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Stepping up Indigenous Knowledge and Technologies for Higher Incomes for Women in Rural Tanzania: A Case of Food Processing and Storage

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This study addresses various indigenous technology and knowledge-based food processing and storage methods used by rural women farming in Tanzania, focusing on the ways these can be improved for higher incomes. Primary data collected in June 2016 from 103 small-scale women farming in Dodoma, Iringa, and Mbeya were analyzed with secondary data in order to meet the study objectives. We found that the food processing activities of the women farming in these areas are largely primary— they are meant to facilitate transportation and/or storage and are accomplished using hands. The storage infrastructure is characterized by traditional methods, and sacks are the most widely used storage vessel. Farmers store the food crops for food security and to sell at a higher price later. The regression results revealed that poor storage facilities discourage increased farm production; therefore, efforts to achieve higher farm production should be accompanied by the improvement of indigenous farmers' storage facilities. Farmers themselves prefer hermetically sealed storage facilities such as drums and hermetic bags.

Keywords: *Indigenous Knowledge, Food Processing, Food Storage, Production Volume and Income*

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1.0 Introduction

Indigenous knowledge and technologies have proven to be of great importance to human livelihoods in many countries. Indigenous knowledge (IK) forms a basis for decision-making in various fields, affecting human wellbeing, including agriculture. In agriculture activities, IK is particularly useful to poor women in rural areas whose livelihoods are based on agriculture (Nwokeabia 2006). Sustainability of agriculture in Tanzania is largely dependent on indigenous knowledge and technology. Rural households' food processing and storage represent an important segment of a series of post-harvest activities benefiting greatly from the use of IK. Since there is a substantial time lapse between harvest seasons (at least seven months for most crops), it is crucial for households to store harvested food to ensure a steady supply of produce in the market and in the household for security of both income and subsistence. There are various reasons part of a crop's yield may be stored (including future family consumption, future sale at higher prices, seed for sowing in the coming season, etc.), but there is no distinction made for storage facilities to suit different purposes. The success of food storage depends on the presence of effective storage facilities at the household level.

Table 1 shows food losses associated with household storage conditions that are favorable to pest infestation. This data also indicates that, aside from pests, poor quality of storage facilities is the leading cause of stored food losses in Tanzania.

Type of Loss	**Type of Farm Scale**	
	Small (<2 Hectare Farm Size)	**Large (>25 Hectare Farm Size)**
Lack of Storage	13	13
Pest Infestation	40	50
Poor Quality of Storage Facilities	23	25

Source: World Bank 2009

Table 1: Losses Related to Storage Conditions in Tanzania (in Percent of Total Maize Losses)

The absence of suitable storage facilities with sufficient capacity is among the factors that force most farmers to sell their crops shortly after harvest to avoid post-harvest losses (Abass et al. 2014). This, too, means they forgo an opportunity to sell the same product at higher prices in the future.

The food storage facilities available in rural Tanzania vary in terms of their storage effectiveness, with most of the commonly used methods having the capacity to store food for only short periods. In spite of this, there is a wide acceptance of the fact that traditional food storage facilities are better adapted to the local conditions than exotic facilities (Proctor 1994). Although there are also modern storage facilities, they are limited, as their adoption depends on the economic status of the household. Poor rural farmers, in many cases, are not able to afford modern storage facilities.

The need to have improved storage facilities emerges from the fact that rural smallholder farmers depend on staple food sales to earn part of their annual incomes, and, therefore, poor food storage infrastructure, leading to post-harvest losses, is cited as one of the factors contributing to reduced disposable income (World Bank 2011). Low agricultural earnings increase the poverty among rural women who mainly carry the burden of farm labor. The possibility of postponing early sales until supply falls in the market could immensely contribute to reducing poverty among rural farmers, especially women (Abass et al. 2014).

Household food storage is normally accompanied by food processing, although some households may prefer to store their food crops unprocessed. Processing can be carried out mainly to facilitate storage (primary processing), or to transform the crops into various useful products (e.g., extracting oil from oilseed, getting cream from milk, etc.), which is known as secondary processing. Secondary processing entails value addition to the raw crops and, therefore, increases the market prospects of various food crops.

Most post-harvest food processing methods are carried out manually and are, to a large extent, performed by women, due to traditional practices found in many rural areas. Many of these methods are labor-intensive and time-consuming, but the incentive of earning an increased income has resulted in many women's persistence in embracing such methods (Abass et al. 2014). The lack of both efficiency in post-harvest food processing and of effective storage technologies not only leads to low income among famers, but also acts as disincentive to increased farm production. Since a large number of rural women are engaged in indigenous food processing, upgrading the processing technologies by, for instance, introducing simple built-in machines that still retain society's traditional values, would improve women's status by enhancing their earnings (Aworh 2008).

1.0.1 Food Crop Preservation

Rural women have indigenous knowledge of storing food for value protection. Various traditional inputs, as well as local herbs, are used by women in different rural areas to treat food crops (seed/grain) to prevent post-harvest losses caused by rodents or pests. The protectants differ from one location to another depending on the cultural practices as well as the agro-ecological conditions of a place (Lwoga, Ngulube, and Stilwell 2010a). This means that indigenous knowledge is location-specific. Using protectants to store food reduces losses, maintains the quality of the food, and postpones early sales after harvest. Although commercial/synthetic chemicals for this purpose do exist, their relatively high prices have been a stumbling block to successful adoption and use of such additives (Abass et al. 2014).

The IK regarding food preservation in rural areas includes the use of materials that are accessible locally, such as tree leaves, roots, bark and husks of particular plant species, chilli pepper, kitchen/wood ash, anthill soils, sand, goat/cattle dung ash, and tobacco. Some of these local herbs/inputs are common in many places, with others being more location-specific (Table 2).

Area	**Crop(s) Preserved**	**Inputs/Local Herbs Used**
Kilosa	Cassava	Salting
	Maize	Kitchen ash
		Burnt rice ash
Moshi Rural	Bean or Maize	Chili pepper
		Wild tobacco
		Concoction of chili pepper and *mabangi mwitu* leaves
		Concoction of *urutupa* and *mabangi mwitu* leaves
		Concoction of *urutupa* and chili pepper
		Kitchen ash
Kasulu	Bean or Maize	*Mshindwi* tree ash
		A mixture of chili pepper and *mshindwi* tree ash
		A mixture of chili pepper and *mtundu* tree ash
		A concoction of chili pepper and ash from any tree
		Kitchen ash
	Peas	Concoction of chili pepper and ash from any tree
Mpwapwa	Bean or Maize	*Msakasaka* plant leaves

		Ground neem leaves
		Kajashi tree ash
		Mluku tree leaves
		A mixture of *msonobali* and chili pepper
		Kitchen ash or goat dung ash or maize cobs ash
	Sorghum	Kitchen ash or goat dung ash or maize cobs ash
Karagwe	Maize	*Kajai* plant leaves
		Kajashi tree ash
		Masaka plant leaves
		A mixture of *kaswagala* and *kajai* tree leaves
		Kitchen ash or mud or dry cow dung or anthill soil
	Sorghum	*Kajai* plant leaves
		Mluku tree leaves
Songea Rural	Bean or Maize	Kitchen ash

***Source*:** Adapted from Lwoga et al. (2010a)

Table 2: Food Crops Preservation Practices in Rural Areas

Some local herbs are believed to be insecticidal; these plant species are used because of their ability to prevent development and growth of destructive pests. These traditional methods are best suited to small quantities of stored food crops, suiting the needs of most rural farmers. They are also an economical option, compared to industrial chemicals, which have further sustained their usage among rural farmers. Moreover, the use of local herbs does not have significant health risks, unlike the industrially manufactured chemicals for which there are environmental and health concerns.

It is, however, important to note that application of IK in agriculture is not limited to crop processing, preservation, and storage only. Rural farmers, due to their limited access to weather forecast information, are able to use indigenous knowledge and skills in many other areas of agriculture, such as for the timing of land preparation and planting or sowing; selection of planting materials and seed; and management of pests and diseases as well as coping strategies for climate change, including managing the environment for sustainable crop cultivation. This knowledge has enabled the majority of poor rural dwellers to sustain their agricultural livelihood. It is with this view that Mascarenhas (2003) emphasizes that had it not been for the use of IK in Tanzania, the agricultural sector would not have developed to the current level.

1.0.2 Women Employment in Agriculture

Gender-based employment disparities are prevalent in various sectors of Tanzania. Men tend to constitute the larger proportion of workers in the formal sector jobs, and women tend to work in low paid jobs with less security compared to their male counterparts (URT 2015).

The largest percentage of Tanzania's economically active population is employed in the agricultural sector. More women than men are employed in this sector (Table 3), although, generally men are considered to be the owners of farms and agricultural products, especially those related to cash crops.

Activity	**% of Hours Spent per Day**	
	Male	**Female**
Land Preparation and Planting	44.2	55.8
Weeding	45.0	55.0
Ridging, Fertilizing, and Other Non-harvest Activities	43.0	57.0
Harvesting	45.0	55.0
Aggregate Agriculture	44.6	55.4

***Source*:** National Panel Survey (NPS) Data 2012-2013

Table 3: Gender Responsibilities in Agriculture

In the countries of sub-Saharan Africa (SSA), about 60 to 80 percent of the labor force in food crop farming is provided by women (Pidatala and Khan 2003). Practically, for the case of food crops, men and women participate rather equally in clearing the site, preparing land, sowing, and planting. Women, however, shoulder a bigger load in the rest of activities, including processing and storage. Post-harvest operations are considered to be the obligations of women (Leavens and Anderson 2011). Men are generally more involved in the cultivation of cash crops, whereas women are more involved in the cultivation of food crops. Revenue resulting from the sale of surplus food crops is, therefore, accrued to women (Leavens and Anderson 2011). The employment gender gap in the agriculture industry is further established in the 2014 Integrated Labour Force Survey (ILFS), which shows women's employment in the sector exceeds that of men by about 6 percent (URT 2015). This is the largest gap (as far as analysis of employment by industry is concerned) out of all of the country's industries, including the food services industry, which is well-known for employing a significant number of women (Table 4).

Industry	**Male**	**Female**	**Gender Gap (In Favor of Females)**
Agriculture, Forestry, and Fishing	64	69.9	**5.9**
Accommodation and Food Service Activities	1.4	6.5	**5.1**
Transportation and Storage	5.0	0.2	**-4.8**
Construction	4.0	0.1	**-3.9**
Mining and Quarrying	1.7	0.4	**-1.3**
Manufacturing	3.6	2.6	**-1.0**
Administrative and Support Service Activities	1.0	0.3	**-0.7**
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	12.4	12.8	**0.4**
Human Health and Social Work Activities	0.7	1.0	**0.3**
Education	2.1	2.1	**0.0**
Others	4.1	4.1	**0.0**

Source: ILFS (2014)

Table 4: Percentage Distribution of Employed Individuals Aged 15+ Years by Selected Industry and Sex in Tanzania Mainland, 2014

The seasonal nature of agricultural activities, accompanied by low earnings from crop sales, have forced women to engage in other occupations. As vulnerable members of society, women tend to be involved in some other income-generating activities or practice garden cultivation through some kind of small-scale irrigation, mainly using a bucket. For example, Tengeru women in

Northern Tanzania tend to cultivate African indigenous vegetables, which they process for sale in various markets, including wholesale, supermarkets, institutions, hotels, and retailers; this activity has increased their incomes (Muhanji et al. 2011). Likewise, based on the gender roles among Maasai societies, women are responsible for milking, processing the milk, selling the surplus on the market, and keeping the proceeds.

Many rural women tend to work as housewives for their households, but do not earn any extra income (FAO 2014). In most cases, their roles in the family and society at large, especially during off-farming seasons, is not valued. This is partly due to the fact that women have lower access to formal education compared to men; however, women have rich farming IK. Improving women's access to agricultural employment opportunities through increased crop production would enhance their incomes. To change women's employment situations, especially when one considers rural employment, recognizing the role of IK can be a good starting point. Thus, this study is focused on examining ways to upgrade indigenous knowledge and technologies that are used by rural women in processing and storing food.

1.1 Statement of the Problem

Food processing and storage activities done by women in rural areas constitute crucial indigenous knowledge that is transmitted from one generation to another as it becomes part of the cultural norms. For a long time, such IK has been underutilized in many societies. As traditional bearers of IK, rural women are better positioned than most to use IK to add value to agricultural products they produce. There is still a lot about indigenous technologies that is unknown to researchers and policy makers; therefore, identifying and scaling up resources available to women utilizing such skills could motivate more production. The slow progress of improvements to the existing indigenous food processing and storage technologies makes women vulnerable to low earnings. The fact that these technologies are supported by social, cultural, and economic aspects acts as a bedrock for rural women to improve revenues for higher earnings through surplus production. Having adequate food processing and storage facilities will enhance farmers' confidence in increasing agricultural production; a view that is maintained by World Bank (2011) states that there is a direct relationship between crop production volume and the available storage technologies. To this end, encouraging farming operations for increased crop productivity will not convince farmers if no sustained and focused efforts are directed towards addressing the poor state of their available food processing and storage technologies.

1.2 Objectives of the Study

Generally, this study intends to take account of various IKs and technologies that are used by women for food processing and storage in rural areas, with a focus on ways to improve them for higher incomes and employment. Specifically, the study's aims are the following:

i. To understand indigenous knowledge applied in food processing and storage in rural areas of Tanzania.
ii. To determine the effect of indigenous food processing and storage technologies on the size of cultivated land and hence rural women's employment.
iii. To analyze ways to improve indigenous food processing and storage technologies for sustainable storage and flexibility in marketing of food crops.

1.3 Significance of the Study

IK plays an important role in the lives of many rural dwellers. It forms a basis for decision-making in the lives of many people worldwide. Survival and subsistence of rural people can be attributed to the existence of various IKs in their communities. Tanzania is no exception, and women play a very important role in agriculture and related post-harvest activities. Most rural women have agricultural IK and rely on farm earnings to sustain their livelihoods.

Identification and documentation of IK in food processing and storage as it is used by Tanzanian rural women will enable its preservation for the next generations, especially as such IKs and technologies are losing their popularity in the country. Moreover, the study will play a vital role in revealing the necessary improvements in such technologies to encompass more employment opportunities for women to increase their incomes. The presence of effective food processing and storage technologies is crucial in enabling rural women who are farmers to safely store their produce over an extended period of time, thus giving wider flexibility in marketing food crops. An understanding of the local situations for most rural farmers will inform policy makers on the ways to harmonize the existing techniques with modern technologies. More specifically, in the wake of increasing damaging effects to stored crops caused by *prostephanus truncatus* or larger grain borer (LGB) (introduced in Tanzania in the late 1970s) and by *sitophilus*, there is a need for research in this area of food storage to take into account what is currently being used by rural farmers and propose more sustainable ways to resolve food losses. As Mascarenhas (2003) and Lwoga, Ngulube, and Stilwell (2010b) put it, it is not a matter of debate on the choice between indigenous or modern knowledge, but rather an appropriate blending of the two that will foster sustainable agriculture and facilitate value addition for most products. A similar argument is given by Lodhi and Mikulecky (2010), that in developing countries, communities at the grassroots level should maintain both indigenous and modern knowledge in order to attain maximum benefit.

2.0 Literature Review

2.1 Economics of Food Processing and Storage in Africa

Customarily, farmers make allocative decisions about harvested food in terms of sale, storage, and other uses like feeding cattle, etc. The decision for each allocation is, in the first place, determined by influencing factors and the individual farmer's primary motive to engage in agriculture. The decision to, for instance, store food is influenced by the farmer's possession of proper food storage technologies. Appropriate storage structures ensure that there is sufficient quantity and quality of food in the market at all times, and at more stable prices.

Most approaches to improving agricultural development so far have focused on substituting the indigenous knowledge and technologies with modern scientific methods; however, these interventions have attained little efficacy as they do not use a participatory approach involving local people who would be the potential beneficiaries (Pidatala and Khan 2003). On top of the aforementioned, the failure of such interventions could also partly be attributed to the fact that experts did not take into account the already existing traditional values in the design of modern technologies (Pidatala and Khan 2003).

Today there is increasing awareness of the need to plan and design storage structures and facilities that are not only capable of storing the food grains with minimum loss, but also with cost effectiveness. Willingness of farmers to invest in an improved storage facility arises only if the expected benefits exceed the cost. Although interventions in agriculture may advocate for the adoption of modern food storage structures amidst high stored food losses, the lack of farmers' incentive to attain lower losses may lead to lower adoption rates (Proctor 1994; World Bank 2011). This shows that it takes farmers a substantial period of time to evaluate results before adopting new storage technology; therefore, quite large losses in the stored food might be incurred before making remarkable changes to their storage systems. These facts are among the reasons for early sale of food grains and the low level of adoption of modern food storage technologies in many African rural societies.

There has normally been a conception that high post-harvest food loss is a justification for implementing new food processing and storage technologies; however, the assessment of the demand for some particular technology by its potential users is crucial before introducing the technology. Current efforts seem to aim at encouraging small-scale rural farmers to adopt modern technologies as a third party, rather than primarily the intended users, but such modern technologies are generally meant for large-scale commercial famers (Hart and Aliber 2010). The fact that these new technologies are associated with a high cost of capital that does not outweigh the value reduction from losses, has made success to introduction of exotic technologies almost impossible, particularly in the developing world (Proctor 1994; Kadjo et al. 2013). This explains rural farmers embracing the traditional food storage facilities. For such farmers, simple improvements to the existing traditional technologies matter more than the adoption of complex technologies. By the same token, one can mention that no success stories in Africa can be found from the intervention of metal silos. In countries such as Tanzania and Mozambique, for instance, the main constraint to fruitful adoption of metal silos is unavailability of galvanized iron sheets of required quality (World Bank 2011), rendering local fabrication impossible. For a particular technology to be successfully adopted, careful evaluation has to first be made of all technical, economic, social, and cultural aspects.

Inadequacy of safe storage facilities among rural farmers is one of the challenging issues for increased crop production. As Kadjo et al., (2013) put it, the sale of grains shortly after harvests, due to lack of effective storage facilities, has withheld many African countries' governments' campaigns to increase crop production at the household level. In the northwestern province of Cameroon, for instance, although potato cultivation is well-known to employ women, its production is limited only to the quantities that are needed during harvest periods because they cannot successfully store crops (FAO 1997). Under such circumstances, farmers are forced to live the puzzle "sell low and buy high," rendering them unsecured. Abass et al. (2014) observed a significant price difference during the harvest (low price) period and towards the end of the post-harvest (high price) period for oil seed (sesame and groundnut) and pulses (beans, green grams, pigeon pea, and cowpea) in semi-arid savanna regions of Tanzania. This shows that sale prices during harvest season are not in favor of farmers and therefore tend to reduce profits.

2.2 Food Processing and Storage Interventions in Africa

2.2.1 Ineffective Project Cases in Africa

Projects to promote farmers' adoption of improved food storage technologies have been in place in SSA since the mid-1970s. In Tanzania, such projects were introduced around the late 1980s in collaboration between the government and NGOs. In Kilosa, in the Morogoro region, the Village Go-Down project was introduced in 1989, targeting the establishment of go-downs made of burnt bricks/concrete blocks with corrugated iron sheet roofing (Makalle 2012). The Vihenge project was also introduced in the same area by the government in collaboration with Food and Agriculture Organization (FAO) for adoption of improved granaries, this time using locally available materials in terms of their construction. However, both of these projects faced low adoption rates of the technologies being disseminated. This is because the technologies could not be culturally accepted, and farmers could not afford the associated capital and operating costs. Most farmers made no use of such improved technologies, and even the early adopters eventually moved back to their traditional technologies (Kadjo et al. 2013).

According to World Bank (2011), the introduction of concrete-filled PVC pipes in Zimbabwe in place of timber posts (used to raise the mud-plastered granaries in the fight against rodents, termites and other insects) could not gain traction due to the fact that the intervention was associated with high costs, and also the PVC pipes and concrete could not be acquired locally.

The government and FAO project to promote metal silos in Malawi also faced low adoption rates among smallholder farmers because of their inability to afford the costs. Culturally, the intervention was not accepted because farmers used to store their produce in bags inside their houses, and therefore could not accept the risk of outdoor storage that was associated with the silos project (World Bank 2011). A similar case of a failed metal silos promotion project is found in Kapchorwa, a district of Uganda, due to cultural reasons, as farmers could not start using technology to store their produce that was superior to their own houses. Similar reasons for the nonperformance of the same project can also be drawn from Mozambique and Tanzania.

The programs to reduce food losses in developing countries, such as the Prevention of Food Losses Program that was initiated by FAO in 1977 and the Global Post Harvest Forum (PhAction), seem to be nonperforming due to farmers' low adoption rate of the storage technologies being advocated. Notwithstanding poor project performance, it is now commonly agreed among development partners and organizations that current efforts on revitalization should focus on nurturing innovation and assist in upgrading whatever best practices are already at the disposal of rural farmers (World Bank 2011).

Much like these cases of storage technologies, the design of improved food processing technologies also have to be socially and economically viable in order to get farmers' acceptance. Willingness to pay for a particular processing or storage technology is an important signal for its effective demand. As shown by Aworh (2008), promotion of low cost traditional food processing technologies is essential in facilitating rural development. The development emerges partly from increased revenue due to increased production coupled with reduced rural urban migration. It is important for the improved food processing technologies to be situated in rural areas where there is adequate supply of raw materials and where practice of these technologies can foster more employment opportunities.

The promotion of manually-driven maize shellers by an FAO project in Tanzania failed because of their processing slowness and not being cost effective; instead, farmers opted to shell by hand through hired labor (FAO 1997). In some places the introduction of improved processing technologies failed because of their consequences of reducing women's labor demand. The fact that labor supply is not a constraint in rural areas has made many farmers opt to use labor in processing because it is cheaper using labor than mechanical processors. Food processing activities in Africa, whether organized at the individual or group level, are a well-known source of employment, as they involve a large number of women and act as a source of income to them. Alteration of perishable foods to sustain longer storage periods, such as *gari*[1] making in West Africa and fish smoking in Ghana, are also well-known sources of employment for women in those areas (FAO 1997). With this usual practice in place, the introduction of large-scale *gari* processing machinery in Nigeria failed because not only did it compromise women's incomes, but the product was also not accepted by consumers because it tasted different. Consequently, producers returned to using hand labor for peeling and grating cassava (FAO 1997).

Although IK is specific to certain cultures, it can be used to promote innovation and experimentation in other societies once exchanged. Sometimes the improvements of existing indigenous food processing and storage technologies can perform better, in terms of farmers' preferences, than a complete introduction of new technologies. As Nukenine (2010) argues in his study, rural farmers are likely to adopt the technology that is a result of an improvement from the prevailing ones. The point by Nukenine clearly underscores the need to nurture innovation in the design of food processing and storage technologies in the societies in which they will be promoted.

2.3 Traditional Additives for Food Storage

Food losses during the post-harvest period can occur at various times, including when the crop is still in the field, during harvesting, processing, and in storage. Abass et al. (2014) found a significant amount of food losses during processing and storage in the semi-arid savannah regions of Dodoma and Manyara in Tanzania. Based on their study, loss during processing is estimated to be between 13 and 20 percent, while during storage is between 15 and 25 percent. Such high loss rates discourage farmers from undertaking measures, leading to increased farm production.

Women farmers traditionally use additives such as extracts from local herbs or inputs in the fight against storage pests, insects, and rodent infestation. Abass et al. (2014) found about 23 percent and 20 percent of households surveyed in Dodoma and Manyara use herbs and wood ash, respectively, to store food crops.

Local herbs are also used in various areas to process and preserve milk. For example, some women in central parts of Tanzania (Dodoma and Singida) use woods from certain herbal plants (such as *Boscia angustifolia*, *Euphorbia candelabrium*, etc.) that are then burnt. The smoke is directed into the gourds containing milk, a practice that increases fresh milk's shelf life, which in turn increases its market opportunities (Komwihangilo, Goromela, and Bwire 1995). Moreover, cream is sometimes separated from milk locally to reduce its rate of deterioration. The cream can then be used for cooking at the household level, or sold to generate cash (Abass et al. 2014).

Local preservation means are used by farmers to facilitate longer storage of food crops with minimal storage loss. The length of storage of the food crops is influenced by, among other things, the storage and climatic conditions of a place. For example, the length of storage is higher in arid and semi-arid areas (Nukenine 2010). The study by Kadjo et al. (2013) found that when farmers are provided with storage protectants, they tend to increase the amount of produce that is allocated to storage.

Thus, it is important to understand and scale up this body of knowledge and skills among rural women who farm in order to foster local innovation at the grassroots level for more reliable crop storage and preservation methods.

2.4 Success Stories of Improved Adaptation

Despite the reported cases of failed project interventions, there are cases of farmers successfully acquisitioning (on their own) modified storage structures that have been improved based on adaptations from existing ones. In Zimbabwe, farmers were able to construct and use storage structures from burnt bricks walled with thatched roofing, an improved adaptation from the pole and mud granaries (World Bank 2011). This improved adaptation came about due to a scarcity in the supply of poles.

In Tanzania, the introduction of the Ram Press for extracting edible oil from oilseed has enabled small-scale farmers to obtain cooking oil at the household level. The Ram Press was initially introduced in Arusha in 1986 and later extended to other regions by Small Industries Development Organization (SIDO) in collaboration with donors. This oil processing technology is low-cost, therefore farmers could afford owning one at the household level. Apart from increasing the cultivation of oilseed, especially sunflower, farmers also reported an increase in income through selling value-added oil (instead of oilseed) and charging for oilseed pressing services extended to other small-scale farmers that could not afford to buy one (Hyman 1992). The promotion of sealed mud silos in some northern districts of Ghana has become more effective compared to their locally grass-woven baskets, such as *kambons* and *kunchuns*. In Namibia, hermetic plastic drums for food storage have been made available to farmers by manufacturers of water tanks. This drum's resemblance to the widely used traditional wood-made storage granaries (known as *mopane),* together with its effectiveness in improving grain quality and storage duration, have made it to be widely adopted by farmers (World Bank 2011).

The introduction of hammer mills and investments in dehulling equipment for processing sorghum flour in Botswana have proved to be extremely useful in saving time for women as it enables them to engage in other domestic and non-farming activities. However, in cases in which the promotion of such processing technologies entailed a loss or reduction in women's employment potentials, they faced a rejection. In Nigeria, the shift from large-scale gari processing mechanization to small-scale gari processing factories was greatly successful because the latter was not only cost effective, but also retained some manual work that women still attended (Aworh 2008).

Understanding the existing IK in agriculture concerning various local conditions can provide useful insight to the stakeholders when planning agricultural interventions. Farmers' likelihood to adopt an improved technology increases when they perceive the new technology as an addition to the effectiveness of the already existing technologies. Proper understanding and utilization of indigenous knowledge promises to be a source of future success for interventions in the agricultural sector (Hart and Mouton 2005).

From reviewing the literature, it is clear that interventions to enable safe processing and storage of food can be sustainable if they reflect three main issues: economic, social, and cultural acceptability. The notion that agricultural technological developments in developing countries ought to be externally induced seems to be insupportable. Various authors have argued that the technology transfer approach, which has been advocated for previously, does not benefit poor farmers— most of them being women. Many technologies could not be adopted by farmers because of either association with high costs, or because their construction materials were not based on locally available means. Finding the best ways based on local innovation for farmers to manage their produce during post-harvest periods will facilitate reaching the food and income security objectives.

3.0 Methodology

3.1 Data Type and Sources

This study uses both primary and secondary data. Using a semi-structured questionnaire for primary data, a total of 103 small-scale women farmers were interviewed in the Dodoma, Iringa, and Mbeya regions in June 2016. In Dodoma and Iringa, 2 districts were surveyed, while 3 districts were surveyed in Mbeya (Table 5). Dodoma was chosen because of its agro-ecology as a semi-arid area with frequently reported cases of food shortages. On the other hand, Iringa and Mbeya are high-production zones, which, in combination with Ruvuma and Rukwa, constitute the southern highlands and are known to be the breadbasket of the country. The regions in the southern highlands receive unimodal reliable rainfall ranging between 800 and 1400 mm per year. The temperature goes as low as 10^0C during the cold season and reaches 20^0C during the hot season. Dodoma, by contrast, receives unimodal unreliable rainfall ranging between 500 - 800 mm per year. The secondary data used was from the 2007/08 national sample census of agriculture, National Panel Survey (2012/13), ILFS (2014), and reviewed literature and reports.

Region	District	Village	Number
Dodoma	Bahi	Bahi	3
		Bahi Sokoni	4
		Kigwe	8
	Kongwa	Kibaigwa	21
Iringa	Iringa Rural	Igula	3
		Ndiwili	6
		Tagamenda	8
	Kilolo	Luhindo	5
		Lulanzi	4
Mbeya	Kyela	Ikambi	20
	Mbarali	Itamboleo	14
	Mbeya Rural	Inyala	6
		Makwenje	1
Total			**103**

Table 5: Distribution of Sample Size According to Village

The analysis is largely facilitated by primary data collected from these villages. The data were collected using a semi-structured questionnaire.

The survey population of the study comprised women living in Dodoma, Iringa, and Mbeya. The sample frame includes entirely women living in 13 selected villages of these regions, as indicated in Table 4. These villages were selected because they are among the most famous places in these regions using indigenous food processing and storage methods. We targeted a sample size of 100 respondents, based on time and financial resources, and the actual number of respondents reached was 103. In Dodoma, 36 women were interviewed, while in Iringa and Mbeya there were 26 and 41 interviewees, respectively.

The sampling procedure involved a combination of both purposeful and random procedures to select the elements from enumeration areas. The three regions and districts of the study were purposefully chosen due to their recognized effective background of traditional applications of food processing and storage methods: they were deemed quite useful for this analysis in the case of Tanzania. Selection of enumeration villages was dictated by the scale of activity. The study focused on and captured data in places noted as areas with reasonable use of indigenous food crops processing and storage methods. The choice of interviewed women in the enumerated villages was done by a simple random sampling procedure.

3.2 Econometric Estimation Model

Most of the literature uses a qualitative approach to studying IK. According to Grenier (1998), a qualitative approach is mostly suited to studies pertaining to human behavior (action), which tends to be subjective and highly variable.

Building on the reviewed literature, this study utilizes both qualitative and quantitative approaches to analyze various indigenous food processing and storage technologies as used by the interviewed farmers. The qualitative approach aims to describe various rural food processing and storage technologies. The quantitative approach involves estimation of an employment model using survey linear regression rather than the Ordinary Least Squares (OLS) method. The employment model investigates the possibility of increase in amount of land cultivated (implying more employment), if farmers were provided with improved storage facilities. The model uses the farm size (i.e., household farms for food crop cultivation, of which women farmers are a major source of labor force) as the dependent variable, while demographic characteristics and storage factors, such as not being satisfied with storage facilities in place, are independent variables.

The farm employment model specification is as follows:

$$logfarmsize_i = \beta_0 + \beta_{11} age_i + \beta_{12} accland_i + \beta_{13} mrtstatus_i + \beta_{14} edn_i + \beta_{15} nchild_i + \beta_{16} disstrgchoice_i + \mu_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (1)$$

where $\beta_0, \beta_{11}, \dots, \beta_{16}$ are coefficients, μ is an error term and:

logfarmsize	=	Logarithm of Size of Farm
age	=	Age
accland	=	Access to Land
mrtstatus	=	Marital Status

edn	=	Education
nchild	=	Number of Children
disstrgchoice	=	Dissatisfaction with Storage Choice

The description of the variables as used in the model and the hypothesized sign of causality of each variable is explained in Table 6:

Variable	**Description**	**Hypothesis**
logfarmsize	Size of land (in acres) cultivated by the household (log)	*regressand*
age	Age of the respondent in years	+
accland	1 if respondent considers easy access to land, 0 otherwise	+
mrtstatus	1 if the respondent is married, 0 otherwise	+
edn	1 if respondent's highest education level is primary and above, 0 otherwise	+
nchild	1 if household has 4+ children, 0 if it has 0-3 children	+
disstrgchoice	Dissatisfaction with storage facilities in use (1 if dissatisfied, 0 otherwise)	-

Table 6: Description of Variables Used in Estimation

We are interested in the effect of each independent variable concerning farm size. The model is multiple regression for isolating the effects of each hypothesized explanatory variable after accounting for others. We will be looking at effects of variables while controlling for the effects of others to find out the extent to which the respective explanatory variables interact to determine the land size utilized and hence the degree of women's engagement. In practice, β_0 is an intercept, which is either estimated or suppressed, depending on the researcher's knowledge and theoretical modelling background. For example, if one knows that the intercept of the regression line is zero, he/she should avoid wasting the variance in the data by estimating what is already known, i.e., to deal with the values that must be estimated.

Note that the parameter β_0 is a constant or autonomous determinant. When estimating a linear regression, we should be able to know what happens if all explanatory variables were inoperative: would the dependent variable be still realizable – at least in part? If yes, it means there is an autonomous determinant, β_0; if no, then there is a reason to suppress the constant in the respective regression.

We adopted standardized software (STATA in this case) to do survey linear regressions as a method to avoid biased results. This appropriately accounts for the effect of the complexities involved in survey design. To understand the problem that results from standard linear regression when it comes to survey data, see the case of a simple (heteroscedastic) format of the general equation: $y_i = \alpha_0 + \alpha_1 x_i + \varepsilon_i$, with $\varepsilon_i | x_i \sim N(0, \sigma_i^2)$. Note that y_i is the dependent variable (farm size) and x_i represents a respective independent variable. The usual OLS estimator of β_1, call it b_1, where sums and products are weighted by the reciprocals of σ_i^2, whose value is assumed to be known, would be an unbiased estimator of β_1, if the model holds. The estimator of the variances of the OLS, *v(b),* is model-unbiased under the appropriate specification (the homoscedastic model in the case of *v(b)*). This being the case for the usual OLS regressions, the validity of the OLS model can be questionable in estimation of survey data. For this reason, instead of estimating β_1, it is appropriate to estimate the finite population counterpart of β_1, which can be denoted as *B*. Although *b* (the OLS estimator) is a model-unbiased estimator for $\beta_1 \approx B$, it is not generally design-unbiased.

In respect to this possible problem of OLS estimation, the estimators in the linear survey regression model are modified to take care of the highlighted possible complexities. If a standard software, like STATA, is employed for survey data regression, it is capable of accounting for such complexities in estimation, and this is what is done in our study. Use of survey linear regression resolves the design and model bias problems smoothly. For further details on how this process works, one can refer to Nathan and Holt (1980).

4.0 Results and Discussion of Findings

4.1 Respondents Profile

Most of the interviewed women (29 percent) were between 40 and 49 years old, with an average age of 42 years (Table 7). Of all the interviewed women, 66 percent were married, and 37 percent were the heads of their household. In total, about 57 percent of the households were headed by women. The 2011/12 Household Budget Survey (HBS) indicates that at that time, about 25 percent of the interviewed households were headed by women. This implies that women are increasingly becoming responsible for household matters, including nurturing the family and the production and preparation of food. This increased responsibility of women is due to accelerated urbanization, which has led to the migration of men to urban areas in search of work, while women remain in rural areas.

Age	20-29	30-39	40-49	50-59	60-69	70+	**Total**
Sample	19	28	30	13	7	6	**103**

Table 7: Distribution of Sample Size According to Age

The increasing responsibility rural women have regarding household matters is also reflected by the role they play in making decisions pertaining to various aspects of farming (Table 8). For most households, decisions on food crop selling — including decisions about when to sell and how the resulting revenue should be spent — are made jointly between husband and wife. Generally, women have an upper hand compared to men in making decisions pertaining to farming activities, reflecting the earlier finding that the largest percentage of interviewed households were headed by women.

	Husband/ Male	**Wife/ Female**	**Husband & Wife**	**Children & Wife**
Food Crops Selling	10.8	38.6	47.0	3.6
Time to Sell	15.0	36.3	45.0	3.8
Revenue Keeper from Sale of Food Crops	16.3	67.5	13.8	2.5
How Revenue Should be Spent	17.7	36.7	41.8	3.8

Table 8: Decision-Making on Various Aspects of Farming (Percent)

Most of the interviewed women attended primary education (about 57 percent), followed by those without formal education (about 38 percent). Only 4 respondents had attained a secondary level of education, and there was 1 respondent with tertiary education.

In the surveyed villages, the primary cultivated crops are maize, beans, paddy, millet, cassava, sunflower, groundnuts, and sweet potatoes. About 81 percent of all interviewed women who farm were engaged in the production and sale of food crops, while the rest farmed for household subsistence only. Information collected from the 2007/08 national sample census of agriculture (as indicated in Table 9) shows decisions by farmers on the percentages of their harvested crops to store and sell. For most food crops, the amount allocated to storage is greater than the amount sold during harvest (with the exception of beans). The amount allocated to storage may not all end up being consumed by the household; some of it might find its way to the market, especially when there is a price surge.

	As Percentage of Produced Quantities	
Staple Food Crops	**Stored**	**Sold**
Maize	60.6	39.1
Beans	43.2	56.8
Paddy	55.0	45.0
Sorghum	72.7	27.3
Millet	67.5	32.5
Cassava	54.9	45.1
Sweet Potatoes	53.0	47.0

Source: National Sample Census of Agriculture, 2007/08 Data

Table 9: Households' Staple Food Allocation to Storage and Market

An examination of annual income per acre generated by women farmers from the sale of food crops indicates that farmers in Mbeya have the highest earnings, averaging TZS[2] 376,000 per year, followed by Iringa, where earnings average TZS 270,000 per year. Farmers in Dodoma earn only TZS 102,000 per year (Figure 1). This difference in earnings could be attributed to the fact that Mbeya and Iringa, on top of having fertile soils, receive reliable and sufficient rains throughout the year, so that farmers enjoy bumper harvest, unlike in Dodoma, which is a semi-arid area, where farmers get only meagre harvests.

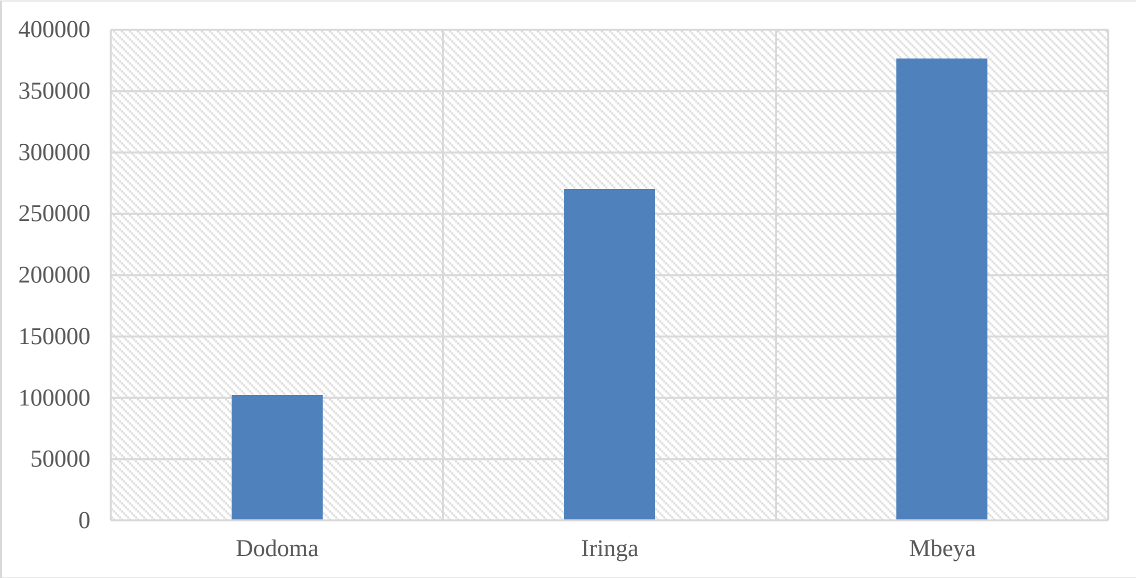

Figure 1: Regional Distribution of Household Average Annual Income from Food Crop Selling

Since farming in the country is seasonal, rural women engage in other activities during off-farming seasons. This study observed that, apart from crop farming, 9 percent of the respondents were engaged in petty business, while 19 percent were engaged in handcrafts' production as side activities. These activities enable women to earn extra income to supplement what is earned from the sale of food crops.

4.2 Farm Level Characteristics

On average, surveyed farmers cultivate farms of about 4 acres in total. Farmers can access land with relative ease in Iringa and Mbeya regions (Figure 2). About 65 percent of respondents from all regions indicated that it was easy to access land, but 56 percent of those who had difficulties accessing land were in Dodoma. Surveyed farmers' easy access to land is evidenced by the largest percentage of them (about 43 percent) claiming that they normally hire land for cultivation. Apart from hiring land, about 22 percent of women farmers cultivate the land that they are entitled to ownership, while 14 percent claimed to cultivate the land owned by their husbands. The remaining percentage involves cultivation of land that is jointly owned by husband and wife. This observed land ownership pattern emphasizes the earlier mentioned point that women have an upper hand in the cultivation of food crops, hence they are likely to have ownership of the land devoted to cultivating food crops. Generally, men have higher ownership of land in most parts of the country.

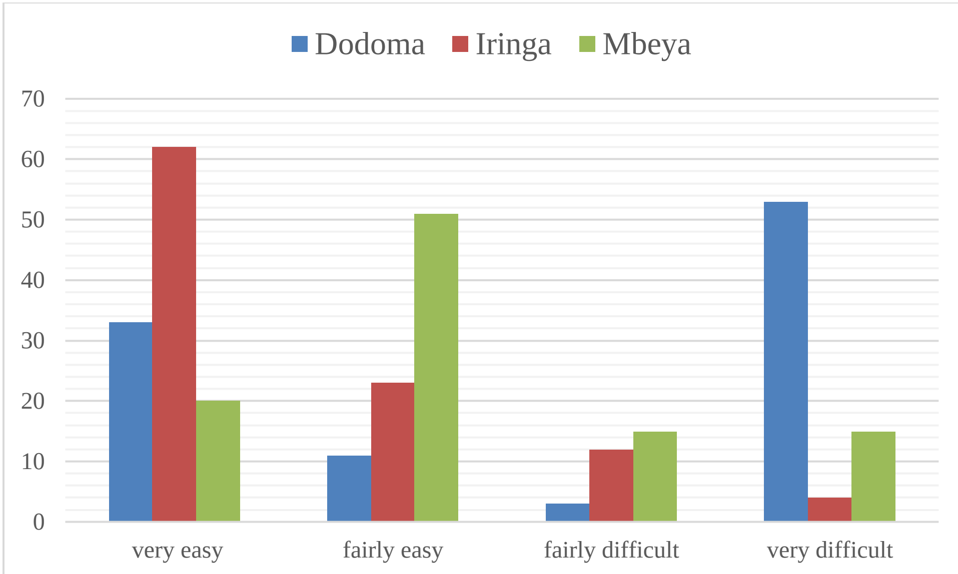

Figure 2: Percentage Distribution of Access to Land by Region

4.3 IK in Food Processing

Indigenous technologies for food processing are mainly primary, i.e., facilitate preparation of the food crops for storage and transportation. The methods used are mainly carried out manually (i.e., using hands) as outlined in Table 10. Secondary processing activities that add value to the crops to obtain a certain by-product are not utilized, despite the existence of indigenous processing knowledge for crops like sweet potatoes, cassava, vegetables, eggplant, etc. As a result, most farmers sell unprocessed crops depriving them of the opportunity to earn more.

Method	**Sample Crops**	**Mechanism/Operationalization**
Threshing	Groundnuts, Beans, Sorghum, Paddy, Sunflower, Millet	-Hitting with sticks
Winnowing	Beans, Sorghum, Paddy, Sunflower, Millet	-Throwing the grain into the air using a sieve/winnower -Dropping the grains from the air using a basket
Shelling	Maize	-Manually using hands -Hitting with sticks

Peeling	Cassava, Sweet Potatoes, Peas	-Using hands and knife
Drying	Cassava, Groundnuts, Maize, Paddy, Sunflower, Vegetable, Eggplant	-Exposure to sunlight by spreading in a thin layer or on the ground -Sweet potatoes and cassava, after being cut into small pieces and soaked, are then exposed to sun -Vegetables (such as *mchicha*) are partially boiled before being exposed to sun -Eggplant, after being peeled and cut into small pieces, is then rinsed with water and exposed to sun for drying

Table 10: Primary Food Processing Methods

One respondent in Mbeya reported using a grinding stone (known as *Luwala*) to obtain flour from finger millet. There was also a reported case of grinding roasted groundnuts using a grinding stone.

Figure 3: A Research Assistant with a Woman who is Processing Cassava (Peeling) for Storage

Figure 4: Drying Vegetables before Storage for Durability

Figure 5: Sun Drying Maize and Beans by Spreading on the Ground

4.4 IK in Food Storage

The survey of rural women shows that sacks/bags are the most commonly used storage facilities for grains in rural areas (Table 11). This finding is in line with the 2007/08 agricultural census survey, which also found that the largest percentage of the interviewed households were using sacks for storing food crops. The significant adoption of sacks as a storage facility is the result of two benefits: the low cost of sacks, and saving space; sacks can easily be stored in-house when they are empty. The decline in the use of granaries (*vihenge*) as a storage facility by most rural farmers is attributed to (among other things) the persistence of rampant theft, as the granaries were constructed outside the houses. However, few farmers had granaries constructed inside their living houses, while some have upheld this technology without dismantling their granaries constructed outside houses even though they are no longer in use. Granaries allow the grain to dry well, and, therefore, cases of grain loss due to high moisture content are almost negligible. The continuous disappearance of granaries as storage technology results in a loss of granary construction skills. The survey revealed that about 70 percent of the respondents acquired IK regarding food processing and storage from their parents/elders, but at present, there has been little knowledge transfer due to the high level of motivation that is given to farmers to adopt modern methods and technologies. As such, the death of a parent/elder implies a loss of IK that this person was endowed with, including granary construction skills.

Storage Facility	***Adoption (Percent)***	***Duration of Possible Storage (Months)***
Granary (*Kihenge*)	4	7
Sack/Bag	95	9
Aerial/Ceiling: Hanging from Tight Lines above Fire Places	1	6
Underground Storage	3	7
Clay Pots/Baskets/Plastic Tins	3	8

Table 11: Commonly Used Food Storage Structures

Some other rural storage methods include underground storage for root tubers, such as cassava and sweet potatoes, which are harvested only when they are to be consumed or sold.

It is clear from Table 11 that sacks, which are the most widely used grain storage facilities, have the capacity to store grains up to a maximum of only 9 months. Since most grains are harvested once a year, while in other years farmers experience a total crop failure due to unfavorable climate change, there is a need for farmers to be provided with improved storage facilities that can foster longer storage periods to even the supply of food in the market and enhance assurance of food security and opportunity to earn higher incomes.

Figure 6: Maize Stored in a Granary

An examination of farmers' motives for food crop storage reveals multiple purposes. All farmers store food to make sure that their households have food security. Others store food to ensure availability of seed for planting in the coming sowing season; while others store crops to sell at higher prices later on and hedge against future cash needs to meet unforeseen contingencies (Table 12). Dodoma has the largest percentage of farmers who store to ensure availability of seed for planting in the coming season, while Mbeya has the largest percentage of those who store to sell at higher prices later. All these storage purposes require the presence of good storage facilities to guarantee that grain quality is maintained throughout the storage period. This acts as a starting point for the assessment of storage technology innovation.

Purpose of Storage	**Dodoma**	**Iringa**	**Mbeya**
Food for Household	100.0	100.0	100.0
Seed for Planting	84.9	34.8	59.3
To Sell at a Higher Price Later	39.4	43.5	55.6
To Meet Future Cash Needs	15.2	73.9	59.3
Others	9.1	0.0	0.0

Table 12: Household Food Storage Reasons

During storage, some farmers use various additives to protect food from damage. They range from industrial chemicals (considered to be modern), to traditional additives (listed in Table 13). Additives are often used for crops stored in sacks, but about 49 percent of the interviewed farmers stored their crops without any additives, especially when storing them in clay pots, baskets, and plastic tins. The fact that there is a high percentage of farmers who reported storing their food crops without any additives may be due to high prices and/or being aware of health effects (such as causing cancerous diseases) associated with modern storage chemicals.

	Storage Protectant			
Storage facility	**Artificial/Industrial Chemicals (Spraying/Dusting)**	**Neem Leaves (mwarobaini)**	**Cowdung/Ashes/ Magadi**	**Smoking**
Granary (*Kihenge*)	✓	0	✓	0
Sack/Bag	✓	✓	✓	0
Aerial/Ceiling	0	0	0	✓
Underground Storage	0	0	0	0
Clay Pots/Baskets/ Plastic Tins	0	0	0	0

Table 13: Food Storage Protectants Used in Surveyed Areas

Famers reported food loss in current storage facilities, despite the use of various protective additives. A significant number of farmers reported food losses caused mainly by rodents and pest/insect infestation (Figure 7). The common food pests causing the greatest loss in the country, according to Tefera and Abass (2012), are beetles*: prostephanus truncatus* or LGB and weevil: *sitophilus*. Both LGB and *sitophilus* destruct crops by making holes or tunnels in the grains as they feed, turning them into flour, although the former is more destructive than the latter (Tefera, Mugo, and Likhayo 2011). These results also confirm similar findings by the World Bank survey (2009). Food losses during storage reduce earnings either due to sale of low volume or poor quality products post-storage, or due to farmers selling during harvest simply out of fear of food loss in storage. In general, this acts as a disincentive for farmers to increase farm production levels, thus immensely limiting engagement in agricultural employment.

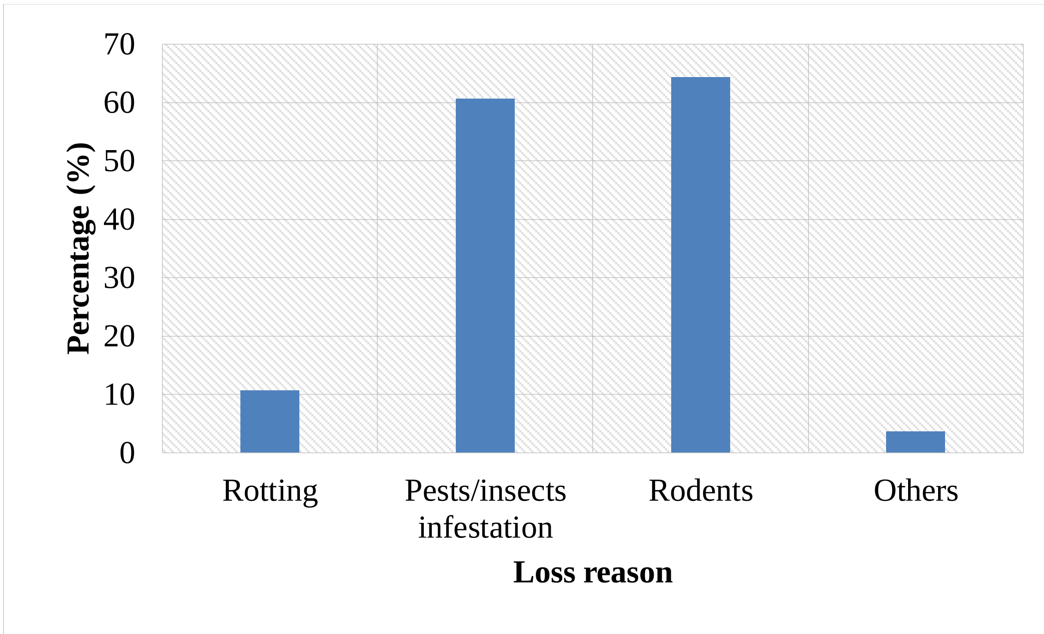

Figure 7: Farmers Reported Food Losses

Figure 8: Damaged Maize (by LGB) from Storage

Following the reported food losses by the households resulting from storage, a simple survey linear regression was performed to see if the existing storage facilities negatively impact farmers' farm production volumes. The approach used is underpinned by the assumption that if a particular farmer reported a food loss, then this is due to poor storage infrastructure. The dependent variable is the logarithm of the size of farm cultivated by the household.

The regression results indicate that three variables are statistically significant in influencing farm employment. These variables are marital status, number of children, and dissatisfaction with storage choice (Table 14). All variables had the expected signs, i.e., showing a positive or negative relationship with the dependent variable as hypothesized earlier, except variables on education (*edn*) and access to land (*accland)* that showed a negative relationship with farm employment whereas were hypothesized to have a positive relationship.

Marriage increases a woman's chance of employment by 32.7 percent, compared to unmarried women. This variable is statistically significant, at a 5 percent level. This is because living together as a couple increases the chance of cultivating larger farms since the labor is shared between husband and wife (although men participate mainly in preparing farming lands, sowing, and planting).

Bigger households cultivate even larger farm lands. The variable number of children per family is statistically significant, at a 5 percent level. This is because the food requirement for bigger households is higher, compared to the food requirements for households with only a few members. Moreover, a larger household also implies a larger labor force to be deployed in farming, hence an incentive to cultivate more farm land. It is common practice among African families for children to provide labor on farms, and, therefore, having many children is an incentive to engage in extensive cultivation.

Variable	**Coefficient**	**Robust Std. Err.**	**P-Values**
age	0.00026152	0.0052791	0.961
mrtstatus	0.32657193*	0.1345515	0.017
edn	-0.07750317	0.1625508	0.635
nchild	0.30182096*	0.1403690	0.034
accland	-0.04790627	0.1561152	0.760

disstrgchoice	-0.37221404*	0.1533397	0.017
_cons	0.87596429**	0.2968106	0.004

legend: * p<0.05; ** p<0.01

Table 14: Regression Results of Employment Model

The results also indicate that households' dissatisfaction with storage facilities reduces farm size by 37 percent, which decreases farm employment for women. The variable is significant at a 5 percent level. This means that the presence of poor storage facilities is a disincentive for increased farm production. This finding is consistent with the argument that quality storage facilities are incentives to increased farm production, which implies that longer storage is associated with higher profits that is realized for selling the crops later when demand is high.

The age of the respondent, although not statistically significant, showed a positive relationship with employment. Although both education and access to land were not statistically significant, they showed a negative relationship with women's employment. Education's negative relationship could be attributed to the fact that educated farmers use modern ways of farming, including the use of modern technologies for higher productivity thus considered as practicing intensive farming rather than extensive farming, as assumed in our model.

The suggested improvements by farmers for better storage showed that farmers want to be provided with safe and secure storage facilities (Table 15). Some of the suggested facilities include drums, hermetic storage bags, and granaries (*vihenge*), reflecting a desire for low-cost storage facilities. All these facilities are improvements to the existing storage facilities. Hermetic storage bags, for instance, would be an improvement from the jute bags that are currently in large-scale use. Demand for granaries arises as some of the farmers are now constructing them inside their houses, although they impose a challenge that they still occupy a place even when they are empty. One of the hurdles to successful adoption of modern storage facilities is the associated high capital cost (Proctor 1994; World Bank 2011; Kadjo et al. 2013), implying that modifications to improve storage facilities should take into consideration cost-effectiveness aspects. Moreover, the common feature of the farmers' suggested storage facilities is that they are all hermetic, meaning that they can safely store food crops without any protective additives. Drums and hermetic sacks can serve this purpose well. Hermetically sealed storage facilities hinder the development and growth of pests/insects due to oxygen deprivation. This suggestion could be a result of farmers' awareness of the harmful health effects (such as causing diseases) associated with the use of industrial storage chemicals.

Suggested Improvements	Suggested Storage facility		Percentage (%)
Provision of safe and secure storage facilities	Use of drums	19.1 %	55.8
	Hermetic storage bags	13.2 %	
	Use of *vihenge*	10.3 %	
	Others	13.2%	
Manufacture of effective storage protectants	*-Nil-*	*-Nil-*	32.4
A method that does not require to put/add artificial protectants	*-Nil-*	*-Nil-*	11.8

Table 15: Respondents Suggested Improvements for Better Food Storage

5.0 Conclusion and Policy Implications

This study surveyed a total of 103 rural women smallholder farmers in Iringa, Mbeya, and Dodoma. Apart from farming, rural women engage in other income-generating activities such as petty business, including handcrafts, to augment income earned from the sale of food crops. Generally, while women own some land for the cultivation of food crops, averaging 4 acres per person, men own larger parcels of land and specialize in the production of cash crops instead of food crops.

As is the case in most parts of Africa, women assume a larger role than men in nurturing the family and catering to household needs; therefore, they apply IK. We found that rural women have various food processing and storage indigenous knowledge and technologies in the studied areas. Most of them acquired food processing and storage IK and technologies from the elders, but according to the rural survey respondents, the rate of knowledge transfer has slowed. This highlights the need to document the know-how associated with such technologies before most of it is lost, so that we can take care of the warning of an old African proverb, which says, “when an elder dies, it is as if a library burned down to the ground.”

The primary food processing activities, such as threshing and shelling, are manually performed, suggesting that advancement to some simple machines like mechanical shellers and threshers could help reduce women's workload in processing and foster increased production. This too will permit women to engage in other income-generating activities. Moreover, the provision of training on food processing for certain crops such as sweet potatoes, cassava, and vegetables could facilitate scaling up to include marketing these products in supermarkets, wholesale institutions, hotels, retailers, etc.

Product quality is an important aspect for attracting good prices in the marketing of food crops. Sun drying through exposure on the ground does not guarantee product quality, and also increases the extent of post-harvest food losses, thereby affecting the amount to be earned upon selling. Provision of drying garments, canvas, or mechanical dryers guarantees product quality and can reduce post-harvest loss to some extent, allowing a modest increase in income from the sale of food crops.

All surveyed households engage in food crop production and storage for various reasons: food security; the assurance of seed availability; and keeping products for deferred sale since prices are usually low during harvest season. The largest proportion of the storage facilities used were traditional, with sacks being the most widely used. These are only able to store food for less than a year, suggesting that improvements that can keep food safely stored for longer periods are needed.

The regression results indicated that poor storage facilities are a disincentive to increased farm production. This implies that the success of the efforts to encourage increased farm production should be accompanied by an improvement of indigenous farmers' storage facilities to achieve increased income for rural women. The reason indigenous knowledge and technology are emphasized is because rural women cannot afford relatively expensive modern methods, whereas traditional storage facilities benefit from locally sourced construction materials as such requiring only low capital and operation cost for their existence and sustainability. By virtue of existence of some means, the critical matter is just to improve the technology. Using some durable inputs, safe storage locations, and coverage from sun and rain can be part of the requirements. The continued upholding of traditional food storage facilities, despite leading to high food losses, suggests that farmers want to maintain low cost storage facilities. Therefore, upgrading to safe and secure storage facilities, such as hermetic structures, as a means for improving existing technologies, would be quite effective.

To this end, establishment of the organized framework for various indigenous knowledge in the country, i.e., taking stock of the available methods and ways to scale them across the country, would be relevant to agricultural productions and welfare of not only women, but households in general. Innovation in IK is important, rather than relying on modern storage facilities that are associated with high capital and operating costs, which may not be achievable for rural areas of developing countries.

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Endnotes

[1] Gari is a product of dried cassava after cassava tubers have been crushed to produce a mash and then fermented.
[2] TZS is Tanzania currency (USD 1=TZS 2,200)