THE INTERNATIONAL JOURNAL OF BUSINESS & MANAGEMENT

Maize Storage Technologies among Smallholder Farmers in Manyara, Tanzania

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Abstract:
Maize is among main food crops produced in most regions in Tanzania, including Manyara region. This study was conducted to determine and documentthe adoption different maize storage technologies in Manyara region Tanzania. The data were collected randomly from 60 smallholder farmers from Sabilo, Seloto and Long villages .The survey design was used because it enable the researcher to collect data at a single point in time. The study adopted stratified sampling and simple random sampling techniqueswhere smallholder farmers were randomly selected for the study.Data were analyzed using Statistical Pack-age for Social Science(SPSS) computer programme In the study descriptive statistics such as frequency tables, percentages and graphs were used to analyze the objectives. The study identified different maize storage technologies like bags, traditional cribs, cribs with chemicals, in-house storage, bags with chemicals and new improved imported technologies such as Super Grain bags were used by smallholder farmers. However it was revealed that farmers were using storage technologies, but they were still experiencing pest attacks which resultedinto quality and weight loss. To address the problem, the study calls for small holder farmers to continue using the bags with chemicals and in house storage when storing maize. Also, extension education on maize storage should be emphasized more to farmers so as to reduce maize losses, especially, during storage.

Keywords: *Maize storage, postharvest losses, technologies, smallholder farmers, extension education*

1. INTRODUCTION

The role of Agriculture to the Tanzanian economy cannot be over emphasized (ACT, 2007). In March 2013, it was reported that Agricultural sector contributed 15.9% of Total Gross Domestic Product (GDP) compared to 16.8% in 2012 same month (BOT, 2013). The sector contributes to the economy through provision of employment, processing, packaging, transporting and livestock keeping. Maize is a major food for most of African countries and household and the main source of income and employment for the majority of rural household (Ajani and Onwubuya, 2012). Across the country, maize is the most planted cereal crop in regions such as Shinyanga, Dodoma, Tanga, Tabora, Mbeya, Mwanza, Manyara, Iringa and Morogoro. Area planted with maize per household was highest in Manyara (1.36ha) followed by Dodoma (1.3ha) (URT, 2012).

Currently Tanzania is concentrating in the production of maize to ensure food security. However due to challenges facing maize production, greater attention has to be taken to know what happens after maize has been harvested. At the national level, the Tanzanian government through the National Strategy for Growth and Reduction of Poverty (NSGRP, 2005) and the current *Kilimokwanza strategy* (2009) underscore the needs to address post-harvest losses reduction (Rugumamu, 2012). The government strategies were in line with United Nation Sustainable Development Goals in eradicating extreme poverty and hunger.

The poor storage practice is among the reasons as to why most farmers fail to take advantage of price increase that occur during the production cycle (Kadjo *etal.*, 2013).Currently, there is lack of reliable and verifiable data on post-harvest losses in most African countries. However, annual grain losses are over 50% in cereals (Obeng, 2011). The traditional storage practice in developing countries cannot guarantee protection against major storage pest of staple food leading to 20-30% grain losses.2002). When effective storage technology is not available in rural areas, often, traditional storage technology unable to dry and store grain properly, this can evenly increase losses during storage (Kadjo, *etal.*, 2013).

With the technological advancement, new technologies like metal silos have been adopted in developing countries to store maize due to seasonality of the produce (Proctor, 1994 cited by Kimenju, 2010). In most of African countries including Tanzania, most small farmer holders' have been adopting post-harvest technologies for storing grains such as maize. The upcoming imported improved storage technologies for maize are being used without being put into trials so as to determine its profitability (Kimenju and Hugo 2010). Few authors like Adetunji (2007), Sadiq(2013), Jabo *etal.,*(2010),

Ajani and Onwubuya(2012) and Meikle(2012) have addressed the maize production and postharvest storage on grains focusing on storage practices and storage technologies.This paper reflects the different maize storage technologies that are being used by farmers in the study area.

2. Materials and Methods

2.1. Study Area, Sampling and Design

The study was carried out in Babati District in Manyara Region.The study area was purposively selected due to its relatively high poten tial for maize production and hence existence of various farmers using different maize storage technologies. It is also the main catchment area for maize supply to Kibaigwa market which is one of the largest maize markets in East Africa. The area is covered with investors on maize production where the cost of maize is too high for food insecure population to accommodate due to high transport cots to central and northern part of the country (URT, 2011).

A cross-sectional research design was used in studying the adoption of different maize storage technologies by smallholder farmers at a particular time. Such design enabled the researcher to build up a picture on different maize storage technologies by small holder farmers.

The study population was smallholder farmers growing maize in Babati district. The smallholder farmers in the population were farmers from *Sabilo*, *Seloto* and *Long* villages growing maize. The farmers in these villages are capable of storing maize for a specified period of time, or sell maize after harvest without storage.A stratified sampling procedure was employed for this study; three maize growing villages with the ability and capacity to store maize were purposely selected for the study. The sampling method was chosen because of the size of population available in the study area hence there was a need to divide a population into strata. The villages which farmers are involved in the production and storage of maize were selected then from each village were selected as units of analysis. From each Village, five (5) wards were selected by village leaders, in each ward, four(4) maize growing farmers were selected making a total of 20 (twenty) smallholder farmers in which the statistical data analysis was done. Twenty (20) smallholder farmers selected made a total of 60 respondents for the three villages.

2.2. Data Collection

In order to address objectives of the study, both primary and secondary data were collected on different maize storage technologies. Moreover, the previous researches on post-harvest and agricultural produce were reviewed to obtain the current status on produce storage. Also data were collected from the smallholder farmers growing, storing and selling maize in each ward in the villages of Sabilo, Seloto and Long. Small holder farmers were asked to give information on their socio economic characteristics such as sex, age, education level, and marital status. The information on different maize storage technologies used during storage, information on problems associated with using various maize storage technologies and smallholder farmers' awareness on the use of the improved imported maize storage technologies was collected.

The questionnaire was used to gather data from sixty (60) smallholder farmer in each selected wards in Manyara region. The questionnaire captured the demographic information of farmers, the practice of growing food crops, the growing of maize, the storage of maize using different storage technologies. Information on different costs related to maize storage for each technology, the revenue received when maize is stored after harvest and revenue received without storage.

2.3. Data Analysis

For this study quantitative data collected were summarized, coded and then analyzed using the Statistical Package for Social Sciences (SPSS) computer programme. Descriptive Statistics (frequency distributions, percentages and cross tabulation) were used in organizing and presenting the information. The information presented included growing of food crops particularly maize, types of maize storage technologies, problems on the use of different maize storage technologies, awareness on improved maize storage technologies, postharvest losses on maize, place of selling maize and the maize market price.

3. Results and Discussion

3.1. Small Holder Farmers Growing and Storing Maize

Table 1shows that 22% of smallholder farmers grew and stored maize soon after harvest. The 20% of smallholder farmers grew maize, but stored with other crops such as pigeon pea and beans. 35.4% of smallholder farmers grew both maize and potatoes but only maize was stored after harvest for future use. The potatoes were sold in the market or used as food in the family. 18.8% of smallholder farmers growing maize and wheat stored only maize after harvesting, while the 70% of the farmers who grew maize and wheat they stored maize and beans after purchasing from other farmer growing beans as summarized in Table 1.

		Farmers Storing			Total
Response	Food crop	maize	maize, beans and pigeon pea	maize and potatoes	
farmers growing	maize	22	2	0	24
		45.8%	20.0%	0%	40.7%
	maize and potatoes	17	1	0	18
		35.4%	10.0%	0%	30.5%
	maize and wheat	9	7	1	17
		18.8%	70.0%	100.0%	28.8%
Total		48	10	1	59
		100.0%	100.0%	100.0%	100.0%

Table 1: Types of Food Crops Grown and Stored by Smallholder Farmers (N=60)
Source: Smallholder Farmer Interviews

3.2. The Reasons For and Place of Maize Storage

The Table 2 shows that 94.7% of small holder farmers were storing maize at home, they stored for food security in their families. On the other hand 95.0% of farmers were storing at their home as they are waiting for better price in the future when the maize price increase in the market. And 100% of farmers storing maize at home stored with the purpose of protecting against vermin like birds in the farms. Only 2.6% of smallholder farmers who were storing maize in the village store, they stored them for the purpose of food security. Some of farmers stored for reason of receiving better price in the future as indicated in Table 2.

Response		**Reasons for storing maize**			**Total**
	Storage practice	food security	anticipation of better price	protection against vermin	
Maize storage place	home	36	19	2	57
		94.7%	95.0%	100.0%	95.0%
	village store	1	1	0	2
		2.6%	5.0%	0%	3.3%
	others	1	0	0	1
		2.6%	0%	0 %	1.7%
Total		38	20	2	60
		100.0%	100.0%	100.0%	100.0%

Table 2: The Reasons for and Place of Maize Storage (N=60)
Source; Smallholder Farmer Interviews

3.3. Traditional Maize Storage Technologies and Maize Storage Losses

3.3.1. Traditional Crib as a Maize Storage Technology

The traditional crib or locally called *kuntii* is constructed locally with small pieces of trees, mud, dried grasses and being placed in the uplifted area to protect against rodent attacks like rats. The maize is stored inside according to different quantity basing on the need of individual household. It is the closed-up basket mud plastered inside and on top, as indicated in Figure 1.

Figure 1: Traditional Crib Maize Storage Technology
Source: Field Surveys

The study found that 100% smallholder farmers who do not opt for traditional crib technology for maize storage they did not incur losses. Only 66.7% of farmers using the technology did not incur losses due to proper storage of their

maize after harvest. However, 33.3% of farmers using the technology were getting maize losses during storage. This was due to improper storage knowledge and poor maintenance of storage structure as summarized in Table 3

Variable		Farmers Using Traditional Crib		Total
Storage losses	Response	No	Yes	
	No	51	6	57
		100.0%	66.7%	95.0%
	Yes	0	3	3
		0%	33.3%	5.0%
Total		51	9	60
		100.0%	100.0%	100.0%

Table 3: Traditional Crib and Maize Storage Losses (n=60)
Source: Smallholder farmer interviews

3.3.2. Traditional Cribs with Chemicals Application and Maize Storage Losses

It was found that traditional crib or locally called *kuntii* is constructed locally with small pieces of trees, mud, dried grasses and being placed in the uplifted area to protect against rodent attacks like rats. However, in traditional cribs and chemicals, the chemicals either traditional chemicals or improved chemicals such as insecticides were being added to the crib so as to protect maize against losses when storing in bulky as indicated in Figure 2.

Figure 2: Traditional Cribs with Chemicals Maize Storage Technology
Source; field surveys

From the study, it was noted that large number of small holder farmers had a tendency of not using traditional cribs with chemicals application compared to the number of users who use traditional cribs and chemicals technology during maize storage. This was due to the reasons: the chemicals are very poisonous and dangerous for human health; the quality of maize in the market tends to lower with the increase in chemicals and this result to lower price in the market. From the study it was discovered that only 19.2% of smallholder farmers who were using the technology did not get losses during maize storage while 80.8% of the users of this storage technology are getting losses during storage. This was associated with poor storage knowledge and poor maintenance and repair of the storage technology, as exemplified in Table 4.

Variable		farmers using traditional cribs and chemicals application		Total
Storage losses on traditional crib and chemicals application	Response	No	Yes	
	No	34	5	39
		100.0%	19.2%	65.0%
	Yes	0	21	21
		0%	80.8%	35.0%
Total		34	26	60
		100.0%	100.0%	100.0%

Table 4: Traditional Cribs with Chemicals Application and Maizestorage Loss (n=60)
Source; Smallholder farmer interviews

3.4. Polypropylene Bags with Chemicals Application and Maize Storage Losses

The Polypropylene bags or sacks are storage bags which were being used by small holders' farmers to store maize soon after being harvested (See Figure 3). The technology was used with the application of chemicals, usually, the insecticides to protect against pests such as rodents and insects.

Figure 3: Polypropylene Bags with Chemical Application
Source: Field Surveys

88.9% of farmers who were using bags with chemical applications were getting losses during maize storage. Only 11.1% of farmers using the technology did not incur losses during storage, as summarized in Table 5

Variable		**farmers using bags and chemicals applications**		**Total**
Storage losses on bags and chemicals applications	Response	No	Yes	
	No	23	4	27
		95.8%	11.1%	45.0%
	Yes	1	32	33
		4.2%	88.9%	55.0%
Total		24	36	60
		100.0%	100.0%	100.0%

Table 5: Polypropylene Bags with Chemicals Application and Maize Storage Loss(n=60)
Source: Smallholder farmer interviews

3.5. Modern Maize Storage Technologies and Storage Losses

3.5.1. Polypropylene Bag and In House Storage and Its Associated Maize Storage Losses

This storage technology involved storing of maize bags in the room or house where a farmer is living. Sometimes, a farmer decides to construct a store basing on the quantity of harvest per season. The use of bags and in house storage during maize storage, 60% was used by the farmer and did not experience maize losses. The only 40% of smallholder farmer were storing maize by using the technology and they experienced maize losses during storage as indicated on Table 8.

Variable		**farmers using bags and in house storage**		**Total**
In-house storage losses	Response	No	Yes	
	No	5	33	38
		100.0%	60.0%	63.3%
	Yes	0	22	22
		0%	40.0%	36.7%
Total		5	55	60
		100.0%	100.0%	100.0%

Table 6: Impact of Polypropylene Bags and In House Storage on Maize Storage Loss (N=60)
Source: Smallholder Farmer Interviews

3.5.2. Adoption of Super Grain Bags by Smallholder Maize Farmers

The super grain bag is the new improved technology for maize storage. The technology adopted the normal technology of plastic sacks. The plastic bags do not contain chemicals for storage, if closed properly no oxygen will penetrate to allow the insects to continue surviving. The maize are stored in the plastic bag then placed in the polypropylene bags to protect against pest attacks as you can see in Figure 5.

Figure 5: Super Grain Bags Maize Storage Technology
Source: Field Surveys

91.7% of smallholder farmers who were storing maize in super grain bags experienced maize losses, while 8.3% of farmers used the technology without incurring losses on maize. Majority of farmers experienced losses because of inadequate knowledge and training on how to use the storage technology. The bags were not properly closed, which left the space for oxygen to penetrate creating conducive environment for pest growth. The results for the impact of Super grain bags on maize losses are summarized in Table 8.

Variable		Farmers Using Super Grain Bags	Total
Losses when using super grain bags	Response	Yes	
	No	5	5
		8.3%	8.3%
	Yes	55	55
		91.7%	91.7%
Total		60	60
		100.0%	100.0%

Table 7: Farmers Using the Super Grain Bags and Maize Storage Losses (N=60)
Source: Smallholder Farmer Interviews

3.6. Challenges on Usingdifferent Maize Storage Technologies

3.6.1. Traditional Crib Maize Storage Technology

From Table 9, it is clear that majority of smallholder farmers were facing with the problem of rodents attack during maize storage. 3.3% of farmers experienced pest attack while, only 1.7% of total smallholder farmers experienced maize quality loss and spillage. All these makes difficult to get better price in the market.

Variable		Frequency	Percent (%)
	Rodents	56	93.3
	Pest	2	3.3
	Quality loss	1	1.7
	Maize spillage	1	1.7
	Total	60	100.0

Table 8: The Problems on Using the Traditional crib Maize Storage Technology (n=60)
Source; Smallholder farmer interviews

3.6.2. The Problems of using Polypropylene Bags only

The smallholder farmers who were using polypropylene bags for storage were experiencing the pest attack and quality loss on the maize. Fewer farmers experienced the problem of maize spillage and decrease in maize weight as summarized in Table 11.

Variable		Frequency	Percent
	Quality losses	24	40.0
	Pest	27	45.0
	Rodent	2	3.3
	Maize spillage	5	8.3
	Weight losses	2	3.3
	Total	60	100.0

Table 9: Problems of Using Polypropylene Bags(n=60)
Source: Smallholder Farmer Interviews

4. Conclusion and Recommendations

The findings showed that most farmers are growing food crops, and maize is the main food crop grown in the study area. The most common maize storage technologies were traditional cribs, traditional cribs with chemicals application, polypropylene bags, polypropylene bags and chemicals application, polypropylene bags, in house storage and the super grain bags.

Moreover the study revealed that with the use of different maize storage technologies including the modern storage technologies, farmers were still experiencing maize loss due to pest attack, poor storage facilities, and low knowledge on using the storage technologies.

The study recommends that smallholder maize farmers should be emphasized on the use of improved storage technologies, as it is the best in terms of reducing postharvest losses compared to other storage practices.

In addition, The government through the Ministry of Agriculture, Livestock and Fisheries as well as other stakeholders must conduct regular short courses, seminars, workshops, and study tours to smallholder maize farmers through extension staff to enhance their understanding of the concept of maize storage technologies and its application in their localities.

5. References

i. ACT (2007).*ReportonoutputMarketsupport*. The report Submitted august 13th 2007 by Business Care Service and Centre for Sustainable Development Initiatives.

ii. Addo, S., Birkinshaw, L.A., and R.J. Hodges. (2002). Ten years after the arrival in Ghana of Larger Grain Borer: Farmers‟ responses and adoption of IPM strategies. International Journal of Pest management. 48(4): 315-325

iii. Adetunji, M.O. (2007).*Economics of maize storage techniques by farmers in Kwara state, Nigeria*. Pakistan Journal of Social science 4(3): 442-450, 2007.

iv. Ajani E.N and Onwubuya E.A (2012). *Assessment of use indigenous maize storage practicesamong farmers in Anambra state, Nigeria*: International Journal of Agriculture, Research, Innovation and technology 2(2):48-53 December, 2012

v. Basavaraja, H., Mahajanashetti, S., and Udagatti, N. (2007): *EconomicAnalysisofPost-harvestlossesinFoodGrainsinIndia*; a case study of Karnataka; Agricultural Economic research review Volume 20 January-June 2007 pp 117-126.

vi. BOT (2013).*Quarterly Economic Bulletin for the quarter ending June 2013*; Bank of Tanzania.

vii. Chendroyaperumal, C. (2009).*ProfitTheories; Modern and Indian*; Department of Management Studies, Saveetha Engineering College India.

viii. FAO (2004a). Grain Storage Techniques: Evolution and trends in developing countries. FAO/AGS Working Paper. (January 2004).

ix. FAO (2010).*Food and Agriculture Organization statistical year book*. The World Food and Agriculture; Rome.

x. FAO (2011). *MissingFood*; the case of postharvest Grain losses in Sub Saharan Africa, Washington, World Bank.

xi. George, C.M. (2011).*Effective Grainstorage for better livelihood of AfricanFarmers Project*; The Swiss Agency for Development and Cooperation (SDC).

xii. Gittinger, J.P. (1982).*Economic Analysisof Agricultural project*: The World Bank Washington for DC, 505 pp.

xiii. Golob, P. *Chemical, physical and cultural control of Prostephanus truncates*, Integrated Pest Management Reviews, Vol. 7, (2002) pp. 245-277.

xiv. Harris, K.L and Lindblad, C.J. (1976).*Postharvest Grain loss Assessment Methods*. A Manual of Methods for Evaluation of Postharvest losses; American Association of Cereals chemists, Office of Nutrition, U.S. Agency for International Development.

xv. Jabo, M.S. M., Maikasuwa, M. A. and Mainasara, M. (2010). *Costsand Returns Analysis of Cowpea Storage* (*Vigna Unguiculata*) *UsingChemical and non-Chemical Methods*. In: Nmadu, J.N and Baba, K.M. (eds). Commercial Agriculture, Banking Reform and Economic Downturn: Setting a New Agenda for Agriculture Development in Nigeria. Proceedings of 11th Annual National conference of National Association of Agricultural Economists.Federal University of Technology, Minna, Nigeria.Pp 192-195.

xvi. Jones, M., Corinne, A., and James, L. (2011).*An initial investigationof the Potential for HermeticPurdue improved cropstorage(PICS) Bags to improve income for maize producers in Sub Saharan Africa*: Department of Agriculture Economics, Purdue University: Working paper, Number 11-3

xvii. Kadjo, D. (2013).*Effects of storage losses and Grain Management Practices on storage*; Evidence from maize production in Benin; Selected paper prepared for presentation at the Agricultural and Applied economics Association 2013.

xviii. Kereth, G. (2013).*Assessmentofpostharvesthandlingpractices*: Knowledge and losses of fruits in Bagamoyo district of Tanzania; Food science and quality management ISSN 2224-6088 Volume 11, 2013.

xix. Kimenju and Hugo. (2010).*EconomicanalysisofalternativeMaizestoragetechnologiesinKenya*; Paper prepared for presentation at the 3rd international conference of the African association of Agricultural Economist, Cape town S.A

xx. *Meikle, W.G., Markham. R.H., Nansen, C., Holst, N., Degbey, P., Azoma, K., and Korie, S.*(2002).*Pest Management in traditional Maize stores in West Africa*; Plant health management division, IITA Benin. Journal of Economics Entomology 95(5): 1079-1088 2002

xxi. Monlruzzaman, M.S. (2009).*Agro-economic AnalysisofMaizeproduction in Bangladesh*. A farm level survey; Bangladesh Journal of Agricultural research 34(1):15-24 March 2009.ISSN 0258-7122.

xxii. Motte, F., Feakpi, R., and Awuku, M. (1995). *Farmer Experimentation in small-scale maize storage: Experiences from Volta Region in Eastern Ghana*. Proceedings from Conference on Postharvest Technology and Commodity Marketing in West Africa, 29 Nov to 1 Dec 1995, Accra, Ghana. IITA 1998. 216-219.

xxiii. Offermann, F., and Nieberg, H. (2000).*Economic performanceof Organic Farm in Europe*; Economic and policy volume 5, Universitat Hofenheim.

xxiv. Ogunlowo, A.S. (1997).*Machineselectionbased on Gross margin costing Analysis*; A case study of Abeokuta local government areas in Nigeria.

xxv. Pandey, I.M. (2007): *Financial Management*; ninth edition. Vikas Publishing house PUT ltd, Modern printers.

xxvi. Rugumamu,C.P. (2009).*AssessmentofpostharvesttechnologiesandgenderrelationsinMaizelossreductioninPangawevillageEasternTanzania*; Tanzania journal of science volume 35, 2009.

xxvii. Sadiq, M.S. (2013).*Profitability and Production efficiency of small scale Maizeproductionin Niger State, Nigeria*. IOSR Journal of Applied Physics (IOSR-JAP) e-ISSN: 2278-4861. Volume 3, Issue 4 (Mar. - Apr. 2013), PP 19-23

xxviii. Shil, N.C.(2008).*Cost Effective Analysis for Arsenic Water supply Project in Bangladesh*. International Journal of Business and Management, volume 3 number 11.

xxix. Tadele, T., and Adebayo, A. (2012).*ImprovedPostharvesttechnologiesforpromotingFoodstorage, processingandhouseholdNutritioninTanzania*. IITA, International Maize and wheat improvement centre.

xxx. URT (2011). *Feed the Future Multiyear strategy 2011-2015*; US Government Feed the Future (FtF)

xxxi. URT (2012). *National Sample Censusof Agriculture smallholderAgriculture* volume ii; Crop sector- National report; Ministry of Agriculture, Food security and Cooperatives.

xxxii. URT (2013). *InvestmentandSocio-economicprofileManyararegion*; Prime Minister's office; Regional administration and Local Government.

xxxiii. Wander, A.E., Didonet,A, D., Moreira, J., Moreira, F., Lanna, A., Barrigossi, J., Quintela, E., and Ricardo, T. (2007). *Economic Viability of small scale organic production of Rice, Common Bean and Maize in Goias state, Braz*il. Journal of Agriculture and Rural Development in the Tropics and Subtropics Volume 108, No. 1, 2007, pages 51–58

xxxiv. World Bank (1996): *Sustainable transport: Priorities for policy reform*. Washington, DC: World Bank, 131.