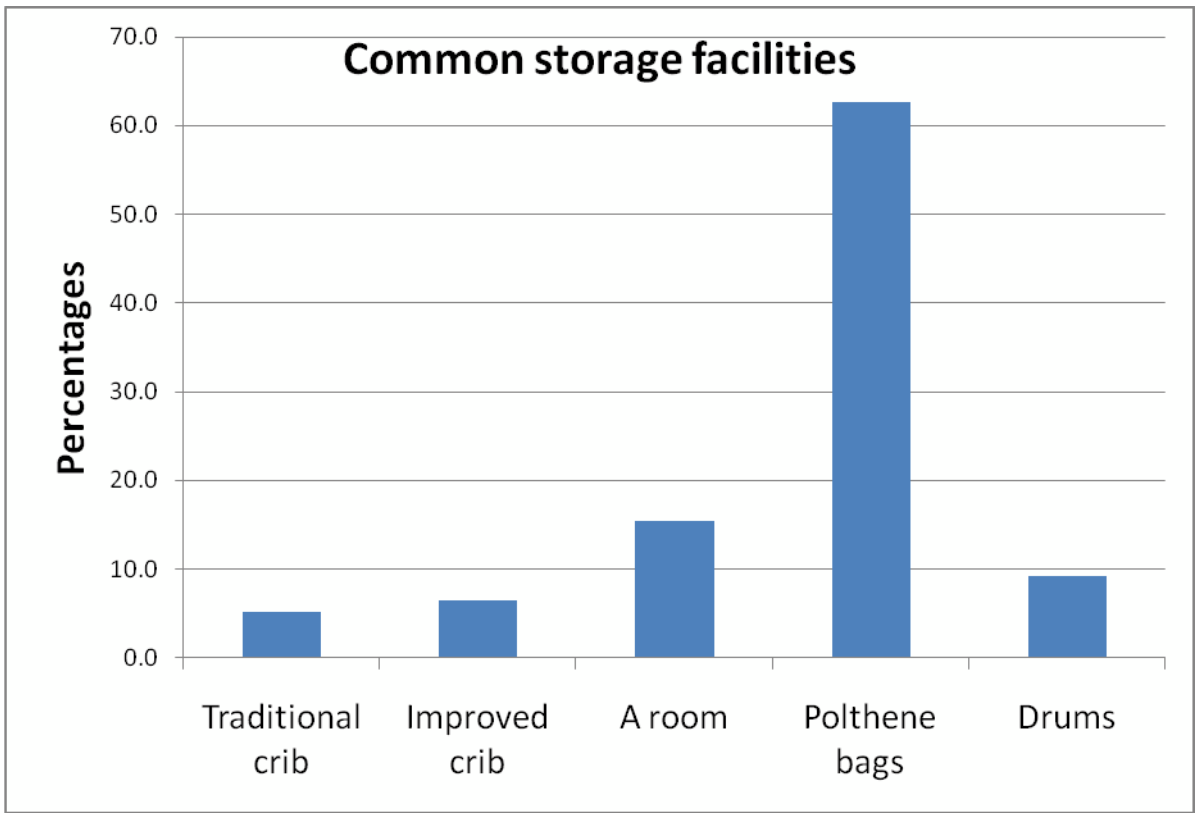
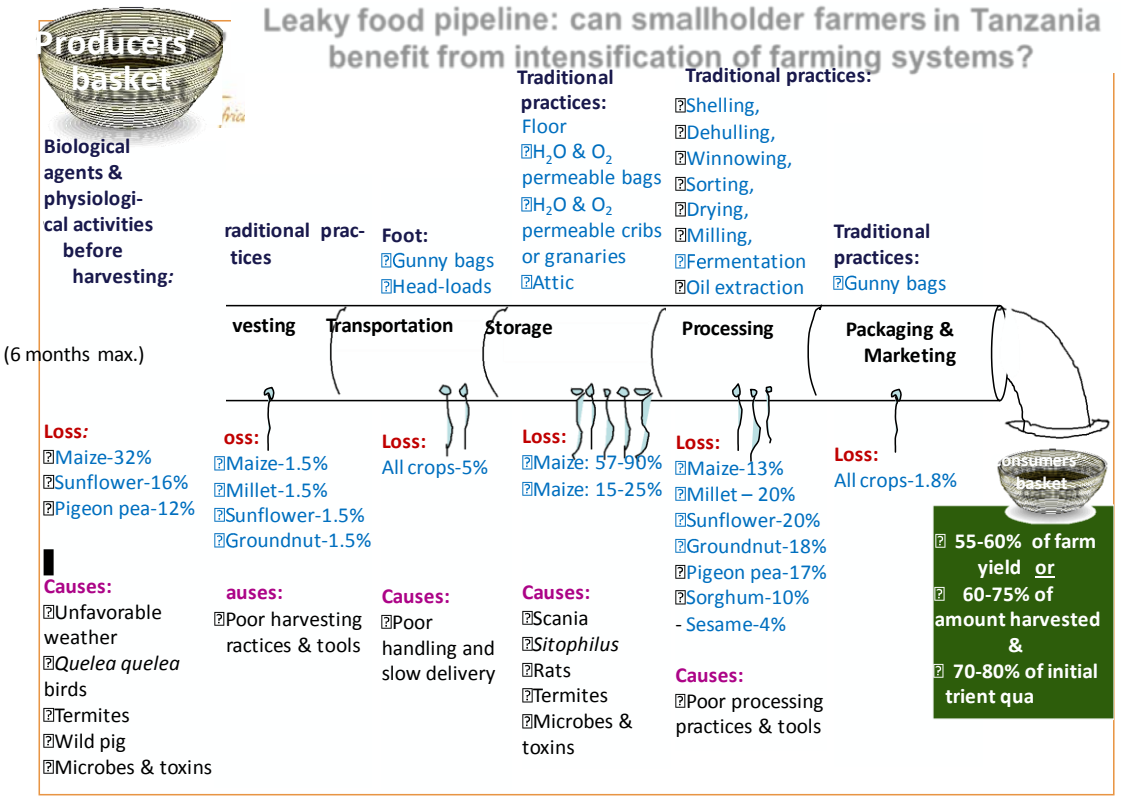


Fig 3. Common storage facilities

The leaky food pipeline for ~~the~~ 14 villages was developed. Five postharvest constraints were identified. These were problems in shelling maize and sorghum, infestation of cereal grains by pests during storage, poor methods used in cream separation from milk, loss of nutrients during food processing and preservation and lack of special feeding programs for special groups of people like children under five years of age. These constraints could significant affect farmers' ability to increase on-farm production or to adopt new technologies that will increase output. Below is the schematic representation of preliminary results of the situation analysis at some stages of traditional postharvest handling operations, where and how farm outputs are lost in the maize-base farming system of Kondoa and Babati.



* Note: This food pipeline should be validated during full season farming operations

Figure 4: Food pipeline for Dodoma and Manyara

Objective 2: Improve post-harvest storage and food processing knowledge of households
Output 2: Appropriate post-harvest handling technologies and processing techniques demonstrated and promoted

Evaluate the improved postharvest technologies with men and women farmers for enhanced adoption of technologies: Demonstrations and experiments were carried out with farmers to promote appropriate postharvest handling technologies and processing techniques. It is expected that the use of improved postharvest loss prevention interventions by farmers will enhance farmers' capacity to intensify production activities.

Four villages (Mondo and Soya villages in Konndoa district, and Mamire and Gedmar villages in Babati district) were selected as intervention villages. Similarly, four counterfactual or control villages were selected in the two districts for these activities.

i. Training (100 achieved): Training of 20 local fabricators of metal silos was done in order to enhance local fabrication of silos; local fabricators will engage themselves in the fabrication and dissemination of silos to farmers. Metal silo is proved effective hermetic storage for grains.

ii. ***Community sensitization and on-farm demonstration*** *(100% achieved):* In the intervention villages, four improved postharvest technologies: 1. Mechanized shelling of sorghum & maize; 2. Improved storage of grains; 3. improved technique of drying of grains; and 3. Improved milk-cream separation techniques, were first introduced through on-farm demonstration to 114 crop growing farmers/farming households and 42 livestock farmers. Besides, community sensitization was carried out in Kondoa, Mbulu and Babati districts, with regards to introduction and testing of two hermetic storages: super grain bags and metal silo. Framers were demonstrated with improved and traditional storage facilities. The improved storage technologies were exhibited at public show grounds, for example at Nane nane, Arusha, were over 5000 stakeholders visited .

iii. ***Mechanised crop processing in pilot environment*** *(50% achievement):* Pilot processing activities for maize and sorghum shelling and improved drying techniques were initiated in the intervention villages. Two threshing machines for maize and sorghum were delivered to pilot groups of farmers (treatment) in the intervention villages. The farmers' groups will install the machines in the villages for threshing of maize and sorghum during next harvest season. Both the intervention and control (no intervention) villages will be evaluated for the extent to which improved the postharvest technologies for threshing would (a) reduce postharvest losses; (b) reduce labour inputs and health complications suffered by women farmers that are associated with manual threshing of maize, millet and sorghum; (c) reduce processing time; and (d) increase willingness of men and women farmers to increase on-farm production (intensify) in the intervention villages compared to counterfactual villages.

iv. ***Improved postharvest storage technology*** *(50% achievement):* Storage experiments were established in two villages of Babati district to compare traditional crib storage systems (control) with improved storage techniques (low cost O_2 and H_2O impermeable storage bags).

The hypothesis of this study was: Oxygen and moisture impermeable bags preserve maize and sorghum better than traditional cribs and polypropylene bags; will reduce storage loss from the current 25% to < 2%; will save storage space for the farmer; will increase farmers ability to increase crop production and will improve health of women and income for men and women farmers. Four farmers' groups per intervention village were involved in the experiment (Table 1).

Table 1: Ongoing storage experiments in two villages

Postharvest technology to be tested		Planned		Achieved	
		• 2 villages in Dodoma • 2 villages in Manyara		• 2 villages in Manyara (Mamir & Gedemer)*	
Name	Type	Households/ Farmers groups	Total grain stored	Households/Farmers groups	Total grain stored
Cribs	Traditional (control)	16	16 cribs (32 tons)	8	8 cribs (16 tons)
Oxygen and moisture impermeable bags (0.2 mm thickness)	Improved	16	32 bags (1.6 tons)	0	0
Polypropylene bag	Traditional (control)	16	32 bags (1.6 tons)	8	16 bags (0.8 tons)
Oxygen and moisture impermeable bags (1 mm thickness)	Improved	16	32 bags (1.6 tons)	8	16 bags (0.8 tons)

*Each village was treated as a block. We purposively selected households and farmers' cooperatives that have traditional storage facility (cribs) and large quantity of maize in each village. The improved storage technologies were set-up side-by-side the traditional crib/bag storage techniques (control) with the farmers.

A total of 41.8 MT of maize and sorghum are currently in the storage experiments being managed by farmers.

The experiments could not be established in Dodoma because farmers did not have sufficient maize or sorghum for the storage experiment. In general, farmers have very poor capacity (knowledge, technology and infrastructure) to store their staple foods (maize, millet and sorghum) for family consumption until next harvest season that starts approximately 10 months after or to store cash crops until a better market price can be obtained (Figure 2). More than 60% of the staple and cash crops (e.g. sunflower, sesame) are sold within the same month of harvesting. This is a major factor that contributes to the nearly perpetual food insecurity situation of farmers in this region, especially in Dodoma.

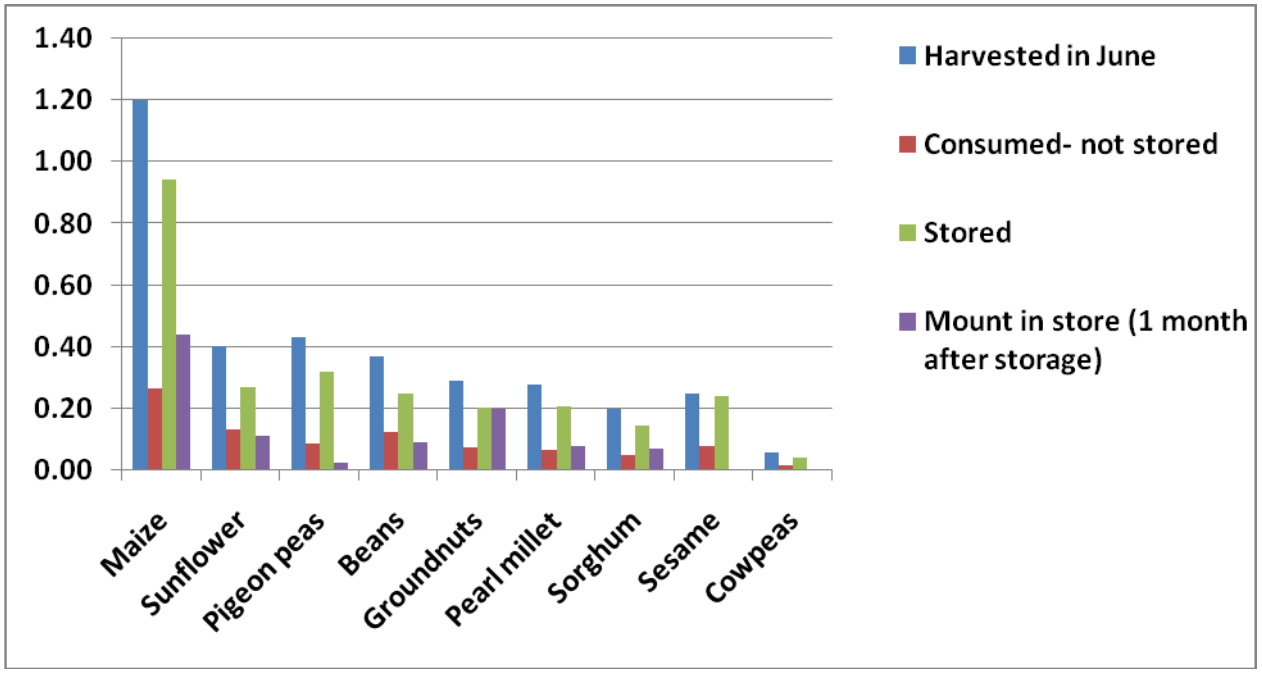


Figure 2: Food storage by farmers

Farmers often question the need to adopt new high yielding crop varieties that will increase their farm outputs but will be lost due to inadequate postharvest processing practices and storage system. For example, increased production of tomatoes in some villages in Babati district often causes price plunge and waste.

Support of AFRICA RISING

How will the outputs support the longer term objectives of Africa RISING?

Results of the postharvest loss assessment study in 8 villages of Kondoa district-Dodoma Region and 6 villages of Babati district-Manyara Region showed that cumulative postharvest loss of 40-45% of farm outputs currently occurs for maize and sorghum in the project area. A strategy to promote intensification of farming system combined with a strategy for postharvest storage of excess production will engender at least a proportionate increase in income and food security of smallholders. The risk of wasteful labour and farm inputs by smallholders as a result of postharvest losses in an intensifying production system will reduce. Integration of knowledge generated in the postharvest experiments being conducted with farmers in Babati and Dodoma will enable Africa Rising to develop a more comprehensive smallholder farming intensification strategy, eliminating the risk of glut and price plunge in event of increased smallholder farm out-puts.

Scalability

If these deliverables are intended to increase in scale during years 2-5 of Africa RISING, what actions do you propose to be implemented in future?

Data collection in the storage experiment started with farmers needs to be completed. A total of 41.8 MT of maize and sorghum are currently in the storage experiments in the two villages. It was planned that storage indices (moisture, residual O_2 inside the storage devices, grain moisture, weevil infestation, and extent of grain damage) will be monitored for a 6 month storage period.

A maize sheller has been placed at an intervention village (Mamire in Babati District) and a Sorghum thresher has been placed at the second intervention village (Mondo in Kondoa District). It is important to evaluate the improvements in value chains for these crops when threshing and shelling are mechanized compared to the counterfactual villages where traditional methods are used. This is possible in the next harvest season.

Continue with data collection from the experiments that have been started with farmers; replicate testing of the technologies in new locations to be identified prior 'during 4^{th} quarter of 2012, and for at least two seasons to arrive at valid conclusions.

Scaling up and out of hermetic storage technologies, such as super grain bags and metal silos, to reach large number of farmers. This calls for formation of innovation/learning platforms and networking an array of relevant stakeholders in order to disseminate information about these technologies.

Conducting economic analysis of metal silos and super bags; identifying policy gaps, incentives and disincentives that affect adoption of postharvest technologies. Initiate policy dialogue with local and national policy makers to include postharvest technologies in to national development agenda.

Lessons learned

What lessons, including about the partnership you had within the project, have been learnt during the implementation of the project that will help Africa RISING to succeed in future?

Partnership

Identification of key partners in project implementation is a critical first step for success of the project. Key partners already identified and implemented the project at local level. Building on already established partnership emanated from common interest and vision is very fundamental, and this will help Africa Rising to succeed in the future.

Awareness creation: awareness creation plays a vital role in implementation of improved storage technologies. Availability improved technology alone may not work unless communities are sensitized and level of awareness enhanced, which in turn affects adoption. Technology promotion should be accompanied with awareness creation at different levels: community, private sector, extension workers, local authorities and media.

Targeting: Targeting project implementation site appeared to influence the outcome of the project. Diffusion of postharvest technology seems high in areas of surplus grain production and where there is high postharvest loss due to biological and non-biological factors. There was no incentive for farmers from low potential areas to invest on and use improved postharvest technologies. Future intervention should take into consideration targeting community.

Duration: It is a challenge to document success factors within five months. The research involves postharvest interventions that should be tested for at least two growing seasons. Validation or assessment of the effectiveness of postharvest innovations compared to traditional practices require replicated testing over more than a growing season. Data need to be collected from the experiments that have been started with farmers. An important lesson is the possible loss of research opportunity and resources if data is not collected after starting experiments with farmers. It could also create credibility issues with farmers.

Publicity

Africa RISING encourages publication of the study results in refereed publications and presentation in conferences for wider public consumption. Advise the potential of your work getting to this stage.

The project has generated some information on postharvest constraints of farmers, how the constraints contribute to food insecurity and why farmers have been unable to intensify production systems. A journal paper is being extracted from the activities done so far; however, this may take quite some time to get it published. However, a paper on the results of the project will be presented at the 7th International CIGR Technical Symposium on "*Innovating the food value chain*" (2nd International Conference on Postharvest Technology & Quality Management) Postharvest Technology and Agri-Food Processing; Stellenbosch, South Africa, 25-29 November, 2012.

Documentation of success

Description of success stories illustrated with pictures

- **Setting-up experiments on simple, cost effective storage methods with farmers to demonstrate effectiveness**

Traditio

Setting-up the storage experiments with farmers using crib as control

Training of farmers' associations and demonstration of mechanized postharvest Management technologies

Demonstration of mechanised threshing, shelling and separation of cream from milk

The next action plan is the establishment of pilot processing centres where these machines will be placed and many smallholder farmers will have access to them for postharvest operations in the experimental villages. USAID indicator number: 4.5.2-27

Training local fabricators of metal silo technology in SARI, Arusha.


Community sensitization on improved storage technologies


On-farm demonstration of improved storage technologies with farmers' traditional practices.

Farmers field day (Nane nane show), Arusha.

Indicators

Proposed:

IdN: 4.5.2-5: At least 2000 farmers and other primary sector producers, individual processors, rural entrepreneurs, etc., will be exposed to new technologies (value-addition, post-harvest management including harvesting, on-farm storage, processing and product handling technologies).

IdN: 4.5.2-7: Interaction with at least 700 households in Arusha, Kilimanjaro, Manyara and Dodoma, through surveys to identify appropriate strategies for expanding postharvest storage, processing and nutrition.

IdN: 4.5.2-27: Processor associations (comprising of at least 400 individual processors and farmers) will be trained or organized around adding value to agricultural production and post-harvest transformation.

Achieved

Indicator number 4.5.2-5

About 275 farmers/households were trained in novel processing and preservation of locally produced grains, legumes, horticulture crops. The average number of household number in Babati and Kondoa is 7. Hence number of people reached was about 1925. The potential number of people that may use the technologies introduced in the four villages is 90,854

Table 1: *Outputs aimed at achieving Indicator No 4.5.2-5.*

District	Village	Type of technology demonstrated	Number of households trained	Potential users of technology	
				Male	Female
Kondoa & Babati	Mondo, Soya, Mamire & Gedemar	Mechanized shelling of sorghum & maize	67	82,220	8,634
		Improved storage of grains	104		
		Improved drying of grains	47		
		Cream separation from milk to livestock farmers	57		
Total			275	90,854	

District	Technology	Number of farmers (both male & female) demonstrated
Mbulu, Babati, Kondoa	Improved grain storage	55
Arusha-Exhibition	Improved grain storage	5,000
Total		5,055

Indicator number 4.5.2-7

Knowledge was imparted to many farmers during focus group discussions in 8 villages of Kondoa district and 6 villages of Babati district, and three regions. Significant skills were impacted to many farmers in the two districts during demonstrations on storage technologies, use of grain safe storage systems, use of collapsible dryers and separation of cream from milk.

Table 2: Outputs aimed at achieving Indicator No 4.5.2-7

Survey	Name of the region/district	Number of households interacted with (during two household surveys) by gender		Focus group discussion	
		Male	Female	Male	Female
Survey 1					
	Kondoa	80	110	86	53
	Babati	**83**	**60**	**75**	**56**
Survey 2					
	Kilimanjaro	49	40		
	Arusha	67	33		
	Manyara	34	18		
	Dodoma	13	12		
	TOTAL	**336**	**283**	**161**	**109**

Indicator number 4.5.2-27

There are at least four farmers' organizations and community based organizations involved in supporting post-harvest transformation in the intervention villages.

Table 3: Outputs aimed at achieving Indicator No 4.5.2-27.

District	**Village**	**Farmers/Processors association**	**Technology**	**Number of households involved**
Babati	Mamire	BENKI NAFAKA	1. Mechanized shelling 2. Mechanized threshing 3. Cream separation from milk 4. Improved storage methods for maize and sorghum	15
	Gedemar	Kikundi cha Kuhifadhi na Kusindika Vyakula		20
Kondoa	Soya	UMOJA		20
	Mondo	WAZALISHAJI MBEGU		11